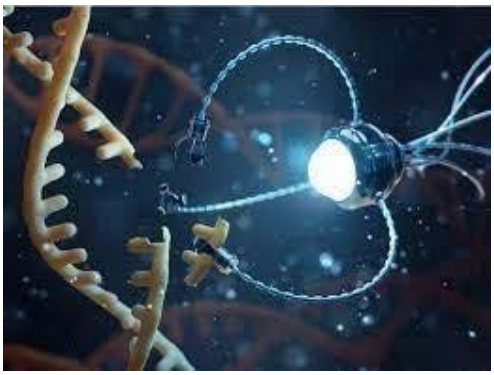
Ideal Systems, Ideal Technology and their Realization Opportunities Using Information Communication & Computation Technology (ICCT) and Nanotechnology (NT)



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CONTENTS

Google Scholar Indexing Page / SSRN Indexing /ResearchGate Page :
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https://papers.ssrn.com/sol3/cf_dev/AbsByAuth.cfm?per_id=2519140
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PREFACE

Ideal Systems, Ideal Technology, and their Realization Opportunities using Information Communication & Computation Technology (ICCT) & Nanotechnology (NT)

Technology management is an area of predicting, identifying, managing, and utilising existing and new technologies for the benefit of people, organizations, and society. Technology management supports the use of technology for solving problems in society through innovations and to create a competitive advantage for the stakeholders. Systems and Technology are two interconnected issues in scientific society. The developments and progress in society depend on the improvements in the performance of every system and innovations in technology. It is believed that the performance of a system and the capability of a technology can be continuously improved by means of comparing their properties with the properties of ideal system or ideal technology, respectively. Research in any system or technology is basically generating *new knowledge* based on intensive study of existing systems or technology and any concepts/issues/problems related to them. Research is also defined as *new interpretation* of existing knowledge about any issues/ concepts/solutions of the problems of any system or technology by means of analysing them using suitable framework. This Book is based on conceptual discussion on how two general purpose technologies can be used in the possibility of improving many practical systems to improve their performance towards their corresponding ideal systems. An ideal system is a hypothetical system with ideal characteristics. Both Information Communication and Computation Technology (ICCT) and Nanotechnology (NT), as general purpose technologies, are continuously expanding their roots to many industries and becoming so-called Universal Technologies. Universal technology is a technology more than general purpose technology where apart from (1) Pervasiveness, (2) Improvement, and (3) Innovation spawning characteristics, additional characteristics like (4) Universal applicability, and (5) Ideal solutions to problems. The advent of both technologies ICCT and Nanotechnology are presently expanding together in many areas including three very important futuristic technologies which are virtual reality, artificial intelligence, and human life expansion.

This book is based on research is carried out during the last five years with an objective of studying the characteristics of some of the ideal systems and comparing their ideal characteristics with characteristics of practical systems with the intention of possible improvements using current and future technologies. The research objectives include the management of nanotechnology innovations to solve real-world problems optimally. The use of nanotechnology in the food sector, drinking water sector, automobile sector, renewable energy sector and health sciences sector to improve the products and services toward ideal systems. The research also includes the use of ICCT to optimize Business, Education, Software, and Computing models. A new model of commercialization of nanotechnology products & services is proposed and the universal technologies are analysed analysis of some of these systems using our newly developed analysis method called ABCD framework. At the outset, two universal technologies and their importance in solving all kinds of problems of society and providing comfortability are studied by identifying and managing opportunities through systematic process.

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In conclusion, I thank all those who have helped me directly or indirectly to do this research and write this Book.

Dr. Sreeramana Aithal

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CHAPTER 1

INTRODUCTION TO GENERAL PURPOSE TECHNOLOGIES & SYSTEMS

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ABSTRACT :
This chapter contains a discussion on various General-Purpose Technologies and their contributions toward developing Sustainable Society, and two prominent general-purpose technologies, which are very active currently identified as Information Communication and Computation Technology (ICCT) and Nanotechnology (NT) and their expected abilities to change the world and possible contributions toward further progressed civilian society are discussed. This chapter also contains the research objective, research design, and research methodology used in the Thesis. The Thesis contains the results of the quantitative research carried out on new conceptual models developed and new interpretation made on a systematic interpretation.

1.1 INTRODUCTION :

Technology management is an area of predicting, identifying, managing, and utilising existing and new technologies for the benefit of people, organizations, and society. Technology management supports the use of technology for solving problems in society through innovations and to create a competitive advantage for the stakeholders. Technology by itself is an application of science is used in many ways to solve many complicated challenges in the society to make human life comfortable and enjoyable. Certain technologies have grown and expanded their branches to many areas and sectors of practice in such a way that they have been designated as General-Purpose Technologies. Such technologies are identified and used by many branches of engineering to solve or simplify the problems of those fields. General Purpose Technologies' (GPT) are characterized by pervasiveness where they have an inherent potential for technical improvements, and innovation complementarities, meaning that through research and development the productivity in sub-sectors increases as a consequence of such innovation in the GPT [1]. Many of the killer applications invented in the history are though costly and less productive initially, emerged eventually as General Purpose Technologies. Examples include the steam engine, railroad, interchangeable parts, electricity, semiconductor electronics, material handling, mechanization, control theory (automation), the automobile,

the computer, the Internet, Information Communication and Computation Technology (ICCT), and Nanotechnology (NT). The major stakeholders of Information Communication and Computation Technology (ICCT) as general purpose technology are Analytics and Big data, Cloud Technology, Artificial Intelligence, Internet of Things (IoT), Digital Marketing, 3D Printing, Virtual Reality, and optical computing. The major stakeholders of Nanotechnology as general-purpose technology are Agriculture with improved and sustained yield, Universal drinking water system, Universal Renewable energy system, Optical computation, Embedded intelligence, Chameleon chips, Flying cars, Space travel, Nanomedicine, and anticipated Immortality.

Table 1.1 : Killer Applications and their transformation into GPT

S. No.	Killer Technology	Spill over Effect	Era
1	Wheel	Mechanization	4000-3000 BC
2	Bronze	Tools & Weapons	2800 BC
3	Printing	Knowledge Economy	16th Century
4	Steam Engine	Industrial Revolution	18th Century
5	Electricity	Power generation & Usage	19th Century
6	Automobile	Long distance commuting & Transportation	20th Century
7	Airplane	International Travel & Transportation	20th Century
8	Telephone	Distance communication	20th Century
9	Television	Video communication	20th Century
10	Computer	Data Processing	20th Century
11	Internet	Data & Information Communication, E-business	20th Century
12	Mobile Communication	Ubiquitous communication	20Th Century
13	Biotechnology	Bio-engineering, Gene Therapy,	20th Century
14	Information Communication & Computation Technology (ICCT)	Ubiquitous computing & Communication	21st Century
15	Nanotechnology (NT)	Solutions to nutritious food, drinking water, renewable energy, Nanomedicine & Therapy	21st Century
16	Artificial Intelligence (AI)	Total automation	21st Century

As listed in table 1.1, some of the killer applications transformed into GPT's and many of them are making an impact only in one or two related areas and replaced by other innovative technologies or die-down eventually. In this paper, we have identified and analysed two killer applications and compared Information Communication and Computation Technology (ICCT),

and Nanotechnology (NT) as two most important general-purpose technologies due to their abilities to solve both basic problems and advanced need of the society. We also studied the similarities and differences between these two GPT's in terms of their specially identified characteristics of Pervasiveness, Improvement, and Innovation spawning abilities. The paper also contains a conceptual and predictive proposal on how various general-purpose technologies including ICCT and NT are potentially contributing towards creating a techno-society and based on further progress and spread of such technologies to every dimension of human life to reach the ultimate level of civilization in or around this earth.

1.2. GENERAL PURPOSE TECHNOLOGIES

A general-purpose technology or GPT is a term coined to describe a new method of producing and inventing that is important enough to have a protracted aggregate impact. Electricity and information technology (IT) probably are the two most important GPTs till 20th century. A GPT can be a product, a process, technology or an organisational system.

Whole eras of technical progress and growth appear to be driven by a few 'General Purpose Technologies' (GPT's), such as the steam engine, the electric motor, and semiconductors. GPT's are characterized by pervasiveness to many sectors, inherent potential for technical improvements, and innovation complementarities to many applications, giving rise to increasing scale of operation. A notable writer Ruttan [2] identified the development of six general-purpose technologies:

- Interchangeable parts and mass production
- Military and commercial aircraft
- Nuclear energy
- Computers and semi-conductors
- The Internet
- The space industries

Based on his reading of the histories of these technologies, Ruttan finds that military and defense-related procurement has been a major source of technology development. He believes that the current technological landscape would look very different in the absence of military and defense-related contributions to commercial technology development. However, from his research, Ruttan determines that commercial technology development would have occurred in the absence of military procurement but more slowly, e.g., the aircraft, computer, and Internet

industries. He cites nuclear power as an example of a general-purpose technology that would not have developed in the absence of military and defense-related procurement [2].

Economist Richard Lipsey and Kenneth Carlaw [3] suggested that there have only been 24 technologies in history that have been identified as true GPTs. They define a transforming GPT follows four criteria which are listed below:

(1) GPT is a single, recognisable generic technology.

(2) Initially GPT has much scope for improvement but comes to be widely used across the economy.

(3) GPT has many different uses in many areas to solve problems or to provide comfortability.

(4) GPT creates many spill over effects to spread its base to many sectors.

1.3. HOW THE GENERAL PURPOSE TECHNOLOGIES ARE DIFFERENT

General purpose technologies have the potential to reshape the economy of the world and boost productivity across all sectors and industries. Such transformations are far more than simple technical innovation, or a new discovery. However, such technologies often require a wholesale remaking of infrastructure environments, of business models, and of cultural norms. There are three fundamental features of GPTs that differentiate them from other technologies which are (1) Pervasiveness – The GPT should spread to most sectors. (2) Improvement – The GPT should get better over time and, hence, should keep lowering the costs of its users. (3) Innovation spawning – The GPT should support to invent and produce new products or processes. Most technologies possess each of these characteristics to some degree, and thus a GPT cannot differ qualitatively from these other technologies [1].

1.4. ICCT & NT AS GENERAL-PURPOSE TECHNOLOGIES & SYSTEMS

1.4.1. ICCT as GPT :

It is observed that Information Communication and Computation Technology (ICCT) is showing all the three characteristics of GPT. In the 21st century, ICCT is grown and spread its roots to all industries and industry sectors from A to Z due to its pervasiveness property as shown in Table 2. The Improvement and Innovation spawning properties of Information Communication and Computation Technology (ICCT) as general purpose technology are created major stake holding areas including Big data and business Analytics, Cloud Technology, Artificial Intelligence, Internet of Things (IoT), Digital Marketing, 3D Printing, Virtual Reality, and optical computing.

(i) Big data and business Analytics :

The emerging subfield of ICCT named big data and business analytics focus on handling huge amount of data continuously generated in any business or data capturing process and analyses it using various quantitative analytical techniques and mathematical models to study the pattern and descriptive information, predictive information, and prescriptive information for supporting the decision makers to take optimum decisions to the problems related to future aspects of the business. Predictive analytics in various functional areas like Marketing analytics, Retail Analytics (Customer Analytics / Supply Chain Analytics), Pricing Analytics, Financial analytics, Social media analytics, sports analytics, and Healthcare analytics are finding importance in the business environment for effective decision making. Further Prescriptive Analytics for optimizing the decisions with multiple objectives / portfolio analytics, optimizing complex decisions / salesforce analytics, and Retail Analytics etc are also have futuristic impact on effective business decisions [4-7].

(ii) Cloud Technology :

Cloud computing is one of the advances in computer technology and is uses information communication technology as well. Due to the ubiquity of cloud computing facility with flexibility in scaling it has become an important topic of research and provides the value for computing processes in the business. The cloud computing model offers so-called Business Intelligence (BI) for any kind of business decisions via the Internet. Using cloud computing model, one can offer a rented hardware as well as software to process the data online. Thus, cloud computing model has three variations as Software as a Service (SaaS), Infrastructure-as-a-Service (IaaS) and Platform-as-a-Service (PaaS) to provide ubiquitous computing service solutions to the business. The cloud computing solution to any business will allow companies to reduce their investment cost and maintenance cost for without compromising to have access to BI solution which will give the business an edge on their competition [8-15]. Could computing is subfield of the Information Communication and Computation Technology (ICCT).

(iii) Artificial Intelligence :

Artificial intelligence (AI) is an area of computer science which focus on the creation of intelligent machines that makes decisions like human beings. The main functions of artificial intelligence machines are to recognize the environment such as speech recognition, Learning, Planning, Problem solving, and hence decision making. Artificial intelligence machine mimics cognitive functions of human beings associated with other human minds, such as learning & memorising and decision making for problem solving. ICCT has created a platform for AI to

be introduced and developed for adding intelligent thinking components in electronic systems used in any industrial sectors [16].

(iv) Internet of Things (IoT) :

It is a network of various electronic, computing, and optical devices/objects including human beings connected virtually by means of internet or intranet for enabling them to send and receive data and information. These objects are provided with unique identifiers (UIDs) and are capable to transfer data and information over a network without requiring human-to-human or human-to-computer interaction by using IOT technology. Such a connection of physical things/objects to the Internet makes it possible to access remote sensor data and to control the physical world from a distance. The mash-up of captured data with data retrieved from other sources, eg, with data that is contained in the Web, gives rise to new synergistic services that go beyond the services that can be provided by an isolated embedded system [17]. Internet-of-Things (IoT) is not in any new disruptive technology but is the pervasive deployment and innovation of ICCT.

(v) Digital Marketing :

ICCT created a new business model called E-business/ M-business model. This model consists of ubiquitous selling proposition. *Digital marketing* is the *marketing* of products or services using *digital* technologies as per such new business model using mainly on the Internet, but also including mobile phones, display advertising, and any other *digital* medium. At a high level, *digital marketing* refers to advertising delivered through *digital* channels such as search engines, websites, social media, email, and mobile apps. Digital marketing is emerged as an essential future marketing activity using ICCT general purpose technology [18].

(vi) 3D Printing :

3D printing is an ICCT application where various materials are joined or solidified using various processes under the control of computer to create a three-dimensional object. In 3D printing, an object is created by laying down successive layers of material until the object is created. 3D printing can be divided into metal, fabrics, bio and a whole host of other industries with many applications in many industries worldwide. 3D printing is a variant of ICCT general purpose technology and has wide scope in various industrial automation and home automation processes. 3D printing comprises of many other technologies along with ICCT. Some of the 3D printers make use of nanomaterials and nanocomposites [19].

(vii) Virtual Reality :

Virtual reality is an artificial environment that is created with the help of computer-based software and presented to the user in such a way that the user suspends belief and accepts it as a real environment. On a computer, virtual reality is primarily experienced through two of the five senses: sight and sound. Currently, the virtual reality is mainly developed and used in simulated training and education as well as the simulated game environment. But it may further find its applications in many other areas including business as augmented reality and may enter the group of general purpose technology [20].

(viii) Optical computing:

High speed computers based on optical signal switching and optical signal processing are expected to breakthrough with their full potentials and capabilities using optical logic gates and flip-flops fabricated by nanocomposites are expected to breakthrough in this century. High speed computation and data storage using nanotechnology based optical computers are going to revolutionize the entire computer industry. Optical computation is joining both general purpose technologies of Nanotechnology and ICCT through the processes of design & production as well as operation & applications respectively [21].

Table 1.2 : Industries and Industry sectors which use and benefit from ICCT

S. No.	Industries	Industry Sectors/Segments	ICCT Applications
1	Agricultural & Allied Industries	Agricultural products, Forestry & logging, Fishery.	Remote sensing using satellite technologies, Geographical information systems, Agronomy and soil sciences, Weather prediction & forecasting etc.
2	Auto components	Engine & Drive Transmission Parts, Suspension & Braking Parts, Electricals, Body and Chassis Parts, Equipment etc.	Product Lifecycle Management, Research & Development Manufacturing automation Sales automation Post sales solution
3	Automobiles	Commercial vehicles, Passenger cars, Three & two-wheelers.	Use of IT in new vehicle design, systems control, manufacturing, sourcing, and marketing.
4	Aviation	Civil aviation, Military aviation	Airport operations, Air-cargo operations, Airline management, Air-ticketing, Security etc.
5	Banking & Insurance	Public Banking Private banking International banking Life insurance General insurance	E-banking, Online banking, Online and mobile services, ERP and networking, Transactional services, ATM management etc.
6	Cement	Cement Production,	Energy efficiency in production

		Cement transportation	Transportation management, Quality monitoring etc.
7	Consumer Durables	Consumer electronics (brown goods) Consumer appliances (white goods)	Production automation, Supply chain management, Online sales, Online payment, Online customer support, etc.
8	E-Commerce	E-procurement E-marketing E-payment	E-cart, Internet, Secured online payment, Customer support, E-advertisement
9	Education & Training	Education, Training	Online education, Online training, E-gadgets, online evaluation etc.
10	Engineering & Capital Goods	Transport equipment, Capital goods, other machinery/equipment and light engineering products such as castings, forgings and fasteners.	Made to order, Order processing, Supply chain management, Quality control systems Online customer management, ERP etc.
11	Financial Services	Credit unions, Banks, Credit-card companies, Insurance companies, accountancy companies, Consumer-finance companies, stock brokerages, Investment funds, etc.	Operational automation, Online transactions, Online services, electronic business, etc.
12	FMCG	Packaged foods, Beverages, Toiletries, Over-the-counter drugs, Other consumables.	Retail management Supply chain management E-distribution Business to Business E-Commerce
13	Healthcare	Hospitals, M*edical* devices, Clinical trials, Outsourcing, Telemedicine, M*edical* tourism, H*ealth* insurance and M*edical* equipment	Communication, Computerization of medical records, Networking of various departments in a hospital, Tele-medicine services
14	Infrastructure	Transportation, Communication, Sewage, Water and electric systems	Basic Communication and Computation
15	IT & ITES	E-Communication Cloud computing, Mobile applications E-services E-Business	Business Automation Business process outsourcing Resource sharing Ubiquitous business
16	Manufacturing	Raw materials, Food manufacturing, Textiles	Automated procurement Quality control Online marketing
17	Media & Environment	Print media, Radio, TV media, Social media, and film,	Digital techniques Online media Internet based social networks etc
18	Pharmaceuticals	Pharmacy Drug production Clinical practice	Online pharmacy Drug information Clinical information sharing
19	Ports	Ports Terminal management	Automation of all activities

		Shipping	
20	Power	Coal Hydro Renewable energy	Automation of all activities Control of wastage
21	Railways	Goods trains Passenger trains Railways Infrastructure	Online booking E-communication Safety
22	Real Estate	Residential sector Commercial sector	Tele communication Entertainment
23	Retail	Convenience Stores, Specialty Stores, Department Stores, Supermarkets, Hypermarkets, Discount Stores, Multichannel Stores.	Communication Online transactions Online store Online payment E-inventory etc.
24	Science & Technology	Research & Development Emerging technologies Bio-technology Space technology Nanotechnology etc.	Back ground support Online Journals Research data Space data & Travel Design 7 development
25	Services	Warehousing and truck transportation services, Information sector services, Commodities, Securities and other investment services	Process Automation Customer service Information E-Business models Online payment
26	Telecommunications	Telecom equipment (the largest), Telecom services (next largest), Wireless communication.	Electronic signal Radiofrequency signal Wireless data Video and audio communication
27	Tourism & Hospitality	Food and beverages, Travel and Tourism, Lodging, Recreation.	Geographical Positioning systems, Online booking Audio & Video recording & Processing.

ICCT has made a major impact due its associated new business models called e-business model and m-business models. These business models provided both business organizations and customers to use ubiquitous concept of selling and buying the goods and services from anywhere, anytime and any amount of time. The business model developed using ICCT general purpose technology is very close to ideal business model [22-24].

1.4.2. Nanotechnology as GPT :

The major stakeholders of Nanotechnology as general-purpose technology are Universal drinking water system, Universal Renewable energy system, Optical computation, Embedded intelligence, Chameleon chips, Flying cars, Space travel, and anticipated Immortality [25-26].

(i) Nanotechnology treated Seeds for Innovations in Agriculture : NT solutions in agriculture reduce applications of plant protection products, minimize nutrient losses in fertilization, and

increase agricultural yields through optimized nutrient management. It also provides nanotech-based tools to detect diseases in a rapid manner, improve the ability of plants to absorb nutrients and promote the molecular treatment of diseases. Use of nano-sensors supports the use of precision farming methodologies to a multifold increase of crop yield. Nanotech-enabled "smart" devices can preventive and warn to choose diseased plant even before they detected by the farmers and simultaneously provide remedial measures. These nanotech systems can also be used to monitor the delivery of chemicals [27].

(ii) Universal drinking water system : Nanotechnology has shown opportunity in solving another fundamental problem of many people of the world which is the scarcity of drinking water. Though we have abundant water in the sea, it is non-potable and hence not useful for drinking and irrigation. Nanotechnology filters are promising solutions to filter soluble and insoluble impurities mixed from the water both in small scale and large scale. This innovation leads to scalable universal drinking water system. Nanotechnology will provide a solution for this challenge of providing abundant drinking water through inexpensive methods of water purification by detection of the molecular level of contaminants, and improved nanomembrane based filtration systems. This helps the conversion of seawater to drinking water at a very low cost [28].

(iii) Automobiles : Automobiles is one of the largest industries in the world. Automobile industry is trying to make a breakthrough in improving the efficiency, durability, and cost of vehicles using nanotechnology solutions along with decreasing the pollution by using hydrogen fuel or electric engines. The major expected impact of nanotechnology innovations on Automobile sector in order to solve the problems in automobile efficiency, durability, cost, and environmental pollution to produce electric/pollution free vehicles with nanotechnology-based auto-components, auto-engines, auto-tyres, auto-electronics, auto-seat materials, auto-bodies, aeroplanes, space crafts, and rockets [29].

(iv) Renewable energy system : The nanotechnology impact on seven areas of energy sector including solar energy, wind energy, nuclear energy, oil-fuel based energy, artificial photosynthesis, energy storage and effective energy management to promote nanotechnology-based energy as ubiquitous energy are discussed and reviewed. The paper includes possible innovations and research opportunities in nano-modified solar cells, Nano-influenced Fuel storage cells, and nanotech based artificial photosynthesis [30-32].

(v) Optical computation : High speed computers based on optical signal switching and optical signal processing are expected to breakthrough with their full potentials and capabilities using

optical logic gates and flip-flops fabricated by nanocomposites are expected to breakthrough in this century. High speed computation and data storage using nanotechnology based optical computers are going to revolutionize the entire computer industry. Optical computation is joining both general purpose technologies of Nanotechnology and ICCT through the processes of design & production as well as operation & applications respectively.

(vi) Embedded intelligence : Embedded intelligence is a technique to modify the ability of a product, process or service to reflect on its own operational performance, usage load, or in relation to the end-user or environment in terms of satisfactory experience and smart improvement. This improvement through self-reflection, facilitated by information collected by sensors and processed locally or remotely, must be considered from the design stage such as to improve the product features, enhance the product lifetime and performance, increase the quality of process or service delivery, or ensure customer satisfaction and market acceptance [33-36]. Embedded intelligence aims at delivering smarter products, systems or services to industry through their integration and purposeful use for a given application. Embedded intelligence (EI) system/service application contains various components/processes which include design for EI, intelligent software, packaging & interconnect, manufacturing solutions and/or system services. Nanotechnology supports the integration of embedded processors with sensors, intelligence, wireless connectivity and other components with high level operating systems, middleware and system integration services.

(vii) Chameleon chips : A chameleon chip is a self-configurable electronic or optical circuit to modify the output signal characteristics as per the system requirements. It has an erasable hardware configuration. It is also possible to rewire it by itself through adapted programming tasks. Chameleon chip consists of many functional blocks which are connected parallel to each other with many computational units which can process signals simultaneously. While reconfiguring these chips as per desired, the connections are automatically changed. i.e., the connections between blocks and inside blocks are changed. After loading the software, the old hardware design will be erased and a new hardware design is generated by activating some connections and inactivating some other connections. Hence the system defines the configuration of hardware for loaded software. Chameleon chips can be realized using dye doped nanocomposite materials [25].

(viii) Space Travel : The growing population and diminished resources on earth suggest identifying an opportunity for space exploration. Space exploration also helps us to monitor the health of our planet, a source of resources and an outlet for our imagination. Using carbon

nanotubes to make the cable needed for the space elevator, a system which could significantly reduce the cost of sending material into orbit. Nanotechnology will create the ability for humans to operate in space more safely. Applications, where nanotechnology will impact space exploration, are propulsion fuels, coatings, structural materials, smart uniforms, electronics and life support environments. These will be more efficient, stronger, self-healing and lighter than what is currently available [37-40].

(ix) Anticipated Immortality : The dream of every human being is to a leave long time with good health. This can be achieved using nanotechnology innovations. There are two ways in which nanotechnology may be able to extend our lives. One is by helping to eradicate life-threatening diseases such as cancer, and the other is by repairing damage to our bodies at the cellular level - a nano version of the fountain of youth. The most exciting possibility exists in the potential for repairing our bodies at the cellular level. Research in this regard is very active at the laboratory level to achieve and realize these dreams in the 21st century itself [25].

Table 1.3 : Industries and Industry sectors which use and benefit from Nanotechnology

S. No.	Industries	Industry Sectors/Segments	NT Applications
1	Agricultural & Allied Industries	Agricultural products, Forestry & logging, Fishery.	Nanotechnology based optimized nutrient management, Nanosensors, Nanotechnology based genetic transformation, Nanoencapsulation of nutraceuticals, Nanofertilizers
2	Automobiles	Commercial vehicles, Passenger cars, Three & two-wheelers.	Nanomaterials for energy storage, increasing body strength, efficient engine and body parts
3	Aviation	Civil aviation, Military aviation	Light & strong materials for airplane
4	Banking & Insurance	Public Banking Private banking International banking Life insurance General insurance	Increased efficiency of ICT components and devices
5	Cement	Cement Production, Cement transportation	Nanomaterials for increasing strength,

			controlling hardness
6	Consumer Durables	Consumerelectronics (brown goods) Consumer appliances (white goods)	Increased performance efficiency of goods and devices
7	E-Commerce	E-procurement E-marketing E-payment	Increased efficiency of ICT components and devices
8	Education & Training	Education, Training	Increased efficiency of ICT components and devices
9	Engineering & Capital Goods	Transport equipment, Capital goods, other machinery/equipment and light engineering products such as castings, forgings and fasteners.	Nanomaterial based light weight components with enhanced durability. Nanocomposite based battery and solar panels to enhance efficiency.
10	FMCG	Packaged foods, Beverages, Toiletries, Over-the-counter drugs, Other consumables.	Nanomaterial based cosmetics, paints, food packaging, drugs & sports equipment etc.
11	Gems & Jewellery	Gems Jewellery	Nanotechnology based artificial gems and jewellery
12	Healthcare	Hospitals, M*edical* devices, Clinical trials, Outsourcing, Telemedicine, M*edical*tourism, H*ealth* insuranc e and M*edical* equipment	Nanomaterial based building materials, Nanomedicine, Nanotechnology based controlled drug delivery
13	Infrastructure	Transportation, Communication, Sewage, Water and electric systems	Nanomaterial based parts, filters, power storage devices
14	IT & ITES	E-Communication Cloud computing, Mobile applications E-services E-Business	Nanomaterial based electronic and photonic components
15	Manufacturing	Raw materials, Food manufacturing, Textiles	Nanomaterials used for fabrication to

			improve the strength and performance
16	Media & Environment	Print media, Radio, TV media, Social media, and film,	Nano ink, Nanotechnology based electronic and photonic components
17	Pharmaceuticals	Pharmacy Drug production Clinical practice	Nanomaterial based medicines, Nanomaterial based controlled drug delivery
18	Ports	Ports Terminal management Shipping	Improved mechanical tensile strength
19	Power	Coal Hydro Renewable energy	Improved technology of power generation, Improved performance of turbines, Solar panel with improved efficiency, Wind turbines with increased durability
20	Railways	Goods trains Passenger trains Railways Infrastructure	Nanomaterial based improved performance
21	Real Estate	Residential sector Commercial sector	Nanomaterial based quality and durable construction materials
22	Renewable Energy	Solar Energy Wind Energy Nuclear energy	Improved efficiency Improved strength Improved safety
23	Retail	Convenience Stores, Specialty Stores, Department Stores, Supermarkets, Hypermarkets, Discount Stores, Multichannel Stores.	Quality and efficient products
24	Roads	Roads Bridges	Nanomaterials for durable roads and bridge construction
25	Science & Technology	Research & Development Emerging technologies Bio-technology Space technology	Research for new smart materials, new smart components, new

		Nanotechnology etc.	and improved devices through improved properties
26	Steel	Iron Ore Steel Steel products	Parts with improved strength and increased durability
27	Telecommunications	Telecom equipment (the largest), Telecom services (next largest), Wireless communication.	Components with Improved efficiency, Improved strength, small size.
28	Textiles	Dying, Treads, Weaving machines	Improved colouration, Improved strengths, Stain-free fabrics, Durable Weaving machines, etc.

1.4.3 Similarities between the ICCT and NT :

Even though both ICCT and NT are emerging as general-purpose technologies, they are not seeming to be competing technologies. Nanotechnology supports industries to do innovations in material and manufacturing processes to improve the performance quality towards optimum systems whereas the ICCT supports industries to do innovations at application and service side of businesses. Thus, both NT and ICCT works like complementary to each other instead of competitive technologies. Thus, both technologies are expanding with time to many industries by showing all the three characteristics of GPT with Pervasiveness, Improvement over time, and Innovation spawning abilities.

1. In both technologies, productivity growth rates are below those attained in the decades immediately preceding the GPT's arrival.

2. Measures of reallocation and invention – the entry and exit of firms to these business market, investment by new firms relative to incumbents, and grants of patents and trademarks – are all higher during both the GPT's.

3. Expansion to various industries rises gradually during each GPT time.

4. Both technologies are supporting each other and hence interrelated and complementary to solve many problems in the organizations and in the society.

1.4.4 Differences between the Information Communication & Computer Technology and Nanotechnology :

1. Innovation measures are growing much faster for ICCT than for Nanotechnology – patents and trademarks surge much more strongly during the ICCT era, and the price of IT is falling 100 times faster, at least, than did the price of Nanotechnology.
2. ICCT is spreading more slowly than did nanotechnology, due to the fact that ICCT is an application type technology rather than Nanotechnology which is a manufacturing technology.
3. The productivity slowdown is stronger in the Nanotechnology era than the ICCT era.
4. Nanotechnology supports various products preparation and quality improvement whereas ICCT improves many applications in various industrial sectors.
5. Nanotechnology has anticipated hidden environmental problems and challenges which is not a case in ICCT.

The differences seem to be quite important. But overall the evidence clearly supports the view that technological progress is uneven, that it does entail the episodic arrival of GPTs, and that these GPTs bring on turbulence and lower growth early on and higher growth and prosperity later.

1.4.5 Measuring the three characteristics of ICCT as GPT :

(1) Pervasiveness of the GPT : The first characteristic is the technology's pervasiveness. The spread of ICCT in various industry segment is immense and the details are given in table 1.2.

(2) Improvement : As per this characteristics, the ICCT should get better over time and, hence, should keep lowering the costs of its users. ICCT is playing this role more effectively. The technology through its digital model lowered the cost of various processes and their applications to a minimum level due to the strategy of attaining the cost leadership by various competitors in different industries. The continuous improvement in both minimizing the size and enhancing the speed of ICCT devices, the customers and hence the society is continuously getting benefits.

(3) Innovation spawning : The ICCT as GPT supports to invent and produce new products or processes. ICCT based innovative new products and processes in high speed computing, electronic communication, business analytics, virtual reality, artificial intelligence, 3D printing, digital marketing, cloud computing, Internet of things technologies are becoming more popular and hence ICCT is growing beyond general purpose technology and marching towards so-called universal technology.

1.4.6 Measuring the three characteristics of NT as GPT :

(1) Pervasiveness of the GPT : The first characteristic is the technology's pervasiveness. Nanotechnology finds its applications in almost every industrial sector as shown in table 1.3.

It has spread its roots in solving both fundamental problems of human beings and offering luxurious facilities in every part and parcel of human life.

(2) Improvement : The GPT should get better over time and, hence, should keep lowering the costs of its users. This is happening nanotechnological solutions. The improvements in material properties and hence the overall performance of devices in almost all industrial sectors support this property of nanotechnology.

(3) Innovation spawning : The nanotechnology as GPT supports to invent and produce new products or processes. In agriculture, it supports to develop new sensors, a new way of controlling genetic transformation, optimization of nutrient management, nanoencapsulation of nutraceuticals, nano-fertilizers etc. It also helps to produce potable water from seawater. It supports to fabricate highly efficient long-life batteries for electric vehicles and allows to fabricate high efficiency solar panels and strong and durable windmills. It also helps to develop an innovative process of controlled drug delivery. Finally, it also supports the most anticipated technology of lifespan expansion of human beings so that is predicted as the ideal technology and technology of the 21st century.

1.5. CONTRIBUTION OF GPT'S TOWARDS DEVELOPING SUSTAINABLE SOCIETY

The symptoms of a GPT proposed by different authors with the three characteristics – its pervasiveness, its rate of improvement, and its innovation-spawning tendency are clearly observed in both the technologies ICCT and NT. Apart from these, additional symptoms as listed below are also observed in the case of these two technologies :

1. Productivity slows down initially – The new technology may not be user-friendly at first, and output may fall for a while as the economy adjusts.

2. The skill premium rises with time – If the GPT is not user-friendly at first, skilled people will be in greater demand when the new technology arrives, and their earnings should rise compared to those of the unskilled. This is true in both cases.

3. Entry, exit, and mergers should rise – This feature is also observed in the case of both technologies as the alternative modes for the reallocation of assets.

4. Stock prices should initially fall – This also applicable in case of both technologies. The speed of such fall depends on the way that the market learns of the GPT's arrival.

5. Young and small firms should do better – The ideas and products associated with both technologies are often be brought to market by new firms. The market share and market value of young firms should, therefore, rise relative to old firms.

6. Interest rates and the trade deficit – The sudden increase in the output due to these technologies cause a rise in interest rates or to worsen the trade balance.

7. Improvements in the living standard of people in the society – The contribution of these two GPT's is expected to raise the living standard of people in the society due to their abilities to solve problems related to both fundamental and luxurious facilities for happy life leading.

1.6. FUTURE OF ICCT & NT

Both ICCT and NT as general-purpose technologies are further expanding their roots to many other industries and becoming so-called Universal Technologies. Universal technology is a technology more than general purpose technology where apart from (1) Pervasiveness, (2) Improvement, and (3) Innovation spawning characteristics, additional characteristics like (4) Universal applicability, and (5) Ideal solutions to problems. The advents of both technologies ICCT and Nanotechnology are presently expanding together in many areas including three very important futuristic technologies which are virtual reality, artificial intelligence, and human life expansion.

1.6.1. Virtual Reality :

Virtual reality is an artificial environment that is created with the help of computer-based software and presented to the user in such a way that the user suspends belief and accepts it as a real environment. On a computer, virtual reality is primarily experienced through two of the five senses: sight and sound. Currently, the virtual reality is mainly developed and used in simulated training and education as well as the simulated game environment. But it may further find its applications in many other areas including business as augmented reality and may enter the group of general purpose technology.

1.6.2. Artificial Intelligence :

Artificial intelligence (AI) is a branch of computer science which focus on the creation of intelligent machines that makes decisions like human beings. The main functions of artificial intelligence machines are to recognize the environment such as speech recognition, Learning, Planning, Problem-solving, and hence decision making.

Artificial intelligence machine mimics cognitive functions of human beings associated with other human minds, such as learning & memorizing and decision making for problem solving. The evidence of computer automated artificial intelligence systems for perception, learning, understanding, and reasoning are already used in the society which includes :

- GPS systems which simplify the complexity of millions of routes to find the best suitable one based on the user's preference.

- Smartphones understand human speech and mobile applications like Siri, Cortana, and Google Now are getting better at understanding user intentions through improved AI techniques.
- Cars from Google and Tesla can drive themselves using currently available AI systems, autopilot systems based on AI technology direct airplanes around the world, and robotic surgeons are operating more exactly and high speed than their human counterparts.

It is predicted that AI enabled super-smart computer devices may allow the blind to see, the deaf to hear, and the disabled and the elderly to walk, run, and even dance. It is also predicted that artificial intelligence is the pivotal step in addressing the grand challenges of humanity and our brains may be able to connect directly with the cloud via nanobots by the year 2030. On the negative side, the uncontrolled and unregulated advents in AI could be a threat to humanity and may have disastrous effects leading to the end of the world.

The integrated version of ICCT and NT applications may support high level advanced and personalized healthcare, virtual reality, and artificial intelligence making human life more comfort and connecting dream and real life of human being on the earth in particular and in the entire universe in general.

1.6.3. Lifespan Expansion :

Nanotechnology supported Life extension science, also known as anti-aging medicine, indefinite life extension, experimental gerontology, and biomedical gerontology, is the study of slowing down or reversing the processes of aging to extend both the maximum and average lifespan.

1.7 CHAPTER CONCLUSION

Technological invention is uneven and emerges in bursts; contributes substantially to the society and changes the lifestyle, culture, and tradition and even thinking of people in the society. Information Communication and Computation Technology and Nanotechnology are, to most observers, the two most important GPTs to date, according to the three criteria that Bresnahan and Trajtenberg proposed. These two technologies emerging as independent, integrated and complementary technologies with two additional characteristics proposed in this paper that is (1) Universal applicability, and (2) Ideal solutions to problems. Thus, these two technologies are emerging as universal technologies of the 21st century. In this paper, we have analyzed how these two GPTs are spreading to many areas of society and changing the lifestyle of human beings. Having discussed in detail these two GPTs we believe that the technological changes and their effects are spilling over the world. The ICCT and NT innovations differ in

some important ways but have made and going to make a further impact on many areas of the society. ICCT is more broadly adopted, whereas NT seems to be technologically more revolutionary and yet to be commercialized so that these two technologies together lead to complete revolution of civilization in this world by solving both fundamental and advanced challenges for human prosperity. The productivity slowdown is stronger in the NT era, but the ongoing spread of NT and its continuing proposed precipitous price decline are reasons for optimism about growth in the coming decades relative to what happened at the end of the 20th century following the spread of ICCT. But it is the similarities between the two epochs that are the most instructive and that will guide our expectations about how the next universal technologies will affect the economy of the world when it comes along [1]. Based on the analysis in this paper, it is also concluded that both the technologies ICCT and NT are potentially contributing towards creating a techno-society and based on further progress and spread of such technologies to every dimension of human life to reach the ultimate level of civilization in or around this earth.

1.8 RESEARCH OBJECTIVES, DESIGN, AND METHODOLOGY

1.8.1 Research Objectives :

The objective of the research is to study the characteristics of some of the ideal systems and comparing these ideal characteristics with characteristics of practical systems with the intention of possible improvements using current and future technologies. The research includes the management of nanotechnology innovations in automobiles and renewable energy sectors and a model of commercialization of nanotechnology products & services. It also includes the analysis of some of these systems using our newly developed analysis method called ABCD framework.

1.8.2 Research Design :

The research work is designed to predict ideal characteristics of some systems and comparison with corresponding practical systems which include : (1) Ideal technology and comparison with nanotechnology, (2) Ideal water purifier and comparison with nanotechnology based water purifier system, (3) Ideal business and comparison with mobile business, (4) Ideal Education System and its realization opportunity using ICCT, (5) Ideal drug system and its realization opportunity using nanopharmaceutical science, (6) Ideal Banking System and its realization opportunity using mobile banking technology, (7) Ideal Software System and its realization opportunity using universal automation system, and (8) Ideal computing system and its realization opportunity using Cloud computing system. Some of the potential technologies

proposed to improve the current systems towards ideal systems are analysed using a suitable framework to interpret the abilities of these technologies to improve the performance of the systems.

1.8.3 Research Methodology :

The research methodology is qualitative in nature, include the development of conceptual ideal system models and prediction of ideal characteristics using qualitative data collection instrument namely focus group method. It also includes identification of suitable breakthrough technologies of the 21st century, analyzing them for realizing or improving the practical systems towards ideal systems to chosen type. Accordingly, various hypothetical ideal systems including (1) Ideal technology and comparison with nanotechnology, (2) Ideal water purifier and comparison with nanotechnology based water purifier system, (3) Ideal business and comparison with mobile business, (4) Ideal Education System and its realization opportunity using ICCT, (5) Ideal drug system and its realization opportunity using nanopharmaceutical science, (6) Ideal Banking System and its realization opportunity using mobile banking technology, (7) Ideal Software System and its realization opportunity using universal automation system, and (8) Ideal computing system and its realization opportunity using Cloud computing system are predicted and suitable innovative technologies to manage and improve corresponding practical systems are identified and analyzed for further research. The research methodology also includes the management of business strategy of nanotechnology products and services in different industries including innovations in automobiles sector and renewable energy sectors are discussed and a new model of commercialization of nanotechnology products & services is also proposed.

The advantages, benefits, constraints, and disadvantages of are analysed for the nanotechnology as universal technology and green technology to solve many basic and advanced problems of the society for living comfortable life using a new self-developed analysing framework called ABCD Analysis Framework. Using the framework, the Factor & Elemental analysis are carried out for Nanotechnology as Green Technology and the results are depicted. This conceptual qualitative research is concluded by interpreting the possible combined potential of two Universal Technologies - Information Communication and Computation Technology (ICCT) and Nanotechnology (NT) in taking the world towards so called '*Technology based Singularity*' and '*Human Immortality*'.

The Thesis is prepared by combining the 30 published papers under the single Project called 'Technology Management'. This post-doctoral project includes both aspects of research -

creating new knowledge and new interpretation of existing knowledge through systematic analysis [37].

REFERENCES :

[1] Boyan J., Peter L., Rousseau (2005). Handbook of Economic Growth, Vol. 1B. pp. 1182-1224, Edited by Philippe Aghion and Steven N. Durlauf, Elsevier B.V. DOI: 10.1016/S1574-0684(05)01018-X.

[2] Ruttan, Vernon (2006). *Is War Necessary for Economic Growth?: Military Procurement and Technology Development*. New York: Oxford University Press. ISBN 0-19-518804-7.

[3] Lipsey, Richard; Kenneth I. Carlaw; Clifford T. Bekhar (2005). *Economic Transformations: General Purpose Technologies and Long-Term Economic Growth*. Oxford University Press. pp. 131–218. ISBN 0-19-928564-0.

[4] Aithal, P. S., (2016). Review on Various Ideal System Models Used to Improve the Characteristics of Practical Systems. *International Journal of Applied and Advanced Scientific Research*, ISSN: 2456 – 3080, *1*(1), 47-56. DOI : http://doi.org/10.5281/zenodo.159749.

[5] Keerthan Raj, & Aithal, P. S. (May 2018). The Significance of Big Data for the Base of the Pyramid Segment. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *2*(1), 72-81. DOI: http://dx.doi.org/10.5281/zenodo.1253705.

[6] Paul P. K.,Aithal P. S. & Bhuimali A, (April 2018). Business Informatics: With Special Reference to Big Data as an emerging Area: *A Basic Review*. *International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)*. 6(4), 21-29. DOI : http://doi.org/10.5281/zenodo.1249786.

[7] Paul, P. K., Neelanarayanan, V., Vijayakumar, V. and Aithal, P. S. (2018). Cloud Computing & Big Data : A Handbook, Information Science & Technology Series, New Delhi Publishers, 2018, pp. 1-170, ISBN No. : 978-93-86453-41-9.DOI :http://doi.org/10.5281/zenodo.1243221.

[8] Aithal, P. S. & Priyesh Pai, T. (2017). Opportunity for Realizing Ideal Computing System using Cloud Computing Model. *International Journal of Case Studies in Business, IT and Education (IJCSBE),* 1(2), 60-71. DOI: http://dx.doi.org/10.5281/zenodo.1094995.

[9] Paul, P. K., Aithal, P. S., Bhuimali, A. and Senthamarai, R. (2018 April). Mobile Cloud Computing - Contemporary issues and possible solutions: A Tool for Healthy Business World. Chapter 9, Cloud Computing & Big Data : A Handbook Edited by P.K. Paul, Neelanarayanan V, Vijayakumar V. and P. S. Aithal, New Delhi Publishers, pp. 101-108. DOI :http://doi.org/10.5281/zenodo.1218711. ISBN :978-93-86453-41-9.

[10] Paul P. K., BhuimaliA, Kalishankar Tiwary, P. S. Aithal, & R. Rajesh (May 2018). Digital Business: The Transition into new age dealing emphasizing inputs from Cloud Computing and Big Data—*A Indian Case. IRA-International Journal of Management & Social Sciences*, 11(2), 91-98. DOI :http://doi.org/10.21013/jmss.v11.n2.p4.

[11] Pai V. T. & Aithal, P. S., (2017). A Review on Security Issues and Challenges in Cloud Computing Model of Resource Management. *International Journal of Engineering Research and Modern Education (IJERME)*, 2(1), 65-70. DOI :http://doi.org/10.5281/zenodo.546323.

[12] Vaikunth Pai T. & Aithal, P. S., (2017). Cloud Computing Security Issues - Challenges and Opportunities. *International Journal of Management, Technology, and Social Sciences (IJMTS),* 1(1), 33-42. DOI: http://dx.doi.org/10.5281/zenodo.569920.

[13] Paul, P. K., Aithal, P. S., & Bhuimali, A. (2017). Mobile Cloud Computing Vis-à-Vis Eco friendliness for Sustainable Development. *International Journal of Engineering Research and Modern Education (IJERME),* 2(2), 28-32.DOI :http://doi.org/10.5281/zenodo.846406.

[14] Paul P. K., Aithal P. S., & Bhuimali A. (2017). *Not Profit Technologies*: Emphasizing Open Source Cloud Computing, *International Journal on Recent Researches in Science, Engineering, & Technology*, 5(8), 1-6. DOI :http://dx.doi.org/10.5281/zenodo.997973.

[15] Aithal, P. S. & Priyesh Pai, T. (2017). Opportunity for Realizing Ideal Computing System using Cloud Computing Model. *International Journal of Case Studies in Business, IT and Education (IJCSBE),* 1(2), 60-71. DOI: http://dx.doi.org/10.5281/zenodo.1094995.

[16] Simon, H. A. (1995). Artificial intelligence: an empirical science. *Artificial Intelligence*, *77*(1), 95-127.

[17] Kopetz, H. (2011). Internet of things. In *Real-time systems* (pp. 307-323). Springer, Boston, MA.

[18] Paul P.K., Bhuimali A., & Aithal P.S., (2018). Business Information Sciences emphasizing Digital Marketing as an emerging field of Business & IT: A Study of Indian Private Universities. *IRA International Journal of Management & Social Sciences*, 10(2), 63-73. DOI: http://dx.doi.org/10.21013/jmss.v10.n2.p1.

[19] Schubert, C., Van Langeveld, M. C., &Donoso, L. A. (2014). Innovations in 3D printing: a 3D overview from optics to organs. *British Journal of Ophthalmology*, 98(2), 159-161.

[20] Zyda, M. (2005). From visual simulation to virtual reality to games. *Computer*, *38*(9), 25-32.

[21] Zhang, X., Hou, J., & Dong, W. (2017). Photonic Integrated Chips for Optical Computing. In *Photonics in Switching* (pp. PTu1D-4). Optical Society of America.

[22] Aithal, P. S., (March 2015). Concept of Ideal Business & Its Realization Using E-Business Model. *International Journal of Science and Research (IJSR)*, 4(3), 1267 – 1274. DOI : http://doi.org/10.5281/zenodo.61648.

[23] Aithal, P. S., (March 2015). Concept of Ideal Business & Its Realization Using E-Business Model. *International Journal of Science and Research (IJSR)*, 4(3), 1267 – 1274. DOI : http://doi.org/10.5281/zenodo.61648.

[24] Aithal, P. S. (2015). Mobile Business as an Optimum Model for Ideal Business. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 146-159, DOI : http://doi.org/10.5281/zenodo.163880.

[25] Aithal, P. S., Shubhrajyotsna Aithal, (2015). A review on Anticipated Breakthrough Technologies of 21st Century. *International Journal of Research & Development in Technology and Management Sciences*, 21(6), 112 – 133. DOI : http://doi.org/10.5281/zenodo.61617.

[26] Aithal, P. S. (January 2016). Nanotechnology Innovations & Business Opportunities : A Review. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 182-204. DOI : http://doi.org/10.5281/zenodo.161153.

[27] Prasad, R., Kumar, V., & Prasad, K. S. (2014). Nanotechnology in sustainable agriculture: present concerns and future aspects. *African Journal of Biotechnology*, *13*(6), 705-713.

[28] Aithal, Shubrajyotsna & Aithal, P. S. (2018). Concept of Ideal Water Purifier System to Produce Potable Water and its Realization Opportunities using Nanotechnology. *International Journal of Applied Engineering and Management Letters (IJAEML)*, 2(2), 8-26. DOI: http://dx.doi.org/10.5281/zenodo.1323714.

[29] Aithal, P. S. & Shubrajyotsna Aithal, (2016). Nanotechnological Innovations & Business Environment for Indian Automobile Sector : A Futuristic Approach. *International Journal of Scientific Research and Modern Education (IJSRME)*, 1(1), 296-307. ISSN: 2455 – 5630, DOI : http://doi.org/10.5281/zenodo.161090.

[30] Aithal, P. S. & Shubhrajyotsna Aithal, (2016). Nanotechnology Innovations & Business Opportunities in Renewable Energy Sector. *International Journal of Engineering Research and Modern Education (IJERME)*, 1(1), 674- 692. DOI : http://doi.org/10.5281/zenodo.160905.

[31] Aithal, P. S., & Shubhrajyotsna Aithal, (2015). Ideal Technology Concept & its Realization Opportunity using Nanotechnology, *International Journal of Application or Innovation in Engineering & Management (IJAIEM)*, 4(2), 153 – 164. ISSN 2319-4847. DOI: http://doi.org/10.5281/zenodo.61591.

[32] Aithal, P. S., and Shubhrajyotsna Aithal, (2016). Opportunities & Challenges for Green Technology in 21st Century. *International Journal of Current Research and Modern Education (IJCRME)*, 1(1), 818-828. ISSN (Online): 2455 – 5428. DOI : http://doi.org/10.5281/zenodo.62020.

[33] Guo, Bin, Daqing Zhang, and Zhu Wang. (2011). Living with internet of things: The emergence of embedded intelligence. *Internet of Things (iThings/CPSCom),* 4th International Conference on Cyber, Physical and Social Computing. 297-304. IEEE.

[34] Basten, Twan, Marc Geilen, and Harmke de Groot, eds. (2003). Ambient intelligence: impact on embedded system design. *Boston: Kluwer Academic Publishers*.

[35] Remagnino, Paolo, and Gian Luca Foresti. (2005). Ambient intelligence: A new multidisciplinary paradigm. *Systems, Man and Cybernetics*, *Part A: Systems and Humans*, IEEE Transactions, 35(1), 1-6.

[36] Kirk, Rod, Tim Christianson, and Danial Faizullabhoy. (1992). Embedded intelligence. *BYTE* 17(3), 195.

[37] Aithal, P. S. and Shubhrajyotsna Aithal (August 2018). Study of various General-Purpose Technologies and Their Comparison towards developing Sustainable Society. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, 3(2), 16-33. DOI : http://doi.org/10.5281/zenodo.1409476.

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CHAPTER 2

REVIEW ON IDEAL SYSTEMS & TECHNOLOGY

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ABSTRACT :
This chapter contains an elaborate review of various ideal system models used to improve the characteristics of practical systems, anticipated breakthrough technologies of 21st century, and nanotechnology innovations & business opportunities : a review on how technology has affected society and its surroundings in a number of ways. In many societies, technology has helped to develop more advanced economies (including today's global economy) and has supported the rise of leisure class people. The concept of the ideal engine, ideal switch, ideal semiconductor devices like ideal diodes, transistors, etc. have been defined and taken as standards to improve the quality and performance of such practical devices or systems. It is found that, by keeping such a hypothetical device or systems in mind, researchers have to continuously improve the characteristics/properties of practical devices/systems to upgrade their performances. Hence, ideal properties of a device or a system can be used to upgrade or improve its properties toward reaching 100% efficiency. By comparing the properties/characteristics of a practical device/system with its ideal counterpart, one can find out the possible modifications in that device/system toward reaching the objective of achieving such an ideal device. In this chapter, we have also developed the concept of Ideal technology by creating a model and identified its important characteristics. These characteristics are grouped into four categories namely input conditions, output conditions, system conditions and environmental conditions/social expectations. These characteristics are further discussed, analyzed and compared with present technologies. Based on the discussion, it is realized that many of the characteristics of the ideal technology are achievable through discoveries and innovations in Nanotechnology. Finally, the characteristics of this ideal technology model are compared with nanotechnology developments and the possible way of realizing nanotechnology as ideal technology is discussed.

2.1 INTRODUCTION :

A system model is a conceptual model used to describe and represent a system. A system comprises of various processes used to convert some form of input into the required form of output based on its objectives. A system will have its own control mechanism to convert the input into output. The performance of the system depends on two factors as the objective of the system and the environment of the system. Further, a system is a set of interrelated components. The systems are orderly arranged according to a design and each component has a definite function to perform in the system. The components forming a system are called

subsystems. Each such subsystem can further be divided into lower level subsystems. This process of dividing a system into lower level subsystems is called factoring of a system and this can be carried on until we get a unit, which is easy to manage. A system can also be defined as an organized or complex entity, combination of things or parts forming a complex entity. The system may be Physical or Abstract. The physical system is a set of elements which operate together to accomplish an objective. Physical systems are made up of objects such as land, building, machines, people and other tangible objects. An abstract system is an orderly arrangement of ideas, concepts, or constructs. The physical systems produce some outputs which may help to achieve its defined objective. Organization systems are more meaningfully defined as an array of components designed to accomplish a particular objective according to a plan. The general model of a physical system is a collection of related elements. These elements take the form of input, process, and output. The objective of the system decides the system, subsystems, their functions, and the systems environment. The features which define and delineate a system form its boundary. A model is a simplified representation of an operation, or is a process, or a system in which only the basic aspects or the most important features of a typical problem under investigation are considered. The objective of a model is to identify significant factors and interrelationships. The reliability of the solution obtained from a model depends on the validity of the model representing the real system. A good model called the ideal model must have the following characteristics:

- An ideal model should be capable of taking new formulations into account without having any changes in its frame.
- Assumptions made in the model should be as small as possible.
- Variables used in the model must be less in number ensuring that it is simple and coherent.
- It should be open to the parametric type of treatment.
- It should not take much time in its construction for any problem.

The significant advantages of using a model for a system are:

- Problems under consideration become controllable through a model.
- It provides a logical and systematic approach to the problem.
- It provides the limitations and scope of an activity of the system.

It helps in finding useful tools that eliminate duplication of methods applied to solve the problems.

- It helps in finding solutions for research and improvements in a system.

- It provides an economic description and explanation of either the operation or the systems they represent.

Predictive Models predict facts and relationships among the various activities of the problem. These models do not have an objective function as a part of the model to evaluate decision alternatives. In this model, it is possible to get information as to how one or more factors change as a result of changes in other factors. An example of a predictive model is the model of an Ideal system. Descriptive Models describe facts and relationships among the various activities of the problem. These models also do not have an objective function as a part of the model to evaluate decision alternatives. In this model also, it is possible to get information as to how one or more factors change as a result of changes in other factors. An example of a descriptive model is the model of a real system.

In this paper, we have reviewed the ideal properties of various hypothetical systems which can be used to upgrade or improve their properties towards reaching 100% efficiency. By comparing the properties/characteristics of a practical device/system with its ideal counterpart, one can find out the possible modifications in that device /system towards reaching the objective of achieving such an ideal system. Even though ideal systems are hypothetical systems, which cannot be realized completely in practice, gives a broad idea on how the practical systems can be improved continuously to reach ideal system characteristics. The ideal system characteristics of technology, business, education, banking, electrical energy, software, computing and strategy, discussed in this review, under input characteristics, system characteristics, output characteristics, and external characteristics shows an opportunity to the scientists and engineers to develop such practical systems further with an objective to reach the goal. Based on the review, we have also discussed the possible characteristics of some of the future anticipated systems like ideal automobiles, ideal home, ideal human being, ideal organization, ideal city and even, ideal world.

Similarly, every rational person in this world constantly aims to improve his standard of living. Forecasting the future technologies is important for dreamers who hope to innovate better tools and techniques and through such research to achieve breakthroughs for the mainstream people who expect to benefit from such new and improved technologies. Many inventions are born in the lab and never enters into the consumer market, while others evolve beyond the expectation of putting good regulations on their use. Since the beginning of the 21st century, mankind has made tremendous strides and struggles in developing new technologies and manage them efficiently and effectively to improve the quality of life. While machines can replicate many

movements and actions of humans, the next challenge lies in teaching them to think for themselves and react to changing conditions [1]. For example, the field of artificial intelligence will one day give machines the ability to think analytically. Exploring space will also push genetic research. It is predicted that travelling to and living in other planets such as Mars with extremely cold temperatures and toxic atmosphere will require genetic changes through gene therapies. Sending humans into space without genetic modification would be impractical. However, we need breakthroughs to achieve this glowing future. Similarly, many anticipated technology breakthroughs are expected to change the lifestyle, comfort and thinking of human beings in near future [2]. Will these breakthroughs happen? Experts believe technologies will develop at lightning speeds during this century. Between 2015 and 2035, we could see more breakthroughs than in the last 200 years. From 2035-to-2050, advances might outpace all of human history; and from 2050-to-2100, massive discoveries beyond the wildest imaginings of science fiction could appear. As we trek into this future, aided by technologies we cannot even imagine today, it's easy to predict and believe that sometime during the 22nd century, more humans will live in space than on Earth. This paper discusses thirteen, the most anticipated possible technology breakthroughs of 21st century which substantially affects the lifestyle of living beings in the world provided they are managed properly by utilizing the advantages of them for human prosperity. These technologies are (1) Nanotechnology based human life comfort, (2) High speed computation through optical computers, (3) Embedded Intelligence, (4) HIV Antivirus, (5) Pseudo Senses - Sensation of existence through virtual reality, through artificial environment, (6) Off Planet Production in micro-gravity, (7) Protein Maps to know how many active genes are coding for proteins in living being, (8) Customized Kids which are used for Customization of Physical and mental ability of children, (9) Development of Chameleon Chips which are reconfigurable photonic circuits using the idea of optical solitons, (10) Flying cars through manipulation of gravitational force, (11) Immortality through nano-bio-technology & stem cell research, Fractal Models for fragmented geometry shapes, and (13) Space travel for everybody. The effect of these technology breakthroughs, their effective management, possible changes in the lifestyle of people in the society and its contribution in solving many basic & advanced problems of human beings on the earth are also discussed in this chapter.

Nanotechnology is expected as the major breakthrough technology of this century and is defined according to the National Nanotechnology Initiative (NNI), as the “understanding and control of matter at dimensions of roughly one to one hundred nanometers, where unique

phenomena enable novel applications," [3]. The U.S. Environmental Protection Agency (EPA) [4] defines nanotechnology as "research and technology development at the atomic, molecular, or macromolecular levels using a length scale of approximately one to one hundred nanometers in any dimension; the creation and use of structures, devices and systems that have novel properties and functions because of their small size; and the ability to control or manipulate matter on an atomic scale. Scientists have been studying and working with nanoparticles for centuries. But the ability to see nano-sized materials using high powered microscope has opened up a world of possibilities in a variety of industries and scientific endeavours. Since nanotechnology is a set of techniques used to manipulate the properties of matter at the microscopic scale, it can support many applications in the society especially to solve problems of living being. Nanotechnology is viewed as a group of technologies over time and is expected to support innovative new product developments. Lux Research, Inc., the New York-based nanotechnology research and advocacy firm, predicts that by 2015 products that incorporate nanotechnology will constitute 15 percent of global manufacturing output and will total $3 trillion. Products of nanotechnology are diverse and growing exponentially due to high priority research investments by many countries. According to the NNI, nanoparticles and nanoscale materials are used in many industries, including agriculture, food, energy, electronics, pharmaceuticals, chemicals, and biomedical, among others. Many areas of industries are producing greater revenue for nanoparticles are chemical-mechanical polishing, solar panel coatings, magnetic recording tapes, sunscreens, automotive catalyst supports, biolabeling, electroconductive coatings, and optical fibers. Many nano-enabled products are available in the market today, which include paints, cosmetics, stain-resistant clothing, electronics, surface coatings, sporting goods etc., among other applications [5]. According to RNCOS, the global nanotechnology market has been witnessing a growth at a compound annual growth rate (CAGR) of around 19% during 2011-2014 [6]. The future prospective growth will be largely driven by massive investment in nanotechnology R&D and commercialization by both government and corporations worldwide. In the coming years, it is expected that nanotechnology based products and services will have a huge impact on most of the industrial sectors and will enter the consumer market in large quantities. Some researchers believe nanotechnology can be used to significantly extend the human lifespan or produce replicator-like devices that can create almost anything from simple raw materials. Others see nanotechnology only as a tool to help us to do what we do now, but faster or better. The third major area of debate concerns the timeframe of nanotechnology- related advances. Will

nanotechnology has a significant impact on our day to day lives in a decade or two, or will many of these promised advances take considerably longer to become realities [7]. Based on the ability, advantages, and applications of nanotechnology in solving problems in almost all areas of the society, it can be considered as an ideal technology [8]. Only time will tell how nanotechnology will affect our lives. The applications of nanotechnology identified in different areas provides lots of business opportunities which includes Medicine, Electronics, Food, Fuel Cells, Solar Cells, Batteries, Space Travels, Fuel, Better air quality, Cleaner water, Chemical sensors, Sporting goods, Consumer goods, cosmetics, Fabrics, Cleaning products, automobiles, Energy, Environment, Health, Lifespan increase etc. These business opportunities may create new business model with a challenge of educating people in the usage of these innovative products & services safely to harness their advantages and benefits.

2.2 REVIEW ON VARIOUS IDEAL SYSTEM MODELS

2.2.1. Ideal Systems:

It is well known that we can improve the performance of any system by comparing it with a hypothetical, predicted system of that kind called "Ideal system" [9]. The word “Ideal system” refers to the system which has ideal characteristics i.e., perfect in every way. It is what the mind pictures as being perfect. The characteristics of the present system can be improved towards the characteristics of the ideal system by doing research and innovation. The concept of an ideal gas, ideal fluid, ideal engine, ideal switch, ideal voltage source, ideal current source, ideal semiconductor devices like ideal diodes, ideal transistors, ideal amplifiers etc. have been defined and taken as standards to improve the quality and performance of such practical devices or systems. Some of the ideal systems are listed table 2.1, along with their definitions. It is found that, by keeping such hypothetical devices or systems in mind, researchers have continuously been improving the characteristics/properties of practical devices / systems to upgrade their performances. Hence, ideal properties of a device or a system can be used to upgrade or improve its properties towards reaching 100% efficiency. By comparing the properties/characteristics of a practical device/system with its ideal counterpart, one can find out the possible modifications in that device /system towards reaching the objective of achieving such an ideal system [10].

Table 2.1: Some of the ideal systems in science, engineering and social sciences with their definitions

S. No.	Ideal Systems	Definition of ideal systems
1	Ideal gas	A hypothetical gas whose molecules occupy negligible space and have no interactions, and which consequently obeys the gas laws exactly.

2	Ideal fuel	It should possess high calorific value, moderate ignition temperature, burn without giving harmful gas, cheap and easily available everywhere, no risk during usage or transportation, burn completely, and burn smoothly.
	Ideal solution	An ideal solution or ideal mixture is a solution in which the enthalpy of solution is zero
3	Ideal fluid	An ideal fluid is one with constant density and has zero viscosity coefficient
4	Ideal Engine	A heat engine operating on perfect reversible cycle with 100 % efficiency.
5	Ideal switch,	An ideal switch would have no voltage drop when closed, and would have no limits on voltage or current rating. It would have zero rise time and fall time during state changes, and would change state without "bouncing" between on and off positions, with negligible power loss.
6	Ideal voltage source	It is a two-terminal device that maintains a fixed voltage drop across its terminals. It is often used as a mathematical abstraction that simplifies the analysis of real electric circuits.
7	Ideal current source	It is a current source that supplies constant current to a circuit despite the voltage dropped in the circuit. It acts as a 100% efficient source of current: it has infinite internal resistance.
8	Ideal Diode	It is a diode that acts like a perfect conductor when a voltage is applied forward biased and like a perfect insulator when a voltage is applied reverse biased. So, when a positive voltage is applied across the anode to the cathode, the diode conducts forward current instantly.
9	Ideal Transistor	The ideal transistor model the base and emitter are at the same AC voltage. They differ only by a constant DC potential. The collector current is equal to the emitter current and proportional to the base current.
10	Ideal Amplifier	Ideal amplifier has Infinite input impedance, zero output impedance, zero common-mode gain, or, infinite common-mode rejection, Infinite open-loop gain, and Infinite bandwidth.
11	Ideal Business	A business which as ideal input characteristics, ideal output characteristics, ideal system requirements and ideal marketing conditions [11-12].
12	Ideal Education System	Has ideal characteristics under Input conditions, Systems requirements, Output conditions and Environmental & social conditions [13].
13	Ideal Technology	An ideal technology system should have characteristics to fulfil its objectives to solve all problems of human beings including both basic needs and advanced gadgets to support comfort living to realize their dreams. Based on various factors which decide the ideal technology system characteristics, a model consisting of input conditions, output conditions, environmental conditions and system requirements [8].
14	Ideal Strategy	It is the mixture of Red ocean strategy, Blue ocean strategy, Green ocean strategy, and Black ocean strategy, also called white ocean mixed strategy [16].
15	Ideal Energy Source	It provides an infinite amount of energy without any constraints of the load. It has 100% energy output efficiency [17]
16	Ideal Banking	Ideal Banking has ideal input conditions, output conditions, system requirements, and social & environmental conditions [18].

17	Ideal Library	Ideal library system is a ubiquitous universal resource centre openly accessible by everybody online to get any type of information from various databases, e-books, Journals and any other type of publications free of cost electronically [19].
18	Ideal software	It is a general purpose software model which can be used for any platform, any type of system, and application automation, without making modifications in the form of structure, coding by an external person/agency [20].

2.2.2. Ideal Technology Model:

The concept of ideal technology can be predicted as a technology which can solve all basic needs of human beings and provide a luxurious comfortable life without affecting the society and environment. Ideal technology should have characteristics in order to elevate the quality of life to a unique level with perfect equality so that every human being in this universe should lead happy and comfortable life and realize the so-called concept of heaven on earth. Based on various factors which decide the ideal technology system characteristics, a model consisting of input conditions, output conditions, environmental conditions and system requirements [10]. The input properties are: (1) Manipulate the fundamental nature of matter to provide solutions to basic and advanced problems of mankind. (2) In-expensive & self-reliable in terms of resources to make it attractive to be used by people/countries of varied economical situations. (3) Ubiquitous so that the technology provides solutions and services at anytime, anywhere, any amount of time to the users. (4) Affordable to everybody so that it uses common materials available in nature and manipulate effectively to the need of human being at an affordable cost. The Output properties are (1) Solve basic needs like food, drinking water, renewable energy, clothing, shelter, health, and clean environment. (2) Provide comfort life to the users by providing solutions to their desires. (3) Equality; ideal technology provides equal opportunity and similar solutions to every user irrespective of their gender, religion, background, education, economic status, and country of origin. (4) Automation; ideal technology automates all processes in every type of industries to avoid human interference in work/control in order to provide an expected output based on programming. (5) Immortality is the ultimate goal of ideal technology so that it can create an avenue for the deathless situation or enhancement of human lifespan. The System Requirement Properties are (1) General purpose technology to support all fields and problems of human & living beings on the earth. (2) Self-directed & self-controlled & self-regulated so that the technology can control itself in order to achieve its goal. (3) Easy, simple, quick & user-friendly to solve all type of problems and to provide a quick ideal solution. (4) Scalable so that it is used for solving the small and simple problem to large and complex problems of life. (5) Omnipotent to identify and solve problems and provide

comfortability to a human being and feeling him like God. (6) Exploring new opportunities to improve and explore comfortability and further leisure in the life of people. (7) An infinite potential for the further development of life in the universe. The Environment/external Properties are (1) Maintain a clean environment through its processes and avoid the footprint of processes while achieving a specific function. (2) Infinite business opportunities by creating new products/services with ideal characteristics. (3) Adaptive to any situations to achieve the stated goal. (4) No side effects so that it should be safe for users, and the environment. Any technology which has the above properties/characteristics is considered as ideal technology and the conventional technologies have serious drawbacks/limitations in terms of the above properties [11]. Many research publications focus on solving various problems of society by utilizing nanotechnology as an ideal technology [7, 22-27].

2.2.3. Ideal Business Model:

An Ideal business system shall have characteristics which can be predicted and classified. Based on various factors which decide the ideal business system characteristics, a model consisting of the input conditions, output conditions, market conditions, and system requirements.

- The Ideal Business sells its products/services to the entire world rather than a single neighbourhood and hence it has an unlimited global market.
- The Ideal Business offers a product/service, which enjoys an inelastic demand in the market. (inelastically refers to a product that people need or desire almost at any price.)
- The Ideal Business markets a product/service that cannot be easily copied. This means that the product/service is original or, at least, it is something that can be copyrighted or patented.
- The Ideal Business has minimal labour requirements. The fewer personnel, the better is the business.
- The Ideal Business operates on a low overhead. It does not need an expensive location. It does not need large amounts of electricity, or advertising, or legal advice, or high-priced employees, or a large inventory.
- The Ideal Business does not require big cash outlays or major investments in equipment or product. In other words, it does not require huge capital.
- The Ideal Business is relatively free of all kinds of government regulations or restrictions.

- The Ideal Business is portable or easily moveable. This means one can shift his business and himself anywhere he wants to.
- The Ideal Business satisfies its owner's intellectual needs. There is nothing like being fascinated with what he does.
- The Ideal Business leaves enough free time to its owner. In other words, it doesn't require his labour and attention of 12, 16, or 18 hours a day.
- The Ideal Business is one in which the income is not limited by the personal output (Leverage). In the Ideal- Business, one can have 10,000 customers as easily as can have one."
- The ideal Business will not have any liability after sales.
- The ideal Business will not have problems like seasonality, perishability and price drop.
- In ideal Business, the demand is always very high than supply and the efficiency of production is always 100%.
- The ideal Business will be sustainable for a long time.

Any business which has the above properties is considered as an ideal business and the conventional business called brick and mortar business has serious drawbacks/limitations in terms of the above properties. Many research publications focus on improving the quality of business towards ideal nature [11-12, 28-29].

2.2.4. Ideal Education Model:

Education at its best will effectively prepare students for the working world. An ideal education system would not only prepare students for the working world but would also prepare them to become empowered to transform the working world to better suit the needs of the people. An Ideal education system shall have characteristics which can be predicted and classified. Based on various factors which decide the ideal education system characteristics, a model consisting of the input conditions, output conditions, system requirements, and social & environmental conditions [13-15].

- The Ideal Education provides education to the entire world rather than a single neighbourhood /Country and hence it has an unlimited global reachability.
- The Ideal Education offers courses of study, which enjoys an inelastic demand in the world market. (Inelastic refers to a Course that people need or desire almost at any price.)

- The Ideal Education provides all types of courses in all field of specialization and imparts knowledge, skills and experience to all people irrespective of their age, gender, previous qualification and country of origin.
- The Ideal Education system provides high-quality education to everybody irrespective of their economic, social, linguistic and cultural background.
- The Ideal Education system needs minimum instructors in identified courses and must utilize optimum service from them.
- The Ideal Education system operates on a low overhead. It does not need an expensive location, big campus and huge amount of infrastructure. Only a few Universities are required to provide quality education to the entire world.
- The Ideal Education system does not require major investments in equipment and other education & training. systems or repetition of a large number of universities in every state and every country. In other words, it does not require huge capital.
- The Ideal Education system is relatively free of all kinds of government regulations or restrictions.
- The Ideal Education system is portable or easily moveable. This means a student registered for a course should get the service wherever he moves.
- The Ideal Education system satisfies its student's intellectual needs. There are no constraints like compulsory subjects, minimum and maximum subjects.
- The Ideal Education system leaves enough free time to instructors as well as students. In other words, it doesn't require attention/study of 12, 16, or 18 hours a day.
- The Ideal Education system is one in which the income of the university does not limit by the personal output (Leverage). In the Ideal Education system, one can train 10,000 students as easily as can have one."
- The ideal Education system students can take exams anytime, any number of times and results should be declared immediately. There is nothing like losing a year due to failure in examination.
- The ideal Education system will provide services to its registered students anywhere, anytime and any amount of time. i.e., it is ubiquitous.
- In an ideal system, the technology is used in such a way that all pedagogies of the education system should be delivered effectively.
- An ideal education system provides all students with not only basic knowledge but also social skills and good behaviours.

- In ideal Education system, the demand for a variety of courses is higher than the supply and the efficiency of the system is always 100%.
- In ideal Education system, the students have a choice of alternative in terms of course/service providers.
- The ideal Education system will be sustainable for a long time.
- Any education system which has the above properties is considered as the ideal education system and the conventional education systems called brick and mortar systems have serious drawbacks/limitations in terms of the above properties [13]. Several research publications focus towards improving the quality of higher education towards ideal nature [30-32].

2.2.5. Ideal Banking Model:

Ideal Banking System model by considering various characteristics under 4 categories such as Input conditions, Systems requirements, Output conditions, and Environmental & social conditions, and analysed these characteristics with an objective to achieve the goal. An ideal banking system would not only prepare students for the working world but would also prepare them to become empowered to transform the working world to better suit the needs of the people. An Ideal banking system shall have characteristics which can be predicted and classified. Based on various factors which decide the ideal banking system characteristics, a model consisting of the input conditions, output conditions, system requirements, and social & environmental condition is developed [18].

- The Ideal Banking system provides banking services to the entire world rather than a single neighbourhood town /Country and hence, it has an unlimited global reachability.
- The Ideal banking system offers services to its customers, which enjoys an inelastic demand in the world market (inelastic means a service that people need or desire almost at any price).
- The Ideal banking system provides all types of banking services of both retail banking and business banking to all customers irrespective of their age, gender, previous qualification and country of origin.
- The Ideal Banking system provides high-quality banking services to everybody irrespective of their economic, social, linguistic and cultural background.
- The Ideal Banking system needs minimum employees in identified areas of operation and must utilize optimum service from them.

- The Ideal Banking system operates on a low overhead. It does not need an expensive location, many branches, and huge amount of infrastructure. Only a few Banks are required to provide quality service to the entire world.
- The Ideal Banking system does not require major investments in equipment and other infrastructure or repetition of a large number of branches in every state and every country. In other words, it does not require huge capital.
- The ideal banking system is relatively free of all kinds of government regulations or restrictions.
- The ideal banking system is portable or easily moveable. This means a customer registered in one bank should be able to get the services wherever he moves and in whichever city he lives.
- The ideal banking system satisfies its customers‟ intellectual needs. There are no constraints like minimum amount transaction, to be registered or avail services only in one bank, minimum and a maximum number of services availed per day.
- The ideal banking system leaves enough free time to service providers/bank employees as well as customers. In other words, it doesn't require attention/study of 12, 16, or 18 hours a day.
- The ideal banking system is one in which the income of the bank does not limit by a personal output (Leverage) of the bank workers. In the ideal banking system, a bank can provide any number of customers as easily as can have one.
- The ideal Banking system, customers can do transactions at any time, any number of times and results should be declared immediately. There is nothing like wasting time in queue, travel time to the bank etc.
- The ideal Banking system will provide services to its registered customers anywhere, anytime and any amount of time. i.e., it is ubiquitous.
- In an ideal system, the technology is used in such a way that all services of the banking system should be delivered effectively.
- An ideal banking system provides all customers with not only basic knowledge of banking but also on authenticity and security for financial transactions.
- In the ideal banking system, the demand for a variety of services is higher than supply and the efficiency of the system is always 100%.
- In the ideal banking system, the customers have a choice of alternative in terms of service providers.

- The ideal banking system will be sustainable for a long time.
- Any banking system which has the above properties is considered as ideal banking system and the conventional education systems called brick and mortar systems have serious drawbacks/limitations in terms of the above properties [33-41].

2.2.6. Ideal Energy Source:

An ideal electrical system must include the various characteristics to fulfill the objectives to solve the problems in the energy system. Based on various characteristics the model consists of three important conditions namely input conditions, system requirements and output conditions [17]. The various properties of an ideal electrical energy system are [42-43]:

The input conditions discuss the ideal characteristics of the energy system at the input side.

- Identify the fundamental nature of the input system at the production/ distribution/utilization.
- What are the differences between the practical input systems with the ideal system?
- How to reach the ideal system in the production/distribution/utilization.
- The challenges in reaching the ideal systems.
- The cost involved in improving towards the ideal system.

The output conditions have the following properties:

- The energy system should provide complete solutions to the requirements.
- The energy of should not be wasted in the form of heat or electromagnetic wave.
- The energy system should completely avoid the hazardous shocks at its output.

The system requirements concentrate on what are the system requirements to achieve the ideal output in the energy production/distribution/utility.

- The general purpose technology to support all the processes in the production/distribution/utility.
- Easy, simple, and affordable system to support the ideal technology.
- It should support the further new opportunities for the improvements.
- The further new opportunities/improvements should upgrade the existing technology without replacement of the existing technology.

The impact of the new proposed ideal system on the environment are as follows:

- Environmental cleanliness.
- The amount of unwanted by-products from the system to the environment.
- Adaptive to any environmental situations to achieve the goal.

No side effects assuring the users about safety.

2.2.7. Ideal Strategy:

An ideal strategy is a planning and execution strategy which confirms the success of the work in any situational conditions and constraints. This strategy ensures the sustainability of the organization with a huge profit. Ideal strategy always ensures winning in an organizational problem with least or zero effort. The ideal strategy is suitable for hypothetical situations to confirm winning but cannot be implemented for real situations. But we can realize the consequences of ideal strategy in practice by means of the new strategy named White Ocean Mixed (WOM) strategy, which is an optimum mixture of all existing strategies like red ocean strategy, blue ocean strategy, green ocean strategy, black ocean strategy, and white ocean strategies. Even though the characteristics of the ideal strategy cannot be implemented in reality, to develop an optimum strategy which will ensure the organizational success, one has to identify characteristics of ideal strategy. The important characteristics of an ideal strategy which will give idea to identify an optimum strategy to the organizational problems are given below:

- The strategy should be independent of types of business and type of problems.
- The strategy should identify ideal solutions to organizational problems and to fulfil organizational objectives.
- The ideal strategy provides solutions to all problems the organization is facing and gives expected output whatever may be the constraints of the business system.
- Flexible to accommodate internal and environmental changes.
- Success through ideal strategy is measurable.
- Ideal strategy will not consume any resources while implementing.
- Ideal strategy is easy to implement and supports to fulfil the objectives at zero cost and zero time without any constraints.
- Ideal strategy includes competitive strategy, monopoly strategy, sustainable strategy and survival strategy to win the organizational challenges.
- Ideal strategy translates organizational business into ideal business.
- Ideal strategy guarantees organizational success in any kind of internal and external environments.

An optimum strategy is the best strategy within organizational or business constraints to fulfil the objectives of an organization. Optimum strategies of an organization can realizable and results can be tested. Optimum strategy in an organization or in a business model supports how

to face competition, how to develop monopoly products and services, how to maintain an environment for sustainability, how to manage turbulent situations for survival, and how to get long term profit for changes in internal and external environments. By mixing various corporate strategies like red ocean competitive strategy [44], blue ocean monopoly strategy [45], green ocean sustainable strategy [46], and black ocean survival strategy [47-50], one can develop white ocean optimum strategy [16, 51] with the intention to use ideal strategy for a given situation.

2.2.8. Ideal Software:

The Quality factors of software can be determined using their input characteristics, operational characteristics, transition characteristics, revision characteristics, and output characteristics. These characteristics are obvious and essential features expected from any project during development and implementation. The prominent eight input characteristics are (1) Zero input resources, (2) Infinite selectivity, (3) Ubiquitous input acceptance, (4) Infinite input security, (5) Infinite reliability, (6) Infinite usability, (7) Infinite efficiency in data acceptance, and (8) Zero energy consumption at input.

System characteristics include operational characteristics, transitional characteristics and maintenance characteristics. The ten prominent operational characteristics are (1) Zero budget, (2) Full correctness, (3) Easy usability, (4) Perfect integrity, (5) 100% reliability, (6) 100% efficiency, (7) Infinite tolerance to security threats, (8) 100% safety against hazards, (9) Infinite functionality, (10) Perfect Robustness. The importance of any of these factors varies from application to application. In systems where human life is at stake, integrity and reliability factors must be given prime importance. In any business, related application usability and maintainability are key factors to be considered. Always remember in Software Engineering, quality of software is everything, therefore try to deliver a product which has all these characteristics and qualities. The four most prominent transaction characteristics of an ideal software are (1) Perfect interoperability, (2) 100% reusability, (3) perfect portability, and (4) 100% performance guarantee. The ten most prominent maintenance characteristics of ideal software are (1) Zero maintenance cost, (2) Perfect flexibility, (3) Perfect generality, (4) Infinite extensibility, (5) Infinite scalability, (6) Easy testability, (7) Highest modularity, (8) Best readability, (9) Easy documentation for anybody use, (10) Infinite tenant efficiency, and (11) Easy reconfigurability.

The prominent eight output characteristics are (1) 100% accuracy, (2) Perfectly correct output, (3) Perfectly reliable output, (4) Long-term sustainability, (5) Infinitely reusability, (6) 100%

output efficiency at very low input, (7) Readability to everyone, and (8) Perfect satisfied user experience. The most prominent external characteristics are (1) Inelastic demand, (2) Infinite market for ideal software, (3) Infinite ability, (4) Cannot be copied by others/competitors, and (5) High-quality service to every user [52, 53].

2.2.9. Future Ideal Systems:

Various systems which are useful in practice to human beings for improving comfortability can be also discussed based on ideal system characteristics. Some of such hypothetical systems which can have ideal characteristics are:

- Ideal Automobile – with characteristics like low procurement cost, zero maintenance cost, easy operation, zero energy consumption etc. which can be achieved using advent in nanotechnology.
- Ideal Library– with characteristics like ubiquitous access of information from any corner of the world with no cost by anybody can be achieved using concepts like universal resource centre [19, 54].
- Ideal Human Beings– with characteristics like honesty, integrity, courage, self-awareness, wholeheartedness, scientific thinking, openness etc.
- Ideal Home – with features for good air and light circulation, independence in energy & water, enough storage space, temperature control facility, low maintenance interiors, and exteriors, healthy environment etc.
- Ideal Organization – with characteristics like total automation, the opportunity for its employees to work from home [55-57], online ubiquitous services, stakeholder satisfaction, customer enlightenment etc.
- Ideal City – with all neat, wide, and clean roads, systematically designed infrastructure and facilities, educated, responsible, and disciplined citizens, independence in all life leading resources, clean potable water, nutritious food, education to everybody, systematically planned sanitary, renewable energy & total health & fitness facilities, every other facility to keep its citizen happy & comfortable.
- Ideal World – without any differentiation between human beings based on gender, religion, race, cast, and age. The ideal world can have one currency, one judiciary system, one military, one common language, and one social system. It is the world with nutritious food, enough potable drinking water, ambient temperature, clean air, renewable energy, shelter, employment, and health for everybody with a comfortable living environment.

2.3 REVIEW ON ANTICIPATED BREAKTHROUGH TECHNOLOGIES OF 21ST CENTURY

2.3.1. Some Anticipated Breakthrough Technologies of this Century

Based on various factors which solve basic needs and advanced comfortability of human life, the technology breakthrough model consisting of nanotechnology and interrelated technologies and a set of independent technologies are derived by a qualitative data collection instrument namely focus group method [58, 59]. The block diagram of such a system is shown in Fig. 2.1. The anticipated breakthrough technologies are divided into two groups and listed below :

Interrelated Technologies :

(1) Nanotechnology

(2) Optical Computation

(3) Embedded Intelligence

(4) Chameleon Chips

(5) Flying cars

(6) Immortality through nano-bio-technology

(7) Space travel

Independent Technologies :

(1) HIV Antivirus

(2) Pseudo Senses

(3) Off Planet Production

(4) Protein Maps

(5) Customized Kids

(6) Fractal Models

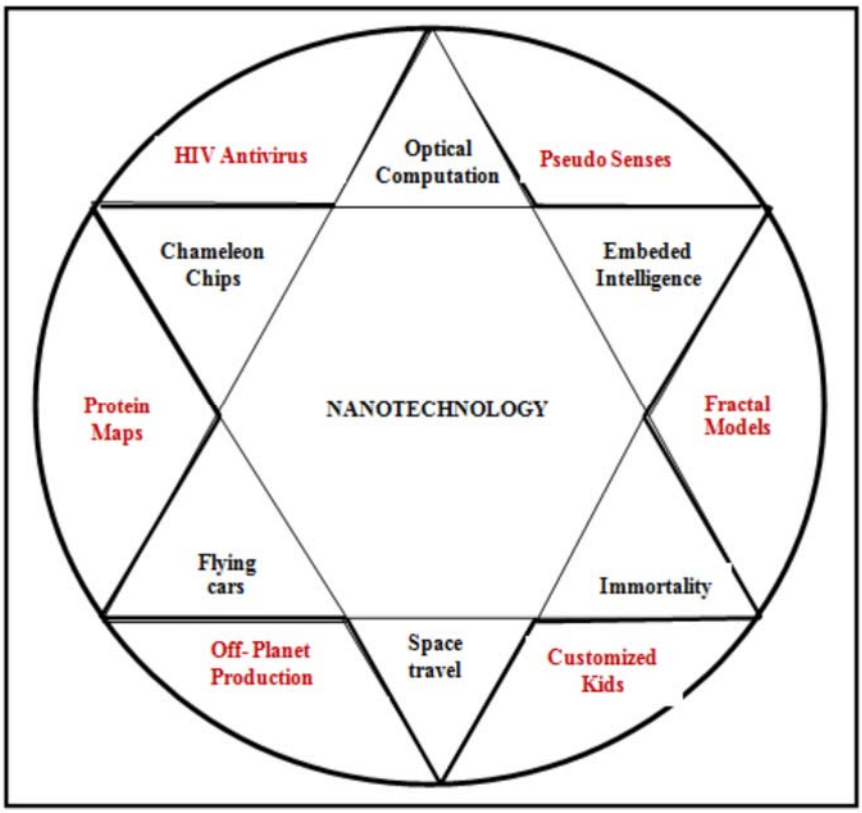

Fig. 2.1 : Block diagram to represent interrelated and independent technologies

2.3.2. Managing Breakthrough Technologies

(1) Nanotechnology :

Nanotechnology is the manipulation of matter at a scale of 1 to 100 nanometers. Using nanotechnology we can control molecules at an atomic level and create materials with unique properties. Fundamentally the properties of materials can be changed by nanotechnology. We can arrange molecules in a way that they do not normally occur in nature. The mechanical, material strength, electronic and optical properties of materials can all be altered using nanotechnology. There are different means like lithography, self-assembly, bottom-up methods to manipulate nanomaterials. Nanotechnology is the first worldwide research initiative of the 21st century.

As general purpose and enabling technologies, nanotechnologies reveal commercialization processes, from small to large firms in collaboration with public sector research, and which lead to changing patterns of industrial organization which influence public policy initiatives to foster their development [60-62]. Nanotechnologies are not only general purpose technologies but they are also technologies that enable the creation of new devices and new ways to improve the quality of life. Nanotechnologies are used in existing industries and new research areas are

developed within existing areas, transforming them from microelectronics to nano-electronics, from photonics to nano-photonics, from biotechnologies to nano-bio-technologies, and from energy to nano energy. Business firms are exploring new ways to address consumer needs, new business models based on the changes nanotechnologies could enable in existing industries. Huge amount of investments in nanotechnology to support scientific and technological researches, the creation of technological and industrial platforms and infrastructures have led to more than two million articles related to nanotechnologies being published, and over one million applications patents were lodged.

Nanotechnology has the potential to change every part of our lives. Nanotechnology affects all materials like metals, ceramics, polymers, organics and biomaterials. In the coming decade, nanotechnology will have an enormous impact in all areas of life. Future advances could change our approaches to manufacturing, electronics, IT & communications technology, space technology, agriculture & food technology, renewable energy, biotechnology and medicine, making previous technology redundant and leading to applications which could not have been developed or even thought about, without this new approach. Nanotechnology will play a major role in solving all the problems of humans like food, drinking water, energy, health, environment and many other areas including lifespan expansion.

Some of the Application areas of Nanotechnology are :

1. Medicine : This includes drug delivery, therapy techniques, diagnostic techniques, antimicrobial techniques, cell repair, cancer detection & curing, gene therapy, nanotech in regenerative medicine & tissue engineering, lifespan extension etc.

2. Electronics : This includes the development of nanotransistors, nanogates, nanodevice based integrated circuits, nanoemmissive display panels, nanomemories, nanowires, nanophotonic devices, Nano-optical computers etc.

3. Agriculture & Food : This includes contamination sensor, antimicrobial packaging, enhanced nutrient delivery, green packaging, pesticide reduction, tracking & brand protection, texture, food flavour, bacteria and virus identification & elimination etc.

4. Cleaner Air & Water : This includes pollution control, nanotech windmill blades, nanostructure membranes, water cleaning nanotechnology devices, nanoparticle catalysts, removal of carbon dioxide from industrial smoke stacks, nanotubes as the pores in reverse osmosis membranes, nanotech based water purifiers etc.

5. Batteries & Fuel Cells : This includes nanostructure fuel cells, hydrogen nanofuel cells, nanotech alternative fuel cells, long life high storage capacity fast rechargeable nanotech batteries etc.

6. Automobile & Space Technology : This includes nanomaterial based automobile parts, space elevators, weight reduction in spaceships and spacesuits, solar power satellites, bio-nano-machines for space applications, new breed of robots to explore the planets etc.

7. Sensors : This includes chemical sensors, MEMS based sensors, nano-hydrogen sensors, Nanocantilevers etc.

8. Consumer Products : Devices like sporting goods, fabrics & textiles, cosmetics, skin care products, sunscreens, flame retardants, nanocleaning products, nanopaints, and any other products based on nanotechnology.

9. Renewable Energy : This include inexpensive solar cells, devices for capturing, storage, & use of energy optimally.

10. Defense : This includes concepts like nano for the soldier, nano for defense vehicles, nano for aeronautics, nano for naval vessels, nanotechnology for weapon systems, nano for satellites, nano for logistics, nano for security, nano for military operations at land, nano for military operations in the air, nano for military operations at sea, nanotechnology for urban operations etc.

11. Civil & Mechanical Engineering Manufacturing : This includes nano-material technology, nano-processing technology, nano-assembly technology, nano-coating technology, and nano-measurement technology in mechanical manufacturing. This also includes nanorobotics, Micro-ElectroMechanical Systems (MEMS) for accelerometer chips, inkjet nozzles, pressure sensors, microphones, RF switches, gyroscope, oscillators etc.

12. Building Materials : This includes various future building materials like aerogels, nanotube mixed concrete, nanopaints, building integrated photovoltaic's, nanophotonic materials as building cooler nanotechnology on construction, and fire protection etc.

Timeline for nanotechnology innovations is predicted in various literatures is as follows :

- *Passive Nanostructures (2000-2015) : Nanomaterials, including nanotubes and nanolayers.*
- *Active Nanostructures (2015-2020) : Change their state during use, responding in predictable ways to the environment.*
- *Systems of Nanosystems (2020-2035) : Assemblies of nanotools work together to achieve a final goal.*

- *Molecular Nanosystems (2035-2050) : Involves the intelligent design of molecular and atomic devices, leading to "unprecedented understanding and control over the basic building blocks of all natural and man-made things.*
- *The Singularity (2050 and beyond) : Growth rate in NT applications become almost infinite.*

The ability to see nano-sized materials has opened up a world of possibilities in a variety of industries and scientific endeavours. Because nanotechnology is essentially a set of techniques that allow manipulation of properties at a very small scale, it can have many applications in all parts of life. Nanotechnology is viewed broadly as many technologies over time are expected to generate numerous new products and applications. Products of nanotechnology are diverse and growing exponentially. It is believed that nanotechnology can be used to significantly extend the human lifespan or produce replicator- like devices that can create almost anything from simple raw materials. The applications of nanotechnology identified in different areas provides lots of business opportunities which include health & medicine, electronics & photonics, food & food preservation, fuel cells & batteries, efficient solar cells, space travels, fuels, better air quality, cleaner drinking water, chemical sensors, sporting goods, fabric, cleaning products, energy, environment, and even lifespan increase. Management of nanotechnology research involves promotion and support of an idea to reality to make some very fine and small-scaled tools called nanotools. These tools have to be assembled at the molecular level in order to perform work at the nano level. The work of nanotechnology is so specialized that the tools need to be modelled and made specifically for each job. Handling the tools involves careful and minute planning so that those skilled in molecular nanotechnology will be in high demand in the workforce [63-64].

Anticipated breakthrough in nanotechnology will soon radically change our lives and the entire world. Researchers and policymakers from around the world believe that nanotechnology is about to radically transform world economies, improve the global environment, and provide a new understanding of what it means to be human.

(2) High speed computing through optical computers :

High performance computing through optical computing is the science of making computing work better using optics and related technologies. Optics has the ability to solve hectic problems in computing hardware. With the growth of computing technology, the need of high performance computers (HPC) has significantly increased [65]. Even though lot of research is taking place in laboratories, optical computing research has so far failed to come out of the lab in the form of a general purpose device. The construction of optical subsystems directly on-

chip, with the same lithographic tools as the surrounding electronics has been made possible by the advances in these tools, which can now create features significantly smaller than the optical wavelength [66].

The need for optical technology arrives from the fact that present day computers are limited by the time response and speed of electronic circuits. A solid transmission medium limits both the speed and volume of signals, as well as generating heat that damages components. These constraints have led scientists to seek answers in the light itself. Light does not have the time response limitations of electronics, does not need insulators, and can even send dozens or hundreds of photon signal streams simultaneously using different colour frequencies. They have low-loss transmission and provide large bandwidth. By replacing electrons and wires with photons, fiber optics, crystals, thin films and mirrors, researchers are hoping to build a new generation of computers that work several million times faster than conventional computers [67].

Some of the advantages of optical computers are listed below :

(1) High performance : The performance of an optical computer in an advanced stage should be several orders of magnitude higher than the conventional computer.

(2) High parallelism : Another key to fasten up optical computers is to compute with higher parallelism. This implies higher performance and higher bandwidth.

(3) Low energy consumption : Optical computers have the potential to be more power-saving than conventional ones.

(4) Less heat dissipation : In optical computers lasers are used as light sources. Those concentrated light beams only consist of a small spectrum of different wavelengths. Depending on the field of application lasers have different needs of energy and produce heat to a greater or lesser extent. Optical computers could be smaller because there is no need for a fan or free spaces for air circulation.

(5) Low noise : Conventional computers produce noise due to rotating fans and drives. Optical computers could be almost noiseless since no fan will be needed. Light sources (e.g. lasers) can be cooled with passive coolers and heat pipes built out of aluminium or copper. Those passive coolers evacuate heat silently.

(6) Flexibility layout : In optical components the distance of communication does not matter. Once the signal is in an optical fiber it does not matter whether the signal runs 1 meter or 1000 meters. Because of the low damping long-range communication is possible. Still the data rate

is very high and there is no crosstalk. So, the optical computer technology has the potential to change the shape and layout of computers fundamentally.

(7) Low loss in communication : The communication with optical fibers is almost lossless due to the total internal reflection. So, amplifying the signal is not or only rarely needed. Furthermore, a higher bandwidth is possible, optical communication is insensible to electromagnetic interfering fields and it is more tap-proof. For high performance communication fiber optics are used.

(8) Less wear : Wear normally occurs at mechanically moving parts. In optical computers fans will not be required. An optical processor does not heat up due to internal friction of the electrons like a conventional computer does. Additionally, new technologies for mass storages in the form of holograms or on molecular basis is possible. Those forms do not need fast rotating parts and do not wear out. It is sure that the scientists of 21st century will make a breakthrough by developing a suitable model and realize such model using suitable materials and components, and algorithms to realize both optical and quantum computers in the society.

(3) Embedded Intelligence :

The ability of a product, process or service to reflect on its own operational performance, usage load, or in relation to the end-user or environment in terms of satisfactory experience and smart improvement is characterised as Embedded Intelligence. This improvement through self-reflection, facilitated by information collected by sensors and processed locally or remotely, must be considered from the design stage such as to improve the product features, enhance the product lifetime and performance, increase quality of process or service delivery, or ensure customer satisfaction and market acceptance [68-71]. Embedded intelligence aims at delivering smarter products, systems or services to industry through their integration and purposeful use for a given application. Embedded intelligence (EI) system/service application contains various components/processes which include design for EI, intelligent software, packaging & interconnect, manufacturing solutions and/or system services.

The integration of embedded processors with sensors, intelligence, wireless connectivity and other components with high level operating systems, middleware and system integration services is possible and it is predicted that over the next 10 years “IT devices for industries including medical, manufacturing, transportation, retail, communication, consumer electronics and energy will take a development direction that makes intelligent designs become a part of all of our lifestyles”. This forecasts a significant growth for embedded systems in future years. The digital devices based on embedded systems just don't have keyboards and screens, since

they're buried inside stereos, vacuum cleaners, microwave ovens, and almost anything else that plugs into the wall or runs on batteries. Wireless-communications technology is wrapping the earth in layer upon layer of interconnectivity. And those tiny chips embedded in everyday gadgets will keep getting more powerful. Soon, the anonymous chips will get smart and be aware of their silicon neighbours, which is possible with the help of integrated sensors and wireless telecom systems. For example, the bedroom clock will just need to reach the phone to check on traffic patterns and flight schedules before deciding whether it should fiddle with its alarm time. Similarly, when rechargeable toothbrush detects signs of a cavity, it can send signals through the electrical wiring and get in electronic daybook to consult with dentist's digital appointment book, then display a few options on the bathroom mirror. Software agents with embedded intelligence will roam the wireless Web, autonomously managing most routine business and household chores. For example, if a product-design problem come up at work, the smart-card companion in the that place will be informed, and it will activate the display circuits in the paint on the nearest wall to display instead of using an electronic fold-up display. Welcome to tomorrow's world of embedded intelligence as a breakthrough technology of 21st century [72-73].

(4) HIV Antivirus :

Satisfactory and complete curing of HIV by discovering a suitable antivirus is one of the anticipated and most required technology breakthroughs of this century. With just 10 genes wrapped in a coating of protein and sugar, the virus that causes aids (left) has managed to stay several steps ahead of humanity's best efforts to control it. More than 55 million people have been infected around the world. But medicine is beginning to control this deadly scourge--with implications that go beyond aids. For instance, scientists have uncovered the wily molecular tricks HIV uses to slip its own genes into cells. That has enabled companies to devise drugs capable of blocking viral entry. The unprecedented research effort is also dramatically boosting our understanding of the immune system. In aids, clever new vaccines based on that knowledge are already offering the hope that the body could keep the virus in check on its own. And the aids breakthroughs will catalyse development of treatments for other diseases as well. Intensive researches are going on at several laboratories to develop suitable antivirus dosage for permanent cure of HIV/AIDS [74-75]. Scientists caution that a permanent cure for aids is still a dream. But new drugs, vaccines, and a growing international commitment to fight the illness as both a health and an economic problem should finally end this epidemic--and also help

improve the public health infrastructure enough to tame malaria and other terrible diseases [76].

(5) Pseudo Senses:

Sensation of existence through virtual reality, by creating artificial environment is another expected breakthrough of this century, it is predicted that virtualized reality will restore the sense of shared community that people had before we began sequestering ourselves in front of TV sets and computer screens.

In pseudoscience literature one frequently encounters the claim that there are some people, called "sensitives" or psychics," who somehow can pick up the thoughts of others and even transmit their own thoughts to people who are not "sensitives." This direct mind-to-mind communication is sometimes claimed to be instantaneous, and independent of distance. It is also often claimed that all people and even domestic animals such as cats, dogs, and horses -- possess this ability to some degree, and that ordinary coincidences are in fact no ordinary, but rather mysterious demonstrations of this supposed ability. Sometimes, but rarely, specific experiments are cited as having confirmed the existence of telepathy, clairvoyance, precognition, telekinesis, or other such "supernatural" abilities in humans or animals. Furthermore, in the course of evolution many kinds of animals have developed extremely acute senses of one kind or another, compared to those of humans. Dogs have much more highly developed sense of smell than do humans; hawks and eagles, more acute eyesight; bats, much wider range of hearing, etc.

Cognitive science through virtual reality represents an awesome look into our future. New theories about functions of our brain are unfolding at increasingly rapid intervals. Some experts believe a new understanding of the brain will lead to the creation of truly intelligent machines. Others suggest far-out technologies such as "Neural Virtual Reality" (NVR). NVR takes existing virtual reality technology to the next level by pumping virtual environments directly into the brain with neural implants. Transmitted signals trick the brain into believing the body is actually participating in a simulated experience. The implant tells the brain what the body is hearing and how it should feel. With all sensory inputs provided by NVR, a sufficiently realistic simulation is indistinguishable from reality, much like a dream. Today, we cannot even conceive all the applications that this extreme technology could provide. However, cognitive science promises a truly "magical future" for all to enjoy [77-79].

(6) Off Planet Production in micro-gravity :

Orbiting 220 miles above the Earth, the International Space Station offers more than just a spectacular view. It also gives scientists the chance to conduct research in the near absence of gravity. The result could be everything from new plant varieties to important new synthetic materials. Gravity, it turns out, is such a strong and pervasive force that it masks many interesting physical properties, including those related to combustion. In the space station, where gravity has only one-millionth the strength it has on Earth, hot gases do not rise, so flames are spherical and stable--and thus easier to study. Such flames can be used to create novel "combustion-synthesized" materials. One such material is a ceramic that could serve as an artificial bone. Powders are mixed and ignited to make the material, which is much more uniform when made in microgravity than when made on Earth. Researchers have also found that a rose is a rose except when it's grown in space. A rose carried aboard a 1998 shuttle flight had a different scent than roses grown on Earth. That heavenly fragrance was later synthesized on Earth and has already been used in a commercial perfume. Thus off-planet production in micro-gravity space may provide new varieties of plants, new structures & colour combinations of flowers, new breed of seeds and even new community of animals. It is anticipated that in 21st century such possibilities will be completely explored [80-83].

(7) Protein Maps to know how many active genes are coding for proteins in living being :

The decoding of the human genome has barely been completed but already scientists are delving into biology's next challenge: proteomics, the large-scale study of proteins. The goal is to understand the functions of the million or so proteins in the human body. With this knowledge, researchers say they can devise treatments to diagnose and eventually eliminate many diseases [84, 85, 2].

Mapping the human proteome is a monumental task. It will require hundreds of millions of dollars in investment and untold trillions of computations. The molecular contrasts tell the whole story: The human genome is made of DNA - simple, linear molecules containing just four basic constituents. Proteins, on the other hand, are exquisitely complicated structures wrought from 20 different building blocks called amino acids. These molecules fold their hundreds of thousands of atoms into precise configurations that can perform specific cellular tasks--building cellular structures, for example, or charging into the bloodstream as disease-fighting antibodies.

The natural origami underlying large proteins such as Factor VIII (left) - a common clotting factor in the blood--is so complex that scientists cannot yet predict the pattern, even with the help of the most powerful supercomputers. But solving the protein-folding mystery will yield

insights into numerous diseases, including Parkinson's, Alzheimer's, and mad cow. And the more they learn about proteins, the closer they come to curing killers such as breast cancer and diabetes [86-90].

(8) Customization of Physical and Mental Ability of Kids :

We all desire perfect lives for our children. So is there anything wrong with giving them every edge we can afford to ensure their success, including removal of genetic flaws before they're born. Deciding how and when to meddle with genes may raise the most difficult ethical questions facing humankind in the third millennium. Already, several doctors have announced efforts to attempt human cloning, making an exact genetic copy of anyone who hands over his or her DNA. Other scientists are furiously working to perfect "germline" engineering, in which a gene would be permanently removed, added, or altered in an embryo, ensuring that certain genetic traits would or would not be replicated in all future generations [35-37]. Surprisingly, cloning has already gained support from some doctors and ethicists as an infertility treatment of last resort. Germline engineering, though, raises more concerns, may sound okay for parents with deadly hereditary diseases to pluck out the offending gene from an embryo. But where might be the consequence ? Rich parents could use this technology to modify children in all sorts of ways, attempting to add genes for athletic prowess or intelligence, creating a social divide of genetic haves and have-nots. This may lead to a new race of reengineered people who might not be able to breed with those whose genetic makeup was left to chance [94-95].

(9) Development of Chameleon Chips which are reconfigurable photonic circuits using the idea of optical solitons :

Some computer scientists are hatching a novel idea that could modify the internal circuitry depending upon application. This will crunch the power requirement and trim costs as well. Such an integrated circuit chip is called chameleon chip [2, 96]. Today's microprocessors carry a general-purpose design, which is both good and bad. The good thing is that the chip can run a range of programs in a computer for different jobs, such as crunching spreadsheets or editing digital photos. The bad thing is that for any one application, much of the chip's circuitry isn't needed, and the presence of those "wasted" circuits slows things down. Based on Chameleon chips idea, one set of chips, little bigger than a credit card, could do almost anything, even changing into a wireless phone. The market for such versatile marvels would be huge, and would translate into lower costs for users.

Chameleon chips would be an extension of what can already be done with field-programmable gate arrays (FPGAS). An FPGA is covered with a grid of wires. At each crossover, there's a

switch that can be semi-permanently opened or closed by sending it a special signal. Usually the chip must first be inserted in a little box that sends the programming signals. But now, labs in Europe, Japan, and the U.S. are developing techniques to rewire FPGA-like chips and even software that can map out circuitry that's optimized for specific problems. The chips still won't change colours. But they may well colour the way we use computers in years to come [97-100].

(10) Flying cars through manipulation of gravitational force :

The absence of flying cars speaks to a failure of engineering or distorted incentives in the marketplace. But the humbling truth is that we don't have these vehicles because we still don't know, even in principle, how to directly manipulate gravity. Indeed, the cars missing from our skies should serve to remind us that, to a degree rarely appreciated, we have surprisingly poor control over most of nature's fundamental forces [101]. Physicists have compiled a comprehensive inventory of all the ways things can pull or push on other things, a complete itemization of nature's forces. They've found just four. The first is gravity, the force that keeps your feet on the ground. The second is electromagnetism, which is responsible for anything involving light or the arrangement of atoms. The third is the strong nuclear force, which binds protons and neutrons together inside every atom. And the fourth is the weak nuclear force, which (among other forces) helps guide the fusion reactions that power stars.

For all the power of modern science, we are masters of only one of these forces: electromagnetism. Laptops, smartphones, wirelessly connected thermostats, google glass - all our high-tech miracles exist because we've learned to control the electromagnetic force at the subtlest of levels. When it comes to electromagnetism, we have powers that are almost godlike. With the other three, we're not even close. For example, nuclear power plants rely on our remarkable knowledge of the strong and weak nuclear forces. But when all is said and done they simply use the heat generated by splitting atomic nuclei to boil water, which then spins turbines, which then generate electricity. That's not so different from a 19th-century steam engine. Compared with the precision of an electron microscope (or even a grocery-store laser scanner), our handling of nuclear forces is still at the level of slamming rocks together. The same is true of gravity. Obviously, we can make a plane fly by forcing air to flow over a wing, which generates the pressure to lift it off the ground. But the interaction of those air molecules is a result of electromagnetic forces and the fuel we use to power planes & blow rockets off the planet is a result of our understanding of chemistry, which again is a matter of electromagnetism. Thus, all our ways of flying involve a heavy-handed application of the

electromagnetic force through fuels and engines. The noise, the danger, the pollution and the inefficiency that accompany the current ways of flying are a testament to our crude approach to defying gravity.

The problem is due to the fact that we don't understand gravity at its most fundamental level. Much as a seemingly smooth shoreline is actually composed of quintillions of individual sand grains, every aspect of the world - matter, energy and motion - is actually parceled into infinitesimal building blocks. The four forces that shape the world come in little packages, too. With electromagnetism and the nuclear forces, we understand how the parceled behavior, the quantum mechanics of these forces works. And the digital culture we've built rests directly on our ability to understand and manipulate electromagnetism's quantum manifestations. But with gravity we remain in the dark. We have no theory of quantum gravity and without the ability to manipulate the quantum gravitational world, we won't be gliding around in the silky hush of hover-cars anytime soon. Instead we will have to fly the old-fashioned electromagnetic way. Hence, all our technological powers, we are still constrained by the deepest structures underlying physical reality. If one force can be easily manipulated at room temperature but another requires the power of a cosmic explosion, then those are facts we just have to work with [102-105].

(11) Immortality through nano-bio-technology & stem cell research :

Immortality is eternal life or the ability to live forever. Biological forms have inherent limitations which medical interventions or engineering may or may not be able to overcome. Natural selection has developed potential biological immortality in at least one species, the jellyfish. Certain scientists, futurists, and philosophers, have theorized about the immortality of the human body, and advocate that human immortality is achievable in the first few decades of the 21st century, while other advocates believe that life extension is a more achievable goal in the short term, with immortality awaiting further research breakthroughs into an indefinite future. newly developing technologies may be used to induce biological immortality in human beings. *Human embryonic stem cells* generated considerable excitement since they were a means of mass-producing replacement cells for the treatment of a host of degenerative diseases involving the loss or dysfunction of cells, including those in osteoarthritis, macular degeneration, diabetes, heart failure, Parkinson's disease, and numerous other disorders. The first report of the isolation of these cells marked the birth of the new field called *regenerative medicine*. When perfected, this technology offered the theoretical potential of rejuvenating an entire human body back to a youthful state**.** Hence *immortality* is the ultimate goal of ideal

technology so that it can create an avenue for deathless situation or enhancement of human life span [106-109].

There are two ways in which nanotechnology may be able to extend our lives. One is by helping to eradicate life-threatening diseases such as cancer, and the other is by repairing damage to our bodies at the cellular level--a nano version of the fountain of youth. The most exciting possibility exists in the potential for repairing our bodies at the cellular level. Techniques for building nanorobots are being developed that should make the repair of our cells possible. For example, as we age, DNA in our cells is damaged by radiation or chemicals in our bodies. Nanorobots would be able to repair the damaged DNA and allow our cells to function correctly. This ability to repair DNA and other defective components in our cells goes beyond keeping us healthy: it has the potential to restore our bodies to a more youthful condition. The extension of the human lifespan could be facilitated through the removal of a substance called lipofuscin from certain types of non-dividing cells, including the brain, heart, liver, kidneys and eyes. Lipofuscin is a metabolic end product that accumulates primarily within lysosomes (the garbage disposal organelles within cells). It's thought that when lipofuscin accumulates to certain levels, it begins to negatively impact cell function, which eventually manifests in many age-related conditions. Aubrey de Grey et al. have proposed that soil bacterial enzymes might have the capacity for degrading lipofuscin. It is proposed that humans might live as long as 1,000 years under the appropriate rejuvenative therapies. In 30 or 40 years, we'll have microscopic machines traveling through our bodies, repairing damaged cells and organs, effectively wiping out diseases. The nanotechnology will also be used to back up our memories and personalities. And in 35 to 40 years, we basically will be immortal [110-114].

(12) Fractal Models which are mathematical models used to represent fragmented geometry shapes :

Clever mathematical techniques are the foundation of increasingly realistic computer models and simulations. Now, math research is on the verge of creating tools that mathematicians hope will cut two ways: help scientists unlock explanations to many phenomena that remain mysterious and produce new modelling systems that could revolutionize product development and manufacturing. All this could be coming from fractals, those crinkly lines that look the same no matter how much they're magnified. "Fractal" is the term mathematicians use for patterns that repeat on all scales--like the spikes on a fern leaf that could be tiny copies of the fern itself [115 - 116]. Fresh research indicates that such recurring patterns may be more fundamental in nature than had been thought. If the new insights can be captured in fractal

algorithms, science could gain extraordinary new powers. The same basic formulas could be "exploded" in scope to help scientists better understand large-scale systems such as the influence on climate from patterns of sunlight reflecting off the ocean's surface. And they could predict traffic flows on the Internet, or on physical highways. Conversely, "imploding" the formulas would adapt them for small-scale use, such as the behaviour of molecules. That could save time in R & D by pointing out which avenues are more promising. Designers and engineers could update near-perfect models to speed their work on new products and processes [117-118].

(13) Space travel for everybody :

The earthly challenges facing humanity are the result of our heavy demand on resources and raw materials. Many of these materials can be found in space but the expense to extract them is a major barrier. In addition to cost, other obstacles to developing space are safety, reliability, and performance. According to the National Space Society there are four reasons why we need to pursue space exploration and colonization. These reasons—survival, growth, prosperity and curiosity—all point to the fact that we, as a species, want more room. Space exploration will give us a means to monitor the health of our planet, a source of resources and an outlet for our imagination. Using carbon nanotubes to make the cable needed for the space elevator, a system which could significantly reduce the cost of sending material into orbit. Nanotechnology will create the ability for humans to operate in space more safely. Applications where nanotechnology will impact space exploration are propulsion fuels, coatings, structural materials, smart uniforms, electronics and life support environments. These will be more efficient, stronger, self-healing and lighter than what is currently available [119-122].

2.3.3. Strategies for Managing these Technologies

Nanotechnology breakthroughs are expected to change the present lifestyle to a greater extent. The general purpose nature of nanotechnology and its advantages in solving both basic and advanced problems in all realm of society including, scientific, engineering, agricultural & food, medical & biomedical, building materials, electronics, cleaner air & water, renewable energy & storage, consumer products, automobiles & space technology, defense, and civil & mechanical engineering manufacturing will provide opportunity to find optimum solutions to many problems in the society. The anticipated breakthroughs in nanotechnology as central technology along with its related technologies like Optical Computation, Embedded Intelligence, Chameleon Chips, Flying cars, Immortality through nano-bio-technology, Space travel and other independent technologies like HIV Antivirus, Pseudo Senses, Off Planet

Production, Protein Maps, Customized Kids, and Fractal Models will eradicate poverty & deceases in the society and fuel to the development of advanced homogeneous society completely different thinking and lifestyle compare to present day society.

Optical Computing will bring faster computers, better storage and communications, advanced artificial intelligence, and simpler ways of interfacing new software and hardware – including connecting radical new applications from machines directly with our bodies. One day, possibly by the end of 21st century or sooner, it will be possible to merge computer programs into our dreams. Computer-assisted dreaming could enable us to create dreams that we could share with others. Interactive shared dreaming could become a popular leisure pursuit.

Similarly, the anticipated breakthrough in off-planet production in micro-gravity may provide new varieties of plants, new structures & colour combinations of flowers, new breed of seeds and even new community of animals and such possibilities will provide new opportunities in further research in science & technology as well as in business processes & industries. This will definitely affect the life style of human beings in terms of solutions to both basic needs and advanced comforts. The people in the society may get more varieties of products and services to make their life happier and more comfortable.

Similarly, the anticipated breakthrough in decoding of the human genome and producing artificial proteins through *protein mapping* will provide opportunity of discovering artificial food and curing many cruel deceases of human being which may lead to hungry-less and decease free, happy and comfortable society. "If we live 20 more years, probably, we may never die". How new technology break through might play out in human life in the process of improving happiness and comfort during 21st century resulting from new innovations in above 13 areas. Nearly all diseases will become curable during this period; replacing aging and worn body parts will become common practice leading to *immortality*. By the end of 21st century it is believed that, most adults will look forward to a radically increased lifespan with near-perfect health.

As the global economy continues to be transformed by new technology breakthroughs, a keen competition will develop for talent, intellectual property, capital and technical expertise. Many of these factors responsible for shaping how nations compete, interact and trade. Technical innovations will increasingly shape economies and market robustness. Technology will continue to drive global and domestic development. Competition will be fuelled increasingly by fast breaking innovations in technology and its adoption. If the proliferation of present technologies to form new business models is any indication of the speed and power of change

in the economy, future technology breakthroughs will make for an even more dramatic paradigm shift. The evolution of a techno-economy, as contrasted with the petro-economy of today, is an intriguing idea. Anticipated technology innovations yet to come will set the timeline for this economic transformation. These technology breakthroughs may become integrated into industries and may become an embedded component of new products.

The social acceptance of these technology breakthroughs depends on Geographical Parameters like location, demography, culture, class, etc., Economic Parameters like the market penetration for the technology, its demand etc., Psycho-Social Parameters like people view on given technology, Affective Parameters like comfort level, Cognitive Parameters like awareness of those technologies, Technical Administrative Parameters like process of regulatory measures, Political Parameters like ability to debate, contention and organized opposition to a technology. This also include normative and quasi-normative parameters for the social acceptability of such technology breakthroughs like Religious Acceptability, Cultural Acceptability, and Ethical Acceptability of the effects and consequences of the penetration of these technologies.

2.4 REVIEW ON NANOTECHNOLOGY INNOVATIONS & BUSINESS OPPORTUNITIES

2.4.1. Challenges for Human Prosperity

The emerging nanotechnology is expected to solve both basic needs and comfort needs of human beings. The basic needs of human being are food, drinking water, energy, cloth, shelter, health and environment and the comfort needs are realizing the automation in every field, space travel and expanded life-span and so on. Nanotechnology is sometimes referred to as a general-purpose technology. That's because in its advanced form it will have significant impact on almost all industries and all areas of society. It will offer better built, longer lasting, cleaner, safer, and smarter products for the home, for communications, for medicine, for transportation, for agriculture, and for industry in general [123].

(1) Food : One of the basic necessities of human being in this society is nutritious food. Due to various reasons, people of major part of the world are struggling to get nutritious food for their hungry. Nanotechnology innovation in agriculture is expected to solve the problems in food sector and maximizes productivity in agriculture. There is an ever-increasing demand for food and adequate nutrition, while world grain harvest has fallen short for the last few years. Biodiversity is being destroyed worldwide and half of our world's forests and a quarter of our coral reefs are gone during last century. The world population is currently at 6.4 billion and is

estimated to swell to 8.9 billion by the year 2050. It is anticipated that 98% of this growth will be in poorer countries. It is also predicted that there will be 5 billion city dwellers by 2030 which will place heavy demands on the growth and distribution of food. Nanotechnology will provide solutions through precision farming using nanosensors, nanopesticides, and inexpensive decentralized water purification. A more advanced nanotechnology solution will be plant gene therapy; creating pest resistant, high yield crops that require less water [124].

(2) Drinking Water : Another basic necessities of human being in this society is clean drinking water. People of many countries are severely suffering due to non-availability of pure drinking water. Nanotechnology has potential to provide efficient, cost effective and environmentally sustainable solutions for supplying portable water for human use and clean water for agricultural and industrial uses. Nanotechnology innovations in low cost water purification are expected to solve drinking water problem of the world. Agriculture currently uses 70% of the world's water supply. To feed 2 billion more by the year 2030 there will be a60% increase in demand on the water supply. Considering the current rates of consumption, population and development, some two-thirds of the world population will be affected by droughts by the year 2050 which will increase the demand for fresh water. Nanotechnology will provide solution for this challenge through inexpensive decentralized water purification, detection on the molecular level of contaminants, and greatly improved filtration systems. This helps conversion of sea water into drinking water at very low cost [125].

(3) Cleaner Breathing Air : Clean air for living beings breathing with required amount of oxygen content is very essential for sustained living on this earth. Based on continued and enhanced pollution and added green gases, the atmosphere gets polluted and contaminated. This created serious problems in human health conditions. Enhanced transportation vehicles and industrialization are partly responsible to this atmospheric degradation. Nanotechnology based new membranes use electrostatic forces to sort molecules by size and can also separate some gases, potentially providing an economical way to capture and prevent the atmospheric release of carbon dioxide from power plants & automobiles. By means of using nanotechnology based air cleaners at suitable places, the essential percentage of oxygen in the atmosphere can be maintained.

(4) Renewable Energy : Energy is the most important basic resource after food and water for human prosperity. Demand for energy on earth is forecasted as increasing 50% by the year2025 with most of these being fossil fuels. Currently over 1.6 billion humans have no access to electricity and 2.4 billion rely on plant material, vegetation, or agricultural waste as an energy

and heating source. It is estimated that our fossil fuel consumption is escalating and could become double by the year 2025. Meanwhile, Earth's glaciers are receding, the CO_2concentrations in the atmosphere have nearly doubled, and world temperatures, recorded since 1861, were the hottest in three of the past five years. 1998 was the warmest of record, 2001 came in the second warmest and 2004 was the fourth warmest [126]. Nanotechnology innovations in renewable energy solves entire energy requirement of human beings for their basic needs and for the comfortable life. Balancing humankind's need for energy with the environmental cost to our planet is a major challenge. Nanotechnology based energy solutions through more efficient lighting, fuel cells, hydrogen storage, solar cells, locally distributed power generation, and decentralized generation and storage by reinventing the power grid are expected to create more potential business opportunities.

(5) Clothing : The fourth basic necessity of human being is cloth. The nature of cloth required to protect their body from the surrounding environment depends on the geographical location on the earth surface. Nanotechnology research opened avenue to make composite fabric with nano-sized particles or fibers allows improvement of fabric properties without a significant increase in weight, thickness, or stiffness as compared to previously-used techniques. It supports creating fabrics that do not wrinkle, stain, or allow the growth of bacteria. Many products that available in markets like anti-microbial socks; underwear and sporting apparel; wind and water proof jackets; wrinkle and stain resistant suits; casual wear; and swimsuits that protect against UVA and UVB rays are all products that are treated with nano-coatings or use nanotechnology in the manufacturing process. The advantages of nanotech fabrics are water and stain resistant, insulates against heat or chill, dirt rinses off in rain, reduces odours and bad smell [127].

(6) Shelter : Another basic necessity of civilised human being is protective shelter. Nanotechnology offers interesting new opportunities in the construction sector through the development of energy efficient, ultra high strength, extra durable, extremely lightweight construction materials. Nano-modification of cement is an emerging field. Synthesis and assembly of materials in the nano-meter scale offers the possibility for the development of new cement additives such as novel super-plasticisers and nano particles. It is now possible to manipulate the fundamental structure of cement phases to control concrete properties, performance and durability. Nano-modification also provides crucial information for predicting the service life of concrete more accurately and insights on improving it further. Preceded by the IT and software revolution, nanotechnology and science are expected to usher

a new paradigm shift in all spheres of technology including infrastructure and construction [128].

(7) Human Health : The degraded environment and its consequence on human health is another challenge for human prosperity. In the previous centuries, men and women expected to live to 48 and 51 years respectively. But life expectancy is now 74 and 80 years and could be significantly longer with anti-aging advancements currently being developed. At the same time, 30 new highly infectious diseases have been discovered in the last 20 years. These diseases account for 30% of the deaths worldwide and include HIV/AIDS, Ebola, Cancer, and the Avian Flu. The important and major area of nanotechnology research is in human health and is making tremendous progress in the medical field. Some of the nanotechnology applications in the arena will be inexpensive and rapid diagnostics, new methods of drug delivery, and faster development of new drugs. Some longer term and even more powerful nanotechnology solutions will repair DNA and cellular damage and customize drug therapy. Nanotechnology may have its biggest impact on the medical industry compared to other industries. Patients will drink fluids containing nanorobots programmed to attack and reconstruct the molecular structure of cancer cells and viruses. There's even speculation that nanorobots could slow or reverse the aging process, and life expectancy could increase significantly. Nanorobots could also be programmed to perform delicate surgeries such nanosurgeons could work at a level a thousand times more precise than the sharpest scalpel. By working on such a small scale, a nanorobot could operate without leaving the scars that conventional surgery does. Additionally, nanorobots could change the physical appearance of human beings. They could be programmed to perform cosmetic surgery, rearranging the atoms of human body to change his/her ears, nose, eye colour or any other physical feature he/she wish to alter [129].

(8) Environment & Climate : There is an ever-increasing demand for natural resources and living space for humans, while toxics continue to build up in our water and soil. Biodiversity is being destroyed worldwide with 7 million hectares of forest being lost annually. Half of our world's forests and a quarter of our coral reefs are gone. With increasing threats especially to the oceans, biodiversity decreases each year. Damage to the atmosphere's ozone layer has slowed but a hole still remains. Many believe that man-made greenhouse gases are causing disruption to the planet's climate, a process popularly termed 'global warming.' Proposals to correct this are expensive and unlikely to be followed by developing nations who see economic advance as more urgent. Nanotechnology will provide solutions through precision pollution

monitoring using nanosensors, lower energy needs due to lightweight strong materials, and reducing the use of harsh cleansers through the applications of nanocoatings to surfaces. A more advanced nanotechnology solution will be building our products with molecular-level precision through the use of productive nanosystems, resulting in virtually no chemical waste and pollution [130].

2.4.2. Challenges

(1) Sustainable transportation :

Nanotechnology will become a key enabling platform technology for next generation transportation systems to develop more efficient and lighter materials for automotive and aircraft systems, High performance tyres for automobiles, efficient and non-platinum based catalytic converters, novel more efficient fuel and power sources etc.

(2) Information communication technology for everybody :

There are currently many people who lack widespread access to communications, information, basic technology services and tech resources. This lack of access creates insurmountable barriers to education, democratization, and economic growth. The use of nanotechnology applications will drastically reduce the cost and increase the performance of memory, displays, processors, solar powered components, and embedded intelligence systems. It will also enable networks to be self-configuring. These improvements would create a pervasive computing environment that would promote greater global communication, cross-cultural understanding and cooperation [131].

(3) Consumer Products :

There are many consumer products using nanotechnology on the market. But nanotechnology or nanomaterials in these products are not easy to recognize. Because nanomaterials are embedded into other materials or used in very small amounts, consumers may not be aware of their presence. The various products come under this category are cosmetics, products used in home and garden, sports, Textiles and Apparel, Cosmetic manufacturers use nanoscale versions of ingredients to provide better UV protection, deeper skin penetration, long-lasting effects, increased colour and finish quality etc. [132].

(4) Entertainment :

Nanotechnology is expected to improve home entertainment electronics, 3D televisions, performance of videogames etc. Macro-scale integrated nanotechnology manufacturing systems will improve product functionality, product design time and manufacturing speed and cost by orders of magnitude. This advance may profoundly affect economics and geopolitics,

creating enormous benefits and risks. It will be difficult to prepare adequately for such a powerful technology.

(5) Medicine :

The applications of nanotechnology in pharmacy supports preparation of drugs containing nano-sized active ingredients, breakthrough drug delivery systems that allow deposition of medications in previously inaccessible areas of the body, and improved diagnostic tests and medical devices. Nanotechnology in the form of nanoparticles has great potential in the drug delivery field. The main advantage of using nanoparticles for drug delivery is the specific delivery of drug in the targeted organ without affecting the non-targeted organs. In this wayside-effect of the drugs can be minimized. In the coming year's advancements in this field will led to an improved form of drug delivery as well as other prospects of medicine and pharmacy.

(6) Manufacturing :

Nanofactories-manufacturing systems that work on the atomic & molecular scale-are gradually moving from science fiction to science fact and one day could be used to build all types of items such as drugs, semiconductor chips and even cell-sized robots that patrol the human body. The first step would be to develop nanoscopic machines, called assemblers that scientists can program to manipulate atoms and molecules at their will. In order to make molecular manufacturing to be reality, one would need trillions of assemblers working together simultaneously. It is predicted that assemblers could first replicate themselves, and then build other assemblers. Each generation would build another, resulting in exponential growth until there are enough assemblers to produce objects. Trillions of assemblers and replicators could fill an area smaller than a cubic millimeter, and could still be too small for us to see with the naked eye. Assemblers and replicators could work together to automatically construct products, and could eventually replace all traditional labour methods and create a method of three dimensional material/device printer. This could vastly decrease manufacturing costs, thereby making consumer goods plentiful, cheaper and stronger. Eventually, such 3D printers allow us to replicate anything, including diamonds, water and food. Famine could be eradicated by machines that fabricate foods to feed the hungry [133].

(7) Space-travel : The challenges facing by humanity on the earth are the result of our heavy demand on various resources and raw materials. Many of these materials can be found in space but the expense to extract them is a major barrier. In addition to cost, other obstacles to developing space are safety, reliability, and performance. According to the National Space

Society there are four reasons why we need to pursue space exploration and colonization. These reasons—survival, growth, prosperity and curiosity—all point to the fact that we, as a species, want more room. Space exploration will give us a means to monitor the health of our planet, a source of resources and an outlet for our imagination. Nanotechnology will create the ability for humans to operate in space more safely. Applications where nanotechnology will impact space exploration are propulsion fuels, coatings, structural materials, smart uniforms, electronics and life support environments. These will be more efficient, stronger, self-healing and lighter than what is currently available.

(8) Extended life span : There are two ways in which nanotechnology may be able to extend our lives. One is by helping to eradicate life-threatening diseases such as cancer, and the other is by repairing damage to our bodies at the cellular level--a nano version of the fountain of youth. The most exciting possibility exists in the potential for repairing our bodies at the cellular level. Techniques for building nanorobots are being developed that should make the repair of our cells possible. For example, as we age, DNA in our cells is damaged by radiation or chemicals in our bodies. Nanorobots would be able to repair the damaged DNA and allow our cells to function correctly. This ability to repair DNA and other defective components in our cells goes beyond keeping us healthy: it has the potential to restore our bodies to a more youthful condition. The extension of the human lifespan could be facilitated through the removal of a substance called lipofuscin from certain types of non-dividing cells, including the brain, heart, liver, kidneys and eyes. Lipofuscin is a metabolic end product that accumulates primarily within lysosomes (the garbage disposal organelles within cells). It's thought that when lipofuscin accumulates to certain levels, it begins to negatively impact cell function, which eventually manifests in many age-related conditions. Aubrey de Grey et al. have proposed that soil bacterial enzymes might have the capacity for degrading lipofuscin. It is proposed that humans might live as long as 1,000 years under the appropriate rejuvenative therapies. In 30 or 40 years, we'll have microscopic machines travelling through our bodies, repairing damaged cells and organs, effectively wiping out diseases. The nanotechnology will also be used to back up our memories and personalities. This strongly make us to believe that in 35 to 40 years, we literally will be immortal [134].

2.4.3. Nanotechnology based Innovative Solutions

(A) Nanotechnology as Ideal Technology :

An ideal technology system should have characteristics to fulfil its objectives to solve all problems of human beings including both basic needs and advanced gadgets to support comfort

living to realize their dreams. Based on various factors which decides the ideal technology system characteristics, a model consisting of input conditions, output conditions, environmental conditions and system requirements [8]. The input Conditions include properties like : (1) Manipulate the fundamental nature of matter to provide solutions to basic and advanced problems of mankind, (2) In-expensive & self reliable in terms of resources to make it attractive to be used by people/countries of varied economical situations. (3) Ubiquitous so that the technology provides solutions and services at anytime, anywhere, any amount of time to the users. (4) Affordable to every body so that it uses common materials available in nature and manipulate effectively to the need of human being at affordable cost.

The Output Conditions include the characteristics like : (1) Solve basic needs like food, drinking water, renewable energy, clothing, shelter, health and clean environment. (2) Provide comfort life to the users by providing solutions to their desires. (3) Equality ; ideal technology provide equal opportunity and similar solutions to every user irrespective of their gender, religion, background, education, economic status, and country of origin. (4) Automation; ideal technology automates all processes in every type of industries to avoid human interference in work/control in order to provide expected output based on programming. (5) Immortality is the ultimate goal of ideal technology so that it can create an avenue for deathless situation or enhancement of human life span.

The System Requirement needs properties like : (1) General purpose technology to support all fields and problems of human & living beings on the earth. (2) Self-directed & self controlled & self regulated so that the technology can control itself in order to achieve its goal. (3) Easy, simple, quick & user friendly to solve all type of problems and to provide quick ideal solution. (4) Scalable so that it is used for solving small and simple problem to large and complex problems of life. (5) Omni-potent to identify and solve problems and provide comfortability to human being and feeling him like God. (6) Exploring new opportunities to improve and explore comfortability and further leisure in life of people. (7) Infinite potential for further development of life in the universe.

Table 2.2: Comparison of nanotechnology with ideal technology model [8]

S. No.	Major Problems of human beings in the Society	Ideal technology solution	Nanotechnology solution
1	Nutritious food for everybody	Basic feature of Ideal technology	Possible to solve using nanotechnology in agriculture.
2	Clean drinking water for everybody	Basic feature of Ideal technology	Possible to solve using nanotechnology filters
3	Renewable energy at affordable cost	Basic feature of Ideal technology	Possible through nanotech solar cells & battery technology

4	Quality and long lasting cloth	Basic feature of Ideal technology	Possible to solve using nanotechnology in fabrics.
5	Affordable Shelter to every body	Essential feature of Ideal technology	Possible to solve using nanotechnology in construction.
6	Health care	Basic feature of Ideal technology	Possible to solve using nanotechnology in medicine.
7	Environment & climate	Essential feature of Ideal technology	Possible to solve using nanotechnology as clean technology.
8	Sustainable technology for every body	Essential feature of Ideal technology	Due to its fundamental nature, nanotechnology is sustainable for everybody and everywhere.
9	Comfort life	Luxurious feature of Ideal technology	Possible to solve using nanotechnology in customer products & ability to upgrade all other technologies.
10	Space travel	Luxurious feature of Ideal technology	Nanotechnology supports low cost & efficient space travel.
11	Life span expansion	Desirable feature of Ideal technology	Bio-medical applications of nanotechnology supports life span expansion.

The Environment Conditions include : (1) Maintain clean environment through its processes and avoids foot print of processes while achieving specific function. (2) Infinite business opportunities by creating new products / services with ideal characteristics. (3) Adaptive to any situations to achieve stated goal. (4) No side effects so that it should be safe for users, and environment. Any technology which has the above properties/characteristics is considered as ideal technology and the conventional technologies have serious drawbacks/limitations in terms of the above properties.

The characteristics and opportunities of nanotechnology can be comparable with the abovementioned characteristics of ideal technology. This supports the possibility of realization of ideal technology using nanotechnology. It is predicted that nanotechnology being a general purpose technology can provide solutions almost all basic and high level problems like hypothetical ideal technology. Table 2.2 compares the possible ideal technology solutions with nanotechnology solutions for solving major problems of human being in the society [8].

(B) Nanotechnology as Breakthrough Technology of 21st Century :

Nanotechnology is considered as anticipated breakthrough technology of 21st century and is spreading quickly as disruptive technology to all areas of the society. A disruptive technology is a new technology that is significantly cheaper than current, and/or is much higher performing, and/or has greater functionality, and/or is more convenient to use. A disruptive technology will revolutionize worldwide markets by superseding existing technologies.

Disruptive technology sounds negative to only organizations that are unprepared for change, and fail to adapt, only to fall behind, and ultimately disappear. The results are not just *evolutionary*, they are *revolutionary*. Nanotechnology is going to be general purpose technology like information technology. It has wonderful features, which are not present in any other technology. Some of other anticipated technology breakthrough also depends on innovations in nanotechnology like Optical Computation, Embedded Intelligence, Chameleon Chips, Flying cars, Immortality through nano-bio-technology, and Space travel [7]. The phenomena, which were not possible few years back, are now easily implemented with the help of nanotechnology. Some of the nanotechnology based products features are described below :

(1) Nanosensors :

Nano-sensors are used for toxins in food, proteins, water; viruses, bacteria, pollutants in water, bioprocess monitoring, process control, biochemicals, intracellular activity, sensors onfoods for tracking, Some of the nano-sensors are [135] :

(a) Nanobiosensors: The nanosensors with immobilized bioreceptors probes which are selective for target analyte molecules are called nanobiosensors. These can be integrated into other technologies like lab-on-a chip to facilitate molecular diagnostics. Their applications include detection of microorganisms in various samples, monitoring of metabolites in body fluids and detection of tissue pathology such as cancer. Their portability makes them ideal for POC applications but they can also be used in laboratory settings.

(b) Nanowire biosensors: Surface properties of these can be easily modified therefore they can be decorated with virtually any potential chemical or biological molecular recognition unit, thus making the wires themselves analyte independent. Boron doped silicon nanowires are used to create highly sensitive, real time electrically based sensors for biological and chemical species.

(c) Viral nanosensors: Essentially the virus particles are called as biological nanoparticles. Herpes Simplex Virus (HSV) and adenovirus have been used to trigger the assembly of magnetic nanobeads as a nanosensor for clinically relevant viruses. By using a magnetic field, as few as five viral particles can easily be detected in a 10 ml serum sample.

(d) PEBBLE nanosensors: Probes encapsulated by Biologically Localized Embedding (PEBBLE) nanosensors consists of sensor molecules which are entrapped in a chemically inert matrix by a microemulsion polymerization process that produces spherical sensors in the size

range of 20 to 200 nm. These are capable of real time inter and intracellular imaging of ions and molecules and are insensitive to interference from proteins.

(e) Optical biosensors: Many biosensors which are currently marketed rely on the optical properties of lasers to monitor and quantify interactions of biomolecules that occur on specially derived surface or biochips. Example: Surface plasmon.

(f) Laser nanosensors: In this laser light is launched into the fibre and the resulting evanescent field at the tip of the fiber is used to excite target molecules bound to the antibody molecules. When laser falls on them, they release optical signals which are coded by photometric detection system. This system is used in analysis of proteins and biomarkers inhuman living cells.

(2) Shaping memory materials

Nanotechnology introduced the techniques to distort the plastic and silicon structures, which allowed the recovering of original shape of the material. This technology is named as SMM shaping memory materials. Metals and aluminium are reshaped and processed at nano scale to produce a chip, which can store bulk of information on it. Aluminium and silicon distortion were impossible before the arrival of nanotechnology.

(3) Assemblies and Chemical sensitivity of porphyrin

Porphyrins is the element with the unique binding properties that are widely exploited in natural world to attain beneficial and essential functions for life, nanotechnology has provided the most accurate and real some the mimic of these functions with synthetic counterparts which provides the basis of chemical bonding and sensitizing.

(4) Metal oxide nano-wires as chemical sensors

Another impressive feature of nanotechnology is that it made possible for the scientists to use metal oxides as the sensors. When metal is treated at nano scale they can carry huge amount of electrons and can be used as chemical sensors, as was discovered in early nineties and nano-wires were introduced.

(5) Use of nano-materials for water purification

Nanotechnology allowed the researchers to process the materials to be used in purification of drinking water such as sand, soil and even glass. Nano filtration plants are present in the developed countries of the world. Nano materials can purify water up to 99.9 percent without affecting the original flavour the water. It was seen for the first time that nanotechnology can extract the safest drinking water.

(6) Self-assembling

Self-assembling the key feature of nanotechnology. There is no other technology in which molecules under processing can rearrange themselves easily. Molecular nanotechnology can produce many new components from the existing ones by simply rearranging themselves.

(7) Miniaturizing mechanical surgery

Recent advances in sub-millimeter scale engineering showed the excellent work of nanotechnology in the field of medical sciences. Nanotechnology introduced such devices, which do not even leave a scar after major surgeries. it has also miniaturized the surgical instruments which are used in the diagnostics and therapeutics applications.

(8) Fabrication of electronic biosensors

Nanotechnology introduced the nano fabrications, which has reduced the cost of some of the major health equipment that includes electronic biosensors. Detection biosensors, which are nano- structured, detect and displays highly revolutionized images.

(9) New carbon nanotubes AFM technology

Nanotechnology also has great value in the field of nuclear sciences because of its extraordinary features to increase the atomic force. it was discovered in mid nineties that uranium if processed at nano level can empower the five times more powerful nuclear bomb. Nanotechnology enlighten the nano particle of carbon, nanotubes of carbon are used to build ultra-sharp tips for cutting the rigid surfaces. The technology of the new carbon tubes is named as AFM (Atomic Force Microscopy). The technology is used for the fabrication of probe tips with ultra sharp points. AFM is also used for synthesizing and for developing new components.

(10) General Purpose technology

Nanotechnology can create machines, peripheral home appliances with best functioning until now. It is the only technology, which is general purpose. From Light Emitting Diodes (LEDs)to socks, all are processed at atomic scale for increasing and improving the quality of the product.

2.4.4. Nanotechnology based Products

The nanotechnology-based products are now entering the consumer market in a big way. Nanotechnology has tremendous application potential in several areas such as Fast-Moving Consumer Goods (FMCG), cosmetics, healthcare, medicine, plastics, composites, coatings, printed electronics, optics, biotechnology, renewable energy and aerospace/ defense among others, where it has offered many opportunities to improve conventional technologies [136].

A wide range of commercialized products containing nanomaterials are already in the market, in areas like health care, cosmetics and fitness, home and garden appliances, electronics and computers, food and beverages, sports goods, paints, clothing, automotive and aerospace

components, etc. Table 2.3 contains the nanotechnology based product category available in the market along with the sub-categories and number of products in each category.

Table 2.3 : Information about the nanotechnology based products available in market as on 2016.

S. No.	Product Category	Sub-categories	No. of products in market
1	Appliances	1. Batteries 2. Heating, Cooling and Air purifiers 3. Large Kitchen Appliances 4. Laundry & Clothing care	68
2	Automotive	1. Exterior 2. Maintenance & Accessories 3. Watercraft 4. Lubricants	214
3	Cross Cuttings	1. Nano Coatings 2. Bulk Materials	142
4	Electronics & Computers	1. Audio 2. Cameras & Films 3. Computer Hardware 4. Display 5. Mobile Devices & Communications 6. Television 7. Video	101
5	Food & Beverage	1. Cooking 2. Food 3. Storage 4. Supplements	118
6	Goods for Children	1. Basics 2. Toys & Games	37
7	Health & Fitness	1. Clothing 2. Cosmetics 3. Filtration 4. Personal care 5. Sporting goods 6. Sunscreen 7. Supplement	908
8	Home & Garden	1. Cleaning 2. Construction Materials 3. Home furnishings 4. Luggage 5. Luxury 6. Paint 7. Pets	356

2.4.5. Nano Technology based Services

A service type of business provides intangible products *(products with no physical form)*. Service type firms offer professional skills, expertise, advice, and other similar products. Some

of the service business opportunities using nanotechnology developments are listed in table 2.4.

Table 2.4 : Service business opportunities using nanotechnology

S. No.	Nanotechnology based service business	Business Benefits
1	Collaborative services for nanotech product design	Information about collaborative opportunities
2	Safety services for nanotech products usage	Employee monitoring, advancing imaging, better testing, new characterization methods.
3	Security services using nanotech	Tagging and tracking, monitoring, advancing sensors technology, improved RFID technology in body armour, combating fraud with nanoparticle based inks.
4	Consultants service with nanotech cases, nanotech events & others	Nanotechnology consultation based earning opportunity
5	Judicial service for Contract lawyers with a lot of nano specific expertise	Opportunity for Judicial service by lawyers
6	Patent office's service with a lot of nano experience	Consultation opportunity for patent service
7	Nanomaterials R&D service, based on nanomaterials know-how	Latest R & D information and information on emerging products in the market
8	Imports of only nanomaterials & nanodevices	Business opportunity to import nano-materials and nanodevices
9	Analysis service, based on equipment for analysing nanostructures	Opportunity for nanostructure analysis service
10	Coating service, based purely on nano coating on surfaces/devices for specific purpose	Durable coatings of materials surface.
11	Tourism industry - Information speedup services through nanotech based displays at airports	Enhanced displays and user interfaces

2.4.6. Impact of Nanotechnology on Business

Nanotechnology is impacting businesses and expected to offer new and improved products and processes and supports the companies to innovate and enter to the new markets. Nanotechnology will change the way the businesses are being carried on. It will lead to the emergence of new businesses as well as business practices and also a new role for research &development, completely different types of product & services compared to present day products & services in the market, and intermediaries. Indeed, all the functional areas of business will undergo changes as follows :

• The new technology will transform business processes, the way products and services are created and marketed, dynamics of competitions, the organization structure of the enterprise and the nature of the enterprise itself. This will include product development, production,

marketing, supply management, customer and sales management, etc. The market driven business will change as product /services driven business.

• Local proximity and customization may no longer be a significant factor in retaining customer. Local markets will be replaced by global markets based on global products &services. Indeed, it may bring to reality the goal of making the whole world as one family by solving the basic problems of human beings. The general universal solutions are possible for most of the basic problems & problems related to comfortable life style.

• Transparency and openness continue and will continue, to be effective business strategy. Already many businesses have started recognizing key customers, employees and suppliers more like a partner in the business. Nanotechnology supported products and services will lead to better customer service, more personalized products, reduced costs, supply chain efficiency and faster time to market due to their effectiveness to all people irrespective of region (country), religion, community, gender and age. The most significant aspect of nanotechnology is new market creation for newly developed products and services which are going to be the part & parcel of everybody's life.

• The change in the business functions will lead to new business models and create new set of facts and circumstances that can materially change the economy and world growth rate.

• The nano-trend will emerge as a new platform for marketing of products and services that will displace and rebuild existing economy. It will affect organizational structure; require different skills for negotiation, new regulatory and legal framework, new environmental policy, taxation and many other things. The evolution of nanotechnology will have profound impact on competition, mobility of enterprises, effect on consumer behaviour, changes in the way the work is defined and managed. The advantages and benefits of nanotechnology products & services in parallel with advents of online communication & internet technology will enable businesses to save time on product design, design according to the individual customer specification, order and delivery of components, tracking sales and getting feedback from customers.

• The businesses can have virtual project team to develop and customize nanotechnology products, virtual learning space so that the employees of the companies for product design, development and marketing, who are dispersed over various countries can work together as if they are together in one physical room. Business can be connected to the retail points in order to ascertain market trends, demand of the products and with the suppliers upstream to order the desired requirements. Better demand forecasting and stock replenishment based on educating

the people online to create greater demand due to incredible advantages of nanotechnology products leads to large scale production which intern can lead to significant reduction in the cost.

• By means of educating more people to understand the advantages and benefits of nanotechnology based products and services, the nanotech companies and the country Government can create awareness among the people to encash the potential benefits in the process of solving both fundamental problems and problems related to luxurious life leading without much human efforts.

(1) Impact on production :

Design of nanotechnology products with tailored properties as per the requirement in the market is greater challenge for organizations. This also includes the production at greater efficiency to meet demand by means of automation to increase efficiency, controlling the wastage and to maintain the standard quality.

(2) Impact on marketing :

Product promotion Nanotechnology based solutions enhances promotion of products due to their attractive features which have to be advertised properly to attract many customers.

Corporate image : The innovative products and services based on nanotechnology will attract many customers so that newcomers started the business can establish corporate images very quickly. Corporate image means trust, which is necessary for direct sales.

(3) Impacts on organizations :

Technology and Organizational Learning: Rapid progress in nanotechnology based products & services will force companies to adapt quickly to the new technology and offer them an opportunity to experiment with new products, services, and processes. To be more flexible and responsive to the market, new processes must be developed. This type of corporate change must be planned and managed.

Changing Nature of Work: The nature of work and employment in the organizations will be transformed due to this disruptive technology. Driven by increased competition in the global market place, firms are reducing the number of employees down to a core of essential staff and outsourcing whatever work they can to countries where wages are significantly less expensive.

New product capabilities: Nanotechnology allows for new products to be created and customized in innovative ways. Such changes may redefine organizations' missions and the manner in which they operate. Mass customization enables manufacturers to create specific products for each customer, based on his or her exact needs.

(4) Impact on Economy :

The nanotechnology enables firms to produce global standardized products which are capable to solve both basic needs and comfortable life leading requirements at very low cost, the poverty will be eradicated and the people irrespective of their country of origin, irrespective of natural resources they have geographically, prosper and lead a happy life. As a result, the economy of all the countries will grow in exponential manner.

(5) Impact on Social life :

Due to its capabilities of solving both fundamental and esteem needs of human beings, nanotechnology changes both life-style and social life of human beings. The differentiation of people based on his or her financial conditions/status will disappear. All people of the world become tech savvy and become matured in thinking of equality and lead happy life. All types of social evils, sufferings due to ill-health will reach to an end.

2.5 CONCLUSION :

Even though ideal systems are hypothetical systems, which cannot be realized completely in practice, gives a broad idea on how the practical systems can be improved continuously to reach ideal system characteristics. The ideal system characteristics of technology, business, education, banking, electrical energy, software, computing and strategy, discussed in this review, under input characteristics, system characteristics, output characteristics, and external characteristics shows an opportunity to the scientists and engineers to develop such practical systems further with an objective to reach the goal. Based on the review, we have also discussed the possible characteristics of some of the future anticipated systems like ideal automobiles, ideal library, ideal home, ideal human being, ideal organization, ideal city, and even, ideal world.

The thirteen most anticipated breakthrough technologies predicted in this paper are expected to substantially affect the human life in the society during the present century. The predicted discoveries and innovations in Nanotechnology and its six related technologies mentioned in technology breakthrough model and other six independent technologies listed in the model are expected to make drastic changes in everyday life of human beings in the world. From high power & speed computers to space travel, from chameleon chips to flying cars, from embedded intelligence to immortality, solutions to basic problems like food, pure drinking water, renewable energy, health & shelter for everybody, and clean environment through nanotechnology will change the lifestyle of the people. Other independent technologies listed in the model like HIV antivirus, pseudo senses, off-planet production, protein maps,

customized kids, and fractal models are also helping to solve many problems of the society and support to solve many other problems. These breakthroughs are expected to create a new community of people called "super-tech-people" with modified social status. This will lead to development of new community without any partiality based on race, religion, country- origin, caste and even gender. The anticipated technology breakthroughs are change all the human beings as god who is ubiquitous, omnipotent and immortal. These breakthrough technologies certainly effect the religious, social, economic, political, cultural and ethical roots of the countries and supports the developments of a new heterogeneous generation as global citizens. The applications of nanotechnology in different identified areas provide lots of business opportunities. It includes Food, Medicine, Cleaner water, Better quality air, Electronics, Fuel Cells, Solar Cells, Batteries, Space Travels, Chemical sensors, Sporting goods, Fabrics, Cleaning products, Energy, Environment, Health, and Life span increase. The paper covers the applications, benefits and uses of nanotechnology innovations in different industries, possible business opportunities for new nanotechnology based products and services due to challenges for human prosperity on earth, the impact of nanotechnology on business, with an expected time scale and future possibilities of nanotechnology innovations and the magic (like science fictions) going to happen in human life. It is also discussed that how nanotechnology is going to be a disruptive innovation by solving all problems in the society like food, energy, drinking water, health and environment and rendering human life limitless [137-139].

REFERENCES :

[1] Mindaugas Bulota, Bertjan Maasdam, Sanne Tiekstra (2013). Breakthrough technologies - More with less, Kenniscentrum Papier en Karton, http://vnp.nl/wp-content/uploads/ 2014/01/64-Breakthrough-technologies-more-with-less.pdf.

[2] www.businessweek.com/bw50/2001/tech_planet.htm.

[3] Jo Anne Shatkin, (2008). Nanotechnology: Health and Environmental Risks, CRC Press, pp. 6 – 8.

[4] Oberdörster G., Oberdörster E., and Oberdörster J. (2005). Nanotoxicology: An Emerging Discipline Evolving from Studies of Ultrafine Particles. *Environmental Health Perspectives,* 17, pp. 823–839.

[5] Frank Stuer-Lauridsen, Anja Kamper, Pernille Borling, Gitte I. Petersen, Steffen Foss Hansen and Anders Baun (2007). *Survey of nanotechnological consumer products,* http://www2.mst.dk/Udgiv/publications/2007/978-87-7052-536-7/pdf/978-87-7052-537-4.pdf

[6] www.uneca.org/sites/default/files/.../st_innovation_report.pdf

[7] Aithal P. S., & Shubhrajyotsna Aithal (2015). Managing Anticipated Breakthrough Technologies of 21st Century - A Review. *International Journal of Research & Developments in Technology and Management Sciences*, 21 (6), 112 - 133.

[8] Aithal, P. S., and Shubhrajyotsna Aithal (2015). Ideal Technology Concept & its Realization Opportunity using Nanotechnology. *International Journal of Application or Innovation in Engineering & Management,* 4(2), 153-164.

[9] Von Bertalanffy, L. (1968). General systems theory. New York, 41973, 40.

[10] Aithal, P. S. (2016). Review on Various Ideal System Models Used to Improve the Characteristics of Practical Systems. *International Journal of Applied and Advanced Scientific Research*, ISSN: 2456 – 3080, 1(1), 47-56. DOI : http://doi.org/10.5281/zenodo.159749.

[11] Aithal P. S. (2015). Concept of Ideal Business &its Realization Using E-Business Model, International Journal of Science and Research (IJSR), 4(3), 1267 - 1274.

[12] Aithal P. S. (2015). Mobile Business as an Optimum Model for Ideal Business. *International Journal of Management, IT and Engineering (IJMIE)*, 5 (7), 146-159.

[13] Aithal P. S. and Shubhrajyotsna Aithal (2015). An Innovative Education Model to realize Ideal Education System. *International Journal of Scientific Research and Management (IJSRM)*, 3(3), 2464 - 2469.

[14] Aithal P. S. and Shubhrajyotsna Aithal (2014). Ideal education system and its realization through online education model using mobile devices, Proceedings of IISRO Multi Conference 2014, Bangkok, 7/01/2014, 140 - 146, ISBN No. 978-81-927104-33-13.

[15] Aithal P. S. & Shubhrajyotsna Aithal (2016) Impact of On-line Education on Higher Education System, *International Journal of Engineering Research and Modern Education (IJERME),*1(1), 225-235.

[16] Aithal P. S. (2016). The concept of Ideal Strategy & its realization using White Ocean Mixed Strategy. International Journal of Management Sciences and Business Research (IJMSBR), 5(4), 171-179. DOI : http://doi.org/10.5281/zenodo.161108.

[17] Sridhar Acharya P. &Aithal P. S. (2016).Concepts of Ideal Electric Energy System for production, distribution and utilization. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 367-379.

[18] Aithal P. S. (2016). Concept of Ideal Banking and Realization of it using Ubiquitous Banking, *Proceedings of National Conference on Changing Perspectives of Management, IT, and Social Sciences in Contemporary Environment*, Manegma 2016, SIMS, Mangalore, India, Vol. 14, 13-24, ISBN 978-93-5265-6523.

[19] Aithal P. S. (2016). Smart Library Model for Future Generations. *International Journal of Engineering Research and Modern Education (IJERME)*, 1(1), 693-703.

[20] Aithal, P. S., & Vaikuth Pai, T. (2016). Concept of Ideal Software and its Realization Scenarios. *International Journal of Scientific Research and Modern Education (IJSRME)*, 1(1), 826-837.

[21] Aithal, P. S. & Priyesh Pai, T. (2017). Opportunity for Realizing Ideal Computing System using Cloud Computing Model. *International Journal of Case Studies in Business, IT and Education (IJCSBE),* 1(2), 60-71. DOI: http://dx.doi.org/10.5281/zenodo.1094995.

[22] Aithal P. S. and Shubrajyotsna Aithal (2015). Nanotechnological Innovations & Business Environment for Indian Automobile Sector: A Review. *International Journal of Scientific Research and Modern Education*, 1(1), 296-307.

[23] Aithal P.S. and Shubhrajyotsna Aithal (2016). Business Strategy for Nanotechnology based Products & Services. *Journal of Management Sciences and Business Research*, 5(4), 139-149.

[24] Aithal P. S. and Shubhrajyotsna Aithal (2016). Nanotechnology Innovations & Business Opportunities: A Review. *International Journal of Management, IT and Engineering*, 6 (1), 182-204.

[25] Aithal P. S. & Shubrajyotsna Aithal (2016). Nanotechnology Innovations and Commercialization – Opportunities, Challenges & Reasons for Delay. *Proceedings of National Conference on Changing Perspectives of Management, IT, and Social Sciences in Contemporary Environment*, Manegma 2016, SIMS, Mangalore, India, Vol. 14, pp-1-12, ISBN 978-93-5265-6523.

[26] Aithal P. S. & Shubhrajyotsna Aithal (2016). Nanotechnology Innovations & Business Opportunities in Renewable Energy Sector. *International Journal of Engineering Research and Modern Education (IJERME)*. 1(1), 674- 692.

[27] Aithal P.S., & Shubhrajyotsna Aithal (2016). Opportunities & Challenges for Green Technology in 21st Century. *International Journal of Current Research and Modern Education (IJCRME)*, 1(1), 818-828. DOI : 10.5281/zenodo.62020.

[28] Aithal P.S., (2016). A Review on Opportunities and Challenges for Mobile Business Activities in India. *International Journal of Management, IT and Engineering (IJMIE)*, 6 (1), 124-148.

[29] Aithal, P. S. (2016). A Review on various E-business and M-business models & Research Opportunities. *International Journal of Management, IT, and Engineering (IJMIE)*, 6(1), 275-298.

[30] Prithi Rao & Aithal P. S. (2016). Green Education Concepts & Strategies in Higher Education Model. *International Journal of Scientific Research and Modern Education (IJSRME)*, 1(1), 793-802.

[31] Aithal, P. S. and Suresh Kumar, P. M. (2015). Applying SWOC Analysis to an Institution of Higher Education. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 231-247.

[32] Aithal, P. S., Suresh Kumar, P. M. and Pavithra Kumari (2015). Methods And Approaches For Employability Skill Generation In Higher Educational Institutions. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 390-410.

[33] Krishna Prasad, K., & Aithal, P. S. (2015). Massive Growth of Banking Technology with the Aid of 5G Technologies. *International Journal of Management, IT, and Engineering (IJMIE)*, 5(7), 616-627.

[34] Aithal, P. S. (2015). Biometric Authenticated Security Solution to Online Financial Transactions. *International Journal of Management, IT, and Engineering (IJMIE)*, 5(7), 455-464.

[35] Aithal, P. S., & Varambally, K. V. M. (2006). Security Issues in Online Financial Transactions with Special Reference to Banking Industry. Quality in Service Sector and Managerial Challenges – Allied Publisher Pvt. Ltd, 103-114.

[36] Varambally, K. V. M., & Aithal, P. S. (2009). Mobile Business Technology and Business Proliferation of Banks – A futuristic Approach. *Amity Business Review*, 10(1), 9–25.

[37] Aithal, P. S., & Varambally, K. V. M. (2015). Customer Perspective on Online Mobile Banking in India - An Empirical Study. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 77-97.

[38] Aithal, P. S. (2015). Biometric Authenticated Security Solution to Online Financial Transactions. *International Journal of Management, IT, and Engineering (IJMIE)*, 5(7), 455-464.

[39] Aithal, P. S. (2015). Recommendations on Policy & Regulatory Guidelines for Mobile Banking in India. *International Journal of Management, IT, and Engineering (IJMIE)*, 5(7), 1-20.

[40] Aithal, P. S. (2015). Factors Affecting Banker's Perspective on Mobile Banking. *International Journal of Management, IT, and Engineering (IJMIE)*, 5(7), 28-38.

[41] Aithal P. S. (2016). A Review on Advanced Security Solutions in Online Banking Models, *International Journal of Scientific Research and Modern Education (IJSRME)*. 1(1), 421-429.

[42] Sridhar Acharya P. & Aithal, P. S. (2015). Innovations in Effective Management of Energy using Green Technology. *International Journal of Conceptions on Management and Social Sciences*, 3(2), 18 – 22.

[43] Sridhar Acharya P. & Aithal, P.S. (2016). Impact of Green Energy on Global Warming - A Changing Scenario. *International Journal of Scientific Research and Modern Education (IJSRME)*, 1(1), 838-842.

[44] Porter M. E., Competitive Strategy, New York, The Free Press, 1980.

[45] Kim W. C., and Mauborgne R., (2004). Blue Ocean Strategy: How to Create Uncontested Market Space and Make the Competition Irrelevant. *Harvard Business Review*, October, 71-81.

[46] Silviu M. and Adrian D. T. (2013). The Green Ocean Innovation Model. *Global Advanced Research Journal of Management and Business Studies*, 2(11), 536-541.

[47] Aithal P.S., Suresh Kumar P. M. (2015). Black Ocean Strategy - A Probe into a New type of Strategy used for Organizational Success. *GE International Journal of Management Research*, 3(8), 45 - 65.

[48] Aithal P. S. (2015). Strategy Development and Deployment in Higher Education Institutions. *Elixir International Journal*, 84, 33594 – 33597.

[49] Aithal P. S. & Acharya R. K. (2016). Strategic Management Models & Indian Epics. *International Journal of Management Sciences and Business Research (IJMSBR)*, 5(4), 180-188.

[50] Aithal P. S., Shailashree V. T., & Suresh Kumar P. M., (2015). Application of ABCD Analysis Model for Black Ocean Strategy. *International Journal of Applied Research*, 1 (10) pp 331 – 337.

[51] Aithal, P. S., Suresh Kumar P. M. (2017). Ideal Analysis for Decision Making in Critical Situations through Six Thinking Hats Method. *International Journal of Applied Engineering and Management Letters (IJAEML)*, 1(2), 1-9. DOI: http://dx.doi.org/10.5281/zenodo.838378.

[52] Aithal P. S., Padmanabha Shenoy, & Priyanka Neelam (2015). Opportunities & Challenges in Starting Software Company in Developing Countries. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 201-214.

[53] Penna Sparrow, Characteristics of a Good Software, Referred from http://www.ianswer4u.com/2011/10/characteristics-of-good-software.html.

[54] Sutherland, K., & Deegan, M. (2016). The Universal Library. In *Transferred Illusions* (pp. 133-168). Routledge.

[55] Suresh Kumar P.M., & Aithal P.S. (2016). Working from Home - A Transition in the concept of Workplace. *International Journal of Current Research and Modern Education (IJCRME)*, 1(1), 244-249.

[56] Reshma, Aithal P. S., Shailashree V. T., & Sridhar Acharya P. (2015). An empirical study on Working from Home: A popular e-business model. *International Journal of Advance and Innovative Research*, 2(2), 12-18.

[57] Harischandra P., Shylesh S, Aithal, P.S. (2016). Information Technology Innovations in Library Management: A Case of SIMS. *International Journal of Current Research and Modern Education (IJCRME)*, 1(1), 657-676.

[58] Rogers, E.M., 'Diffusion of Innovation', The Free Press, NY, (1995).

[59] Morgan, R. M. and Hunt, S. D. (1994). The commitment-trust theory of relationship marketing, *Journal of Marketing*, 58(7), 20–38.

[60] http://www.understandingnano.com/nanotech-applications.html

[61] Wilkinson, J. M. (2003). Nanotechnology applications in medicine. *Medical device technology* 14(5), 29-31.

[62] http://www.nanowerk.com/nanotechnology-applications.php

[63] Cao, Guozhong. Synthesis, Properties and Applications. London, Imperial College Press, (2004).

[64] Wolf, Edward L. (2008). Nanophysics and nanotechnology: An introduction to modern concepts in nanoscience. John Wiley & Sons.

[65] Vasavi, B., Ch. Bhargava, Hemanth Chowdary (2012). Optical Computing Alternative for High Speed Interconnectivity and Storage**.** *International Journal of Information and Communication Technology Research***,** 2(2), 112 - 121.

[66] Dolev. S and Oltean, M (Eds.): OSC 2009, LNCS 5882, pp. 2–4, (2009).

[67] Goswami, D. (2003). Optical computing. *Resonance*, *8*(6), 56-71.

[68] Guo, Bin, Daqing Zhang, and Zhu Wang. (2011). Living with internet of things: The emergence of embedded intelligence." Internet of Things (iThings/CPSCom), 2011 *International Conference on and 4th International Conference on Cyber, Physical and Social Computing*. IEEE.

[69] Basten, Twan, Marc Geilen, and Harmke de Groot, eds. Ambient intelligence: impact on embedded system design. Boston: Kluwer Academic Publishers, (2003).

[70] Remagnino, Paolo, and Gian Luca Foresti (2005). Ambient intelligence: A new multidisciplinary paradigm. *Systems, Man and Cybernetics, Part A: Systems and Humans*, IEEE Transactions on 35.1, pp. 1-6.

[71] Kirk, Rod, Tim Christianson, and Danial Faizullabhoy (1992). Embedded intelligence. BYTE 17(3), pp. 195.

[72] Deakin, Mark (2011). The embedded intelligence of smart cities. Intelligent *Buildings International*, 3(3), 189-197.

[73] Berger, Robert J. (2003). Open Spectrum: A Path to Ubiquitous Connectivity. *ACM Queue*, 1(3), 60-68.

[74] TONG, Qiao-xia, and Duan-de LUO. (2006). Progress in antivirus treatment of AIDS. *Practical Journal of Clinical Medicine*, 5, 002.

[75] Norris, Vic, Mark S. Madsen, and Shaun Heaphy (1993). Designer antiviruses for HIV. *Trends in microbiology*, 1(9), 355-357, (1993).

[76] Esté, José A., and Tomas Cihlar (2010). Current status and challenges of antiretroviral research and therapy. *Antiviral research*, 85(1), 25-33.

[77] Lanier, Jaron, and Frank Biocca. (1992). An insider's view of the future of virtual reality. *Journal of communication*, 42(4), 150-172.

[78] Gutierrez, Mario, Frédéric Vexo, and Daniel Thalmann. (2008). Stepping into virtual reality. Springer.

[79] Fuchs, Philippe, Guillaume Moreau, and Pascal Guitton, eds. Virtual reality: concepts and technologies. CRC Press, (2011).

[80] Kriegh, Michael, and Julie Kriegh. Growth, form and proportion in nature: lessons for human habitation in off planet environments. No. 2003-01-2653. SAE Technical Paper, (2003).

[81] Uri, John J., and Vic Cooley (2003). International Space Station-a unique place for research. Aerospace Conference, 2003. Proceedings. IEEE. Vol. 1. IEEE.

[82] Nickerson, C. A., Ott, C. M., Wilson, J. W., Ramamurthy, R., & Pierson, D. L. (2004). Microbial responses to microgravity and other low-shear environments. *Microbiology and Molecular Biology Reviews*, *68*(2), 345-361.

[83] Ivanova, T., Sapunova, S., Kostov, P., & Dandolov, I. (2001). First successful space seed-to-seed plant growth experiment in the SVET-2 space greenhouse in 1997. *Space Research Institute, Bulgarian Academy of Sciences*. pp 12-23. *http://www. space. bas. bg/astro/Aerosp16/tania1. pdf.*

[84] Wilkins, M. R., Sanchez, J. C., Williams, K. L., & Hochstrasser, D. F. (1996). Current challenges and future applications for protein maps and post-translational vector maps in proteome projects. *Electrophoresis*, *17*(5), 830-838.

[85] Bouchez, T., Blieux, A. L., Dequiedt, S., Domaizon, I., Dufresne, A., Ferreira, S., ... & Martin-Laurent, F. (2016). Molecular microbiology methods for environmental diagnosis. *Environmental chemistry letters*, *14*(4), 423-441.

[86] Ahmed, Nuzhat, and Gregory E. Rice (2005). Strategies for revealing lower abundance proteins in two-dimensional protein maps. *Journal of Chromatography B*, 815(1), 39-50.

[87] Braun, H. P., & Senkler, M. (2012). Functional annotation of 2D protein maps: the GelMap portal. *Frontiers in plant science*, *3*, 87.

[88] Futschik, Matthias E., Gautam Chaurasia, and Hanspeter Herzel (2007). Comparison of human protein–protein interaction maps. *Bioinformatics*, 23(5), 605-611.

[89] Gerrits, R. J., Lunney, J. K., Johnson, L. A., Pursel, V. G., Kraeling, R. R., Rohrer, G. A., & Dobrinsky, J. R. (2005). Perspectives for artificial insemination and genomics to improve global swine populations. *Theriogenology*, *63*(2), 283-299.

[90] Sasaki, T., Matsumoto, T., Antonio, B. A., & Nagamura, Y. (2005). From mapping to sequencing, post-sequencing and beyond. *Plant and cell physiology*, *46*(1), 3-13.

[91] Stock, Gregory, and John Howland Campbell (2000). Engineering the human germline: An exploration of the science and ethics of altering the genes we pass to our children. Oxford University Press, USA, (2000).

[92] Engelhardt, H. Tristram (2002). Germline engineering: the moral challenges. *American journal of medical genetics*, 108(2), 169-175.

[93] Baird, Stephen L. (2007). Designer Babies: Eugenics Repackaged or Consumer Options?. *Technology Teacher*, 66(7), 12-16.

[94] Sebo, Zachary L., Han B. Lee, Ying Peng, and Yi Guo (2013). A simplified and efficient germline-specific CRISPR/Cas9 system for Drosophila genomic engineering. *Fly*, 8(1). 8-9.

[95] Stock, Gregory. (2005). Germinal choice technology and the human future. *Reproductive biomedicine online*, 10, 27-35.

[96] http://www.businessweek.com/bw50/2001/tech_chameleon.htm

[97] Mark Weiser. (1991). The Computer for the Twenty-First Century, *Scientific American*, 94-10, (1991).

[98] Kalte, H., Langen, D., Vonnahme, E., Brinkmann, A., & Ruckert, U., (2002). Dynamically reconfigurable system-on-programmable-chip. In Parallel, Distributed and Network-based Processing, 2002. Proceedings. 10th Euromicro Workshop on (pp. 235-242). IEEE.

[99] Yoon, J. H., Nam, E. H., Scong, Y. J., Kim, H., Kim, B. S., Min, S. L., & Cho, Y. (2008). Chameleon: A high performance flash/FRAM hybrid solid state disk architecture. *Computer Architecture Letters*, 7(1), 17-20.

[100] Smit, G. J., Kokkeler, A. B., Wolkotte, P. T., Hölzenspies, P. K., van de Burgwal, M. D., & Heysters, P. M. (2007). The Chameleon architecture for streaming DSP applications. *EURASIP Journal on Embedded Systems*, (1), 11-12.

[101] Becker, E. P. (2017). The future of flying is near. *Tribology & Lubrication Technology*, *73*(8), 96.

[102] Millis, Marc G. (1997). Challenge to create the space drive. *Journal of Propulsion and Power*, 13(5), 577-582.

[103] Gregory Daigle, http://gravitymodification.com /wp-content/uploads /2014/07 /Terrestrial-and-space-applications-of-gravity-like-fields.pdf (accessed 01 November 2014).

[104] Adam Frank, http://www.nytimes.com /2014/06/08/opinion/sunday/i-was-promised-flying-cars.html? (accessed 01 November 2014).

[105] Charles Platt, Breaking the Law of Gravity, http://archive.wired.com/wired/archive/6.03/antigravity_pr.html, (accessed 01 November 2014).

[106] Clarke, M. F., Dick, J. E., Dirks, P. B., Eaves, C. J., Jamieson, C. H., Jones, D. L., ... & Wahl, G. M., (2006). Cancer stem cells—perspectives on current status and future directions: AACR Workshop on cancer stem cells. *Cancer research*, 66(19), 9339-9344.

[107] Rando, T. A. (2006). Stem cells, ageing and the quest for immortality. *Nature*, 441 (7097), 1080-1086.

[108] Bongso, A., & Richards, M., (2004). History and perspective of stem cell research. Best Practice & Research Clinical Obstetrics & Gynaecology, 18(6), 827-842.

[109] Joy, Bill (2000). Why the future doesn't need us. *Nanoethics–the ethical and social implications of nanotechnology*, pp. 17-39.

[110] Keiper, A. (2003). The nanotechnology revolution. *The New Atlantis*, (2), 17-34.

[111] Parry, B. (2004). Technologies of immortality: The brain on ice. *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences*, 35(2), 391-413.

[112] Sethe, Sebastian (2007). Nanotechnology and life extension. *Nanoethics—the ethical and social implications of nanotechnology*. New Jersey, pp. 353-365.

[113] Rommetveit, K. (2012). Immortality. In Sacred Science? Wageningen Academic Publishers, pp. 111-126.

[114] http://www.thatsreallypossible.com/news/852/nanotechnology-superhumans/

[115] Di Martino, G., Iodice, A., Riccio, D., & Ruello, G. (2007). A novel approach for disaster monitoring: fractal models and tools. *IEEE Transactions on Geoscience and Remote Sensing*, *45*(6), 1559-1570.

[116] Kashtanov, A., & Petrov, Y. (2004). Fractal models in fracture mechanics. *International journal of fracture*, 128(1-4), 271-276.

[117] Singh, S. L., S. N. Mishra, and W. Sinkala. (2012). A new iterative approach to fractal models. *Communications in Nonlinear Science and Numerical Simulation*, 17(2), 521-529.

[118] W. Wertz, Fractal models in biology, http://www.statistik.tuwien.ac. at/forschung/MS/MS-2009-1complete.pdf

[119] Keiper, Adam (2003). The nanotechnology revolution. *The New Atlantis*, 2, 17-34.

[120] Peterson, Christine, and Jacob Heller. (2007). Nanotech's promise: Overcoming humanity's most pressing challenges. *Nanoethics: The ethical and societal implications of nanotechnology*, 57-70.

[121] Yousaf, A. S., and Salamat Ali (2008). Why Nanoscience and Nanotechnology? What is there for us?. *J. of Faculty of Eng. & Technol*, 5, 11-20.

[122] Tarun Singhal, Deepak Rana, Arvind Dewangan and Nitin Agarwal (2010). Various Prospects of Nano Technology. *International Journal of Nanotechnology & Applications*, 4(2), 125-132.

[123] Wonglimpiyarat, Jarunee. (2005). The nano-revolution of Schumpeter's Kondratieff cycle. *Technovation*, 25 (11), 1349-1354.

[124] Gruère, Guillaume P. (2012). Implications of nanotechnology growth in food and agriculture in OECD countries. *Food Policy,* 37(2), 191-198.

[125] Brame, Jonathon, Qilin Li, and Pedro JJ Alvarez (2011). Nanotechnology-enabled water treatment and reuse: emerging opportunities and challenges for developing countries. *Trends in Food Science & Technology,* 22(11), 618-624.

[126] Knell, Mark, (2011). Nanotechnology and the sixth technological revolution. In *Nanotechnology and the Challenges of Equity, Equality and Development*, pp. 127-143. Springer Netherlands.

[127] Kaounides, L., Hailing Yu, and T. Harper (2007). Nanotechnology innovation and applications in textiles industry: current markets and future growth trends. *Materials Science and Technology,* 22 (4), 209-237.

[128] Bartos, Peter (2004). *Nanotechnology in construction*. Vol. 292. Royal Society of Chemistry, 2004.

[129] Cattaneo, A. G., Gornati, R., Sabbioni, E., Chiriva-Internati, M., Cobos, E., Jenkins, M. R., & Bernardini, G. (2010). Nanotechnology and human health: risks and benefits. *Journal of applied Toxicology*, *30*(8), 730-744.

[130] Diallo, Mamadou, and C. Jeffrey Brinker (2011). Nanotechnology for sustainability: environment, water, food, minerals, and climate. *Nanotechnology Research Directions for Societal Needs in 2020*. Springer Netherlands, pp 221-259.

[131] Hullmann, Angela (2007). Measuring and assessing the development of nanotechnology, *Scientometrics*, 70(3), 739-758.

[132] Kimbrell, George A. (2006). Nanomaterial consumer products and FDA regulatory challenges and necessary amendments. *Nanotech. L. & Bus.,* 3, pp 329.

[133] Hocken, Robert J., and Jimmie A. Miller (1993). Nanotechnology and its impact on manufacturing. *Tokyo: Japan/USA Symposium on Flexible Automation*, Japan, p 15.

[134] Gelles, David (2009). IMMORTALITY 2.0. *The Futurist,* 43(1), p 34.

[135] Gupta A, Arora A, Menakshi A, Sehgal A, Sehgal R, (2012). Nanotechnology and Its Applications in Drug Delivery: A Review. *Webmed Central: International Journal of Medicine and Molecular Medicine*, 3(1), 2867.

[136] www.nanotechproject.org/cpi/browse/categories/appliances/

[137] Aithal, P. S. (2016). Review on Various Ideal System Models Used to Improve the Characteristics of Practical Systems. *International Journal of Applied and Advanced Scientific Research*, 1(1), 47-56. DOI : http://doi.org/10.5281/zenodo.159749.

[138] Aithal, P. S., Shubhrajyotsna Aithal, (2015). A review on Anticipated Breakthrough Technologies of 21st Century. *International Journal of Research & Development in Technology and Management Sciences*, 21(6), 112 – 133. DOI : http://doi.org/10.5281/zenodo.61617.

[139] Aithal, P. S. (2016). Nanotechnology Innovations & Business Opportunities : A Review. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 182-204. DOI : http://doi.org/10.5281/zenodo.161153.

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CHAPTER 3

IDEAL TECHNOLOGY & ITS REALIZATION OPPORTUNITY

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ABSTRACT :
This Chapter contains the concept of ideal technology and its realization opportunity using nanotechnology, opportunities & challenges for green technology in 21st century, concept of ideal water purifier system to produce potable water and its realization opportunities using nanotechnology, and nanotechnological innovations & business environment for automobile sector : a futuristic approach, nanotechnology innovations & business opportunities in renewable energy sector, concept & characteristics of ideal energy system and its realization constraints, realization opportunity of ideal energy system using nanotechnology based research and innovations and the concept of ideal drug &its realization opportunity using present pharmaceutical sciences scenario.

3.1 INTRODUCTION :

Technology is defined as a set of processes for making, modifying, using, and knowing of tools, machines, techniques, crafts, systems, and methods of organizing them in order to solving a problem, improving a pre-existing solution to a problem, achieving a goal, handling an applied input/output relation or perform a specific function. Technologies considerably affect human beings and other animal species' ability to control and adapt to their natural environments. Technology has affected society and its surroundings in many ways has helped to develop more advanced economies (including today's global economy) and has supported the rise of a leisure class people even with laziness & lethargy. Science has contributed many technologies to the society which include Aircraft technology, Automobile technology, Bio-technology, Computer technology, Telecommunication technology, Internet technology, Renewable energy technology, Atomic & Nuclear technology, Nanotechnology, Space technology etc. have changed the lifestyle of the people and provided comfortability. In order to sustain this comfortness of people in the society, they have to vary about sustainability of the surrounding environment. Technology is the branch of scientific knowledge that deals with the creation, application and use of technical means and their interrelation with human life, society, and the environment, drawing upon such subjects as engineering, applied science, pure science and industrial arts. Many technological processes generate unwanted by-products,

which give rise to pollution, and deplete natural resources, to the detriment of Earth's environment. Implementations of new technology influence the culture and values of a society and often raises new ethical questions. To improve any present systems in the society, it is normal practice that such systems have to be compared with a hypothetical, predicted system of that kind called "Ideal system". The word 'Ideal system' refers to the system which has ideal characteristics i.e., perfect in every way. It is what the mind pictures as being perfect [1].

The concept of ideal gas, ideal engine, ideal switch, ideal fuel, ideal semiconductor devices like ideal diodes, ideal transistors, ideal amplifiers etc. have been defined and taken as standards to improve the quality and performance of such practical devices or systems. It is found that, by keeping such hypothetical device or systems in mind, researchers have continuously improved the characteristics/properties of practical devices / systems to upgrade their performances. Hence ideal properties of a device or a system can be used to upgrade or improve its properties towards reaching 100% efficiency. By comparing the properties/characteristics of a practical device/system with its ideal counterpart, one can find out the possible modifications in that device /system towards reaching the objective of achieving such an ideal device [2-3].

An ideal gas is a hypothetical theoretical gas composed of many randomly moving particles that do not interact each other except when they collide each other elastically. The ideal gas concept is important and useful because it obeys the ideal gas law, a simplified equation of state, and is amenable to analysis under statistical mechanics. (1) The molecules of an ideal gas do not attract one another. (2) The molecules of an ideal gas repel one another. (3) The volume of the ideal gas molecules is negligible compared to the volume of the container [4-5].

The Characteristics of an ideal fuel are (1) The fuel should have high calorific value, (2) The fuel should have proper ignition temperature. (3) The rate of combustion should be balanced and moderate. (4) The content of non-volatile substances should be as low as possible. (5) There should be no poisonous or residue by-products on combustion. (6) The fuel should be easily available in plenty. (7) The fuel should be available at a low cost. (8) There should be convenience in transporting the fuel and should be easily storable [6].

An ideal operational amplifier has properties like (1) Infinite input resistance, (2) Zero output resistance, (3) Zero offset voltage, (4) Infinite bandwidth, (5) Infinite common-mode rejection, (6) Infinite open-loop voltage gain, and (7) Infinite Slew rate so that the output voltage changes occur simultaneously with the input voltage change [7]. The characteristics of an ideal heat engine are : (1) It should have a source of infinite thermal capacity, (2) It should have a sink of

infinite thermal capacity, (3) The efficiency such heat engine during the conversion process of heat into work and conversely is 100% [8]. Similarly, ideal fabric is the fabric which satisfies the three conditions, good hand, good appearance of suit, and mechanical comfort for wear.

In this chapter, some of the ideal systems like ideal technology, ideal water purifier system, ideal transportation system, ideal energy source, and ideal drug system are proposed along with detailed discussion of their characteristics. The chapter also contains the possible use of the nanotechnology as universal technology to realize various characteristics of such ideal systems.

3.1.1 Introduction to Ideal Technology :

The ideal technology model is essential to plan the improvement in the performance of any practical technology. The concept of ideal technology can be predicted as a technology which can solve all basic needs of human beings and provide luxurious comfortable life without affecting the society and environment. Ideal technology should have characteristics in order to elevate the quality of life to unique level with perfect equality so that every human being in this universe should lead happy and comfortable life and realize the so-called concept of heaven on earth. Based on various factors which decide the ideal technology system characteristics, a model consisting of input conditions, output conditions, environmental conditions and system requirements [2]. The input properties are (1) Manipulate the fundamental nature of matter to provide solutions to basic and advanced problems of mankind. (2) In-expensive &self-reliable in terms of resources to make it attractive to be used by people/countries of varied economical situations. (3) Ubiquitous so that the technology provides solutions and services at anytime, anywhere, any amount of time to the users. (4) Affordable to everybody so that it uses common materials available in nature and manipulate effectively to the need of human being at affordable cost. The Output properties are (1) Solve basic needs like food, drinking water, renewable energy, clothing, shelter, health and clean environment. (2) Provide comfort life to the users by providing solutions to their desires. (3) Equality ; ideal technology provide equal opportunity and similar solutions to every user irrespective of their gender, religion, background, education, economic status, and country of origin. (4) Automation; ideal technology automate all processes in every type of industries to avoid human interference in work/control in order to provide expected output based on programming. (5) Immortality is the ultimate goal of ideal technology so that it can create an avenue for deathless situation or enhancement of human life span. The System Requirement Properties are (1) General purpose technology to support all fields and problems of human & living beings on the earth. (2) Self-directed &self-controlled & self-regulated so that the technology can control itself in order to

achieve its goal. (3) Easy, simple, quick & user friendly to solve all type of problems and to provide quick ideal solution. (4) Scalable so that it is used for solving small and simple problem to large and complex problems of life. (5) Omni-potent to identify and solve problems and provide comfortability to human being and feeling him like God. (6) Exploring new opportunities to improve and explore comfortability and further leisure in life of people. (7) Infinite potential for further development of life in the universe. The Environment/external Properties are (1) Maintain clean environment through its processes and avoids foot print of processes while achieving specific function. (2) Infinite business opportunities by creating new products / services with ideal characteristics. (3) Adaptive to any situations to achieve stated goal. (4) No side effects so that it should be safe for users, and environment. Any technology which has the above properties/characteristics is considered as ideal technology and the conventional technologies have serious drawbacks/limitations in terms of the above properties [9]. One of the properties of ideal technology is sustainability and zero green gas emission to environment i.e., ideal technology is green technology and the chapter contains the proposal on how the technologies can be made sustainable by adding green component so that they can avoid environmental degradation and converted into green technologies to provide clean environment for future generations [10].

The chapter also discusses the opportunities and challenges for green technology for agriculture, green technology for potable water, green technology for renewable energy, green technology for buildings, green technology for aircraft and space exploration, green technology for industrial automation, green technology for computers and communication, green technology for education, green technology for food & processing, and green technology for health and medicine in 21st century.

3.1.2 Introduction to Ideal Drinking Water System :

For more than two million years, human beings are struggling and searching to get Nutritious food, clean drinking water, energy in different form, and comfortable health. In the twentieth century, Abraham Maslow (1943) proposed Hierarchy of Needs Theory [11] based on his assumption of five different needs which are defined as Physiological need, Safety needs, Social needs, Esteem needs, and Self-actualization needs. Out of these five needs, the physiological need is the basic need also called the basic problems of human beings including food, water, energy, and health. Other four needs are together categorized as comfortability of human beings. As the civilization is developed with time, the scientific thinking among the human beings is started and science had helped to solve many of these basic problems to a

certain extent. After industrialization, the availability of drinking water in many countries is becoming scared and there is a cry on future challenges in earning potable water for many regions on earth. It is reported that between 1990 and 2015, the world population using an improved potable water source has increased from 76 % to 91 %. It is estimated that more than 40 % of global population is affected by water scarcity and is proposed to increase further. In the global scenario, over 1.7 billion people are presently living in river basins where water use exceeds recharge. Similarly, over 2.4 billion people have no access to basic sanitation facilities. It is reported that each day, nearly 1,000 children die due to preventable water and sanitation-related diarrhoeal diseases. It is a challenge for the society to achieve universal and equitable access to safe and affordable drinking water for all. It is a challenge for decreasing substantially the proportion of untreated wastewater by increasing recycling and safe reuse globally. It is also a challenge to enhance the efficiency of use of water across all sectors by producing pure water at low cost and ensure a sustainable supply of potable water to manage water scarcity and hence to decrease the number of people affected from scarcity of potable water. Table 3.1 lists the causes of water pollution and its types [12].

Table 3.1 : Causes of water pollution & Types

S. No.	Type of water pollution	Reason	Solution
1	Undissolved impurities	Mix of various undissolved impurities in both surface and groundwater	Filtering
2	Chemical water pollution or oxygen depletion	Natural organic matter (NOM) found in all surface, ground, and soil waters	Most of the NOM can be removed by coagulation, although, the hydrophobic fraction and high molar mass compounds of NOM are removed more efficiently
3	Infected water with microbial	Bacterial cell components and viruses as microbial pollution	Antimicrobial nanomaterials for water disinfection and microbial control
4	Chemical toxin pollution	Various inorganic and organic chemicals	Use of CNTs as adsorbent media to concentrate and remove pathogens, NOM, and cyanobacterial toxins from water systems.
5	Calcium ions dissolved in water	Dissolved metal ions	Nanophotonics
6	Desalination of seawater	Dissolved NaCl	Nanomembranes
7	Treatment of sewerage Water	Inorganic and organic pollutants	Chlorine Dioxide

One of the research methodologies to improve the systems in the nature and society is identifying the characteristics of an existing system where improvements are required in terms of quality, cost, and easiness of using the system, and comparing such real system with an

anticipated hypothetical predicted system and its characteristics. Based on such comparison, the possibilities and challenges of improvement of present system can be identified. This chapter also contains the proposal and detailed discussion on an ideal water purifier system in terms of its input, internal processes, output, and environmental characteristics [13].

3.1.3 Introduction to Ideal Transportation System :

The Indian auto industry is one of the largest in the world growing very fast with an annual production of 23.37 million vehicles during 2014-15, with the annual growth of 8.68 per cent. It accounts for 7.1 per cent of the country's gross domestic product (GDP). As per Automotive Component Manufacturers Association of India (ACMA) the turnover of the auto component industry is INR 2340 billion (USD38.5 billion) during 2014-15, registering a growth of 11 per cent over the previous year and a Compounded Annual Growth Rate (CAGR) of 11 per cent over the last six years. The auto component industry in India is expected to scale up to Rs. 6347 billion in turnover by 2020 with exports to grow the in range of Rs, 2200-2550 billion. Indian Government is encouraging R&D in automobile industry for technological innovations by giving a 15 per cent reduction of rate of income tax on royalty and fees for technical services. To support sustainable technology development further to provide an industry perspective on emerging affordable and accessible technologies, ACMA has taken initiative to give priorities on light weighting, electrification of powertrains, improving the safety and fuel efficiency, and electronics of vehicles. In addition, Global automotive Original Equipment Manufacturers (OEMs) and suppliers identified India as a key market working on various technologies such as light weighting, electrification of power trains and safety features. Several initiatives by the Government of India and the major automobile players in the Indian market are expected to make India a leader in the world by 2020. Some of the major investments and developments in the automobile sector in India are as follows [14]:

- Global auto major Ford plans to manufacture in India two families of engines by 2017, a 2.2 litre diesel engine codenamed Panther, and a 1.2 litre petrol engine codenamed Dragon, which are expected to power 2,70,000 Ford vehicles globally.
- The world's largest air bag suppliers Autoliv Inc, Takata Corp, TRW Automotive Inc and Toyoda Gosei Co are setting up plants and increasing capacity in India.
- General Motors plans to invest US$ 1 billion in India by 2020, mainly to increase the capacity at the Talegaon plant in Maharashtra from 130,000 units a year to 220,000 by 2025.
- US-based car maker Chrysler has planned to invest Rs 3,500 crore (US$ 525 million) in Maharashtra, to manufacture Jeep Grand Cherokee model.

- Mercedes Benz has decided to manufacture the GLA entry SUV in India. The company has doubled its India assembly capacity to 20,000 units per annum.
- Germany-based luxury car maker Bayerische Motoren Werke AG's (BMW) local unit has announced to procure components from seven India-based auto parts makers.
- Mahindra Two Wheelers Limited (MTWL) acquired 51 per cent shares in France-based Peugeot Motorcycles (PMTC).

The Government of India encourages foreign investment in the automobile sector and allows 100 per cent FDI under the automatic route. Some of the major initiatives taken by the Government of India are [14-15] :

- Encouraging automobiles manufacturers to become driver of 'Make in India' initiative, as it expects passenger vehicles market to triple to 9.4 million units by 2026, as highlighted in the Auto Mission Plan (AMP) 2016-26.
- In the Union budget of 2016-17 the Government has announced to provide credit of Rs 850,000 crore (US$ 127.5 billion) to farmers, which is expected to boost the tractors segment sales.
- The Government plans to promote eco-friendly cars in the country i.e. CNG based vehicle, hybrid vehicle, and electric vehicle and also made mandatory of 5 per cent ethanol blending in petrol.
- The government has formulated a Scheme for Faster Adoption and Manufacturing of Electric and Hybrid Vehicles in India, under the National Electric Mobility Mission 2020 to encourage the progressive induction of reliable, affordable and efficient electric and hybrid vehicles, aims at creating a vehicle base of ~7 million electric cars by 2020 in the country by providing incentives to buyers as well as suppliers and for undertaking R&D initiatives, to create public charging infrastructure, to encourage retro-fitment of vehicles.
- The Automobile Mission Plan (AMP) for the period 2006–2016, designed by the government is aimed at accelerating and sustaining growth in this sector. Also, the well-established Regulatory Framework under the Ministry of Shipping, Road Transport and Highways, plays a part in providing a boost to this sector.
- The National Electric Mobility Mission Plan 2020 and policy of Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India aims at creating a vehicle base of ~7 million electric cars by 2020. National Automotive Board (NAB) under the supervision of the department of heavy industries has been constituted for implementation of the plan.

- The government of India has extended support to the industry by increasing customs duty on CBUs of commercial vehicles from 10 percent to 40 percent, reduction in duty on chassis for ambulance manufacturing from 24 percent to 12.5 percent, extension in concession on select parts used in the manufacture of electric & hybrid vehicles and weighted deduction up to 200 percent of expenditure on R&D for computation of expenses under Corporate Tax.

India's automotive industry is one of the most competitive in the world. The Indian automotive sector has the potential to cover 100 per cent of technology or components required and to generate up to US$ 300 billion in annual revenue by 2026, create 65 million additional jobs and contribute over 12 per cent to India's Gross Domestic Product, as per the Automotive Mission Plan 2016-26 prepared jointly by the Society of Indian Automobile Manufacturers (SIAM) and government [16]. Some of the challenges identified in Indian automobile sector to reach its goal as per Automotive Mission Plan 2016-26, are:

- Challenge to attract capital investments required to implement roadmap developed by AMP 2016-26.
- Challenge to fulfil global emission standards and safety norms to erase the environmental footprint.
- Challenge to adopt new breakthrough technologies to make automobiles ideal for use.
- Challenge of lack of infrastructure, urban congestion, integration of smart concepts, meeting efficiency needs.
- Challenge to safeguarding intellectual property rights developed by R & D institutions.
- Other challenges like (a) Customs duty and transfer pricing issues plaguing the industry, (b) Planning and implementing simpler tax structures, (3) Policy of withdrawal for old vehicles. (c) Lack of growth opportunities for auto industry companies may attract them to invest in other sectors etc.

While the Indian government is making serious efforts on policy implementation, automobile industry is trying to make a breakthrough in improving the efficiency, durability and cost of vehicles using nanotechnology solutions [16-19] along with decreasing the pollution by using hydrogen fuel or electric engines. The chapter also contain the proposal of ideal automobile system to solve transportation problems of the country [20].

3.1.4 Introduction to Ideal Energy Source :

According to ideal energy system model ideal energy source is a system which produces energy with ideal characteristics which are divided into input characteristics, system characteristics, output characteristics, and environmental characteristics. Based on the Google search

information [21], an ideal source of energy should possess the following characteristics. (a) It should be capable of giving an adequate amount of useful energy. (b) It should be convenient to transport, store and use. (c) It should be economical, (d) It should be capable of supplying the desired quantity energy at a study rate over a long period of time. But when we study the broad picture of ideal energy system, we have considered many more characteristics like, availability, power output, volume, mass, cost, renewability, user safetyness, Maintenance, etc. Accordingly, a systematic study of ideal energy system is required and study will help the new researchers in energy system research to re-define their objectives [22].

3.1.5 Introduction to Ideal Drug System :

The objective of drug research is continuous improvements of existing drugs in terms of their curing ability and to discover new drugs which have substantial improved abilities to cure many existing and new diseases and the final goal of drug research is directed to identifying one drug which has the ability to cure all diseases. All research work in pharmaceutics is directed towards improving drug properties including their effectiveness, safety, selectivity, no side effects, cost, accessibility, time of cure, etc. The ideal drug is a material which shows ideal characteristics. According to ideal drug model it is a system which operates on other systems based on its own properties and these properties are divided into input characteristics, operational characteristics, output characteristics, and environmental characteristics. Based on various factors which decide the ideal drug system characteristics, a model consisting of input conditions, output conditions, environmental conditions and system requirements is proposed [23].

3.1.6 Introduction to Nanotechnology as Enabling Technology :

Technological innovations have changed the lifestyle of human beings since many years and solved their basic problems and provided happy & comfort life. Many killer technologies have been invented in the history which has become essential to lead life of common man. Killer technologies are those technologies invented in the society and penetrated common man's lifestyle in such a way that without them the life of human being is going to be miserable. For example, invention of wheel, mechanical engine, electricity, automobile, telephone, radio, television, computer, mobile phone, windows operating system, android based smart phones etc. are examples for killer application technologies. Many of the killer application technologies became general purpose technologies and spread their arms to all areas of the organizations and the society. For example, computer technology, information and

communication technologies transformed themselves into general purpose technologies and became essential in the progress of all other fields and became part and parcel of human life. Recently, during last 20 years, nanotechnology is growing as killer application technology and due to its importance and potential advantages, growing as another general purpose technology and expected to change the society substantially. Nanotechnology deals with the manipulation of matter at near atomic level to produce new materials, structures, devices and systems that exhibit properties and phenomenon that are unique at these scales. Nanotechnology is not only general purpose technology –it is also technology that enables the creation of new devices and new ways to improve the quality of life. Nanotechnology used in existing industries and new research areas are developed within existing areas, transforming them from microelectronics to nano-electronics, from photonics to nano-photonics, from biotechnology to nano-bio-technology, and from energy to nano energy. Business firms are exploring new ways to address consumer needs, new business models based on the changes nanotechnologies could enable in existing industries. Huge amount of investments in nanotechnology to support scientific and technological researches, the creation of technological and industrial platforms and infrastructures have led to more than two million articles related to nanotechnologies being published, and over one million application patents were lodged by the year 2015 [24]. To realize the ideal technology [9] in practice, we need to identify a general-purpose technology that should manipulate the fundamental nature of matter. The technology should be microscopic and able to provide solutions to the problems and challenges of fundamental needs of human beings and also support the processes required to enhance the comfort ability of the people. The products/services developed through such technology should have properties, at least close to Ideal technology properties. The presently developed technologies like agricultural technology, space technology, computer technology, electronics & communication technology, Automobile technology, bio-technology, and laser technology are unable to show all the characteristics which are close to ideal technology characteristics mentioned above. But it is expected that using the innovations in nanotechnology can solve the basic needs of human being are food, drinking water, energy, cloth, shelter, health and environment and the comfort needs are realizing the automation in every field, space travel and expanded life-span and so on [20]. Nanotechnology is considered as one of the anticipated breakthrough technologies of 21st century along with supporting some other interrelated Killer application technologies like Optical Computation, Embedded Intelligence, Chameleon Chips, Flying cars, Immortality through nano-bio-technology, and Space travel [24]. Nanotechnology will play major role in

solving all the problems of humans like food, drinking water, energy, health, environment, and many other areas including life span expansion. Some of the Application areas of Nanotechnology are [25-27] :

Agriculture & Food: This include contamination sensor, antimicrobial packaging, enhanced nutrient delivery, green packaging, pesticide reduction, tracking & brand protection, texture, food flavor, bacteria and virus identification & elimination, etc.

Potable Water: This include water cleaning nanotechnology devices, nanotubes as the pores in reverse osmosis membranes, and nanotech based water purifiers for polluted water, sewage water and even sea water in large scale.

Cleaner Air& Environment: This includes pollution control, nanotech windmill blades, nanostructure membranes, nanoparticle catalysts, removal of carbon dioxide from industrial smoke stacks.

Renewable Energy: This includes inexpensive solar cells, devices for capturing, storage, &use of energy optimally [28].

Electronics: This includes development of nanotransistors, nanogates, nanodevice based integrated circuits, nanoemmissive display panels, nanomemories, nanowires, nanophotonic devices, Nano-optical computers etc.

Batteries & Fuel Cells: This include nanostructure fuel cells, hydrogen nanofuel cells, nanotech alternative fuel cells, long life high storage capacity fast rechargeable nanotech batteries etc.

Health & Medicine: This include drug delivery, therapy techniques, diagnostic techniques, antimicrobial techniques, cell repair, cancer detection & curing, gene therapy, nanotech in regenerative medicine & tissue engineering, life span extension etc.

Automobile: This includes nanomaterial-based automobile parts to increase working life of the automobiles, to decrease running cost and maintenance cost, and to decrease the environmental degradation to zero level [20].

Sensors & Detectors: This includes chemical sensors, MEMS based sensors, nano-hydrogen sensors, Nanocantilevers etc.

Consumer Products: Devices like sporting goods, fabrics & textiles, cosmetics, skin care products, sunscreens, flame retardants, nanocleaning products, nanopaints, and any other products based on nanotechnology.

Defense: This include concepts like nano for the soldier, nano for defense vehicles, nano for aeronautics, nano for naval vessels, nanotechnology for weapon systems, nano for satellites,

nano for logistics, nano for security, nano for military operations at land, nano for military operations in the air, nano for military operations at sea, nanotechnology for urban operations etc.

Civil & Mechanical Engineering Manufacturing: This includes nano-material technology, nano-processing technology, nano-assembly technology, nano-coating technology, and nano-measurement technology in mechanical manufacturing. This also include nanorobotics, Micro-Electro Mechanical Systems (MEMS) for accelerometer chips, inkjet nozzles, pressure sensors, microphones, RF switches, gyroscope, oscillators etc.

Building Materials: This includes various future building materials like aerogels, nanotube mixed concrete, nanopaints, building integrated photovoltaics, nanophotonic materials as building cooler. Nanotechnology on construction, and fire protection etc.

Pharmaceutical Industry: The major goal of the nanotechnology is to improve the present way to drugs administration for efficient way of recovery of the patient. This include the creation of new drugs with a specific function till the fabrication of new drug delivery systems for the movement of different barriers in the human body with special care of increase the efficiency of drugs in terms of solubility [23]. Nano-drugs can cure dreadful diseases like AIDS, cancer, tuberculosis, diabetes, malaria, prion disease, etc.

Aircraft, Rocket and Space Technology: This includes low cost, less weight, high strength space elevators, weight reduction in spaceships and spacesuits, solar power satellites, bio-nano-machines for space applications, new breed of robots to explore the planets etc.

Lifespan Expansion: The two possible ways to extend the lifespan of human being are either by helping to eradicate life-threatening diseases such as cancer, and the other is by repairing damage to our bodies at the cellular level--a nano version of the fountain of youth. Techniques for building nano-robots are being developed that should make the repair of our cells possible [29].

3.2 IDEAL TECHNOLOGY CONCEPT & ITS REALIZATION OPPORTUNITY

3.2.1. Ideal Technology :

Technology is the branch of scientific knowledge that deals with the creation, application and use of technical means and their interrelation with human life, society, and the environment, drawing upon such subjects as engineering, applied science, pure science and industrial arts. Many technological processes generate unwanted by-products, which give rise to pollution, and deplete natural resources, to the detriment of Earth's environment. Implementations of new technology influence the culture and values of a society and often raises new ethical questions.

For example, the rise of the notion of efficiency and effectiveness in terms of human productivity, a term originally applied only to machines is now became common traditional norms [30].

To improve any present systems in the society, it is normal practice that such systems have to be compared with a hypothetical, predicted system of that kind called "Ideal system". The word 'Ideal system' refers to the system which has ideal characteristics i.e., perfect in every way. It is what the mind pictures as being perfect. The concept of ideal engine, ideal switch, ideal voltage source, ideal current source, ideal semiconductor devices like ideal diodes, ideal transistors, amplifiers etc. have been defined and taken as standards to improve the quality and performance of such practical devices or systems. It is found that, by keeping such hypothetical devices or systems in mind, researchers have continuously been improving the characteristics/properties of practical devices / systems to upgrade their performances. Hence ideal technology model is essential to plan the improvement in the performance of any practical technology. In this chapter, an attempt is made to develop a conceptual ideal technology model by considering it as a system and identifying various characteristics of the system. Similarly, the concept of ideal technology can be predicted as a technology which can solve all basic needs of human beings and provide luxurious comfortable life without affecting the society and environment. Ideal technology should have characteristics in order to elevate the quality of life to unique level with perfect equality so that every human being in this universe should lead happy and comfortable life and realize the so-called concept of heaven on earth.

3.2.2. Ideal Technology Model :

An ideal technology system should have characteristics to fulfill its objectives to solve all problems of human beings including both basic needs and advanced gadgets to support comfort living to realize their dreams. Based on various factors which decides the ideal technology system characteristics, a model consisting of input conditions, output conditions, environmental conditions and system requirements are derived by a qualitative data collection instrument namely focus group method [31-33]. The block diagram of such a system is shown in Figure 3.1.

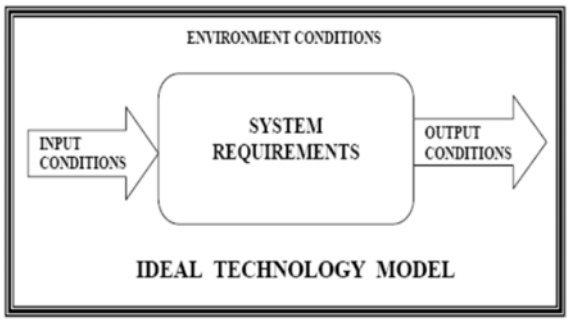

Fig. 3.1: System model of classifications of Ideal Technology characteristics.

3.2.2.1 Input Conditions

1. Manipulate the fundamental nature of matter to provide solutions to basic and advanced problems of mankind.

2. In-expensive &self-reliable in terms of resources to make it attractive to be used by people/countries of varied economical situations.

3. Ubiquitous so that the technology provides solutions and services at anytime, anywhere, any amount of time to the users.

4. Affordable to everybody so that it uses common materials available in nature and manipulate effectively to the need of human being at affordable cost.

3.2.2.2 Output Conditions

1. Solve basic needs like food, drinking water, renewable energy, clothing, shelter, health and clean environment.

2. Provide comfort life to the users by providing solutions to their desires.

3. Equality : Ideal technology provide equal opportunity and similar solutions to every user irrespective of their gender, religion, background, education, economic status, and country of origin.

4. Automation: Ideal technology automates all processes in every type of industries to avoid human interference in work/control in order to provide expected output based on programming.

5. Immortality is the ultimate goal of ideal technology so that it can create an avenue for deathless situation or enhancement of human life span.

3.2.2.3 System Requirement

1. General purpose technology to support all fields and problems of human & living beings on the earth.

2. Self-directed & self controlled & self regulated so that the technology can control itself in order to achieve its goal.

3. Easy, simple, quick & user friendly to solve all type of problems and to provide quick ideal solution.

4. Scalable so that it is used for solving small and simple problem to large and complex problems of life.

5. Omni-potent to identify and solve problems and provide comfortability to human being and feeling him like God.

6. Exploring new opportunities to improve and explore comfortability and further leisure in life of people.

7. Infinite potential for further development of life in the universe.

3.2.2.4 Environment Conditions

1. Maintain clean environment through its processes and avoids foot print of processes while achieving specific function.

2. Infinite business opportunities by creating new products / services with ideal characteristics.

3. Adaptive to any situations to achieve stated goal.

4. No side effects so that it should be safe for users, and environment.

Any technology which has the above properties/characteristics is considered as ideal technology and the conventional technologies have serious drawbacks/limitations in terms of the above properties.

3.2.3. Analysis of Ideal Technology Characteristics :

Ideal Technology characteristics can be explained based on their effectiveness in improving the qualities and comfortability of human life in the society. The characteristics mentioned in ideal technology model are depicted in figures 3.2 –3.5 and further discussed below :

3.2.3.1 Input Conditions :

1. Manipulate the fundamental nature of matter :

Ideal technology manipulated fundamental nature of matter. This includes four Interactive Forces manipulation, and Unified Field manipulation. The ideal technology is able to control the four interactive forces of Strong Force, Weak Force, Electromagnetism, and Gravity all in one. Ideal technology allows user to control four fundamental forces of the universe, reaching nearly any effect they desire. As a result, the user can rearrange matter to create other configurations and can even transmute elements and manipulate space-time to a degree by using gravity to distort them. Hence, ideal technology helps to manipulate the fundamental nature of matter to provide solutions to basic and advanced problems of mankind.

2. In-expensive &self-reliable in terms of resources :

Any technology should be cheap, simple, universal, self reliable in terms of resources so that can be used by anybody, anywhere with available basic resources. One of the examples of such technology is Appropriate technology which is an ideological movement (and its manifestations). Though the nuances of appropriate technology vary between fields and applications, it is generally recognized as encompassing technological choice and application that is small-scale, decentralized, labor-intensive, energy-efficient, environmentally sound, and locally controlled [34]. Schumacher and many modern-day proponents of appropriate technology also emphasize the technology as people-centered [34].

Appropriate technology is most commonly discussed in its relationship to economic development and as an alternative to transfers of capital-intensive technology from industrialized nations to developing countries [35-36]. Today appropriate technology is often developed using open source principles, which have led to open-source appropriate technology (OSAT) and OSAT has been proposed as a new model of enabling innovation for sustainable development [37]. Such property of technology makes it attractive to be used by people/countries of varied economical situations.

3. Ubiquitous :

Ubiquitous, means being present everywhere simultaneously or existing everywhere at the same time. The very concept behind this kind of technology being everywhere and still being virtually inexistent or invisible. This technology is sometimes also referred to as pervasive computing - things that think, or calm technology. The aim of such technology is to establish an environment where people can always be on-the-go, and still carry information and power to solve their problems at their inconvenience, without being bound by the location of any particular technological device. The main underlying principle or rather thought behind Ubiquitous technology is to turn the virtual reality inside out [38-39]. Virtual reality always attracts a common user into a technical system and makes him/her a part of a world, which is beyond mediation. On the other hand, this technology makes systems live and work in a world with people. Thus, Ubiquitous technology provides solutions and services at anytime, anywhere, any amount of time to the users.

4. Affordable to everybody :

Ideal technology should be so smart, so simple and so powerful it works for everybody. Development and maintenance of such technology should be simple, cost effective with fewer constraints for implementation. Innovative technology like smart phones and tablets are becoming more accessible as new models are being brought out at cheaper prices. For example,

advent of technology made healthcare services more affordable than ever before. Hence ideal technology is affordable to everybody so that it uses common materials available in nature and manipulate effectively to the need of human being at affordable cost.

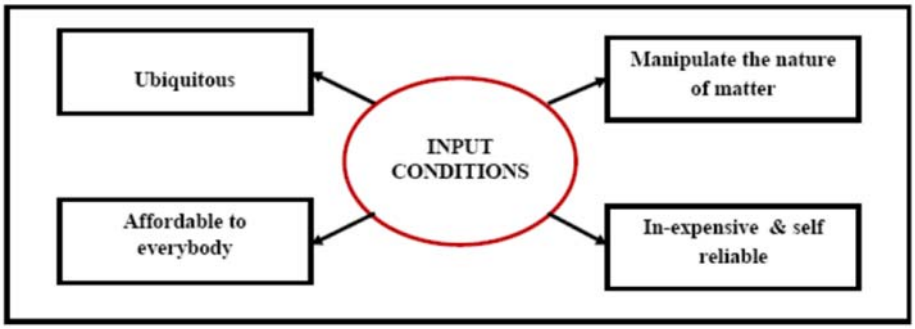

Fig. 3.2 : Input condition characteristics of Ideal technology

3.2.3.2 Output Conditions

1. Solve basic needs :

Science and technology are essential means of meeting society's needs for food, water, energy, health care, shelter, safety and alleviation of poverty. Technology is produced through the existence of the "scientific establishment", formed by the group of institutions, persons and resources directly involved in the production of new knowledge accordingly to certain "internal" rules and procedures. Basic human needs to lead comfortable life constitute a major worldwide shameful problem in the twenty first century. In contrast to the dazzling scientific advancement in fundamental and biomedical science there exists at the other end of the spectrum a formidable picture of unmet basic needs leading to serious health problems. Currently people in underdeveloped and developing countries are suffering from poor quality of life because of (1) Food shortage and malnutrition. (2) Unsafe drinking water. (3) Improper or absent sanitation system. (4) Poor or absent Health Care. (5) Overcrowding or shelter deprivation. (6) Primitive in effective education. (7) Weak or absent social security. Those problems are localized in underdeveloped and developing countries in contrast to being nearly unknown in developed ones. The gap between people who enjoy such services and the people who are not is astronomically widening. Lack of scientific social and technologic development is recognized as the root causes of that disparity in the quality of life and living conditions. Hence ideal technology should have capability to solve basic needs like food, drinking water, renewable energy, clothing, shelter, health and clean environment.

2. Provide comfort :

Technological development offers new possibilities to make people's daily lives more healthy, safe, understandable, independent, fun and comfortable. New technologies provide us, for instance, with energy-friendly and sustainable solutions to improve the environment in which we live as well as tools for elderly people to live longer on their own. Furthermore, new technologies provided us with new means of communication and entertainment. Examples are smartphones, ambient intelligence and smart homes, online shopping and communities, 3D television and renewable energy technologies like hydrogen technology and biomass. In the historical accounts of engineers, comfort is generally presumed to be a definable human condition or attribute, with each new innovation bringing society closer to the achievement of ideal indoor conditions. Starting from a different set of assumptions, social historians take comfort to be a malleable construct and social achievement. Ideal technology through its ingredients provide comfort life to the users by providing solutions to their desires.

3. Equality :

Technology provides equal opportunity to everybody in terms of identifying and en-cashing opportunities throughout the world. Thus, ideal technology also should provide equal opportunity and similar solutions to every user irrespective of their gender, religion, background, education, economic status, and country of origin.

4. Automation :

Automation or automatic control, consists of using various control systems for operating equipment such as machinery in industries, boilers and heat-treating ovens, processes in factories, switching in telephone networks, steering and stabilization of ships, controlling aircraft and other applications with minimal or reduced human intervention. Ideal technology automates all processes in every type of industries to avoid human interference in work/control in order to provide expected output based on programming.

5. Immortality :

Immortality is eternal life or the ability to live forever. Biological life has inherent limitations which medical interventions or engineering may or may not be able to overcome. Nature in its natural selection has developed potential biological immortality in some living species like jellyfish. Certain scientists, futurists, and philosophers, have theorized about the immortality of the human body, and advocate that human immortality is achievable in the first few decades of the 21st century, while other believes that life extension is a more achievable goal in the short term, with immortality awaiting further research breakthroughs into an indefinite future. It is predicted that newly developing technologies may be used to induce biological immortality

in human beings. Human embryonic stem cells research created considerable excitement for the development of mass-producing replacement cells for the treatment of degenerative diseases involving the loss or dysfunction of cells, including those in osteoarthritis, macular degeneration, heart failure, diabetes, Parkinson's disease, and several other disorders. The preliminary report of the isolation of these cells marked the birth of the new area of research called regenerative medicine. This technology offers the theoretical potential of rejuvenating an entire human body back to a youthful state. Hence immortality is the ultimate goal of ideal technology so that it can create an avenue for deathless situation or enhancement of human life span.

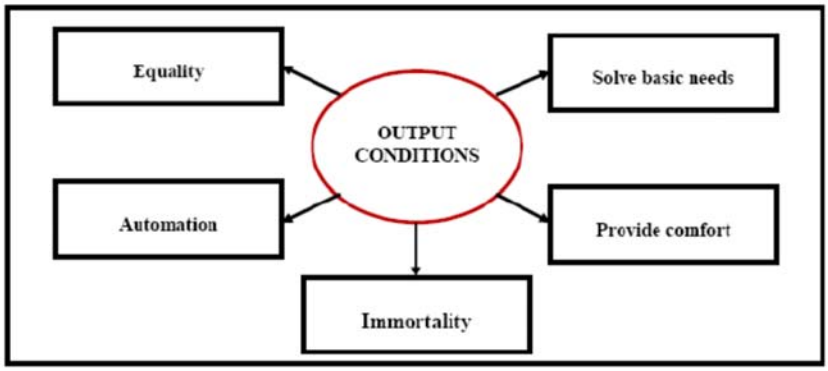

Fig. 3.3 : Output condition characteristics of Ideal technology

3.2.3.3 System Requirement :

1. General Purpose Technology :

General-purpose technologies (GPT) are technologies that can affect an entire economy of the world. GPTs have the potential to drastically alter societies through their impact on pre-existing economic and social structures. Steam engine, railroad, interchangeable parts, electricity, electronics, material handling, mechanization, automation, the automobile, the computer, the Internet and the mobile phone are few examples for GPT. Thus, as GPT's spread throughout the economy, bringing about generalized productivity gains. Ideal technology should be general purpose technology in order to support all fields and problems of human & living beings on the earth.

2. Self-directed & self controlled & self regulated :

Ideal technology is expected to be self-directed, self-controlled and self-regulated so that the technology can control itself in order to achieve its goal. Changes in any parameters due to internal or environmental variations should be re-adjusted through feedbacks and automatic controls.

3. Easy, simple, quick & user friendly :

User-friendly describes a hardware device or software interface that is easy to handle. It is "friendly" to the user, meaning it is not difficult to learn or understand by an ordinary person. The common attributes of such user-friendly technology are (a) simple, a user-friendly interface is not overly complex, but instead is straight forward, providing quick access to common features or commands. (b) clean, a good user interface is well-organized, making it easy to locate different tools and options. (c) intuitive, in order to be user-friendly, an interface must be making sense to the average user and should require minimal explanation for how to use it. (d) reliable, an unreliable product is not user friendly, since it will cause undue frustration for the user. A user-friendly product is reliable and does not malfunction or crash. These features allow to solve all type of problems and to provide quick ideal solution.

4. Scalable :

Scalability is the ability of a system, network, or process to manage a growing amount of work in a capable manner or its enlarged ability to accommodate such growth. For example, it can refer to a systems capacity to increase its total output under an increased load when resources are added. It also refers to anything whose size can be increased. For example, a font is said to be scalable if it can be represented in different sizes. Scalability is the ability of a system based on technology it uses so that it is used for solving small and simple problem to large and complex problems in society.

5. Omni-potent :

The noun omnipotence describes having an enormous amount of power, or even an infinite amount of power. Omnipotent technology has an ability to solve problems of many and multiple areas. Hence it can identify and solve problems and provide comfortability to human being and feeling him like God.

6. Exploring new opportunities :

The technological opportunity discovery (TOD) can be divided into two types: anticipating new technology and applying existing technology to solve basic and advanced problems. Ideal technology should focus on exploring new opportunities to improve and explore comfortability and further leisure in life of people.

7. Infinite potential for further development :

An ideal technology has ability to expand to all realm of the society and all branches of science. It should show its existence in solving problems of physical, chemical and biological areas. Through its innovative ability of improving quality of human life, it has infinite potential for further development of life in the universe.

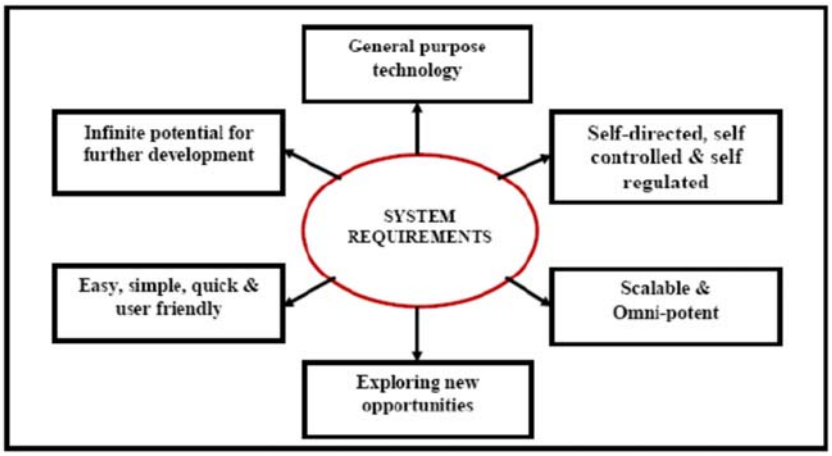

Fig. 3.4 : System requirement characteristics of Ideal technology

3.2.3. 4 Environmental Conditions

1. Maintain clean environment :

Environmental technology or clean technology is the application of one or more processes of environmental science, green chemistry, model and conserve the natural environment and resources, environmental monitoring and electronic devices to monitor, and to curb the negative impacts of human involvement in environmental pollution. Clean technology includes recycling, renewable energy, green transportation, electric motors, lighting, grey water, information technology, and many other appliances that are now more energy efficient. It is a procedure to create energy in the form of electricity and fuels, with lower environmental footprint and minimise pollution. Thus, ideal technology maintains clean environment through its processes and avoids foot print of processes while achieving specific function.

2. Infinite business opportunities :

New technology creates new business opportunities in many areas depending upon its ability to solve problems provide innovative solutions in different areas in the society. When considering the characteristics of ideal technology, it should offer infinite business opportunities without any boundaries and constraints by creating new products / services with ideal characteristics.

3. Adaptive :

Another aim of this technology is to make the devices so advanced that they can sense the changes in the surrounding and environments and change themselves accordingly. This way, they become adaptive enough to function as per the necessary changes and preferences.

4. No side effects :

In addition to its intended benefits, every design is likely to have unintended side effects in its production and application. On the one hand, there may be unexpected benefits. For example, working conditions of the workers may become safer when materials are moulded rather than stamped, and materials designed & developed for space vehicles may become useful in consumer products. On the other hand, substances or processes involved in production work may harm production workers or the public in general giving rise to side effects; for example, sitting in front of a computer for long period may strain the eyes and lead to isolation from other employees. There may be enhanced opportunity and increased employment for the people involved in the new technology, which in turn decreases employment for others involved in the old technology. This may change the nature of the work people must do in their jobs. But ideal technology should be free from all such kind of side effects so that it should be safe for users, and environment.

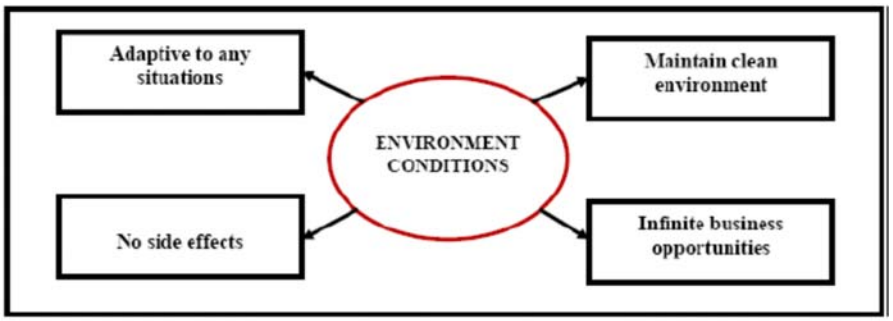

Fig. 3.5 : Environment characteristics of Ideal technology

3.2.4. Challenges to Achieve Ideal Technology :

To realize the Ideal Technology in practice, we need to identify a general purpose technology which should manipulate the fundamental nature of matter. The technology should be microscopic and able to provide solutions to the problems and challenges of fundamental needs of human beings and also support the processes requited to enhance the comfortability of the people. The products/services developed through such technology should have properties, at least close to ideal technology properties. The presently developed technologies like agricultural technology, space technology, computer technology, electronics & communication technology, automobile technology, bio-technology, and laser technology are unable to show all the characteristics which are close to ideal technology characteristics mentioned above.

3.2.5. Nanotechnology as Ideal Technology :

The emerging nanotechnology is expected to solve both basic needs and comfort needs of human beings. The basic needs of human being are food, drinking water, energy, cloth, shelter, health and environment and the comfort needs are realizing the automation in every field, space

travel and expanded life-span and so on. Nanotechnology is the manipulation of matter on an atomic, molecular, and supra-molecular scale. The earliest, widespread description of nanotechnology [40-41], referred to the particular technological goal of precisely manipulating atoms and molecules for fabrication of macro scale products, also now referred to as molecular nanotechnology. Some of the applications of nanotechnology initially thought are :

• Clean, secure, affordable energy;

• Stronger, lighter, more durable materials;

• Low-cost filters to provide clean drinking water;

• Medical devices and drugs to detect and treat diseases more effectively with fewer side effects;

• Lighting that uses a fraction of the energy associated with conventional systems;

• Sensors to detect and identify harmful chemical and biological agents; and

• Techniques to clean up harmful chemicals in the environment.

Nanotechnology is sometimes referred to as a general-purpose technology. That's because in its advanced form it will have significant impact on almost all industries and all areas of society. It will offer better built, longer lasting, cleaner, safer, and smarter products for the home, for communications, for medicine, for transportation, for agriculture, and for industry in general [39].

(1) Food : Nanotechnology innovations in agriculture is expected to solve the problems in food sector and maximizes productivity in agriculture. There is an ever-increasing demand for food and adequate nutrition, while world grain harvest has fallen short for the last four years. Biodiversity is being destroyed worldwide with 9.4 hectares of forest being lost annually. Half of our world's forests and a quarter of our coral reefs are gone. The world population is currently at 6.4 billion and is estimated to swell to 8.9 billion by the year 2050. It is anticipated that 98% of this growth will be in poorer countries. It is also predicted that there will be 5 billion city dwellers by 2030 which will place heavy demands on the growth and distribution of food. Nanotechnology will provide solutions through precision farming using nanosensors, nano-pesticides, and inexpensive decentralized water purification. A more advanced nanotechnology solution will be plant gene therapy; creating pest resistant, high yield crops that require less water.

(2) Drinking Water : Nanotechnology has potential to provide efficient, cost effective and environmentally sustainable solutions for supplying portable water for human use and clean water for agricultural and industrial uses. Nanotechnology innovations in low cost water

purification is expected to solve drinking water problem of the world. Water is one of the Earth's most precious natural resources. Most of it is saltwater. Fresh usable water is only 3% of the world's supply and two-thirds of that is frozen in glaciers, ice caps and icebergs. The remaining 1% is available for human consumption. Today 1.1 billion people don't have access to safe water and 2.4 billion lack sanitation facilities.80% of developing world diseases are water-borne with an estimate of 3.4 million deaths, mostly children, in 1998 of water-related diseases. Demand for fresh water is increasing. Agriculture currently uses 70% of the world's water supply. To feed 2 billion more by the year 2030 there will be a 60% increase in demand on the water supply. Considering the current rates of consumption, population and development, some two-thirds of the world population will be affected by droughts by the year 2050. Nanotechnology will provide solution for this challenge through inexpensive decentralized water purification, detection on the molecular level of contaminants, and greatly improved filtration systems. This helps conversion of sea water into drinking water at very low cost.

(3) Renewable Energy : Nanotechnology innovations in renewable energy solves entire energy requirement of human beings for their basic needs and for the comfortable life. Balancing humankind's need for energy with the environmental cost to our planet is a major challenge. Demand for energy on earth is forecasted as increasing 50% by the year 2025 with most of these being fossil fuels. Currently over 1.6 billion humans have no access to electricity and2.4 billion rely on plant material, vegetation, or agricultural waste as an energy and heating source. Our fossil fuel consumption is escalating and could become double by the year 2025. Meanwhile, Earth's glaciers are receding, theCO_2 concentrations in the atmosphere have nearly doubled, and world temperatures, recorded since 1861, were the hottest in three of the past five years. 1998 was the warmest of record, 2001 came in the second warmest and 2004 was the fourth warmest [42]. Nanotechnology will help to solve our need for energy solutions through more efficient lighting, fuel cells, hydrogen storage, solar cells, locally distributed power generation, and decentralized generation and storage by reinventing the power grid.

(4) Clothing : Nanotechnology based cloths are presently available in market. Making composite fabric with nanosized particles or fibers allows improvement of fabric properties without a significant increase in weight, thickness, or stiffness as might have been the case with previously-used techniques. It supports creating fabrics that do not wrinkle, stain, or allow the growth of bacteria. Anti-microbial socks, underwear, and sporting apparel; wind and water proof jackets; wrinkle and stain resistant suits and casual wear; and swimsuits that protect

against UVA and UVB rays are all products that are treated with nanocoatings or use nanotechnology in the manufacturing process. The advantages of nanotech fabrics are water and stain resistant, insulates against heat or chill, dirt rinses off in rain similar to property of the lotus plant, reduces odours and bad smell [43].

(5) Shelter : Nanotechnology offers interesting new opportunities in the construction sector through the development of energy efficient, ultra-high strength, extra durable, extremely lightweight construction materials. Preceded by the IT and software revolution, Nanotechnology and Science are expected to usher a new paradigm shift in all spheres of technology including infrastructure and construction. In a nutshell, Nanotechnology is today recognised as a revolutionary technology that can help address key needs relating to energy, environment, health, shelter and agriculture in developing countries. It has been estimated that $ 1 trillion worth of products worldwide will incorporate nanotechnology in key functional components by the year 2015. To achieve this goal, the Govt. of India has launched an ambitious mission mode programme with a budgetary allocation of Rs. 1000 crore under which several major research initiatives have been initiated. Nano-modification of cement is an emerging field. Synthesis and assembly of materials in the nano-meter scale offers the possibility for the development of new cement additives such as novel super-plasticisers and nano particles. It is now possible to manipulate the fundamental structure of cement phases to control concrete properties, performance and durability. Nano-modification also provides crucial information for predicting the service life of concrete more accurately and insights on improving it further. Nanotechnology may have its biggest impact on the medical industry. Patients will drink fluids containing nanorobots programmed to attack and reconstruct the molecular structure of cancer cells and viruses. There's even speculation that nanorobots could slow or reverse the aging process, and life expectancy could increase significantly. Nanorobots could also be programmed to perform delicate surgeries such nanosurgeons could work at a level a thousand times more precise than the sharpest scalpel. By working on such a small scale, a nanorobot could operate without leaving the scars that conventional surgery does. Additionally, nanorobots could change your physical appearance. They could be programmed to perform cosmetic surgery, rearranging the atoms of human body to change his ears, nose, eye colour or any other physical feature he wishes to alter.

(6) Human health : The important and major area of nanotechnology research is in human health. Humans are living longer lives. In the previous centuries, men and women expected to live to 48 and 51 years respectively. But life expectancy is now 74 and 80 years and could be

significantly longer with anti-aging advancements currently being developed. At the same time, 30 new highly infectious diseases have been discovered in the last 20 years. These diseases account for 30% of the deaths worldwide and include HIV/AIDS, Ebola and the Avian Flu. HIV/AIDS, the most critical threat, has killed 22 million and infected 42 million. In 2003 roughly 5 million people became infected worldwide. AIDS according to a United Nations study is increasingly becoming global as it spreads rapidly to Eastern Europe and Asia. Cancer kills over 500,000 people and 1.5 million are diagnosed annually in the United States.

According to the World Cancer Report, there could be a 50% increase to 15 million new cases in the year 2020 primarily attributed to an aging population worldwide. Recent nanotechnology research is making tremendous progress in the medical field. Some of the nanotechnology applications in the arena will be inexpensive and rapid diagnostics, new methods of drug delivery, and faster development of new drugs. Some longer term and even more powerful nanotechnology solutions will repair DNA and cellular damage and customize drug therapy. In the Expert Opinion essays, longer-term applications of advanced nanotechnology to health and longevity are explored [44].

(7) Environment & Climate : There is an ever-increasing demand for natural resources and living space for humans, while toxics continue to build up in our water and soil. Biodiversity is being destroyed worldwide with 7 million hectares of forest being lost annually. Half of our world's forests and a quarter of our coral reefs are gone. Biodiversity decreases each year, with increasing threats especially to the oceans. Damage to the atmosphere's ozone layer has slowed but a hole still remains. Many believe that man-made greenhouse gases are causing disruption to the planet's climate, a process popularly termed 'global warming.' Proposals to correct this are expensive and unlikely to be followed by developing nations who see economic advance as more urgent. Nanotechnology will provide solutions through precision pollution monitoring using nanosensors, lower energy needs due to lightweight strong materials, and reducing the use of harsh cleansers through the applications of nanocoatings to surfaces. A more advanced nanotechnology solution will be building our products with molecular-level precision through the use of productive nanosystems, resulting in virtually no chemical waste.

Table 3.2: Comparison of nanotechnology with ideal technology model.

S. No.	Major Problems of human beings in the Society	Ideal technology solution	Nanotechnology solution
1	Nutritious food for everybody	Basic feature of Ideal technology	Possible to solve using nanotechnology in agriculture.

2	Clean drinking water for everybody	Basic feature of Ideal technology	Possible to solve using nanotechnology filters
3	Renewable energy at affordable cost	Basic feature of Ideal technology	Possible through nanotech solar cells & battery technology
4	Quality and long lasting cloth	Basic feature of Ideal technology	Possible to solve using nanotechnology in fabrics.
5	Affordable Shelter to every body	Essential feature of Ideal technology	Possible to solve using nanotechnology in construction.
6	Health care	Basic feature of Ideal technology	Possible to solve using nanotechnology in medicine.
7	Environment & climate	Essential feature of Ideal technology	Possible to solve using nanotechnology as clean technology.
8	Sustainable technology for every body	Essential feature of Ideal technology	Due to its fundamental nature, nanotechnology is sustainable for everybody and everywhere.
9	Comfort life	Luxurious feature of Ideal technology	Possible to solve using nanotechnology in customer products & ability to upgrade all other technologies.
10	Space travel	Luxurious feature of Ideal technology	Nanotechnology supports low cost & efficient space travel.
11	Life span expansion	Desirable feature of Ideal technology	Bio-medical applications of nanotechnology supports life span expansion.

(8) Sustainable transportation, & information communication technology for everybody : Nanotechnology will become a key enabling platform technology for next generation transportation systems to develop more efficient and lighter materials for automotive and aircraft systems, High performance tyres for automobiles, efficient and non-platinum based catalytic converters. Novel and more efficient fuel and power sources etc. There are currently many people who lack widespread access to communications, information, basic technology services, and tech resources. This lack of access creates insurmountable barriers to education, democratization, and economic growth. The use of nanotechnology applications will drastically reduce the cost and increase the performance of memory, displays, processors, solar powered components, and embedded intelligence systems. It will also enable networks to be

self-configuring. These improvements would create a pervasive computing environment that would promote greater global communication, cross-cultural understanding and cooperation [45-46].

(9) Nano-factories : Nanofactories-manufacturing systems that work on the atomic & molecular scale-are gradually moving from science fiction to science fact and one day could be used to build all types of items such as drugs, semiconductor chips and even cell-sized robots that patrol the human body. The first step would be to develop nanoscopic machines, called assemblers, that scientists can program to manipulate atoms and molecules at their will. In order to make molecular manufacturing to be reality, one would need trillions of assemblers working together simultaneously. It is predicted that assemblers could first replicate themselves, and then build other assemblers. Each generation would build another, resulting in exponential growth until there are enough assemblers to produce objects. Trillions of assemblers and replicators could fill an area smaller than a cubic millimeter and could still be too small for us to see with the naked eye. Assemblers and replicators could work together to automatically construct products and could eventually replace all traditional labour methods and create a method of three-dimensional material/device printer. This could vastly decrease manufacturing costs, thereby making consumer goods plentiful, cheaper and stronger. Eventually, such 3D printers allow us to replicate anything, including diamonds, water and food. Famine could be eradicated by machines that fabricate foods to feed the hungry [47-48].

Table 3.3 : Comparison of ideal technology and Nanotechnology in terms of their characteristics.

S. No.	Ideal technology Characteristics	Conventional Technology	Nanotechnology
1	General purpose technology	Special purpose technology	General purpose due to its ability to provide solutions in many fields.
2	Self-directed & self controlled & self regulated	External control by human being is required in many cases.	Can be Self-directed & self controlled & self regulated by molecular programmed nano-machines & nano-factories.
3	Easy, simple, quick & user friendly	Most of the conventional technologies are simple, easy & user friendly.	Possible to get easy, simple & quick solutions to many problems.
4	Scalable	Not all	Scalable depending on application.
5	Omni-potent	Not applicable except mobile technology	Partially applicable for some areas.
6	Exploring new opportunities	Limited opportunities	Unlimited opportunities.
7	Infinite potential for further development	Finite potential	Infinite potential due to its general purpose nature and

			ability to solve fundamental and other problems of society.
8	Maintain clean environment	Failed drastically	This is major advantage of nanotechnology.
9	Infinite business opportunities	Limited business opportunity	Infinite business opportunities due to multiple field applications.
10	Adaptive nature	Partially possible	More or less possible
11	Manipulate the fundamental nature of matter	No	Yes due to atomic level & molecular level manipulation.
12	In-expensive & self reliable in terms of resources	No	Yes due to its fundamental nature.
13	Ubiquitous	Only few like mobile computing technology	Yes due to its fundamental general purpose nature.
14	Affordable to everybody	No	Yes in most cases due to its fundamental nature.
15	Solve basic needs	No	Yes by using only one technology.
16	Provide comfort	Partially	Yes due to its potential to solve real world problems to provide luxury to human life.
17	Equality	Partially	Yes irrespective of various affecting factors.
18	Automation	Partially	Possible in almost all application fields.
19	Immortality	No	Yes in long time span.
20	No side effects	No	Yes based on careful handling.

(10) Space-travel : The challenges facing by humanity on the earth are the result of our heavy demand on various resources and raw materials. Many of these materials can be found in space but the expense to extract them is a major barrier. In addition to cost, other obstacles to developing space are safety, reliability, and performance. According to the National Space Society there are four reasons why we need to pursue space exploration and colonization. These reasons—survival, growth, prosperity and curiosity—all point to the fact that we, as a species, want more room. Space exploration will give us a means to monitor the health of our planet, a source of resources and an outlet for our imagination. Nanotechnology will create the ability for humans to operate in space more safely. Applications where nanotechnology will impact space exploration are propulsion fuels, coatings, structural materials, smart uniforms, electronics and life support environments. These will be more efficient, stronger, self-healing and lighter than what is currently available.

(11) Extended life span : There are two ways in which nanotechnology may be able to extend our lives. One is by helping to eradicate life-threatening diseases such as cancer, and the other is by repairing damage to our bodies at the cellular level - a nano version of the fountain of youth. The most exciting possibility exists in the potential for repairing our bodies at the

cellular level. Techniques for building nanorobots are being developed that should make the repair of our cells possible. For example, as we age, DNA in our cells is damaged by radiation or chemicals in our bodies. Nanorobots would be able to repair the damaged DNA and allow our cells to function correctly. This ability to repair DNA and other defective components in our cells goes beyond keeping us healthy: it has the potential to restore our bodies to a more youthful condition. The extension of the human lifespan could be facilitated through the removal of a substance called lipofuscin from certain types of non-dividing cells, including the brain, heart, liver, kidneys and eyes. Lipofuscin is a metabolic end product that accumulates primarily within lysosomes (the garbage disposal organelles within cells). It's thought that when lipofuscin accumulates to certain levels, it begins to negatively impact cell function, which eventually manifests in many age related conditions. Aubrey de Grey et al. have proposed that soil bacterial enzymes might have the capacity for degrading lipofuscin. It is proposed that humans might live as long as1,000 years under the appropriate rejuvenative therapies. In 30 or 40 years, we'll have microscopic machines travelling through our bodies, repairing damaged cells and organs, effectively wiping out diseases. The nanotechnology will also be used to back up our memories and personalities. And in 35 to 40 years, we literally will be immortal [49]. Table 3.3 compares the possible ideal technology solutions with nanotechnology solutions for solving major problems of human being in the society.

The system properties like - General purpose technology, Self-directed & self controlled & self regulated, easy, simple, quick & user friendly, Scalable, Omni-potent, exploring new opportunities, Infinite potential for further development, the environmental conditions like - Maintain clean environment, Infinite business opportunities, Adaptive nature, and no side effects nature of ideal technology are also can be realizable using nanotechnology for various products/services. The input properties like - Manipulate the fundamental nature of matter, In-expensive &self reliable in terms of resources, Ubiquitous, Affordable to everybody; the output conditions like – Solve basic needs, Provide comfort, Equality, Automation, Immortality of ideal technology model also realizable to certain extent using nanotechnology as shown in Table 3.3.

3.3 OPPORTUNITIES & CHALLENGES FOR GREEN TECHNOLOGY

A sustainable society is founded on equal access to nutritious food, clean drinking water, health care, smart shelter, education, energy, economic opportunities and employment. In this ideal society, humans live in harmony with their natural environment, conserving resources not only for their own generation, but also for their future generations. Each citizen enjoys a high quality

of life and there is social justice for all. Many technologies like nanotechnology, next generation nuclear power, bio-fuels, bio-plastics, smart monitoring & prediction analysis, tidal energy etc. are some of the possible sustainable technologies for future. Sustainable cities need sustainable technology for construction, maintenance and further growth. Sustainable construction means recycled construction materials, green roofs for storm water management, zero-energy buildings (those that generate at least as much renewable energy as they use), natural ventilation systems, etc., sustainable infrastructures like sustainable urban drainage systems, low-irrigation landscaping, renewable energy sources such as biogas created from sewage, etc., sustainable Transport Systems like public trains and buses that run on renewable fuels, coordinated bike paths and walkways, increased access to transport, tolls for private vehicle use, etc., and sustainable local resource production: like recycled rainwater for drinking and irrigation, farm scrapers, urban agricultural plots, farmers markets, etc. By means finding means to decrease the cost of production, maintenance, improving government policies to support research and adoption of such technologies, and educating people to promote and use such technologies in day-to-day life the sustainable technologies can be promoted.

3.3.1. Green Technologies

Green Technology (GT) is environmental healing technology that reduces environmental damages created by the products and technologies for peoples' conveniences. It is believed that GT promises to augment farm profitability while reducing environmental degradation and conserving natural resources Green technologies are sustainable technologies which will not create footprint when used for various processes/applications. Green technologies support the use of natural organic resources and avoid production of green gasses. They also consume less resource and do not support to increase the entropy of the universe. Green technologies do not support any kind of environmental degradation. They support automation of every process and hence avoid human intervention. Since they are do not support environmental degradation and contribute to creating the footprint, they are sustainable, improves the lifestyle of the people and contribute for human comfortability. The major technologies used in present day like Aircraft technology, Automobile technology, Biotechnology, Computer technology, Telecommunication technology, Internet technology, Renewable energy technology, Atomic & Nuclear technology, Nanotechnology, Space technology etc. can be made green using the principle of green technology [50-58]. Such green technologies may contribute to solving problems of the society both basic and advanced kind of civilization. The objectives of green technologies in some of the basic and advanced fields of society are listed in table 3.4.

Table 3.4 : Objectives of green technologies in various areas of the society

S. No.	Area	Objectives of green technologies
1	Agriculture	To avoid environmental degradation in agricultural processes.
2	Food Processing	To eliminate poisonous contents in food and to avoid green gas emission and environmental degradation in all food packaging processes.
3	Potable water	To large scale filter used water and sea water through green processes without environmental degradation.
4	Sustainable Energy	To develop technologies for harvesting potential natural energy sources to generate required energy to human civilization without degrading environment.
5	Consumer products	To produce variety of new generation consumer products without side effects and without degrading environment in any production, packaging and in actual use by consumers.
6	Automobiles	To produce energy efficient, zero emission automobiles using renewable energy processes.
7	Construction	To build environmental friendly, energy efficient, smart buildings.
8	Industrial Automation	To develop industrial processes which are environmental friendly, no green gas emission, recyclable waste products using green energy.
9	Computer and Information Communication	To develop and utilize environmental friendly, recyclable electronic and computer components which uses renewable energy and efficient performance.
10	Education	Use of green technology in all education services.
11	Health	Use of green technology and green processes in all health and medical services.
12	Aircraft & Space Travel	Use of green energy and green materials and environmental friendly processes in air and space travel.

3.3.2. Nanotechnology as Green Technology :

The emerging nanotechnology is expected to solve both basic needs and comfort wants of human beings. The basic needs of human being are food, drinking water, energy, cloth, shelter, health and environment and the comfort wants are realizing the automation in every field, space

travel, expanded lifespan and so on. Nanotechnology is the manipulation of matter on an atomic, molecular, and supramolecular scale. The earliest, widespread description of nanotechnology, referred to the particular technological goal of precisely manipulating atoms and molecules for fabrication of macro scale products, also now referred to as molecular nanotechnology. Planned and controlled development in nanotechnology leads to environmental sustainability and hence can be used as green technology. Some of the applications of nanotechnology initially thought as green technology are :

• Clean, secure, affordable, renewable energy;

• Stronger, lighter, more durable recyclable materials;

• Low-cost filters to provide clean drinking water from seawater;

• Medical devices and drugs to detect and treat diseases more effectively with fewer or no side effects;

• Lighting that uses a fraction of the energy associated with conventional systems;

• Sensors to detect and identify harmful chemical and biological agents; and

• Techniques to clean up harmful chemicals in the environment.

• Green building and sustainable infrastructure.

• Modified production processes to minimize green gas emission.

The green Nanotechnology is going to be evolving as a general-purpose technology due to its applications in all areas of society. Hence in the advanced form, it will have a significant impact on almost all industries and all areas of society by offering better built, longer lasting, cleaner, safer, and smarter products for the home, for communications, for medicine, for transportation, for agriculture, and for the industry in general. Thus, by controlled utilization of nanotechnology for environmental sustainability, it can be developed as green technology for sustainable society.

3.3.3. Green Technology for Agriculture and Food :

The green technology should be efficient, practical, cost effective and free from pollution. The sustainability factor should be looked at the ability of the agricultural land to maintain acceptable levels of production over a long period of time, without degrading the environment. Some define sustainability as the maintenance of productivity under stress conditions. Agricultural sustainability in this context should seek to maximize food production within constraints of profitability.

The specific challenges for green technology in agriculture are:

(1) Identifying appropriate technology suitable for income generation through sustainable agriculture i.e., ecological agriculture, rural renewable energy, etc;

(2) Examining the impact and implications of national policies for making recommendations for the extension of appropriate technology;

(3) Diagnosing policy-level impact of such green technology (GT) on rural income generation under the sustainable agriculture development framework;

(4) Reviewing the challenges and available policy options for the adoption of GT sustainable agriculture integrates three main goals-environmental health, economic profitability, and social and economic equity.

Some of the opportunities towards sustainable agriculture are:

(1) Integrated Pest Management (IPM), (2) Rotational Grazing, (3) Soil conservation, (4) Water quality/wetlands, (5) Cover crops, (6) Crop/ landscape diversity, (7) Nutrient management, (8) Agro-forestry, and (9) Marketing of green products.

The revolution in the challenge is to make applied technology competitive and sustainable nanotechnology innovations in agriculture are expected to solve the problems in the food sector and maximize productivity in agriculture. There is an ever-increasing demand for food and adequate nutrition and nanotechnology will provide solutions through precision farming using nanosensors, nano-pesticides, and inexpensive decentralized water purification. A more advanced nanotechnology solution will be plant gene therapy; creating pest resistant, high yield crops that require less water etc. which also supports a sustainable environment.

3.3.4. Green Technology for Potable Water :

Nanotechnology has the potential to provide efficient, cost-effective and environmentally sustainable solutions for supplying portable water for human use and clean water for agricultural and industrial uses. Nanotechnology innovations in low-cost water purification are expected to solve drinking water problem of the world by providing sustainable drinking water to everybody making it as green technology. Water is one of the Earth's most precious natural resources. Most of it is saltwater. Fresh usable water is only 3% of the world's supply and two-thirds of that is frozen in glaciers, ice caps and icebergs. The remaining 1% is available for human consumption. Today 1.1 billion people don't have access to safe water and 2.4 billion lack sanitation facilities. 80% of developing world diseases are water-borne with an estimate of 3.4 million deaths, mostly children, due to water-related diseases. Demand for fresh water is increasing. Agriculture currently uses 70% of the world's water supply. To feed 2 billion more by the year 2030 there will be a 60% increase in demand on the water supply. Considering

the current rates of consumption, population, and development, some two-thirds of the world population will be affected by droughts by the year 2050. Nanotechnology as a green technology will provide a solution for this challenge through inexpensive decentralized water purification, detection on the molecular level of contaminants, and greatly improved filtration systems. This helps to recycle rain water into clean drinking water, conversion of sea water into drinking water large scale at very low cost. Water purification plants functioning using green nanotechnology can produce a large amount of drinking water using renewable solar or wind energy so that the water purification plant can be sustainable with minimum maintenance cost.

3.3.5. Green Technology for Sustainable Energy :

Nanotechnology innovations in renewable energy solve entire energy requirement of human beings for their basic needs and for the comfortable life. Balancing human beings need for energy with the environmental cost to our planet is a major challenge. Demand for energy on earth is forecasted as increasing 50% by the year 2025 with most of these being fossil fuels. Currently over 1.4 billion humans have no access to electricity and 2.2 billion rely on plant material, vegetation, or agricultural waste as an energy and heating source. Our fossil fuel consumption is escalating and could become double by the year 2025. Meanwhile, Earth's glaciers are receding, the CO_2 concentrations in the atmosphere have nearly doubled, and world temperatures, recorded since 1861, were the hottest in three of the past five years. 1998 was the warmest on record, 2001 came in the second warmest and 2004 was the fourth warmest. Nanotechnology will help to solve our need for energy solutions through more efficient lighting, fuel cells, hydrogen storage, solar cells, locally distributed power generation, and decentralized generation and storage by reinventing the power grid. Nanotechnology as green technology supports large-scale renewable solar energy and wind energy production and distribution at low cost without any environmental degradation, contributing sustainable energy solution. Even though research in nanotechnology is progress towards developing highly efficient solar cells, the challenge is to achieve 100 % solar conversion efficiency.

3.3.6 Green Building Technologies :

Nanotechnology offers interesting new opportunities in the construction sector providing green solutions through the development of energy efficient, ultra high strength, extra durable, extremely lightweight construction materials. Preceded by the IT and software revolution, nanotechnology is expected to usher a new paradigm shift in all spheres of construction technology. Nanotechnology is recognised as a revolutionary green technology that can help

address key needs of green buildings relating to energy, environment, and health aspects. Nano-modification of cement is an emerging field. Synthesis and assembly of materials in the nanometer scale offers the possibility for the development of new cement additives such as novel super-plasticisers and nanoparticles. It is now possible to manipulate the fundamental structure of cement phases to control concrete properties, performance, and durability. Nano-modification also provides crucial information for predicting the service life of concrete more accurately and insights on improving it further. The challenges lie in how to improve energy efficiency and heat control of the buildings, how to improve the speed and durability of construction etc. using green nanotechnology.

3.3.7. Green Technology for Aircraft & Space Travel :

The challenges faced by humanity on the earth are the result of our ambition of flying everybody at low cost which created heavy demand on various resources and raw materials. Many of these materials can be found in space but the expense to extract them is a major barrier. In addition to cost, other obstacles to developing space are safety, reliability, and performance. According to the National Space Society, there are four reasons why we need to pursue space exploration and colonization. These reasons—survival, growth, prosperity, and curiosity—all point to the fact that we, as a species, want more room. Space exploration will give us a means to monitor the health of our planet, a source of resources and an outlet for our imagination. Nanotechnology as green technology will create the ability for humans to operate in space more safely. Potential applications where nanotechnology will impact space exploration are propulsion fuels, coatings, structural materials, smart uniforms, electronics, and life support environments. Green nanotechnology is expected to provide materials which will be more efficient, stronger, self-healing and lighter than what is currently available.

3.3.8. Green Technology for Education :

Green higher education is all about creating of knowledge, skills, attitudes and values related to the environment. It's more needed in higher education because of the dependence of environment with the economy. Higher education plays a pivotal role in creating and developing human capital. This resource that is created should not just look at the economic point of business but societal aspect as well. The demands for green jobs are on high. The solar energy and wind energy have to be still be utilized to reach out the masses in an efficient manner which calls for efficient green managers. From the construction industry to all management sector there is a need to create sustainable future which means that many green-oriented graduates are needed. The infrastructure has to be in such a way that buildings, energy

costs, reliability and performance which has a positive impact on the environment. The faculties will be promoting learning in a conducive environment where they will address local, regional and national development issues. The systems, processes, structures, procedures and devices to learn green are eco-friendly ways. Green can be used in a large way when it is open and distance learning. Continuous research on green jobs, green concepts, and promotion of it in operations management is needed. The college resources should be in a manner of commitment by top administrators, building facilities, faculties who believe in green ideology, a curriculum that supports philanthropic and interest amongst students. It is essential that sustainability is brought into the business model. The environment provides typical challenges to the current and future generation in terms of climate change, resources getting depleted, water issues, poverty, food and war issues, environment caused diseases and pollution. This is further accelerated in developing countries because of less economic development and high population explosion. Initiatives taken from the colleges and universities will help students develop knowledge, skills and attitudes to fighting with these issues. As a university, they have an important role in reviewing the various courses and degrees and address issues which address about sustainability. The teachers who are a crucial stake in this system have a great role to keep updated and informed and transfer knowledge an innovative way. The whole methodology of teaching should be learning oriented rather than teaching oriented. Pedagogy should include the real world learning experiences so that the learning is very fruitful. The subjects that can be added in this kind of systems are agriculture, organic farming, climate and atmosphere, green tourism, green medical services, green transportation etc. In this form people, planet, and profit will be achieved in all industries. Green education also includes enhancing student knowledge in using green technology. Computer and information technologies are already considered as green technologies due to their contribution to clean environment in many industrial automation processes. Green nanotechnology has been described as the development of clean technologies, to minimize potential environmental and human health risks associated with the manufacture and use of nanotechnology products, and to encourage replacement of existing products with new nanoproducts that are more environmentally friendly throughout their lifecycle. Green nanotechnology is the study of how nanotechnology can benefit the environment, such as by using less energy during the manufacturing process, the ability to recycle products after use, and using eco-friendly materials [59].

3.3.9. Green Technology for Health & Medicine

The important and major area of green nanotechnology research is in human health. Humans are living longer lives. In the previous centuries, men and women expected to live to 48 and 51 years respectively. But life expectancy is now 74 and 80 years and could be significantly longer with anti-aging advancements currently being developed. At the same time, 30 new highly infectious diseases have been discovered in the last 20 years. These diseases account for 30% of the deaths worldwide and include HIV/AIDS, Ebola, and the Avian Flu. HIV/AIDS. According to the World Cancer Report, there could be a 50% increase to 15 million new cases in the year 2020 primarily attributed to an aging population worldwide. Green nanotechnology research provides tremendous opportunity in making progress in the medical field. Some of the nanotechnology applications in the arena will be inexpensive and rapid diagnostics, new methods of drug delivery, and faster development of new drugs. Some longer-term and even more powerful nanotechnology solutions will repair DNA and cellular damage and customize drug therapy. The longer-term applications of advanced nanotechnology for sustainable health and longevity are explored. Developments are expected in pharmaceutics and green nanotechnology, which allows patients to drink fluids containing nanorobots programmed to attack and reconstruct the molecular structure of cancer cells and viruses. There's even speculation that nanorobots could slow or reverse the aging process, and life expectancy could increase significantly. Nanorobots could also be programmed to perform delicate surgeries such nano-surgeons could work at a level a thousand times more precise than the sharpest scalpel. By working on such a small scale, a nanorobot could operate without leaving the scars that conventional surgery does. Additionally, nanorobots could change our physical appearance. They could be programmed to perform cosmetic surgery, rearranging the atoms of the human body to change his ears, nose, eye colour or any other physical feature he wishes to alter [3].

The green nanotechnology may be able to extend our lives by helping to eradicate life-threatening diseases such as cancer, and the other is by repairing damage to our bodies at the cellular level--a nano version of the fountain of youth. The extension of the human lifespan could be also facilitated through the removal of a substance called lipofuscin from certain types of non-dividing cells, including the brain, heart, liver, kidneys and eyes. Lipofuscin is a metabolic end product that accumulates primarily within lysosomes (the garbage disposal organelles within cells). It's thought that when lipofuscin accumulates to certain levels, it begins to negatively impact cell function, which eventually manifests in many age-related conditions. It is proposed that humans might live as long as 1,000 years under the appropriate rejuvenation

therapies. In 30 or 40 years, we'll have microscopic machines travelling through our bodies, repairing damaged cells and organs, effectively wiping out diseases. The nanotechnology will also be used to back up our memories and personalities. And in 35 to 40 years, we literally will be immortal [29].

3.3.10. Green technology for food & processing

Food is an essential component of life and human existence. Since the beginning of time, humans have had to eat to survive. Finding a balance between food supply and demand in a manner that is sustainable and which ensures the long-term survival of the human species will be one of the most important challenges for humankind. Heavy population growth in the world during the last several centuries has made the need for sustainable food production and processing technologies even more important. Green technologies in food and food processing sector have challenges associated with the use of technologies to reduce the generation of process-induced toxins; social factors that influence consumer perceptions about some of the current and emerging agri-food technologies including nanotechnology, and the need and importance of biodiversity in maintaining sustainable diets of world populations [60]. Food processing is a diversified sector encompassing the use of various raw materials, processes, and end products and need special attention for maintaining quality, safety, and nutritional properties through green technology. Various technologies like Bio-preservation, Electromagnetic wave heating, Electric and magnetic fields, Nonthermal technologies etc. under the broad umbrella of biotechnology and nanotechnology have potential opportunities to reduce process-induced toxins in the food and environmental impact of food production and processing.

3.4 CONCEPT OF IDEAL WATER PURIFIER SYSTEM :

An ideal water purifying system removes both undissolved and dissolved impurities by removing all contamination of water using a filter which uses a fine physical barrier, a chemical process, optical process, or a biological process. It converts impure water of type and any quantity into 100% pure water. Filters cleanse water to different extents for various purposes and various purity levels which include the applications like supplying drinking water, providing water for agricultural irrigation, food processing, constructions, industrial processes, public and private aquaria, and the safe use of ponds, swimming pools, and other water-based utilities. Ideal Filters may use sieving, adsorption, ion exchanges, and other processes to remove unwanted substances from water. Unlike a sieve or screen, a filter can potentially remove particles much smaller than the holes through which its water passes. Types of water

filters include media filters, screen filters, disk filters, slow sand filter beds, rapid sand filters, cloth filters, and biological filters such as algae scrubbers. The schematic diagram of ideal water purifying system along with its internal components to convert any type of impure water to perfectly pure water is shown in figure 3.6. It takes impure water or sea water as an input, processes water for removing both dissolved and un-dissolved impurities and converts it into 100% pure water. For drinking purpose and agricultural purpose, a pre-determined amount of minerals can be added by using the mineral mixing system.

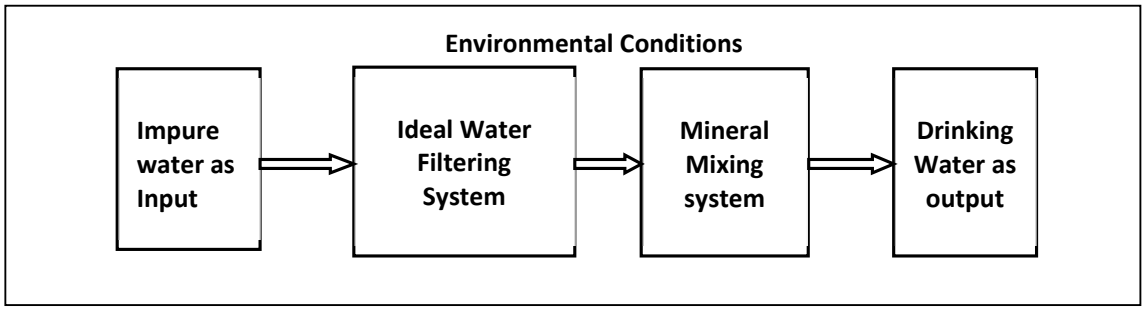

Fig. 3.6 : Block diagram of Ideal water purifier system

3.4.1. Characteristics of an Ideal Water Purifier System :

The system model of Ideal water purifier allows us to discuss its characteristics in terms of input conditions, Purifier Requirements, output conditions, and environmental conditions.

Input Conditions :

(1) Ideal water purifier takes any type of impure water for purification.

(2) Ideal water purifier takes any amount of input water at a time for purification.

(3) Scalable system to any level.

Purifier System Requirements :

(4) Ideal water purifier produces 100% pure water for any level for any type of input impurity.

(5) Ideal water purifier system removes both undissolved and dissolved impurities completely.

(6) Ideal water purifier filters water instantly and there is no time lag between input and output.

(7) Ideal water purifier does not consume any external power for filtering process – self reliable system.

(8) Ideal water purifier does not consume any resources for its operation. Hence it has zero operating cost.

(9) Zero investment & zero maintenance cost.

(10) Simple technology & easy to use.

(11) Long life & reliability.

(12) Self-directed & self-controlled & self-regulated system.

(13) Programmability to decide the output quality.

Output Requirements :

(14) Ideal water purifier produces 100% pure water

(15) Ideal water purifier produces zero wastage of water

(16) Separation of by-products for reuse.

(17) Provision to add minerals for specified applications

Environmental Conditions :

(18) No environmental degradation

(19) Safe to use.

(20) Location independency.

(21) Portability.

3.4.2 Analysis of Ideal Water Purifier Characteristics :

Ideal water purifier characteristics can be explained based on their effectiveness in improving the quality of water purification. The characteristics mentioned in the ideal water purifier model are depicted in figures 3.7–3.10 and further discussed below :

3.4.2.1 Input Conditions :

(1) Purifying any type of impure water : Ideal water purifier takes any type of impure water for purification. Impure water usually contains either suspended impurities or dissolved impurities or both. Suspended impurities are substances that are not completely soluble in water and are present as particles. These particles usually impart a visible turbidity to the water. Dissolved impurities may contain dissolved minerals like chlorides, sulphates, bicarbonates of sodium, magnesium, calcium, and iron. Wastewater contains both suspended impurities and dissolved impurities including substances such as human waste, food scraps, oils, soaps, and chemicals. Ideal water purifier should have the capability to treat and purify any type of impure water including, salty water, groundwater, wastewater, sewage, river water, etc. for both drinking and agricultural applications. It also allows recycling of water in industrial and household applications.

(2) Purifying any amount of water: Ideal water purifier takes any amount of input water between zero to infinity at a time for purification. This allows purification of water for small-scale (home) to large scale (industrial/agricultural) applications. The ideal water purifier can purify and desalinate sea water in any quantity as well as recycling of used water from any application.

(3) Scalability : Ideal water purifier is a scalable system to any level. It can be used in homes, offices, business units, industries, or irrigations and can take a small amount or a large amount of water at a time at input depending on output requirement.

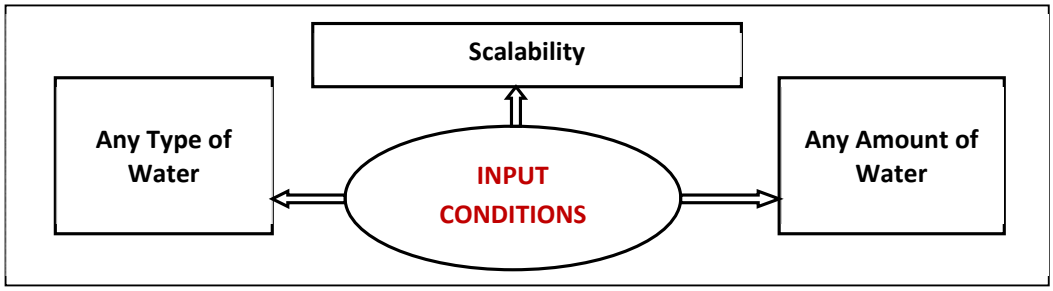

Fig. 3.7 : Input condition characteristics of Ideal Water Purifier

3.4.2.2 Purifier System Requirements :

(4) Production of Pure Water : Ideal water purifier produces 100% pure water for any input level and any type of input impurity. The system removes all undissolved and dissolved impurities including physical, chemical and biological impurities.

(5) Removes all impurities : Ideal water system removes both undissolved and dissolved impurities completely. The undissolved physical impurities like dust, fine sand, clay, rust, etc remain suspended in the water and cause muddy water or cloudiness in water. The amount of chemical impurities dissolved in the water and is usually expressed as 'parts per million' (ppm) or as 'milligrams per liter' (mg/L). The biological impurities like algae, bacteria, protozoa, pathogens, microbes, Viruses, Parasites and their eggs etc. collectively known as microorganisms or germs also contaminates the water and causes various diseases to human beings.

(6) Instantaneous Process : Ideal water purifier converts impure water into pure water instantly and there is no time lag between input and output. This characteristic avoids any processing delay between input and output and hence ensures that all processes used for removal of dissolved and undissolved impurities are ideal processes. This characteristic nullifies the waiting time of the user.

(7) Self-Reliable System : Ideal water purifier does not consume any external power for filtering process. In that sense it is a self-reliable system. Either it produces its power requirement internally or its processes do not need any external power for filtering both tangible and intangible contaminations.

(8) Zero Operating Cost : Ideal water purifier does not consume any resources for its operation. Hence it has zero operating cost.

(9) Zero Investment : By definition, an ideal water purifier system requires zero investment and zero maintenance cost. There is no cost for fabrication of such system. Since it has no operating cost and repairing cost, its maintenance cost is also predicted as zero.

(10) Easy to Operate : Ideal water purifier must be simple for operation and must use simple technology. The simple technology of the system makes easy to operate so that non-technical people should also able to use the system.

(11) Long life &Reliability : Since the ideal water purifier does not need maintenance, it works comfortably for long time without any trouble. Hence such system is reliable and independent on internal failure and environmental catastrophe.

(12) Self-directed, self-controlled & self-regulated System : The ideal water purifier system is a hypothetical system completely independent on external control and external stimulation so that it is a self-regulated and self-directed system. Hence to control the system, human intervention is not required.

(13) Programmable : The ideal water purifier can be programmable to get different water quality at the output for different applications like pure water, drinking water, irrigation water etc. and to get output water for different time intervals.

3.4.2.3 Output Requirement :

(14) Pure water at Output : Ideal water purifier produces 100% pure water at output irrespective of the quality of input water. Such pure water is free from any type of minerals, germs, and any other dissolved & undissolved impurities. For potable purpose, additional minerals in pre-determined amount can be added using a mineral adding subsystem.

(15) Produces Zero Wastage of water : Ideal water purifier will not waste any water during the purifying process. All input water is processed in such a way that the impurities are separated in the form of their actual format and not in liquified format. This avoids wastage of water during impurity separation process.

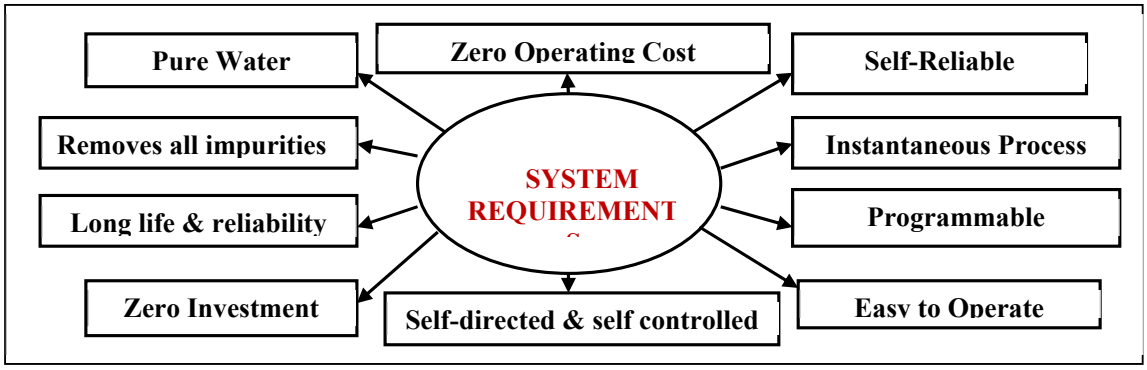

Fig. 3.8 : System Requirement characteristics of Ideal Water Purifier

(16) Separation of by-products for reuse : In ideal water purifier, the dissolved and undissolved impurities get separated in such a way that they can be reused in their original form either as fertilizers or minerals.

(17) Provision to add minerals : For specified applications like producing drinking water/water for irrigation, using additional subsystem, one can add required minerals at the output of ideal water purifier system.

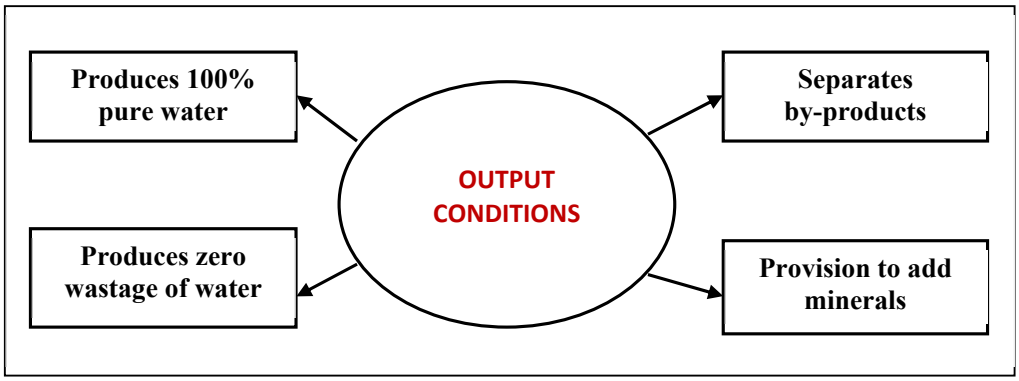

Fig. 3.9 : Output condition characteristics of Ideal Water Purifier

3.4.2.4 Environmental Conditions :

(18) No environmental degradation : In ideal water purifier, the purification process takes place internally without consuming any external resources. As a result, no emission of unwanted green house gases or poisonous by-products to the environment. Hence there is no environmental degradation/pollution occurs.

(19) Safe to use : Since ideal water purifier, is a self-controlled, self-regulated and self-directed system, without consuming any resources externally for its operation, it is safe to use and monitor while producing pure water at output.

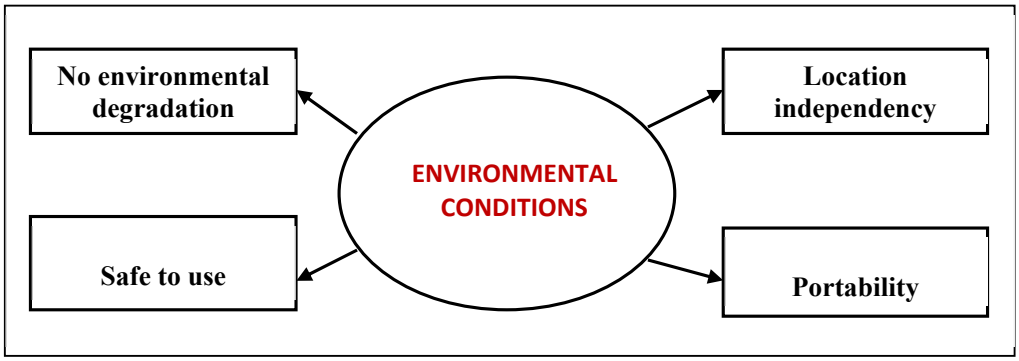

Fig. 3.10 : Environmental condition characteristics of Ideal Water Purifier

(20) Location independency : The performance of ideal water purifier is independent on the geographical region. It should give satisfactory performance at output for any quality of input water at any location in the whole universe.

(21) Portability : An ideal water purifier functions equally in any geographical location and hence portable to any place.

3.4.3. Challenges to Achieve Ideal Water Purifier :

Conventional water-treatment technologies include filtration, ultraviolet radiation, chemical treatment, and desalination. The general method uses five stages including coagulation, flocculation, sedimentation, filtration, and disinfection. Such conventional water treatment, include a pre-filter for filtrating sediment and removing debris from received water; an ionization and oxidation unit for sanitizing water received from the pre-filter; an ultraviolet (UV) light unit for sanitizing water received from the ionization and oxidation unit with ultraviolet (UV) light; a reverse osmosis (RO) unit including a series of membranes for removing impurities from water received from the ultraviolet (UV) light unit; a remineralization filter for reinfusing water received from the reverse osmosis (RO) unit with trace minerals and salts; and an alkalinization and ionization with integrated (UV) light filtration unit for performing an electrodialysis process on water received from the remineralization filter. But these systems cannot be scalable easily, high cost, and high energy consuming methods needs further improvement in performing in various stages of the purification process.

Another method frequently used to treat iron manganese, and traces of hydrogen sulphide in utility plants is called Manganese greensand filtration system. It is found that high levels of manganese and iron dissolved in water will damage plumbing fixtures, give water an unpleasant taste and colour and provide nutrients to certain strains of bacteria. The manganese greensand filtration system does not use coagulation and flocculation, but it typically uses aeration and chlorination (or any other type of oxidant addition) followed by pH adjustment of the water.

Most of the seawater desalination systems are energy intensive, which consume a large amount energy like gas, electricity, oil and fossil fuels. These processes lead to carbon footprints, which causes depletion of ozone layer as well as health hazards on mankind. The potential of harnessing solar energy is most efficient and effective for heat to heat conversion. The thermal desalination is a low temperature application processes with one-time investment for life time water production up to 10 to 15 years. There are a variety of solar thermal desalination methods

such as direct and indirect methods are being used. The indirect methods are preferable for medium and large-scale desalination systems, whereas the direct methods employing the solar stills are more suitable for small scale systems. The performance of the low cost solar stills can be improved with simple modification by using various locally available materials. These low-cost stills can be easily and economically fabricated for meeting the daily need of the fresh drinking water. These low cost solar stills are sufficient for the small households and communities living in islands, coastal areas. It can also be used for distillation of brackish water for the population residing near river banks. Such a system also suitable for the fluoride affected area to remove fluoride from the water. The low cost solar water purifier is sufficient for the removal of arsenic, mercury, cadmium, coliform, virus, and bacteria [61-62]. Various constraints and disadvantages associated with such system for scalability and to make location independence are discussed [62].

Thus achieving ideal characteristics like : any type of impure water for purification, any amount of input water at a time for purification, scalable system to any level, producing 100% pure water for any level for any type of input impurity, removing both undissolved and dissolved impurities completely, developing purifier which operates instantly with no time lag between input and output, system which does not consume any external power for filtering process – self reliable system, system which does not consume any resources for its operation and hence has zero operating cost, Zero investment & zero maintenance cost, Simple technology & easy to use, Long life & reliability, Self-directed & self-controlled & self-regulated, Programmability to decide the output quality, produces 100% pure water, system which produces zero wastage of water, Separation of by-products for reuse, Provision to add minerals for specified applications, No environmental degradation, Safe to use, Location independence, and Portability etc is difficult using conventional purifier methods and technology. Further, current technologies for purifying contaminated and impure waters are typically expensive and ion specific, and therefore a significant need for new technologies and approaches.

3.4.4. Possibility of Realization of Ideal Water Purifier Using Nanaotechnology :

Nanotechnology is emerging as multi-disciplinary new frontier of Science & Technology capturing the imagination of scientists and engineers worldwide due to its potential applications in solving many problems/needs/requirements of human beings. Nanotechnology has the ability to provide cost effective, efficient, and environmentally sustainable optimum solutions for supplying potable water for drinking and clean water for irrigation and industrial uses. Using nanotechnology innovation, one can develop low cost water purifiers to solve the

drinking water problem of the world. Water is one of the Earth's most precious natural resources. Most of the water available on the earth surface is saltwater. Only 3% of the world's supply is drinking/sweet water and two-thirds of it is frozen in glaciers, ice caps, and icebergs. The remaining 1% is available for human consumption. As per the reports, today 1.1 billion people don't have access to safe water and 2.4 billion lack sanitation facilities. 80% of developing world diseases are water-borne with an estimate of 3.4 million deaths, mostly children, in 1998 of water-related diseases. Demand for fresh water is increasing. Agriculture currently uses 70% of the world's water supply. To feed 2 billion more by the year 2030 there will be a 60% increase in demand on the water supply. Considering the current rates of consumption, population, and development, some two-thirds of the world population will be affected by droughts by the year 2050. Nanotechnology will provide a solution for this challenge through inexpensive decentralized water purification, detection on the molecular level of contaminants, and greatly improved filtration systems. This helps the conversion of seawater to drinking water at a very low cost [3]. The use of highly advanced nanotechnology ideas and concepts to traditional process engineering opens new opportunities in technological developments for advanced water and wastewater technology processes. The nano-enabled technologies include a variety of different types of membranes and filters based on carbon nanotubes, nanoporous ceramics, magnetic nanoparticles and other nanomaterials. Ref. [63] contains a comparison between conventional and nano-enabled technologies for water treatment.

Separation membranes with the structure at the nanoscale can also be used in low-cost methods to produce potable water. In a recent study in South Africa, several polymeric nanofiltrations and reverse osmosis membranes were tested for the treatment of brackish groundwater. The tests showed that nanofiltration membranes can produce potable water from the brackish groundwater. As expected, the reverse osmosis membranes removed about 99% of all the solutes, but the concentrations of essential nutrients, such as calcium and magnesium ions, were reduced to levels that were below the specifications of the World Health Organization standard for drinking water. The product water, therefore, had to be spiked with these nutrients to provide drinking water of the required quality.

Nano-enabled technologies for water treatment are already on the market — with nanofiltration currently seeming to be the most mature — and many more are on their way. Although the current generation of nanofilters may be relatively simple, many researchers believe that future generations of water-treatment devices will capitalize on the new

properties of nanoscale materials and may prove to be of interest in both developing and developed countries [64-76].

A huge amount of research results has been published since 1980 on the idea of the use of various nanomaterials and nanocomposites as water purification filters for both dissolved and undissolved impurities. Nanomembranes are very useful for treating and purify any type of impure water including, salty water, groundwater, wastewater, sewage, river water, etc. for both drinking and irrigation applications. Table 3.5 contains some of the published results of use of nanotechnology for different types of water purification processes.

Table 3.5 : Use of nanotechnology for different types of water purification processes

S.No.	Purification process	Nanomaterial/system used	Reference
1	Water desalination	Carbon nanotube membranes	Das, R., et al [77]
2	Removal of contaminants	Carbon nanotube technology	Upadhyayula, V. K., [78]
3	Removal of arsenic	Nanoparticles of hydrous iron oxide	Sylvester, P. et al [79]
4	Water disinfection and microbial control	Antimicrobial nanomaterials	Li, Q., et al [80]
5	Cleaner water	Bimetallic nanoparticle catalysts	Wong, M. S. et al [81]
6	Water disinfection and microbial control:	Antimicrobial nanomaterials	Mahendra, S. et al [82]
7	Ultrafast permeation of water	Protein-based nanomembranes	Peng, X. et al [83]
8	Heavy metal removal and disinfection control	Smart magnetic graphene	Gollavelli, G. et al [84]
9	Water decontamination	Novel magnetic nanoparticles	Zhang, X. et al [85]
10	Removal of arsenic	Nanocrystalline magnetite	Mayo, J. T. et al [86]
11	Virus inactivation for drinking water treatment	Silver doped titanium dioxide nanoparticles	Liga, M. V. et al [87]
12	Point-of-use drinking water disinfection	Silver nanoparticle-alginate composite beads	Lin, S. et al [88]
13	Nitrate removal from water	Nano-alumina	Bhatnagar, A. et al [89]
14	Complete removal of pathogenic bacteria from drinking water	Nano silver-coated cylindrical polypropylene filters	Heidarpour, F. et al [90]
15	Point-of-use water treatment	Bactericidal paper impregnated with silver nanoparticles	Dankovich, T. A. et al [91]
16	Providing Safe and Clean Water to Each Individual	Magnetic nanoparticles	Roy, E. et al [92]
17	Drinking Water Treatment	Hybrid Nanoadsorbents	Gupta, A. K. [93]
18	Drinking water purification	Nanocomposite filtration membranes	Anadão, P. [94]
19	Elimination of hazardous fluoride from drinking water	Th–Mn nanoadsorbent.	Tomar, V. [95]
20	Rapid water disinfection	Vertically aligned MoS_2 nanofilms and visible light.	Liu, C. [96]
21	Phosphate Removal from Wastewater.	Modification of Titanium Dioxide Nanoparticles	Antwi, D. M. B. [97]

22	Universal water purification	Amyloid–carbon hybrid membranes	Bolisetty, S. [98]
23	General water purification.	Magnetic graphene–carbon nanotube iron nanocomposites as adsorbents and antibacterial agents	Sharma, V. K. [99]
24	High efficiency water purification	$Fe(OH)_3/g\text{-}C_3N_4$ composite membrane	Wang, Y. et al [100]
25	Water desalination	Single-layer MoS_2 nanopore	Heiranian, M. et al [101]
26	Water desalination	Graphyne as the membrane	Kou, J. et al [102]
27	Antibacterial behaviour for water purification	Halloysite nanotubes decorated with copper nanoparticles in a novel mixed matrix membrane	Duan, L. et al [103]
28	Adsorption, photodegradation and antibacterial study of for multipurpose water purification application	Graphene–Fe_3O_4 nanocomposite	Santhosh, C. et al [104]
29	Fast water purifier	Cellulose nanofiber intermediary to fabricate highly-permeable ultrathin nanofiltration membranes	Soyekwo, F. et al [105]
30	Water purification for disinfection	Silver–magnetic nanocomposites	Surendhiran, D. et al [106]
31	Effective Water purification	Polymer nanocomposites	Pandey, N. et al [107]
32	Removal of inorganic pollutants, organic pollutants, and biological pollutants.	Inorganic, organic, and inorganic-organic hybrid nanoporous membranes.	Wang, Z. et al [108]
33	General water purification	Gelatin hydrogel nanocomposites	Thakur, S. et al [109]
34	Drinking Water Production	Chitosan-based Nanocomposite Beads	Masheane, M. L. et al [110]
35	Water purification and its applicability to volatile organic compounds	Zinc oxide nano-enabled microfluidic reactor	Azzouz, I. et al [111]
36	Antibacterial water treatment	Nanosized metal oxides (NMOs) and polyoxometalates (POMs)	Carraro, M. et al [112]
37	Removal from Wastewater	Titanium Dioxide Nanoparticles for Phosphate	Antwi, D. M. B. et al [113]

By cascading of different types of nanomembranes in a serial manner for removing all type of impurities leads to the production of pure water in any scale and can be called as universal nanotechnology water purifier as shown in figure 3.11. This leads to the development of universal water purifier at low cost and low energy consumption which is going to be a step towards achieving ideal water purifier.

Where
F1 = Physical Impurities Filter
F2 = Inorganic Impurities Filter
F3 = Organic Impurities Filter
F4 = Biological Impurities Filter

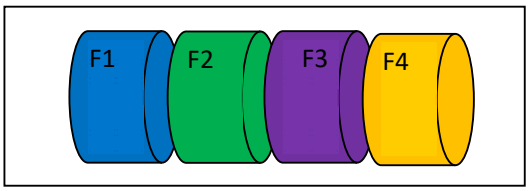

Fig. 3.11 : Block diagram of Cascaded universal water purifier using nanotechnology filters

3.4.5. Risk of nanotechnology in producing Drinking Water :

Though nanotechnology shows potential opportunities for developing devices for water-treatment, there is also a need to do further research to assess the possible human health and environmental risks. There are only a few studies have been carried out, and it is expected that the unique properties of nanomaterials (for example, size, shape, reactivity, conductivity) may convert water to be toxic [114]. Thus, it is imperative that information about possible risks and risk-management approaches should be developed and monitored systematically and need to be weighed up against the potential benefits [115-117].

3.4.6. ABCD Listing of Use of Nanotechnology Based Universal Water Purifier :

Many analysing frameworks are used to study any system or a model which include, SWOT [118], SWOC [119], PEST [120], ABCD [121-122], Competitive Force Model [123] etc. In this paper, for analysing a practical water purifier system using nanotechnology, we felt that ABCD qualitative analysing framework is found suitable. In ABCD qualitative analysing framework [124-133] lists the Advantages, Benefits, Constraints, and Disadvantages of realizing such a system from various stakeholder's point of view are discussed.

1. Advantages :

(1) Nanotechnology based filters are small in size and high mechanical strength.

(2) Nanotechnology based filters can be cascaded for filtering different types of impurities.

(3) Nanotechnology based filters can be fabricated to any structure so that it can be scaled to any extent.

(4) Filters any type of input impurity 100 %.

(5) Nanotechnology based filters remove both undissolved and dissolved impurities completely.

(6) Nanotechnology based membranes filter water instantly.

(7) Nanotechnology based filters do not consume any external power for filtering process – self reliable system.

(8) Nanotechnology based filters do not consume any resources for its operation.

(9) Nanotechnology based filters have very low investment cost/per filter for large scale production.

(10) The technology behind nanotechnology based universal filter is simple.

(11) Nanotechnology based universal water purifier has a long working life.

(12) Nanotechnology based universal water purifier can be programmable to decide the quality of output.

(13) Nanotechnology based water purifier is not producing any impure water outlet.

(14) Nanotechnology based universal water purifier separates by-products at individual filters.

(15) Nanotechnology based universal water purifier has provision to add minerals at output.

(16) It is assumed that nanotechnology based universal water purifier does not make environmental degradation.

(17) The performance of nanotechnology based universal water purifier is location independent.

2. Benefits :

(1) Nanotechnology based universal water purifier light in weight.

(2) Nanotechnology based universal water purifier filters all kind of impurities.

(3) Any amount of input water can be purified at a time.

(4) Purity of output water is 100 %.

(5) Nanotechnology based filters are useful for removal of both undissolved and dissolved impurities completely.

(6) The instantaneous filtering property gives the benefit of no time lag between input and output.

(7) Since there is no external power required for filtering process, nanotechnology based universal filter is a self-reliable system.

(8) Nanotechnology based filters has no operating cost.

(9) Nanotechnology based filters have low maintenance cost.

(10) Nanotechnology based filters are easy to use.

(11) Nanotechnology based universal water purifier is reliable for long duration.

(12) Nanotechnology based universal water purifier has facility to decide the output water quality.

(13) Nanotechnology based water purifier produces no wastage of water.

(14) Separated by-products can be used for respective applications.

(15) Mineral water can be also produced at the output of nanotechnology based universal water purifier.

(16) Safe to use provided the required precaution is taken.

(17) The location independence makes it portable.

3. Constraints :

(1) Technology development

(2) Water management

(3) Construction of mega plant for water purification

(4) Maintenance

(5) Creating awareness

4. Disadvantages :

(1) Predicted risk on human health

(2) Predicted Environmental risk

The characteristics of ideal water purifier can be comparable with the predicted characteristics of nanotechnology based universal water purifier and is listed in table 3.6. It is observed from table 3.6 that nanotechnology based universal water purifier is almost in par with the expected qualities of ideal water purifier for all practical purpose.

Table 3.6 : Comparison of ideal water purifier properties with nanotechnology based universal water purifier

S. No.	Water Purifier Characteristics	Ideal water purifier System	Nanotech based Universal water purifier system
1	Any kind of impure water	Can be purified 100 %	Can be purified to pure water level
2	Any amount of input water	Can be purified instantaneously	Can be purified to desired level
3	Scalable system to any level	Zero to Infinity	Small scale to large scale
4	Output water quality	Always 100% pure	Required purity level
5	Type of filtration	Removes both undissolved and dissolved impurities completely	Removes both undissolved and dissolved impurities to the required level
6	Time for filtration	Filtration of water instantly and there is no time lag between input and output	Filtration of water in real time and there is no considerable time gap between input and output
7	Power for filtering process	No consumption of any external power	Can use renewable power from Sun or Wind
8	Operating cost	Zero operating cost	Low operating cost
9	Investment	Zero investment	Low investment
10	Type of technology	Ideal technology	Nanotechnology
11	Life & Reliability	Infinite life and reliability	Long life and reliability

12	Programmability to decide the output quality	Yes	Yes, for a certain extent
13	Wastage of water	Zero	Minimum or zero
14	By-products	Automatically separable and reusable for their applications	Easily separable and reusable for their applications
15	Environmental degradation	Absolutely not	Yet to be decided
16	Portability	Yes	Possible
17	Safe to use for living beings	Yes	O.K. but questionable

3.5 NANOTECHNOLOGICAL INNOVATIONS & BUSINESS ENVIRONMENT FOR INDIAN AUTOMOBILE SECTOR :

3.5.1. Electric/ Hydrogen Fuel Technology for Pollution Free Automobiles:

Due to the reasons of global warming and the inevitable exhaustion of Earth's oil reserves, it has become highly desirable to find an alternative energy source for automobiles. Major challenge of Indian transport system is decreasing the automobile fuel cost and polluted gas emission. Making automobile sector free from fuel consumption, India can be made the land based, water based and air based automobiles. By means of renewable electric energy technology or hydrogen fuel technology, Indian automobile sector, can solve many of its problems and contribute heavily on development of the country by decreasing foreign payments. Generating renewable electric energy through different technologies and storing them for powering automobiles using electrical storage technology for long period is the major challenge of automobile sector. Generation of renewable electrical energy is possible by means of solar, wind, tidal, hydro or even nuclear energy, which can be made pollution free. By using new technology batteries and super capacitors, energy storage constraints can be minimized. Indian automobile sector should focus on developing low cost, light weight, durable, efficient automobile electrical engines and low cost, light weight, high storage batteries/ storage cell technologies during next decade. This solution in turn, minimizes green gas emission and hence automobile based pollution of the country. Alternately, hydrogen fuel technology also contributes to the green power requirement of automobile sector in the country. Hydrogen fuel cells are used extensively as green fuel in developed countries even though, the cost of such technology of manufacturing and storage of hydrogen gas in the form of condensed fuel cells for powering the automobile is high. By means of developing hydrogen fuel technology the automobile sector can be made pollution free. Hydrogen storage and refilling is found to be major technological barrier to the development of hydrogen fuel cell based automobiles. To overcome this barrier, solid fuel cells are recently adopted. Solid oxide fuel cells offer a clean, pollution-free technology to electrochemically generate electricity at high efficiencies. These

fuel cells provide many advantages over traditional energy conversion systems including high efficiency, reliability, modularity, fuel adaptability, and very low levels of NO*x* and SO*x* emissions. Based on present strategy of Indian government's investment for research and developments in nanotechnology through nanotechnology initiative programme, it is expected that the country can find optimum solution to its automobile sector problems/requirements to increase the quality, durability and performance, and decrease the cost of land based, water based and air based vehicles. This will also improve the efficiencies and controls the green gas emission and hence controls the pollution level in the country.

3.5.2. Nanotechnology Based Opportunities:

In addition to contributing to building and maintaining lighter, smarter, more efficient, and "greener" vehicles, aircraft, and ships, nanotechnology offers various means to improve the transportation infrastructure:

- Nano-engineering of steel, concrete, asphalt, and other cementitious materials, and their recycled forms, offers great promise in terms of improving the performance, resiliency, and longevity of highway and transportation infrastructure components while reducing their cost. New systems may incorporate innovative capabilities into traditional infrastructure materials, such as the ability to generate or transmit energy.
- Nanoscale sensors and devices may provide cost-effective continuous structural monitoring of the condition and performance of bridges, tunnels, rails, parking structures and pavements over time. Nanoscale sensors and devices may also support an enhanced transportation infrastructure that can communicate with vehicle-based systems to help drivers maintain lane position, avoid collisions, adjust travel routes to circumnavigate congestion, and other such activities.
- The use of nanofluids as coolants in automobile engines would support to decrease the use of fluids and hence the small size of the radiators. This will also shrink the size of coolant pump and the automobile engines can be operated at higher temperatures to improve the efficiency. This is due to their higher conductivity and better heat transfer properties. Hence nanofluids have higher potential to improve automobile engine cooling rates by increasing the efficiency, lowering the weight and decreasing the complexity of convective heat transfer performance. It is already reported that use of nanofluids showed about 20% increase in frictional pressure drop and 40% increase in pumping power compared with water [134].

- Nanotechnology based coatings and paints are highly scratch resistant, self-healing and dirt repellant. Such coatings and paints developed for automobile bodies last for the lifetime of the vehicle without aging, and require cleaning much less often. Paints manufactured using nanotechnology can alter their heat-reflecting properties depending on the intensity of the incident sunlight and also reflect different colours depending on surrounding temperature [135]. As a result, the colour of the vehicle changes with time. The nanotechnology based paints also helps to regulate the inside temperature using air-conditioner thereby saving fuel. Nano coatings outside the glass creates hydrophobic (water-resistant) surface thereby eliminates the requirement of wipers on vehicle glass. Similar approach of use nano-coating inside the glass prevents water vapour condensing on the glass in humid conditions.

3.5.3. Nanotechnology Based Solutions:

(a) Nanotechnology Based Auto-Components: Nanotechnology can be used to make wide range of automotive components for making new models of automobiles, making it possible to build them with extensive service life; lower component failure rate and smart materials for repairing. Automobiles developed with nanomaterials have advantageous in terms of durability, strength, efficiency and cost [136]. Nanotechnology based global automotive markets expect exponential positive returns, but hurdled by high initial investments and limited research and development. Although nanotechnology applications in automotive industry are manifold, many of the solutions are still untapped. Many features like sustainability, safety, comfortability, and eco-friendliness, leads to CO_2- free engines, safe driving, quiet cars, self-cleaning body, and windscreens etc. are expected to be real [137]. Nanotechnology is not only finding its way into every corner of automobiles, but is also bringing great benefits in several domains like frames and body parts, engines, paints and coatings, suspension and breaking systems, lubrication, tires, exhaust systems, etc. Certain nano-materials like carbon nanotubes and carbon black produced in India have enhanced mechanical, physical, and processing properties will render new functionalities. In addition, they may improve manufacturing speed and enhance environmental, thermal, and mechanical stability [138]. This means automobile bodies will undergo less wear, better gliding, thinner coating, fewer lubrication, longer service intervals, and weight reduction. Lighter vehicle bodies will use less material, without compromising the stiffness and crash resistance and will indirectly save fuel.

Nanotechnology based auto-components include nanomaterial based automobile parts, components of space elevators, components for weight reduction in spaceships and spacesuits,

components of solar power satellites, bio-nano-machines for space applications, components of new breed of robots to explore the planets etc. Automotive industry will see nanotechnology benefits from advanced power train designs, lighter weight, stronger materials, sensing technology, and higher efficiency. Since almost all automobile components can be improved through nanotechnology, innovations and new markets are practically guaranteed, assuming that manufacturing costs can be kept down. In all areas like, body style, brakes, acceleration, and safety will depend mostly on the ability of the company to develop and include nanomaterials. Future applications are likely to see energy-harvesting bodywork, self-healing paint, shape-shifting skin, and improved fuel cell performance of future electric and hydrogen-powered cars- all the next wave of innovation in the automobile sector.

(b) Nanotechnology Based Auto-Engines: Auto engines working on oil/gas based combustion as well as based on electric energy will get benefit due to inventions and innovations in nanotechnology. Nanotech additives act like minuscule ball bearings to lubricate moving metal surfaces that come into contact inside engines, reduce friction in automobile engines and machines, and hence improves fuel efficiency. By apply nanostructure coatings to automobile engines one can make heat transfer far more efficient. Use of nanofluids as coolants in automobile engines would contributes to increase thermal conductivity by minimizing heat build-up which increases fuel efficiency and reduces wear. Due to less energy wasted through friction, which boosts instantaneous power and torque in the engine. Thus, auto engines will consume less power, reduce exhaust gas and particle emission, becomes eco-friendly. Further, engine parts made by nanoparticle enforced steel will increase the durability of the engine due to decreased wear and tear. Nanotechnology supports to increase the strength of engine parts but reduces the engine weight and fuel consumption. Long term research in nanotechnology may lead to automobile engines with 100 % efficiency as in case of ideal engines.

(c) Nanotechnology Based Auto-Tyres: One of the dreams of automobile industry is innovation to give long life to auto-tyres in such a way that if auto-tyres last long for 10 – 50 years, then the maintenance cost as well as recycling them to reduce environmental pollution will be reduced. It is found that use of nano-material additive for the rubber mixture of the tyre tread significantly cuts wear in automobile tyres. As a result, the tyre will give longer service life. It is also found that use of such nano-material additives to enhance wear resistance does not effect on rolling resistance or wet grip of the tyre. By using such nano-materials as additive at tyre manufacturing stage, Indian auto-tyre manufacturers can add values to automobiles and expand their market share. Use of nano-materials like carbon black, silica, and nano-clays are

found to be promising candidates to green tyre industry. Adding such materials have the potential to decrease tyre rolling resistance, which improve the fuel consumption and decreases the CO_2 emissions, and lower wear resistance which increases tyre lifetime while maintaining wet road grip and existing safety levels [139]. Thus, nanotechnology bridges the gap between the characteristics of ideal tyres and practical tyres.

(d) Nanotechnology Based Auto-Electronics: This includes Electronic control units/ Vehicle controls, Sensors, Smart functions through artificial intelligence, Telematics/vehicle communication etc. The technology of thermal interface materials (TIMs) based electronic control unit (ECU). The TIM assembly is playing a key role in achieving good heat conductions within and from a package to heat sinking device. Emerging nanotechnology in TIMs shows that carbon nanotubes (CNTs) and carbon nanofibres (CNFs) when used as the structure of TIM or TIM filler could improve the overall thermal and mechanical properties of TIMs. Automotive manufacturer has initiated research and development for connected vehicle systems, vehicle connectivity can prevent crashes, optimize travel routes, issue road condition warnings, and generate environmental benefits by taking advantage of continuous, real-time connectivity to vehicles, infrastructure, and wireless devices.

Electronic display units with improved performance and unique features are possible by nanotechnology. Light emitting devices, such as LEDs, OLEDs (Organic Light Emitting Diode), fluorescent or field-emissive displays, electro-luminescent and perhaps lasers, are utilizing nano-phosphors and nanolayers to improve their performance. Lower cost laser light emission sources are possible to improved performance, longer life, higher energy efficiency, unique presentation features, reduced package size become the value proposition for adopting such new technology. An electronic display based on carbon nanotube technology (CNT) is being explored for low voltage field-emission displays which are potentially very efficient and long-lasting emitters in applications like nano-electronics. Using nano-photonics technology, many new devices like optical thin films, non-linear holographic reflectors, micro-lenses, and light conversion films are being developed to modulate or redirect electromagnetic radiation [140]. Electronic systems can be miniaturized using nanotechnology which can also have cumulative effect in miniaturization of electronic components in automobile industry. The future automobiles based on nanotechnology will be lighter, stronger, faster, safer, and more intelligent than the driver by using nano-electronic and eco friendly components.

(e) Nanotechnology Based Auto-Seat Materials: Textiles are used extensively in cars - from seat coverings and seatbelts to air filters and tyre cord. There is a general trend in automotive

design towards replacing more and more hard surfaces inside the vehicle with fabrics, as they are an easy way to reduce weight, and improve overall recyclability. Conventional fabrics are highly susceptible to wear and tear, collection of dust and dirt, and can be a fire hazard if untreated. A wide array of nanotechnologies can be applied to textiles to improve their performance and lifetime. Nanofibre based auto interior provides safety, good looking, and comfort including good management of heat and water vapour transfer; moisture wicking, self-cleaning, anti-stain/easy to clean characteristics; antimicrobial/antibacterial properties; anti-allergic trimming; Flame resistance; antistatic properties; tear and wear resistance, UV resistance, noise reduction, and improved acoustic performance. A product already available in the market called NANOMAN is a Spray which protects automotive fabrics and textiles from water, dirt, contaminant and stains, without affecting the fabric's appearance, colour, or feel and is easy to use, whilst remaining totally invisible. Even water, coffee and liquids are repelled from NANOMAN treated textiles and hence provide ideal protection for automobile seats and convertible roofs. The look, breakability and feel of the fabric remain unchanged. Auto seats with integrally knitted nanotechnology sensors, warn drivers when they start to fall asleep at the wheel, are also under development. Thermo-electric fabrics made by nanotechnology generate electricity by absorbing passengers/drivers body heat. The fabric made up of tiny carbon nanotubes locked up in flexible plastic fibers and made to feel like fabric that uses temperature differences to create a charge. Hence use of nanotechnology in automobile cloths and fabrics fills the gap between conventional cloths properties and ideal cloths properties.

(f) Nanotechnology Based Auto-Bodies: The main objectives of nanotechnology usage in automobiles are weight reduction and increasing the strength of the body. This will increase the fuel efficiency and the durability of the vehicle. It is found that nanoengineered thermoplastic materials allow a weight reduction of up to 40% compared to traditional steel chassis parts. Embedded nano-particles of metallic carbon nitride can increase the permanent strength of steel to use as chassis. By means of further processes, it can be made corrosion free. This will improve the life of the automobile to greater extent. The outer metal bodies are also can be replaced by nanoplastic/polymer sheet bodies which will further reduce the weight and strength of the vehicle. Nanocomposite glasses used in windows also contribute for weight reduction and body strength. This will also support recycling of materials and avoids environmental foot print. Thus, nanotechnology supported innovations in automobile bodies decreases the body weight to the large extent without compromising in strength and durability.

The countries like India which are not independent in crude oil production will get substantial benefit to become self-reliant. Thus, the automotive industry in India will see nanotechnology benefits in all areas of automobile production including power train designs, lighter weight, stronger materials, sensing technology, and higher efficiency to become world leader in exporting automobiles and components.

(g) Nanotechnology Based Aeroplanes: Nanomaterials with their exceptional multifunctional properties may transform the aviation industry dramatically. There are many benefits to improve aeroplane performance using nanotechnology. Some of them are:

- Use of nanotechnology to store hydrogen in solid state so that hydrogen can be used as a clean alternative to hydrocarbon based fuels in aeroplanes.
- Nanotube coating on plane outer surface would absorb radar beam making it undetectable to enemies.
- Ultrathin nanofilm coating on outer surface of aeroplane aimed at decreasing the drag and improving the fuel efficiency.
- Nanotechnology based products may help to keep the aeroplane dry and self-cleaning.
- Nanotechnology based innovations are capable to develop aircraft wings, propellers, and transport vehicles that can literally change shape to improve performance and efficiency.
- Aircraft wings with smart materials make them more aerodynamic and easier to control. Such a craft would sense conditions while in flight. Sensors in the wings will measure the pressure on each wing's surface. Using actuators, the wing can respond, even changing shape, just as a bird's wing responds to air pressure or weather.
- Lighter and stronger materials will be of immense use to aircraft manufacturers, leading to increased performance.
- Nanotech is lowering the mass of supercapacitors that will increasingly be used to give power to assist electrical motors for launching hang gliders off flatland to thermal-chasing altitudes.
- Continuous innovation in aircraft design has led to fuel savings, noise reductions and lower fares for passengers by making flights more efficient.
- Nanomaterials can fulfil the requirement of aerospace industry to improve the properties like Light Weight High Strength High Toughness Corrosion Resistance Easy Reparability & Reusability Less Maintenance & Durability of aeroplanes.

- The nanocomposite coatings are used for low friction and wear resistant applications of aircraft.
- Nano Electro Mechanical Systems offer the possibility of developing a standard fuel management unit which controls the fuel control in aero-engines.
- Nanostructured metals used in aircrafts primarily yield strength, tensile strength and corrosion resistance, coupled with low density which helps keep the total weight of the aircraft down.

(h) Nanotechnology Based Spacecrafts:

- With stated benefits of weight reduction, enhanced strength, enhance corrosion resistance, allows countries to produce low cost, high quality, smaller weight spacecrafts so that countries like India can also provide space travel opportunities to its citizens.
- Radiation shielder : certain kind of nano coating in spacecrafts can act as safe space radiation shielder for astronauts to protect them from harmful high frequency space radiations.
- Satellite protection from enemies: Nanotechnology can be used to improve the design of satellites to mitigate the threats posed by ground-based directed energy weapons and high-powered microwaves.
- Space elevator: Space elevator based on carbon nanotube cable provides a strong cable between space stations to earth surface thereby providing an easy access to space travel.

(i) Nanotechnology Based Rockets: Innovations in rockets technology using nanotechnology has following advantages:

- Enhancement of thrust of rockets using nanotechnology: Nanoparticle Field Extraction Thruster (nanoFET) is a device based on nanotechnology in which nanoparticles are charged by losing electrons when they touch an electrode at a positive voltage. After the nanoparticles are charged, an electric field can accelerate them, providing thrust to the spacecraft.
- Nanotechnology based rocket fuels: By adding certain metallic nanopowder with solid or liquid propellant of rocket, the efficiency of acceleration can be increased.
- Based on above discussions, one can realize the challenges of automobile sector in India and the opportunities to handle such challenges using next generation nanotechnology. The table 3.7 contains the applications & benefits of NT in Automobile sector:

Table 3.7: Applications & benefits of NT in Automobile sector

S. No	Applications	Business Benefits
1	Nano-clearcoats with high scratch and wear resistance	Improve scratch resistance
2	Nano-coatings with anti-corrosion performance for car bodies	Protect metal body of the vehicle against corrosive materials.
3	Smart nano-scale container anticorrosive coating	Self-repairing coatings are further enhance anticorrosive properties of metal substrates
4	Weathering resistant automotive coatings	Protecting the car body against environmental conditions and imparting desirable aesthetic appearance
5	Spark plugs	Quick start & durability
6	Smart windows based on electrochromism	Controlling all types of energy like sound, light and heat which enter the car body
7	High-strength steels for vehicle bodies	Enhance protection of vehicles and passengers safety at crashes
8	Nanostructured rubber tyres	Significantly enhance tyres durability as well as higher fuel efficiency.
9	Nanotechnology based seat fabrics	Novel anti-microbial textiles to avoid micro-organisms growth especially at proper humidity and temperature in contact to human body.
10	Nono-tech super hydrophobic surfaces	To create self-cleaning surface on seat & interior fabrics as well as wiper free self cleaning front glasses.
11	Nano-coatings for engine application	Act as improved Lubricator reduce load, Thermal insulator to reduce heat losses and frictional losses to improve fuel efficiency
12	Nanotube composites in the braking systems	Nanotube composites in the braking systems results in effective braking performance, and is also likely to reduce brake system weight while increasing acceleration.
13	Nano super capacitors & Nano tech solar cells	Alternative fuel for vehicles

3.5.3 Impact of Nanotechnology on Indian Automobile Sector:

The expected inventions and innovations in automobile sector based on nanotechnology opportunities are going to do many changes in production, usage and even export of automobiles in the country. The possible impacts of these innovations on economical, political and renewable energy sector of the country are listed below:

- **Impact on Economical Environment:**

Based on possible decrease in cost, size, weight, environmental degradation of automobiles and increase in efficiency, durability, comfortability, demand, nanotechnology innovated automobiles are going to be very attractive in the country. By using renewable energy and enhanced vehicle lifespan there will be enhanced demand for vehicles. Due to innovations, the production cost of the vehicles is going to be very nominal and the maintenance cost is going to be zero. If India is the first innovator in this area, it can get the economical advantage by producing and exporting such automobiles to other countries. Additionally, India can get benefit of saving its foreign exchange cost on oil import which is going to give big economical advantage to the country. Thus, anticipated nanotechnological breakthrough in automobile sector will give huge economical advantage to the country both for development and for citizens' comfortability. The nanotechnology based innovations in automobile sector creates new business opportunities for which organizations have to be prepared. Organizations should plan for financial investment strategy for nanotechnology infrastructure development, investment through Research & Development and product commercialization to encash opportunities and for long term profit. The economy of the country will also get benefit through such technological innovations. The impact of such developments will be affecting on automobile garages, used vehicle sales, and also on Insurance companies to re-think their business model.

- **Impact on Political Environment:**

When the economy of the country is improved through technological breakthroughs, the political environment is also get affected. Changes in the structure of international business and the improvements in quality of life in the society, the political decisions on budget investment and the road map on Country development plans should be redesigned. Since nanotechnology is general purpose technology and is expected to impact on all areas in the society, the poverty level in the country is going to be re-defined. New issues like environmental safety will become political debatable issues.

- **Impact on Renewable Energy Sector:**

Use of nanotechnology based solar cells with 100 % conversion efficiency will solve energy problems in all households, factories, and for automobiles. Smart homes, smart factories, and smart automobiles with zero maintenance cost are going to be common after the year 2050 with energy independency. Low cost air travel and space travel are going to be common and is going to be affordable to the common people of the country.

- **Impact on Public Life: (Comfortness & Luxury)**

Innovations in automobile sector and its effect on road transportation, sea transportation and air transportation in terms of cost, affordability, efficiency and availability to everyone, the quality of human life is going to be moderate in future days. In India, according to the World Bank estimate during 2015, about 17.2 crores people are below poverty line. This is about 12.4 % of the total population. If Government and private organizations invest on research and development of nanotechnology based automobile sector innovation, the poverty of the country can be reduced to zero. Alternately all the people of the country can lead comfort luxurious life in future days. In countries like India where the population of poor and the corruption in the society are considerably high, only technological solutions can be effective in solving the problems and gives hope for future generations. Low cost air travel and space travel are going to be common and is going to be affordable to the common people of the country.

- **Impact on Public Perception:**

Ever increasing oil prices, uncontrollable cost of vehicle maintenance, sky shooting vehicle prices, Short life of automobile vehicles due to tight emission norms, continuous degradation of environment and rise of temperature due to green gas emission, are decreasing the hope and confidence of publics on better future. Social problems like poverty, corruption, and struggle for basic needs like food, clean drinking water, low cost renewable energy, low cost affordable shelter and comfortable health are major challenge & threats in the society for human prosperity. In such bad time for the people of developing country like India got hope on future due to expected and projected breakthroughs of nanotechnology. If nanotechnology innovations are able to reach the expectations of publics unlike science fiction, the human life is going to be happy and prosperous in future generations and the dream and hope of human beings growth and perception are going to be true.

3.6 NANOTECHNOLOGY INNOVATIONS & BUSINESS OPPORTUNITIES IN RENEWABLE ENERGY SECTOR :

3.6.1. Possible Impact of Nanotechnology on Energy Sector:

Out of basic needs of human which include food, drinking water, energy, cloth, shelter, health and clean environment, perhaps, solving energy problem by providing a way to generating, storing, and converting it to required form at any time and any amount of time called 'ubiquitous energy' is the opportunity and the challenge for scientific world and for human prosperity. The potential of nanotechnology in energy sector involves generation of different form of energy, transition of generated energy from one place to another, storage of energy in

different form to minimize the loss, and usage of stored or instantaneous produced energy for useful work using nanotechnology principles. While analysing any system, it is customary to compare it with ideal system of that kind [9, 141-144]. As per the definition of ideal energy system, it should provide infinite amount of energy to the user continuously and it should able to convert one form of energy into another form without any internal loss i.e., ideal energy system has 100% efficiency. Nanotechnology is also expected to play a major role in the process of conversion of energy from one form to another with up to 100% efficiency. Such invention leads to easy accessibility of energy for individuals, homes, offices, companies, and industries at almost zero cost, ubiquitously and makes major impact on economy of every country.

(1) Energy Sources: The possible impact of nanotechnology on energy generation is multi-fold. Nanotechnology supports efficient generation of electrical energy by converting other form of energy in nature. This includes conversion of light/electromagnetic energy into electrical energy by means of photo-electric converters, conversion of wind energy into electrical energy by means of wind turbines optimized using nanotechnology, conversion of mechanical energy of motion into electrical energy efficiently using hydro-electric turbines optimized using nanotechnology, conversion of gravitational energy into electrical energy, or conversion of nuclear energy into electrical energy using steam based turbines optimized their efficiency using nanotechnology etc. Out of different types of energies, electrical energy is most convenient energy to be used for useful work and to be stored by means of existing technologies. Progress in nanotechnology research focus on how all other forms of energies can be converted in to electrical form for easy transmission, utilization and storage. Nanotechnology provides easy way to convert heat energy into electrical energy, light energy into electrical energy, sound energy into electrical energy, mechanical energy into electrical energy, Wind energy into electrical energy, Geothermal energy into electrical energy, Atomic and nuclear energy into electrical energy at optimum cost & efficiency, leading to a concept of "unification of energy".

(2) Energy Transmission: The possible impact of nanotechnology on energy transmission is improving the efficiency by minimizing the loss. Nanotechnology based transmission cables are already proven their enhanced efficiency and leading towards zero transmission loss. Nanotechnology based transmission cables are also expected to reduce the cost, increase the durability, and to be environmental friendly. Research is also progressing on developing wireless energy transmission systems for transmission of electrical energy with minimum loss

between distant points on the surface of earth as well as between space and earth surface and will get boost and viability through nanotechnology. Once we reach such stage of wireless transmission of energy between distant points, huge amount of solar energy can be taped by sending large number of solar space stations sent very near to sun and convert into electrical energy and transmitted to earth to solve the energy crunch of civilized society.

(3) Energy Storage: The possible impact of nanotechnology on energy storage is development of batteries and fuel cells with small size, low weight, low cost, huge storage capacity, and long durability. Nanotechnology supports to develop and maintain ideal batteries to store huge amount of electricity in a small battery. Fuel cells generate electricity instantaneously depending on requirement and nanotechnology supports developments of fuel cells having ideal characteristics. The nanotechnology based batteries and fuel cells are going to make revolution in automobiles, electronic communication, industrial production, aircraft technology, and space technology leading to new industrial revolution.

(4) Energy Utilization: The possible impact of nanotechnology on energy utilization is improvement in systems performance due to improved efficiency of the systems. Since the nanotechnology based systems are expected to be very close to ideal systems with ideal characteristics, their performance efficiency is always close to 100%. Hence, they need very low energy for their functions. In such scenario of both the energy supply and the energy utilizing system shows optimum performance with least energy usage. Thus, nanotechnology based energy sources and systems are going to be best systems in the nature to keep the entropy of the universe at lowest level.

3.6.2 Seven areas of Nanotechnology Impact on Energy Sector:

The nanotechnology impact on seven areas of energy sector including solar energy, wind energy, nuclear energy, oil-fuel based energy, artificial photosynthesis, energy storage and effective energy management to promote nanotechnology based energy as ubiquitous energy system (figure 3.7) and are reviewed as given below. Ubiquitous energy system is a concept of integrated energy system provides energy to everybody, anywhere, anytime, and any amount of time like ubiquitous banking in banking system [145-146].

(1) Solar Energy: Advances in nanotechnology based solar cells can lead to higher efficiencies and lower costs. Nanotechnology can increase the efficiency problem, by tinkering with solar power cells at a fundamental level to boost their ability to convert sunlight into power, and by providing the industry to use less expensive materials. One of the methods used in nanotechnology is to reduce the amount of light reflected back from solar cell surface by

increasing the absorption at the outer surface. Other methods are using organic solar cells with quantum dot sensitized, and dye sensitized solar cells with various permutations and combinations to increase the efficiency with low cost and long durability. Research in solar collecting paint based on nanotechnology is also under progress which uses a stable, electricity-conducting liquid filled with solar-collecting nanocrystals, which can be painted or printed like an ink onto surfaces such as window glass or plastic roof panels, leads to smart houses with self-sustainable electrical systems. Table 3.8 contains the summery of review on nanomaterial usage and their advantages in solar cells research.

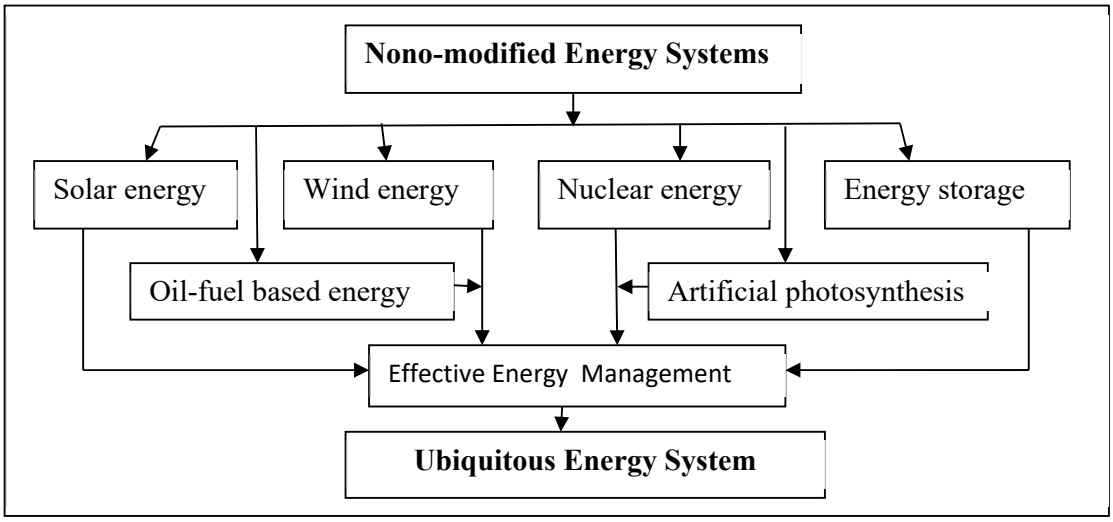

Fig. 3.12 : Concept of Ubiquitous Energy System effective management of Nano-modified energy systems.

Table 3.8 : Review on Nanomaterial usage in solar cells research

S. No.	Nanomaterial Usage	Advantage	References
1	Quantum Dot Solar Cells based on these Zn–Cu–In–Se QDs	An average PCE of 11.66% and a certified PCE of 11.61% have been demonstrated	[147]
2	Silicon nanowire-based solar cells on silicon wafers	From a partially illuminated area of 0.6 cm^2 open-circuit voltages in the range of 230–280 mV and a short-circuit current density of 2 mA cm^{-2} were obtained.	[148]
3	Nano-structured ZnO	dye-sensitized solar cells with enhanced efficiency	[149]

4	Quantum dot-sensitized solar cells	Efficiency is further boosted to as high as 5.38%.	[150]
5	Dye Sensitized Solar Cell (DSSC)	It was observed that incorporating graphene sheets of various sizes in the photo anode helped to improve the efficiency of DSSC significantly, giving a maximum efficiency of 6.62%. In case of novel dyes used in the DSSC fabrication the D-A-pi-A indoline dyes showed a great enhancement in the cell efficiency, with efficiency of up to 6.9%. Incorporation of Pt in counter electrodes and 3D-CE also showed notably good efficiency in DSSC, the efficiency improving up to 8.8%.	[151]
6	Quantum Dot Sensitized Solar Cells	Amorphous TiO_2 Buffer Layer Boosts Efficiency of Quantum Dot Sensitized Solar Cells to over 9%	[152]
7	Plasmon enhanced absorption in dye sensitized solar cells (DSSC) over a broad wavelength range.	45% enhancement in the power conversion efficiency is observed with the inclusion of plasmonic gold nanoparticles (NPs).	[153]
8	Graphene in perovskite solar cells	Achieved 7.8 percent conversion of sunlight to electricity.	[154]
9	Discovered radical new properties in a nano-metamaterial which opens new possibilities for highly efficient thermophotovoltaic cells,	This nano-metamaterial harvest heat in the dark and turn it into electricity.	[155] & [156]
10	CdS/CdSe quantum dot sensitized solar cells with a ZnSe passivation layer	Doubling the power conversion efficiency	[157] [158]

(2) Wind Energy: The global wind turbine manufacturing industry growing industry and there is increasing interest in manufacturing new types of turbine blades with enhanced properties. It is essential to design and produce blades with good fatigue resistance and good stiffness properties to ensure operational longevity. Nanotech polymer matrix composites dominate the wind turbine blade market because of their low-cost, lower weight-to-power ratios, superior fatigue characteristics, high specific strength and modulus, and ability to make complex geometries. Wind turbine blade manufacturers are faced with the challenge of constructing technologically increasingly robust, more sophisticated, larger wind turbines with the total production cost per turbine as low as possible. Nano-particle lubricant additives for wind

turbine gearbox will increase the power generation by decreasing rotation resistance for the turbines. Table 3.9 contains a review on various nanomaterials used in wind mills research.

Table 3.9 : Review on Nanomaterial usage in wind mills research

S. No.	Nanomaterial Usage	Advantage	References
1	Reinforcing wind turbine blades with carbon nanofibers	Larger, more resilient wind energy conversion (WEC) systems	[159]
2	Boron based surface treatment and nano-particle lubricant additives for wind turbine gearbox applications.	*Nano*-particle lubricant additives for *wind turbine* gearbox decreases Friction and wear.	[160]
3	Multifunctional carbon nanofiber (CNF) paper-based nanocomposite coating was developed for wind turbine blades.	Shows great promise for usage with wind turbine blades, owing to its excellent damping properties, great friction resistance, and super hydrophobicity.	[161]
4	Carbon nanotubes / polymer nanocomposites used in wind turbine blade	Good fatigue resistance and good stiffness properties to ensure operational longevity	[162]
5	Carbon nanotubes, are a potential candidate to be incorporated into marine current turbines.	Structural reinforcement, fouling release coating, structural health monitoring, high performance wires/cables and lubrication.	[163]

(3) Nuclear Energy: Nuclear energy generated using nanotechnology can be more efficient, safer and generate less radioactive waste than current technologies. Nanomaterials and nanotechnologies are useful for advanced nuclear fuel fabrication, spent nuclear fuel reprocessing, nuclear waste disposal and nuclear environmental remediation. Table 3.10 contains a review on various nanomaterials used in nuclear reactors research.

Table 3.10 : Review on Nanomaterial usage in nuclear reactors research

S. No.	Nanomaterials Used	Advantage	References
1	Nanostructured sorption materials (carbon materials included)	Purification of radioactive waste.	[164]
2	Alumina nanoparticles	Maximizing heat transfer efficiency in nuclear reactors	[165]

3	Zero-valent iron nanoparticle and its graphene composite	Efficient removal of uranium from aqueous solution in Nuclear power plant waste	[166]
4	Nanopowder of dysprosium hafnate changing instead of using boron carbide.	Control-rod modernization in nuclear reactors	[167]
5	Nanocrystalline uranium dioxide fuels	Grain boundaries absorb defects, lengthen life of nuclear fuel	[166]
6	Carbon nanotubes	Water-cooled reactor designs featuring enhanced safety	[168]

(4) Oil –Fuel Based Energy: Nanotechnology has the potential to introduce revolutionary changes in several areas of the oil and gas industry, such as exploration, drilling, production, enhanced oil recovery, refining and distribution. Nano-sensors have been developed rapidly to enhance the resolution of the subsurface imaging leading to advanced field characterization techniques. Nanotechnology also strikes the stage of production enormously to enhance the oil recovery via molecular modification and manipulate the interfacial characteristics. Some of the nanomaterials which have potential advantage in such applications with more efficient, less expensive, and more environmentally sound, are listed in table 3.11.

Table 3.11: Review on Nanomaterial usage in crude oil purification research

S. No.	Nanomaterial Used	Advantage	References
1	Magnetic shell cross-linked knedel-like nanoparticles (MSCKs) using iron oxide	Crude oil purification by successful removal of the hydrophobic contaminants	[169] & [170]
2	Nanocatalysts portray unique catalytic and sorption properties due to their exceptionally high surface area-to-volume ratio and active surface sites.	In-situ heavy oil upgrading and recovery enhancement.	[171]
3	Polydimethylsiloxane (PDMS)–graphene sponge	Exhibited high adsorption performance for the removal of petroleum products, organic solvents and emulsified oil–water mixtures.	[172]
4	Carbon nanotube sponges	Oil spill cleanup from sea water	[173]
5	Carbon nanomaterials such as mesoporous carbon (CMK-3), sulfur-	Improved performances in detection, assessment as well as	[174]

	or nitrogen-doped porous carbon and carbon black	purification of oil and natural gas are studied and demonstrated.	

(5) Energy Storage: Materials store and deliver energy in the forms of batteries, super capacitors, or fuel cells. High performance nanomaterials for storing hydrogen would enable more energy efficient vehicles and off–grid operation. Nanotechnology improves battery technology by increasing the available power from a battery, decreasing the time required to recharge a battery, reducing the possibility of catching fire, and increases the shelf life of a battery by separating liquids from the solid electrodes with the help of nanomaterials when there is no power draw on the battery. Some of the nonmaterial used in Battery and Fuel cell research are listed in table 3.12.

Table 3.12: Review on Nanomaterial usage in Battery and Fuel cell research

S. No.	Nanomaterial Used	Advantage	References
1	Three-dimensional hierarchical Co_3O_4/CuO nanowire heterostructure arrays on nickel foam for high-performance lithium ion batteries.	The superior electrochemical performances of electrodes composed of hierarchical Co_3O_4/CuO NW arrays connected directly on nickel foam make them potential anode materials for high performance LIBs.	[175]
2	TiO_2 nanotubes.	Provide an open-circuit voltage of 3.39 V and a short-circuit current density of 1.01 mA/cm^2. Such an integrated power pack could serve as a power source for mobile electronics.	[176]
3	Activated carbon nanotubes.	Improved electrochemical properties of batteries.	[177]
4	Nanostructured $FePO_4$ for sodium-based batteries.	Improved capacity and power performance.	[178]
5	Nano-Sn electrode with high-quality nano-SEI formation for lithium ion battery.	Improved stability.	[179]

(6) Artificial Photosynthesis: As an alternative to fossil fuels, technology can lead to some of the most efficient energy supply methods possible for future. By attempting to directly harness the power of the sun as bacteria, algae, and plants do through natural photosynthesis, scientists are seeking to produce viable renewable energy resources. Artificial photosynthesis is a

chemical process that replicates the natural process of photosynthesis, a process that converts sunlight, water, and carbon dioxide into carbohydrates and oxygen. This leads to artificial food production. The recent breakthroughs in nanotechnology have led to a more bottom up approach more similar to natural photosynthesis, where engineered nanostructures are used for the capture and conversion of light into usable energy. In artificial photosynthesis, scientists are trying to mimic the core processes in natural photosynthesis like light gathering, charge separation, and recombination with the aim to create efficient synthetic nanostructures that can function as antennae and reaction centers. Table 3.13 contains a summery on review on nanomaterial used in artificial photosynthesis.

Table 3.13: Review on Nanomaterials usage in Artificial Photosynthesis.

S. No.	Nanomaterial Used	Advantage	References
1	Artificial Photosynthesis systems contain a chromophore, such as a porphyrin, covalently linked to one or more electron acceptors, such as fullerenes or quinones, and secondary electron donors.	This system uses sunlight to split water to oxygen and hydrogen fuel, but efficiencies are low and an external electrical potential is required.	[180]
2	Nanoparticle made of four zinc tetraarylporphyrin molecules, $(P_{ZP})_3$-P_{ZC}, a free-base porphyrin, and a fullerene molecule, P-C_{60}.	Efficient synthetic nanostructures that can function as antennae and reaction centers for artificial photosynthesis.	[181]
3	Highly efficient photosynthetic energy and electron transfers were realized at gold and indium–tin oxide (ITO) electrodes modified with self-assembled monolayers of porphyrin–fullerene-linked systems.	Porphyrin-modified gold nanoclusters were found to have potential as artificial photosynthetic materials and photonic molecular devices.	[182]
4	Rational Design and Engineering of Quantum-Dot-Sensitized TiO2 Nanotube Arrays for Artificial Photosynthesis.	Nanotubular morphology and hybridization of TiO_2 with CdS enables highly efficient photoregeneration of cofactors by ensuring better diffusion of reaction species and rapid charge separation.	[183]
5	Clusters of nano-sized cobalt-oxide molecules (CoO) acts as catalyst for artificial photosynthesis.	Found to be stable and highly efficient triggering agent in an artificial photosynthesis system.	[184]

6	A team of scientists at MIT, used a man-made virus to serve as a scaffold that attracts molecules of the catalyst iridium oxide and a biological pigment (zinc porphyrins).	The viruses then become "wire-like" and are able to split the water molecules into hydrogen and oxygen by having just the right spacing to induce the reaction.	[185]

(7) Effective Energy Management: Renewable energy can be generated using nanotechnology materials and components in efficient manner at low cost by means of proper planning using nano-modified solar cells or by means of artificial photosynthesis and generated electrical energy has to be distributed by means of nanotechnology based transmission system and stored by means of nanotechnology batteries so that one can decrease the loss of energy during distribution as well as storage of energy. By means of properly planned energy management system, the loss of energy can be minimized. By means of properly arranged solar cells and battery system can provide continuous electrical energy for the concept of ubiquitous energy (any time, any amount and any amount of time).

3.6.3. Innovations and Business Opportunities for Nano-Modified Solar Cells:

Nano-modified solar cells and solar paints are potential products for future business both in developed countries and developing countries due to their enhanced conversion efficiency, low cost, and durability. The improved characteristics of such solar panels increase the demand in the market so that the business firms which involve in nano-modified solar panel business have huge business opportunities for long period of time.

Business of Smart House: The planning and construction of smart house and smart office using nanotechnology is going to be major business in 21st century. In smart house and smart office, the green electricity is generated for keeping the night warm, running the electrical appliances including air conditioners and all other requirements using the nano modified solar paint pasted on both roof, walls, and windows. All houses and buildings are going to be independent and self sustainable in electrical energy usage.

Business of Solar Energy: Generating solar electricity in large volume either planning big solar parks or generating electricity near sun using space stations and transmitting the electrical energy to earth stations by wireless electricity transmission systems is a new challenge for 21st century.

Solar Automobiles: Improved battery storage and solar cell technology using nanotechnology, solar automobiles can be developed which can use renewable energy without environmental pollution and improves the efficiency in terms of mileage. By developing efficient battery

storage technology and manufacturing of automobile body by solar panels or solar paint, the automobile companies have huge business potential for long period.

Solar Industries: The heavy industries also have opportunity to make use of renewable energy either using nanotech solar park, or nanotech wind park or nano-modified nuclear reactors to improve the efficiency and to lower operational cost.

3.6.4. Innovations and Business Opportunities in Nano-Influenced Batteries & Fuel Storage Cells:

Fuel cells are electrochemical devices that convert chemical energy to electricity and thermal energy. Fuel cell systems are used for applications ranging from portable electronics, automobiles, computers, space vehicles, in Electronic entertainment Devices & Security Devices, and to utility power plants. Many types of fuel cells are already in market. Nanotechnology increases the efficiency and decreases the size and weight of the fuel cells so that they can last longer period with required energy output. Fuel cells can offer a higher energy storage density and more convenience than conventional battery systems. Fuel cells are also environmentally friendly due to their low emission nature. Nanostructured fuel cells find business opportunities in many areas in the society which include:

Fuel Cell Automobiles: Fuel cell vehicles powered by hydrogen, or ethanol or gasoline with nano-material as catalyst lead higher efficiency and low cost and hence have potential business opportunities.

Fuel Cells in Computers: Business opportunity is also open for fuel cells with nanocomposites as catalyst to provide continuous electrical energy to maintain as server for providing undisturbed support to the entire world.

Fuel Cells in Space Vehicles: A fuel cell combines a fuel (hydrogen or hydrogen source) with an oxidizer (oxygen or air) to produce electrical power. Business opportunities are open to the organizations to develop fuel cells to provide auxiliary equipment power to commercial aircraft, for reusable launch vehicles, for Mars airplane, and for Space Shuttle upgrade, as well as for systems to produce electricity and store energy on the Moon, Mars or any other planet.

Fuel Cells in Electronic entertainment Devices & Security Devices: Nanotechnology offers business opportunity to develop micro fuel cells to use with devices such as digital cameras, portable radios, and notebook computers. A micro fuel cell is a power source for electronic devices that converts chemical energy into electrical energy mostly uses methanol or solid oxides instead of hydrogen.

Fuel Cells for Electrical and Thermal Power to Buildings: Nanotechnology supported stationary fuel cells are ideal for power generation, either connected to the electricity grid to provide supplemental power and backup for critical areas, or installed as a grid independent generator for on-site services The advantages are operate virtually silently, reduce noise pollution as well as air pollution, the waste heat from a fuel cell can be used to provide hot water or room heating, and are highly efficient and have relatively low maintenance requirements.

Nanotech Batteries: Nanotechnology allows to increase the available power from a battery and decreasing the time required to recharge a battery. This is possible by coating the surface of an electrode with nanoparticles to increases the surface area of the electrode thereby allowing more current to flow between the electrode and the chemicals inside the battery. Nanotechnology also increases the shelf life of a battery and eliminates the possibility of batteries catching fire. As a result, huge business potential exists for organizations due to the advantages of nanotech batteries compared to presently using metal-acid or lithium-ion batteries.

3.6.5 ABCD Analysis of Nanotechnology Business Opportunities in Energy Sector:

ABCD listing and ABCD framework are two models of qualitative [126-133] and quantitative ABCD analysis [121-122, 186-190] respectively. In this section, we have used ABCD analysis for qualitative listing of advantages, benefits, constraints and disadvantages from business service providers and customer's point of view.

Advantages:

- Nanotechnology solar cells are expected to be highly efficient in conversion of light into electricity, easy to large scale fabrication and maintenance for business service providers.
- Nano-solar cells and panels are efficient, durable and cost-effective for the customer point of view.
- Nano-solar cells are expected to solve the world energy problem by effective use of solar energy and contribute to the development of civilian society.
- Nanotech polymer matrix composites dominate the wind turbine blade market because of their low-cost, lower weight-to-power ratios, superior fatigue characteristics, high specific strength and modulus, and ability to make complex geometries.

- Nanomaterials and nanotechnologies have the advantage in nuclear fuel fabrication, spent nuclear fuel reprocessing, nuclear waste disposal and nuclear environmental remediation.
- Battery - Nanotechnology decreases the time required to recharge a battery, reducing the possibility of catching fire, and increases the shelf life of a battery by separating liquids from the solid electrodes with the help of nanomaterials when there is no power draw on the battery.
- Nanotechnology has advantage in crude oil exploration, oil well drilling,
- Oil production from the wells, enhanced oil recovery, improved refining and distribution. Nanotechnology is used in detection, assessment as well as purification of oil and natural gas.
- High performance nanomaterials for storing hydrogen in fuel cells enable more energy efficient vehicles and off–grid operation.
- Nanotechnology helps artificial Photosynthesis systems to use sunlight as the renewable energy source to produce carbohydrates and oxygen.
- In the case of solar cells, much higher output power can be expected from nanosized structures compared to their bulk forms.
- Opportunity for developing ubiquitous energy system.

Benefits:

- Due to higher absorption coefficient, nano-solar cells are highly efficient in conversion of light into electricity. The organic nano-solar cells are easy to fabricate and cost effective to both business service providers and the customers.
- Nano-metamaterial used in nano-solar cells harvest heat in the dark and turn it into electricity.
- Due to low-cost, lower weight-to-power ratios, superior fatigue characteristics, high specific strength and modulus, and ability to make complex geometries, nanotech polymer matrix composites, decreases the weight and strength of wind turbine blades.
- Environmental sustainability due to reduced.
- Nanotechnology improves battery technology by increasing the available power from a battery, increases the durability, and recharge cycles, and decreases the recharge time, size, and weight of the battery.
- Nanotechnology improves electrochemical properties of batteries.
- Increased efficiency in crude oil purification.

- Nanotechnology improves the performances in detection, assessment as well as purification of oil and natural gas.
- Nanotechnology-supported artificial photosynthesis system produces artificial food to the society.
- The benefit of using energy anytime, anywhere, and any amount of time through Ubiquitous energy system.

Constraints:

- Educating the people to shift from conventional energy sources to renewable energy sources.
- Higher initial cost for commercialization of new technology.
- Achieving higher efficiency in artificial photosynthesis using suitable nanostructures to convert sunlight, water, and carbon dioxide into carbohydrates and oxygen.
- The problem of complexity is the major constraints. The more advanced systems have huge numbers of parts, and their design and manufacturing involve a series of projects impressive in their complexity.

Disadvantages:

- Nanoparticles as though they are hazardous materials and take measures to ensure they are contained during manufacture and disposal.
- Presently artificial photosynthesis is costly process compared to natural food production.
- Deliberate abuse of the technology by hostile entities ranging from governments to terrorists, could be used for weapons of mass destruction.

3.6.6. Molecular Nanotechnology: A Futuristic Possibility to Solve Ever Demanding Energy Crisis:

Advanced research in nanotechnology is expected to produce some molecular machine systems which have the ability to self-replicate to make copies of themselves. Constructing an artificial self-replicating system at the molecular level will be difficult, but once made, it could make many copies of similar system and perhaps too many copies lead to over replicated machines as virus do. A molecular machine can be defined as an assembly of a discrete number of molecular components – that is, a supramolecular system – in which the component parts can display changes in their relative positions as a result of some external stimulus. Molecular machines and motors are of interest not only for basic research, but also for the growth of

nanoscience and the subsequent development of nanotechnology to make further impact on solar energy, wind energy, nuclear energy, oil-fuel based energy, artificial photosynthesis, energy storage and effective energy management to promote nanotechnology based energy as ubiquitous energy system.

3.7 CONCEPT OF IDEAL ENERGY SOURCE AND ITS REALIZATION OPPORTUNITY USING NANOTECHNOLOGY :

3.7.1 Introduction to Energy Source :

Energy research is one of the primary areas of research due to the objective of providing renewable, cheap, and safe energy to every user including industry, home, and individual human beings throughout the world. The major research areas in the energy sector include Renewable energy, Fossil and nuclear energy, Energy storage and grid modernization, Energy policy and economics, Energy end-use efficiency, and Energy environmental impacts. Out of these areas, the effective use of renewable energy sources and the impact of energy sourcing and utilization on the environment are getting priority and are able to attract huge funding from both developed and developing countries. Renewable energy research area has various alternative fields like bioenergy field, photovoltaics field, wind energy field, solar thermal field, and renewable fuels field. Many environmental effects like greenhouse effect, degraded air and water quality, climate change, and their consequences on a sustainable environment. Renewable energy is an energy produced from such energy systems which are based on renewable resources, usually naturally replenished with time, such as sunlight, rain, tides, wind, waves, geothermal heat etc. An energy system is a system which produces or converts and delivers energy for useful work. An energy system is primarily designed to supply energy to various processes in the dynamic world and to provide both basic needs and luxurious services to end-users. There are many energy sources of different types used in practice. The sustainability model of the universe suggests the use of renewable energy sources for harvesting energy for practical use. Renewable energy research is finding importance due to its priority of maintaining environmental sustainability. The objective and direction of renewable energy research can be properly guided by considering the properties of Ideal energy source.

3.7.2. Concept of Ideal Energy Systems :

Predicting the ideal system model in terms of its ideal characteristics to study any practical system with an objective to improve it is a new research method recently introduced.Ideal systems are hypothetical systems predicted to find out their ideal characteristics. Such ideal characteristics of a given system can be used to improve the characteristics of the

corresponding practical systems with an objective to continuous improvement towards 100 percent efficiency. By comparing the characteristics of a practical device/system with its ideal system counterpart, it is possible to modify the device /system towards reaching the objective of achieving such an ideal device.

The concept of ideal voltage source and current source are already defined in many electrical and electronics textbooks and their characteristics are compared with the practical voltage source and current source. In this section, we are proposing the concept of ideal energy system in a systematic manner using system model. In system model of any concept, the characteristics of a system are divided in terms under input characteristics, system characteristics, output characteristics, and external characteristics. Based on the Google search information [191], an ideal source of energy should possess the following characteristics. (a) It should be capable of giving an adequate amount of useful energy. (b) It should be convenient to transport, store and use. (c) It should be economical, (d) It should be capable of supplying the desired quantity energy at a study rate over a long period of time. But when we study the broad picture of ideal energy system, we have considered many more characteristics like, availability, power output, volume, mass, cost, renewability, user safetyness, Maintenance, etc. Accordingly, a systematic study of ideal energy system is required and study will help the new researchers in energy system research to re-define their objectives.

3.7.3. System Model of Ideal Energy System :

According to ideal energy system model it is a system which produces energy with ideal characteristics which are divided into input characteristics, system characteristics, output characteristics, and environmental characteristics. Based on various factors which decide the ideal energy system characteristics, a model consisting of input conditions, output conditions, environmental conditions and system requirements are derived by a qualitative data collection instrument called focus group method mentioned earlier part of this chapter [31-33]. The box representation of such ideal energy system is shown in Figure 3.13. The expected characteristics of ideal energy system under these categories are listed below :

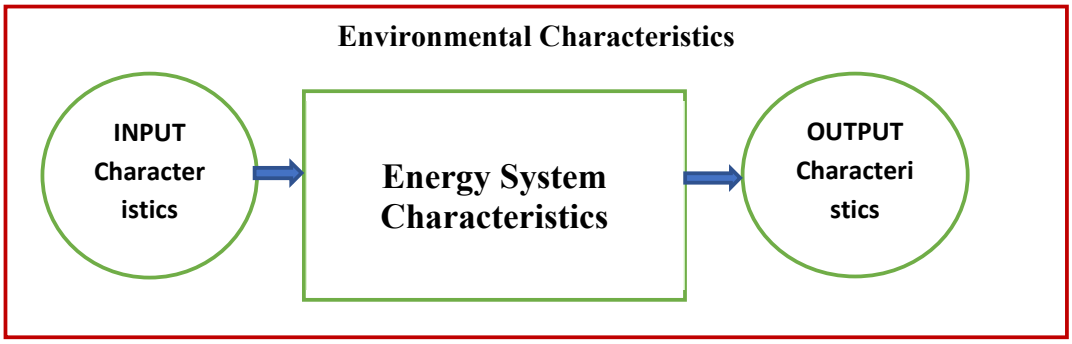

Fig. 3.13 : Box representation of Ideal Energy System model in terms of its characteristics

(a) Input Characteristics :

(1) Zero input or input should be abundant and freely available everywhere

(2) Self reliable system

(3) Affordable system

(4) Ubiquitous system

(5) Takes any type of input

(b) System Characteristics :

(1) Instantaneous

(2) Scalable

(3) No investment and no maintenance cost

(4) Portable system

(5) Sustainable and renewable source of energy

(6) No effect on environment

(7) Use Safe processes

(8) Simple system

(9) Huge energy storage/delivery capacity

(10) The system should not be poisonous.

(11) Provide great amount of energy per unit mass or volume.

(12) Low cost processes

(c) Output Characteristics :

(1) Free energy

(2) Infinite output energy

(3) Output energy may be in any form

(4) Output energy is clean & green

(5) Output is instantaneous

(6) Output is scalable to any amount

(7) Output should be continuous

(8) Ubiquitous

(9) Output energy is safe

(10) Inexhaustible

(d) Environmental Characteristics :

(1) Green energy

(2) No environmental degradation

(3) Renewable energy

(4) Pure energy

(5) No environmental pollution

(6) Location independent

(7) No leakage of energy to the environment & rise of entropy.

3.7.4. Analysis of Ideal Energy System Characteristics :

(a) Input Characteristics :

*(1) Zero input or input should be abundant and freely available everywhere :*The ideal energy system

Ideal energy source gives output continuously, of any amount, without any material input.

(2) Self reliable system :

An ideal energy system is expected to be self reliable. It does not need any stimulation or bias from an external energy source.

(3) Affordable system :

Since an ideal energy system is independent on any material input and external bias or stimulation, it gives output energy continuously without any input and hence such systems are affordable to everybody in terms of cost, in terms of design, in terms of fabrication, and in terms of maintenance.

(4) Ubiquitous system :

An ideal energy system is ubiquitous in the sense that it can give an output of any quantity, any amount of time, anywhere, in any form of output energy, without any input.

(5) Takes any type of input :

In case if ideal energy system which works on abundant and freely available input everywhere then it should capable to take any material in any format.

(b) System Characteristics :

(1) Instantaneous :

An ideal system generates its output instantaneously, whenever required. There is no time gap between input and output.

(2) Scalable :

An ideal system is scalable. i.e., it can be used for generating any amount of energy as per user requirement. As the external demand increases the system has the capacity to increase the output proportionately. The relation between energy demand and output demand is linear at any point.

(3) No investment and no maintenance cost :

An ideal energy system is a simple system in such a way that it should be fabricated using the materials freely available in environment or earth surface. Thus, ideal systems do not need huge investment in terms of various resources. Further, ideal energy system does not take any input or it takes only the input which is abundantly available in nature so that such systems are self sustainable and hence have no maintenance cost.

(4) Portable system :

An ideal energy system is portable in the sense that it can be used anywhere in the world or in the universe with any kind of environment. Portable energy system provides same the amount of output in any place with the same efficiency.

(5) Sustainable and renewable source of energy :

An ideal energy source is always sustainable in such a way that it is able to meet the external growing demand without compromising the future requirement. As demand changes the output energy also changes. Sustainable energy source has two inherent properties including continuous renewability and constant efficiency.

(6) No effect on the environment :

An ideal energy source does not produce a negative effect or degrade the environment. Since an ideal energy source is renewable, it produces green energy and is not involved in polluting the environment.

(7) Use Safe processes :

An ideal energy system does not use any process which affects the normal life of living beings. There will be no by-products which are poisonous or degrade the environment. Such systems will not pose any risk or threat to the sustainability of living systems in the universe.

(8) Simple system :

An ideal energy system is a simple system in which there are no complex interconnections between various subsystems and maintaining such systems are easy and low cost in terms of using various resources to build and maintain.

(9) Huge energy storage/delivery capacity :

An ideal energy system produces any amount of energy depending on the external requirement. An ideal energy system which takes the external material as input is capable to store huge amount of energy in order to deliver any amount of energy requirement at the output.

(10) The system should not be poisonous :

An ideal energy system produces clean and green energy at every time and at any amount of input and output load. The system does not leave any poisonous by-products while providing energy as output.

(11) Provide a great amount of energy per unit mass or volume :

In an ideal energy system, the energy density is infinite so that it can give any amount of energy at a given time as output energy. Energy density is the amount of energy stored in a given system or in a given space per unit volume.

(12) Low cost processes :

As mentioned earlier, an ideal energy system contains simple processes internally to increase or decrease the output energy whenever required at low production and maintenance cost. Every ideal system of any type, as per their definition, consumes less or zero resources so that they are always low cost or zero cost natural systems.

(c) Output Characteristics :

(1) Free energy :

In the first model of ideal energy source, it gives output energy in any form without any input. Thus here, the output energy is available in any amount without any input so that output energy is freely available to the users.

In the second model of ideal energy source, it gives output energy by consuming freely available resources in nature. As a result, the output energy is also freely available in this type of ideal energy system.

(2) Infinite output energy :

As per the definition of the ideal energy source, the output energy can be varied between zero to infinity. Even though it cannot be achieved in practice, an ideal energy source should able to supply energy levels required for any type of practical applications.

(3) Output energy may be in any form :

The output energy for ideal energy source may be in any form including mechanical energy, electrical energy, magnetic energy, gravitational energy, chemical energy, ionization energy, nuclear energy, chromodynamic energy, elastic energy, sound energy, thermal energy, rest energy, and radiant (electromagnetic or light) energy.

(4) Output energy is clean &green :

Since an ideal energy system is sustainable and renewable, it provides renewable clean and green energy ubiquitously to its users.

(5) Output is instantaneous :

The output of the ideal energy system is instantaneous. There is no time lag between input and output.

(6) Output is scalable to any amount :

Scalability is the capability of a system to vary the output to the desired level. In case of an Ideal energy system, the output can be varied to any extent even between zero to infinity. Ideal energy system should be scalable to any level depending on the application of energy usage.

(7) Output should be continuous :

Ideal energy system provides output continuously at any output level during the entire period of observation. The user will not find irregularity or discontinuity in such systems while collecting the energy for useful work.

(8) Ubiquitous :

As per the definition, an Ideal energy system can give any amount of energy output in any form (including mechanical energy, electrical energy, magnetic energy, gravitational energy, chemical energy, ionization energy, nuclear energy, chromodynamic energy, elastic energy, sound energy, thermal energy, rest energy, or radiant energy) anywhere, anytime, with any environment, and any amount of time continuously. Such property of ideal system makes it as a ubiquitous energy source.

(9) Output energy is safe :

Another important property of energy source is the safety of the energy system and the output energy it delivers as output. In case of ideal energy source, it gives clean, green, and safe energy as output for any and every application. Ideal systems will not give any by-products which are poisonous or degrading the environment.

(10) Inexhaustible :

An ideal energy system can give output energy any amount between zero to infinity. Hence the system can take any load at a given time and for any amount of time without a decrease in output energy. Hence an ideal energy system is inexhaustible.

(d) Environmental Characteristics :

(1) Green energy :

Green energy is the energy obtained from natural sources like sunlight, wind, water, rain, tides, plants, algae and geothermal heat. These sources produce energy without any contribution to global warming and climate change.

(2) No environmental degradation :

Since the energy produced from the ideal energy source is green energy which does not contribute to global warming, climate change, and poisonous to living beings. Hence the ideal energy system will not contribute to environmental degradation which is a challenge for the sustainability of the earth and other planets.

(3) Renewable energy :

Renewable energy is the energy in any form, produced by renewable energy resources. Such sources are naturally replenished in a short duration of time so that the replenishment is faster than consumption. The sources of such energy are sun, wind, rain, tides, and geothermal heat etc. In case of ideal energy source, it does not take any energy or material as input to provide energy as output or it takes only natural resources which are available plenty. Thus, the output energy of the ideal energy source is renewable.

(4) Pure energy :

Since the ideal energy source produces green, clean, renewable and energy in a useful form at the output without any side effects or environmental degradable items, it is considered as pure energy. Such pure energy will not contribute to an increase in entropy of the universe.

(5) No environmental pollution :

An ideal energy system will not contribute to the production of green gases and other contaminants which are dangerous for human and animal life on the earth. The pollutants are a threat to the sustainability of the earth and hence human life.

(6) Location independent :

As per the performance of the ideal energy system is concerned, its output does not depend on its environmental factors like variation in temperature, variation in pressure, energy type to be obtained at output etc. Moreover, the performance of the energy source shows ubiquitous so

that it is not location dependent. Thus, the performance and the efficiency of the ideal energy system is independent of its location as well as its surrounding environment.

(7) No leakage of energy to the environment & rise of entropy :

An ideal energy source is a fool proof system where the energy output can vary to any level whenever required. During the non-operational time, the ideal energy source is perfectly insulated from the environment. There is no leakage of energy in the form of heat or pressure or in any other format to its surrounding environment. i.e., in an ideal energy source, the aging of the system will not affect the output performance of the system. Moreover, due to no leakage of energy in any form to the environment, the entropy of the environment is not affected by such a system.

3.7.5. Constraints in Achieving Ideal Energy Source in Practice :

As discussed in the above sections it is not possible to realize an ideal energy system in practice but many characteristics of the ideal system can be achievable to a certain extent using renewable energy sources and by adopting the suitable technology. Table 3.14 shows the comparison of the properties of ideal energy system with practical renewable energy system using suitable technology. Based on table 3.14, one can hope that by identifying suitable technology and improving it through research and innovations, many of ideal energy system characteristics can be practically realizable for at least renewable source based electrical energy system.

Table 3.14 : Comparison of ideal energy system properties with practical energy (Electrical) system

S. No.	Ideal System Characteristics	Achievable Characteristics of a Practical Energy system
(a) Input Characteristics		
1	Zero input or input should be abundant and freely available everywhere	Input should be abundant and freely available everywhere
2	Self reliable system	Self reliable system as a renewable energy source
3	Affordable system	Can be an affordable system based on technology used
4	Ubiquitous system	Ubiquity can be achievable to some extent based on design & technology used
5	Takes any type of input	Uses renewable energy sources as input
(b) System Characteristics :		
6	Instantaneous	Instantaneous electrical energy is possible
7	Scalable	Scalable to some extent based on design & technology used
8	No investment and no maintenance cost	Low investment and low maintenance cost is possible depending on the type of renewable energy used and type of technology adopted
9	Portable system	Portability is possible for a small system for home applications which further depend on the type of renewable source and type of technology used

10	Sustainable and renewable source of energy	Sustainable and renewable source of energy is possible
11	No effect on environment	Very low effect on the environment for renewable solar systems with proper technology
12	Use Safe processes	Use Safe processes is possible for solar energy using proper technology
13	Simple system	Simple system is possible for a system based on optimum technology
14	Huge energy storage/delivery capacity	Limited energy storage/delivery capacity
15	The system should not be poisonous	The renewable energy systems are green and clean
16	Provide a great amount of energy per unit mass or volume	Optimum systems can be developed to provide an optimum amount of energy per unit mass or volume using suitable technology
17	Low cost processes	Low cost processes are possible for simple systems based on the renewable energy of right technology
(c) Output Characteristics :		
18	Free energy	Low cost energy for renewable energy system using optimum technology
19	Infinite output energy	Finite amount of output energy is possible and the efficiency depends on the technology used
20	Output energy may be in any form	Output energy may be in electrical energy form for many renewable energy systems
21	Output energy is clean & green	Output energy is clean & green for renewable energy systems
22	Output is instantaneous	Instantaneous output is possible which is depending on the type of the technology
23	Output is scalable to any amount	Output is scalable to some amount and is depends on technology and input material used
24	Output should be continuous	Output is continuous only for certain level of output and is further depends on technology
25	Ubiquitous	Presently not Ubiquitous but can be improved depending on the technology
26	Output energy is safe	For renewable energy system, the output energy is safe for all stakeholders
27	Inexhaustible	Renewable energy sources are inexhaustible to a certain level of output
(d) Environmental Characteristics		
29	Green energy	Renewable energy systems provide green energy which further depends on technology
30	No environmental degradation	Renewable energy systems are not creating environmental degradation which further depends on technology
31	Renewable energy	Renewable energy based systems produce renewable energy
32	Pure energy	Renewable energy systems are producing pure energy which further depends on technology
33	No environmental pollution	Renewable energy systems are not contributing to environmental pollution
34	Location independent	Difficult but depends on the technology used
35	No leakage of energy to the environment & rise of entropy	Possible using suitable technology for renewable energy systems

3.7.6. Possibility of Realization of Ideal Energy System Using Nanotechnology :

3.7.6. 1 Nanotechnology as Universal Technology :

Nanotechnology is a field of study, design, preparation, modifications, manipulation, application, and use of various functional materials, components, and systems through use of matter of low dimensions typically 1 to 100 nanometers to exploit novel characteristics of mater at that dimension including, physical characteristics, chemical characteristics, electrical characteristics, optical characteristics, magnetic characteristics and mechanical characteristics. These modified characteristics at nanoscale range made these materials to be unique and potential to many navel devices with optimal properties including solar photovoltaic cells for highly efficient renewable electric energy generation. Nanotechnology is considered as universal technology and created hope for scientists and engineers to be a potential candidate in solving both types of problems in the society related to fundamental needs and advanced wants of human beings. By proper applications of nanotechnology techniques, many basic problems in the primary industrial sectors like agriculture, food, drinking water, shelters, renewable energy, and healthcare can be solved optimally [192-193]. Nanotechnology is also expected to contribute advanced applications in many industry sectors like automobiles, aircraft, space vehicles, artificial intelligence and robotics, optical computing, ubiquitous communication, entertainment, organ replacement, environmental purification, lifespan expansion, singularity, and even, immortality [194]. Based on such possible wide applications of nanotechnology in many industry sectors it is recently classified as one among two universal technologies (along with information communication and computation technology (ICCT)) for 21st century [195]. It is also estimated that nanotechnology, due to its special ability of support practical systems close to ideal systems is considered as 21st century technology and is expected to do many breakthroughs in this century [196-199].

3.7.6.2 Nanotechnology Based Energy Systems :

Nanomaterials are used to improve the efficiency of energy storage devices. Nanomaterials, being light in weight and strong in strength, are also used in turbine manufacturing in the wind and geothermal based power generation. By identifying or developing suitable novel nonmaterial or their mixtures through continuous research, one can develop an optimum device based on nanotechnology to realize many properties ideal energy system. It is proved that nanomaterials can be used for improving efficiency and hence productivity of renewable energy systems. Currently, solar cells are made up of semiconductor materials which have low efficient in energy conversion and costly in such a way that a common man in a developing

country cannot afford to use such systems. On the other hand, nanomaterials used for solar cells manufacturing are cheap and through intensive research, novel nanomaterils developed can be used to manufacture new solar cells or coatings to improve efficiency. Thus, there is a hope that nanomaterials based photovoltaic cells are potential candidates to develop energy system mimic to ideal energy system [200]. The conceptual model of energy system using solar panels and storage systems fabricated based on nanotechnology is shown in figure 3.14. There are different principles and methods to improve the efficiency of solar cells using nanotechnology which include :

(1) Improving the efficiency of solar cells using nanomaterial coatings on conventional semiconductor solar cells.

(2) Developing new solar cells using nanomaterials

(3) Developing efficient solar cells using nanocomposite materials

(4) Fabricating solar cells using nano charge sensitive materials doped polymer films for enhanced efficiency.

(5) Developing new kind of nano-paints to be pasted on roof-structures or vehicle bodies for effective utilization of solar energy anywhere round the clock.

(6) To improve the battery life using efficient, tailored hybrid nanostructures.

(7) Improving the efficiency of any other energy system using nanotechnology principles.

(8) Improving the durability of such systems using nanomaterials and nanosystems.

(9) Developing methods and designs to combine elements to produce nano-compounds of binary, ternary, and quaternary systems have created much more interest in terms of improving the energy conversion efficiency.

(10) Devices based on new principles like Antenna-rectifier system for exploiting the wave nature of sunlight into electrical energy. Using nanomaterials one can design and fabricate of antennas with a typical dimension of ~100–1000 nm and can reach the efficiency up to 95% is possible theoretically.

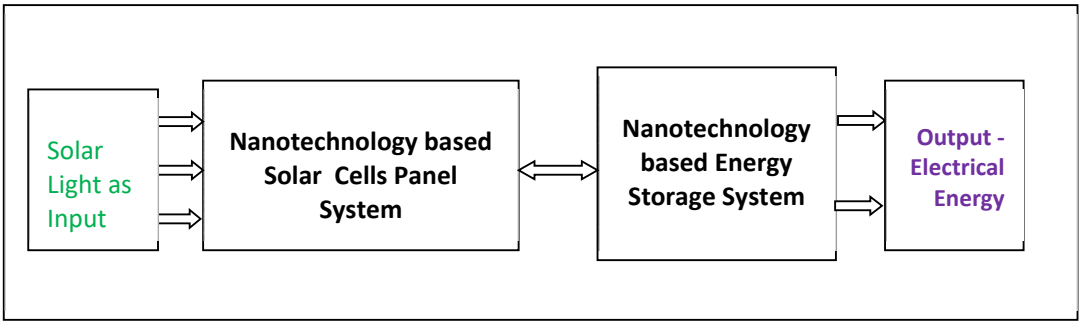

Fig. 3.14 : Conceptual model of Energy system using various processes based on nanotechnology

3.7.6.3 Analysis of Use of Nanomaterials for Solar Cells :

Due to peculiar surface, mechanical, structural and electrical properties of nanomaterials and further the possibility of tailoring such properties to optimum level, they are considered as potential candidates for solar cells as well as any other efficient energy system. Nanomaterials or nanostructures combined with other material systems have potential ability to improve the required properties of solar based electrical energy systems like solar cells or nanoantenna based rectifiers. The continuous improvement in such systems based on intensive research in nanotechnology, solar energy conversion efficiency of more than 95% can be achieved against the 20% conversion efficiency of presently used solar cells. The analysis of the use of nanomaterials for solar cells is carried out using qualitative ABCD listing [201].

Advantages of using nanomaterials for solar cells :

It is expected and proved partially in many types of research that nanomaterials have many advantages in using in development of optimum energy systems. Some of them are :

(1) Cost effective

(2) Improved manufacturing methods

(3) Reduced pollution

(4) Light weight systems

(5) Strong and durable

(6) Enhanced efficiency

(7) Easy handling

(8) Possibility of further innovations

(9) Changed principles of operation

(10) Superior technology

(11) Flexible usage form like full structured solar cells or Coatings for solar cells etc.

(12) Possibility of new breakthroughs like antenna-based rectifier systems using nanomaterials.

(13) Theoretical solar light conversion efficiency up to 95%.

Benefits of using nanomaterials for solar cells :

(1) Efficient energy systems

(2) Low cost, durable system for continued output energy

(3) Effective use of renewable energy

(4) Low atmospheric pollution

(5) Efficiency of conversion up to 95% in case of nanotechnology antenna-based rectification systems.

(6) Self sustainability in solar energy gives rise to economically independent countries which intern leads to enhanced growth.

Constraints of using nanomaterials for solar cells :

(1) Funding for research and innovation

(2) Continuous follow-up in research

(3) Accountability in many new researchers.

(4) Further research requirement.

(5) Developing a suitable product with all expected characteristics of ideal energy systems.

(6) Commercialization of technology challenges.

Disadvantages of using nanomaterials for solar cells :

(1) Anticipated side effects of nanomaterials.

(2) Nanotechnology is yet to reach its matured level due to comparatively less research personnel and facilities.

(3) Realization of theoretical findings and expectations in practice is found to be difficult and is considered as a hindrance in further progress.

(4) Anticipated ecological effects and genetic effects on nature hinders the public funding on nanotechnology research.

(5) Device manufacturing difficulty due to nanoscale processes.

3.7.7. Comparison of Ideal Energy System Characteristics with Nanotechnology based Energy System :

The use of nanotechnology in developing electrical energy systems which mimic many characteristics of ideal energy system is possible. Many nanotechnology based structures and systems are used to improve the characteristics of solar cells towards ideal model. The different characteristics of Nanotechnology based systems are compared with conventional solar panels and is depicted in table 3.15.

Table 3.15 : Comparison of Nanotechnology based systems with conventional solar panels

S. No	Ideal Energy System Characteristics	Semiconductor Technology based systems using silicon	Nanotechnology based systems
(A) Input Characteristics :			
1	Input should be abundant and freely available everywhere	Yes, Solar energy	Yes, Solar energy
2	Self reliable system	Possible some extent	Possible more extent

3	Affordable system	Not affordable for developing countries	Affordable for every countries and people at matured stage
4	Ubiquitous system	No.	Possible through advanced storage techniques
5	Takes any type of input which is renewable	Yes. Solar energy in IR spectrum	Yes. Solar energy in broad spectrum
(B) System Characteristics :			
6	Instantaneous	Yes	Yes
7	Scalable	Yes. But low efficiency	Yes. High efficiency and hence flexible output range
8	No investment and no maintenance cost	High investment and low maintenance cost	Low investment and low maintenance cost
9	Portable system	Not for large energy systems	Possible due to small size
10	Sustainable and renewable source of energy	Yes. Lower efficiency	Yes. Higher efficiency
11	No effect on environment	Low	Low
12	Use Safe processes	Yes	Yes
13	Simple system	Yes	Yes
14	Huge energy storage/delivery capacity	No	Possible
15	The system should not be poisonous	Not poisonous	Not poisonous
16	Provide a great amount of energy per unit mass or volume	No	Possible
17	Low cost processes	No	Possible
(C) Output Characteristics :			
18	Free energy	Low cost	Very low cost
19	Infinite output energy	No	High output
20	Output energy may be in any form	Electric form but possible to convert to other forms	Electric form but possible to convert to other forms
21	Output energy is clean & green	Yes	Yes
22	Output is instantaneous	Yes	Yes
23	Output is scalable to any amount	No. Low range scalability	Comparatively better range scalability
24	Output should be continuous	No.	Yes. Using advanced high storage battery
25	Ubiquitous	No.	Possible through advanced storage techniques
26	Output energy is safe	Yes	Yes
27	Inexhaustible	Yes. Low efficiency	Yes. Improved efficiency
(D) Environmental Characteristics :			
28	Green energy	Yes	Yes
29	No environmental degradation	Low	Very low
30	Renewable energy	Yes	Yes
31	Pure energy	Yes	Yes
32	No environmental pollution	Low	Low
33	Location independent	No	No

34	No leakage of energy to the environment & rise of entropy	Yes	Yes

3.7.8. Dye Sensitized Nanocomposite Doped Polymer Films as Solar cells :

3.7.8.1 Nanocomposite Solar cells :

Nanocomposites are the materials that incorporate nanosized particles into a matrix of standard material. Such addition of nanoparticles leads to drastic improvement in various properties including mechanical strength, toughness, electrical, optical, and thermal properties of the resultant nanocomposites. Nanocomposite solar cells promise significant advantages with respect to cost-efficient mass production since they do not require imprinted chemical potential gradients for charge separation. Organic and inorganic nanocomposites have been successfully used in the preparation of thin film organic solar cells with the view either to enhance the harvesting of solar energy or to assist in the charge transport processes. The optical absorption, electrical conductivity, and environmental stability of the nanocomposites are the main criteria that determine the suitability of the material for solar energy application. Table 3.16 identifies some of the research results carried out by various research teams during last few years.

Table 3.16 : Some of the published results of nanocomposite solar cells research

S. No.	Solar cells research using Nanocomposites	Reference
1	Graphene-based polymer composites	Das, T. K., &Prusty, S. (2013) [202]
2	Poly (3-hexylthiophene): TiO_2 nanocomposites	Kwong, C. Y., et al (2004) [203]
3	Hybrid organic/inorganic nanocomposites	Liu, R. (2014) [204]
4	CH_3 NH_3 SnI_3 /TiO_2 nanocomposites	Grätzel, M. (2014) [205]
5	ZnO–SnO_2 nanocomposite	Song, J., (2016) [206]
6	Graphene oxide/mesoporous TiO_2 nanocomposite	Han, G. S., (2015) [207]
7	Yb_2O_3/Au upconversion nanocomposites	Liu, T., et al (2014) [208]
8	CdTe–ZnO nanocomposites	Huang, W. J., (2015) [209]
9	Polymer/copper indium sulfide nanocomposites	Rath, T., et. al (2011) [210]
10	TiO_2/$CuInS_2$ nanocomposites	O'Hayre, R. et al (2006) [211]
11	$CuInS_2$–Poly (3-(ethyl-4-butanoate) thiophene) nanocomposite	Maier, E., et al (2011) [212]
12	Polythiophene and ZnO nanoparticles	Beek, W. J., et al (2006) [213]
13	Molybdenum disulphide/titanium dioxide nanocomposite-poly 3-hexylthiophene bulk heterojunction	Shanmugam, M., et. al (2012) [214]
14	TiO_2/CdS nanocomposite	Zhao, D., et al (2016) [215]

3.7.8.2 Dye Sensitized Nanocomposite Solar Cells :

Among the renewable energy sources, solar energy is at the forefront with a clean and most abundant form of energy and affordable cost/efficiency performance of solar cells. From the various types of solar technologies, dye-sensitized solar cell (DSSC) technology is an

inexpensive and environmentally friendly solution to meet today's increasing energy needs. In the conventional p–n junction solar cells, only the electrons and holes that can diffuse to the space charge region can be collected as a current. In order to get a long diffusion length, the purity of semiconductors should be increased and the defect concentration should be decreased, resulting in expensive solar cell materials. In a dye-sensitized solar cell, a photon absorbed by a dye molecule gives rise to electron injection into the conduction band of nanocrystalline oxide semiconductors such as TiO_2 or ZnO. Because of the high surface area, relatively high photocurrent can be obtained in spite of the simple process. Dye-sensitive solar cells are considered as inexpensive and environmentally friendly solar cell devices with good and acceptable power conversion efficiency. Some of the published results of dye sensitized nanocomposite solar cells research are summarized in table 3.17.

Table 3.17 : Some of the published results of dye sensitized nanocomposite solar cells research

S. No.	Solar cells research using dye sensitized Nanocomposites	Reference
1	Dye-sensitized nanocrystalline solar cells employing a polymer electrolyte.	Nogueira, A. F., (2001) [216]
2	Dye-sensitized solar cells based on nanocomposite of polyaniline/graphene quantum dots	Dinari, M., (2016) [217]
3	Graphene-based dye-sensitized solar cells	Singh, E., et al (2015) [218]
4	Dye-sensitized carbon nanotube aerogel–Pt nanocomposites	Chen, H., et al (2016) [219]
5	Dye-sensitized nanocomposite Semi-Solid Redox Ionic Liquid Electrolytes	Rutkowska, I. A., et al (2015) [220]
6	Dye-sensitized TiO_2–Au Nanocomposite	Pandikumar, A., et al (2015) [221]
7	Dye-sensitized solar cells employing polymers	Yun, S. et al (2016) [222]
8	Dye-sensitized solar cells with tetra alkyl ammonium cation-based ionic liquid functionalized graphene oxide	Kowsari, E. et al (2017) [223]
9	Nano-structured TiO_2/ZnO nanocomposite for dye-sensitized solar cells	Boro, B. et al (2017) [224]
10	Dye sensitized solar cells: From genesis to recent drifts	Sharma, S. et al (2017) [225]
11	Ionic nanocomposite gel electrolytes	Usui, H. et al (2004) [226]
12	Dye-sensitized Nanowire-based composites	Baxter, J. B. et al (2005) [227]
13	Dye-sensitized anatase TiO_2 hollow spheres/carbon nanotube composites	Yu, J. et al (2011) [228]
14	TiO_2–Au plasmonic nanocompositeTiO_2–Au plasmonic nanocomposite	Muduli, S. et al (2012) [229]
15	Dye-sensitized solar cells based on Titania nanotube array electrodes	Paulose, M. et al (2006) [230]
16	Dye-sensitized ZnO–TiO_2 nanocomposite films for high light harvesting efficiency	Manthina, V. et al (2012) [231]
17	Dye-sensitized solar cells using 2-(hexylthio) thiophene conjugated bipyridine	Cao, Y. et al (2009) [232]

18	Dye-sensitized photoelectrochemical solar cells based on nanocomposite organic–inorganic materials	Stathatos, E. et al (2005) [233]
19	Poly (ethylene oxide)/Poly (vinylidene fluoride)/TiO_2 Nanoparticle composites	Han, H. W. et al (2005) [234]
20	Dye-sensitized tin sulfide nanoparticles with reduced graphene oxide	Yang, B. et al (2015) [235]

3.7.9 Predictive Analysis of Dye Sensitized Nanocomposite doped Polymer Films :

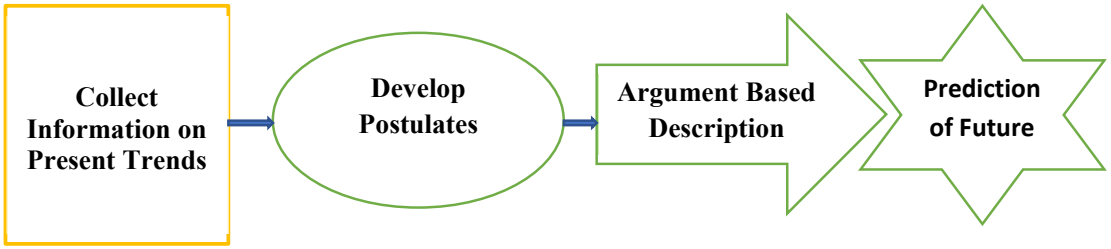

Fig. 3.15 : Predictive Analysis Model to predict future

Predictive analysis is a method consisting of several techniques to predict future possibilities using present trends. It is different from predictive analytics in such a way that it will support to predict future. On the other hand, predictive analytics is a method of generating information from historically available dataset to determine and predict future trends and outcomes. In this section, we have used predictive analysis qualitatively to predict future possibilities by studying present trends using self-developed predictive analysis model shown in figure 3.15. As per present trend, many research groups globally working in dye-sensitized metal nanoparticle doped solar cells. In this analysis, we suggest, a new combination of nanocomposites sensitized by nonlinear photosensitive dyes and doped in polymer film base called polymer matrix as proposed efficient, low weight, low cost, durable solar cells/panels. Accordingly, following postulates can be predicted :

Postulates :

(1) Nanocomposites are potential candidates for efficient solar cell structure

(2) Dye-sensitized nanocomposite solar cells are to be researched to enhance the conversion efficiency.

(3) Nonlinear organic dyes are better candidates as sensitizers for charge transfer and hence to enhance the conversion efficiency [236-243].

(4) Instead of using polymer-based nanocomposites, it can be argued that dye-sensitized nanocomposites doped in the polymer matrix as a film for solar cells show better conversion efficiency.

(5) Finally, Non-linear dye sensitized, nonlinear nanocomposites doped, polymer matrix in film form is predicted to be efficient solar cells with highest conversion efficiency.

Argument Based Description :

There are many nonlinear dyes with high nonlinear susceptibility. Many azo dyes are widely identified as very attractive candidates for nonlinear optical properties due to their highly deformable & distributed π - electrons which give rise to high molecular level optical nonlinearities in the form of either Two-Photon Absorption (TPA) and/or Reverse Saturation Absorption (RSA) [244-253].

In the case of dye molecular medium with molecules of high RSA, when solar light passes through the medium, the number of the molecules in the excited state increases. Such an increase in the number of excited state molecules is proportional to the ground state cross section and the incident photon flux. The increase in excited state molecules in dye medium will give rise to more charge carriers and responsible for the increase in photo-electric current. To enhance the charge carrier generation, the conditions required are :

(1) The ratio of the excited state absorption cross-sections and ground state absorption cross-sections should be large so that the material will absorb incident light.

(2) The dye material should possess comparatively high transmission at the lower intensity incident light beam to increase the efficiency at low light intensity.

(3) The spectral response of dye material should be wide to cover the substantial amount of the light in the visible region.

(4) The dye material should have a fast response time for the incident light beam.

Most of the molecular design schemes underlying the design and the optimization of efficient molecules for nonlinearity are based on intramolecular charge transfer (ICT) processes from a donor species toward an acceptor moiety through a π-electron conjugated chain, such as in benzene, azobenzene, polyene, stilbene, or thiophene derivatives [254-255]. It is found that in the organic molecular systems the delocalized π-electrons that govern various macroscopic arrangements and thereby show characteristic nonlinear optical responses through intramolecular charge transfer.

For real applications, these dyes can be used to sensitize nanocomposites doped in thin films of the polymer substrate [256-261]. Molecules with high optical nonlinearity responses must possess small differences between the ground and low excited states, and there must be a large difference between the dipole moments of the ground and excited states [255]. These properties can be accomplished by compounds with a D-π-A structure, where an electron donor (D) group

and an electron acceptor (A) group are placed away from each other in the molecule through a π-conjugated system, therefore creating a high asymmetry in the electronic density [262]. Hence based on predictive analysis, such nonlinear dye sensitized nanocomposite doped polymer films may be potential candidates for enhanced conversion efficiency solar cells in near future.

3.7.10. Other Possibilities & Suggestions :

Nanoantenna based rectifiers are another type of devices which are considered as complementary to nanotechnology based solar cells due to their ability to absorb heat part (infrared part) of the solar light spectrum. Such nanotechnology-based antenna-coupled rectifiers are predicted as emerging systems that has the potential to provide ultra-high efficiency, low-cost solar energy conversion systems. Both antenna and rectifier made by nanomaterial/structure have the ability to convert up to 95% of IR energy part of solar light energy against 20 to 30% efficiency of solar cells. Such nanoantenna based rectifier systems if fabricated in the form of wide area large array kind system, are capable to act as highly efficient electrical energy systems. Such systems can also be used in any industrial processes and natural processes where heat is generated and wasted. Such excess heat can be absorbed through nanoantenna based rectifier arrays to convert them back into electrical energy [263-267]. If improved properly, such rectennas are expected to be future electrical energy sources close to ideal energy systems in terms of their characteristics and able to solve the energy problems of the world. Table 3.18 depicts the comparison of the properties of the ideal energy system with nanotechnology based electrical energy system which is based on the predictive analysis of the possible features of nanotechnology and its various anticipated processes.

Table 3.18 : Comparison of the properties of the ideal energy system with nanotechnology based electrical energy system

S. No.	Ideal System Characteristics	Achievable Characteristics of a Nanotechnology based Electrical Energy system based on predictive analysis
(a) Input Characteristics		
1	Zero input or input should be abundant and freely available everywhere	Input solar light is abundant and freely available everywhere with varied intensity
2	Self reliable system	Self reliable system as a renewable energy source
3	Affordable system	Nanotechnology is expected to be low cost technology at its matured stage
4	Ubiquitous system	Ubiquity can be achievable to a greater extent in case of nanotechnology based solar cells or nanotechnology based antenna rectifiers
5	Takes any type of input	Uses renewable solar energy source as input
(b) System Characteristics :		
6	Instantaneous	Instantaneous electrical energy is possible

7	Scalable	Scalable to some extent based on design
8	No investment and no maintenance cost	Low investment and low maintenance cost for solar based electrical energy system
9	Portable system	Portability is possible for a small system for home applications as well as industrial applications
10	Sustainable and renewable source of energy	Nanotechnology used sustainable and renewable source of energy
11	No effect on environment	Very low effect on the environment for renewable solar systems using nanotechnology. Further nanotechnology can be used for environmental cleaning
12	Use Safe processes	Use Safe processes is possible for solar energy using proper technology
13	Simple system	Nanotechnology based energy system is expected to be simple system
14	Huge energy storage/delivery capacity	Nanotechnology based batteries are expected to store substantially high amount of electrical energy
15	The system should not be poisonous	The nanotechnology based renewable energy systems are green and clean
16	Provide a great amount of energy per unit mass or volume	Optimum systems can be developed to provide an optimum amount of energy per unit mass or volume using nanotechnology
17	Low cost processes	Low cost processes are possible for simple systems based on nanotechnology for electrical energy using renewable energy sources
(c) Output Characteristics :		
18	Free energy	Low cost energy for renewable energy system using nanotechnology is possible
19	Infinite output energy	Finite amount of output energy is possible with good conversion efficiency for nanotechnology based solar cells or nanotechnology supported antenna based rectifier systems
20	Output energy may be in any form	Output energy is in electrical energy form but can be further converted in to any form
21	Output energy is clean & green	For nanotechnology based renewable energy systems the output energy is clean & green
22	Output is instantaneous	Instantaneous output is possible in case of nanotechnology based energy systems
23	Output is scalable to any amount	Output is scalable to some extent for nanotechnology based electrical energy systems
24	Output should be continuous	Output of nanotechnology based energy systems is continuous for continuous input or through stored energy
25	Ubiquitous	Certain level of ubiquity is possible for nanotechnology based energy systems
26	Output energy is safe	For renewable energy system based on nanotechnology, the output energy is safe for all stakeholders
27	Inexhaustible	Renewable energy sources are inexhaustible to a certain extent hence the output of nanotechnology based energy systems
(d) Environmental Characteristics		
29	Green energy	Renewable energy systems provide green energy which is further assured by nanotechnology

30	No environmental degradation	Nanotechnology based renewable energy systems are not creating environmental degradation and can be made environmental friendly
31	Renewable energy	Nanotechnology supports optimum renewable energy electrical systems using solar cell model and solar antenna based rectifiers model
32	Pure energy	Nanotechnology based renewable energy systems are producing pure electrical energy
33	No environmental pollution	Nanotechnology based solar renewable energy electrical systems are not contributing to environmental pollution
34	Location independent	The performance of nanotechnology based electrical energy systems depending on solar light availability in IR spectrum region
35	No leakage of energy to the environment & rise of entropy	Nanotechnology based battery systems can be made leak proof.

3.8 CONCEPT OF IDEAL DRUG & ITS REALIZATION OPPORTUNITY USING NANOPHARMACEUTICAL RESEARCH SCENARIO :

3.8.1. Introduction to Drug :

A drug is a chemical material made up of various molecules obtained naturally or synthetically that affects the physiological functions of human beings/animals. Drug is used to diagnose, cure, treat, prevent, or relief some kind of discomfort in many types of diseases and the curing process is called drug therapy. The field pharmacology is focussed on the continual advancement of drugs and the field pharmacy is focussed on appropriate management of drugs. Every drug interacts with the human body or any living systems (or vice-versa) through chemical processes and can be triggered through two major mechanisms which include activating or inhibiting normal body processes, and binding to regulatory molecules. The drug molecules usually different chemical reactions by disrupting some negative process occurring in the patient called *Therapeutic Effects*. It also causes Toxic effects, as used by parasites on their host. Thus, any drug can act like an **agonist** or an **antagonist**. An *agonist* drug acts as an activator or promotes the activity of a specific regulatory system or body process. An *antagonist* drug acts as an inhibitor, having the opposite effect to the agonist. The three general characteristics of *an effective pharmacological drug* are listed below [268-269] :

- The drug should have specific molecular size, shape, and charge to interact with the receptor.
- The drug molecule should able to travel to its site of action from its location of administration.
- The drug must be easily excreted from the body once it completes its action.

Apart from the above general physical properties of a drug, it should some additional desired characteristics like effectiveness in response, safety for the living body, and selectivity in action. If the drug is not effective in response, it should not be used. There is no such drug as a safe drug to the living body. All drugs will cause harm either directly or indirectly. There is no drug presently available in practice which is completely selective because all drugs can cause side effects. Thus effectiveness, safety, and selectivity of drug action are the challenges of drug research. Drug research is considered as a very important research area and probably found more investments of resources and time during the last few centuries [270]. Drug research also contributed to the progress of medical sciences substantially and improving characteristics of drugs in terms of various predicted properties is continued as a challenge and agenda of these researches. Focus on new drug discovery which has better properties towards achieving improvements in effectiveness, safety, and selectivity is the drug research agenda of many pharmaceutics research laboratories around the world. In order to further intensify the objectives of drug research, in this paper, we have predicted the characteristics expected in a hypothetical drug called ideal drug and also discussed the possibility of realizing such ideal drug in practice. The objectives of the study are as follows :

- To formulate a method to improve the performance of drugs by knowing the objectives of drug research.
- To study the characteristics of the ideal drug by considering it as an ideal system.
- To discuss the characteristics of the ideal drug in detail using ideal system model.
- To analyse the possibility of realising ideal drug in practice.
- To investigate the possibility of realising ideal drug using nanotechnology &nano-biotechnology.
- To compare the ideal drug characteristics with predicted nanotechnology-based drugs.
- To predict a timeline to achieve the expected solutions.

3.8. 3. Ideal Drug System Model :

The objective of drug research is continuous improvements of existing drugs in terms of their curing ability and to discover new drugs which have substantial improved abilities to cure many existing and new diseases and the final goal of drug research is directed to identifying one drug which has the ability to cure all diseases. All research work in pharmaceutics is directed towards improving drug properties including their effectiveness, safety, selectivity, no side effects, cost, accessibility, time of cure, etc. The ideal drug is a material which shows ideal characteristics. According to ideal drug model it is a system which operates on other systems

based on its own properties and these properties are divided into input characteristics, operational characteristics, output characteristics, and environmental characteristics. Based on various factors which decides the ideal drug system characteristics, a model consisting of input conditions, output conditions, environmental conditions and system requirements are derived by a qualitative data collection instrument namely focus group method. The block diagram of such ideal drug system is shown in Figure 3.16. The expected characteristics of ideal drug under these categories are listed below :

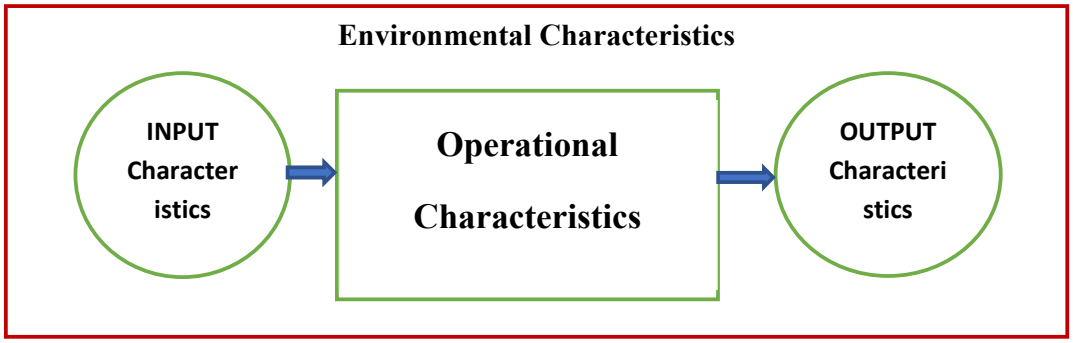

Fig. 3.16 : System model representation of Ideal drug in terms of its characteristics

(a) Input Characteristics :

(1) Ideal drug can have any type of physical state.

(2) Ideal drug independent on dosage.

(3) Ideal drug is a scalable system.

(4) Ideal drug is affordability for patients in terms of material usage.

(5) Ingredients used in ideal drug are abundant and freely available to everybody.

(b) System/Process Characteristics :

(1) Ideal drug should be non-toxic, biocompatible, and biodegradable.

(2) Ideal drug has no side effects.

(3) Ideal drug shows the selectivity in its action.

(4) Rate of ideal drug release is instantaneous and controllable.

(5) In ideal drug, the drug release has no relationship with the drug action.

(6) Ideal drug release is as per required therapeutic amount.

(7) No carrier is required to take ideal drug to reaction site.

(8) The delivery system for ideal drug should be easy, simple, and cost effective.

(9) The ideal drug should be easily eliminated from the body by simple metabolic processes after its action.

(10) The ideal drug will not get accumulated in any part of the body causing inflammation.

(11) Ideal drug is 100 % effective in curing the disease.

(12) Ideal drug is100 % safe for the living body.

(13) Ideal drug shows broad spectrum of efficacy.

(c) Output Characteristics :

(1) Ideal drug cures the disease completely.

(2) Ideal dug cures diseases immediately.

(3) Ideal drug produces no by-products.

(4) No repetition of same disease again.

(5) No therapies and rest required after recovery.

(d) Environmental Characteristics :

(1) No side effects so that it should be safe for users, and environment.

(2) No environmental harm and degradation.

(3) Location independence.

(4) Solutions to all types of health problems.

Ideal drug cures every disease of every living human beings & animals and hence decreases mortality. The ideal drug also helps to regenerate human organs where ever necessary. Hence it is expected that this hypothetical drug solves all health problems in the society.

3.8. 4. Descriptions of Ideal Drug Model :

New drugs are designed and discovered by many scientists belonging to the subject called pharmaceutics. Pharmaceutics is the subject of pharmacy that deals with the process of discovering a new drug or old drugs into a new drug used by patients for curing their disease safely and effectively. The listed characteristics of ideal drug are further described below :

(a) Input Characteristics :

(1) Ideal drug can have any type of physical state :

The physical state of an ideal drug can be solid, liquid, or gases and the physical state of the drug is not a constraint for feeding it to the living body as medicine.

(2) Ideal drug independent on dosage :

The action and effect of the ideal drug are independent on the dosage. Whatever the quantity of drug is fed to the body will able to selectively cure the disease. In practice dosage increases with an increase in drug quantity and an optimum dosage is required to cure a particular disease of particular gravity.

(3) Scalable system :

Ideal drug is a scalable system and can be used for zero to infinite number of dosages to any number of patients. Practical drug systems have limited capacity in terms of dosage and scalability.

(4) Affordability in terms of material usage for Ideal Drug :

The materials used for the preparation of an ideal drug should be freely available in nature. The cost of an ideal drug should be zero so that everybody can afford for it.

(5) Ingredients used are abundant and freely available to everybody :

The ingredients used for the preparation of ideal drug are freely and abundantly available in all parts of the universe so that every living being has equal access to such ingredients to prepare the drug irrespective of their physical location.

(b) System/Process Characteristics :

(1) Ideal drug should be non-toxic, biocompatible, and biodegradable :

It is believed that all practical drugs are toxic for one or other organs of the living body. Drug reactions are of two types as allergic and toxic. Allergic drug reactions are independent on the dose of medication and are unpredictable. Toxic reactions occur in the body when there is an accumulated of too much drug in the bloodstream which leads to adverse effects on the body. Ideal drug by its definition does not be toxic to the body due to its nature of biocompatible and biodegradable. Biodegradation refers to the process by which the drug delivery system is broken down inside the body.

(2) Ideal drug has no side effects :

All practical drugs come with side effects. Some side effects are just an inconvenience, some are minor, a few are serious, and a few are just plain strange. Many drugs produce an allergic reaction which can range from itching and rash to even a life-threatening anaphylactic reaction. But as per the definition, the hypothetical ideal drug is free from all kinds of side effects.

(3) Ideal drug shows the selectivity in its action :

Restrict drug distribution to target cells or tissues or organs only and should have uniform capillary distribution. The ideal drug is highly specific in activity in identifying and curing the diseases. It also works with only diseased cells or organs and acts on it to cure the disease completely.

(4) Rate of ideal drug release is instantaneous and controllable :

Drug release is an important property of a therapeutic system, constituting a prerequisite to absorption of the therapeutic agent and one that contributes to the rate and extent of active availability to the body. When placed in a release medium, the agent that has to diffuse to the

surface of the membrane for release immediately. In the case of an ideal drug, it is assumed that drug release is instantaneous and controllable, biodegradation occurs immediately through diffusion or dissolution.

(5) In ideal drug, the drug release has no relationship with the drug action :

In pharmacology, the drug action refers to the biochemical interaction with the specific molecular targets to which the drug binds, such as an enzyme or receptor. Drug release is an important property of a therapeutic system, constituting a prerequisite to absorption of the therapeutic agent and one that contributes to the rate and extent of active availability to the body. In case of an ideal drug, the drug release is instantaneous and has no relationship with the drug action.

(6) Ideal drug release is as per required therapeutic amount :

Since drug release is an important property of a therapeutic system in curing the diseases, it should be instantaneous and as per the requirement of the therapeutic amount in the releasing region. In case of practical drug release, there is no perfect equilibrium between optimum drug requirement in curing region and the drug release. But as per definition, in case of an ideal drug, the drug release amount is as per therapeutic requirement.

(7) No carrier is required to take an ideal drug to reaction site :

Ideal drug identifies its destination itself, i.e., its reaction site automatically and hence no carrier is required. Drug carrier is a material used along with the drug and is works to manage the drug release in a systematic circulation so that the selectivity, safety, and effectiveness of the drug can be improved. In case of an ideal drug, the drug itself identifies its destination so that no separate carrier is required.

(8) The delivery system for the ideal drug should be easy, simple, and cost effective :

Drug delivery is the method of administering a drug to achieve a therapeutic effect in a systematic manner. In practical drug delivery systems many concepts, methods, and techniques are used and together have been named as controlled release technology. Examples of controlled release technologies are transdermal and transmucosal controlled-release delivery systems, drug-impregnated lozenges, ml6 nasal and buccal aerosol sprays, encapsulated cells, iontophoretic devices to administer drugs through the skin, oral soft gels, and a variety of programmable, implanted drug-delivery devices [271]. These technologies are technically complex and expensive for the common man. As per the definition of the ideal drug, the delivery system for the ideal drug should be easy, simple, and cost effective.

(9) An ideal drug should be easily eliminated from the body by simple metabolic processes after its action :

Once the drug reaction is complete, the excess drug should be eliminated by a simple metabolic process so that there will be no side effects on any other cells or organs of the body. This is possible only in hypothetical ideal drug whereas, in conventional drugs, the side effect is due to the action of the drug with other regions/body parts which is unacceptable.

(10) The ideal drug will not get accumulated in any part of the body causing inflammation :

Inflammation is a self defense mechanism of the human body to heal any damaged cells, irritants, and pathogens. It is a part of every body's immune response. Usually, during medication, the part of the drug leftover or access in the body may cause inflammation which is unnecessary. But in the case of an ideal drug, since there is no accumulation of drug in any part of the body, there is no possibility of causing inflammation.

(11) Ideal drug is 100 % effective in curing the disease :

All drugs are not equally effective in curing diseases. But as per the definition, an ideal drug cures a disease completely and is 100 % effective.

(12) Ideal drug is100 % safe for the living body :

Since the ideal drug is not showing any side effect due to its peculiar property of selectivity and noninflammability, it is completely safe to the living body.

(13) Ideal drug shows a broad spectrum of efficacy :

Efficacy means the ability to produce a desired or intended result. Broad spectrum of efficacy means the ideal drug can fight against both Gram-positive and Gram-negative bacteria or virus to cure the diseases.

(c) Output Characteristics :

(1) Ideal drug cures the disease completely :

An ideal drug defined here has the property to cure a given disease completely. An ideal disease can cure one or more disease completely. As per the definition, an ideal drug should cure all the diseases completely in every living being.

(2) Ideal dug cures diseases immediately :

The ideal drug defined here has property to cure a given disease instantaneously and completely. In case of the practical drugs, some of them may cure the diseases by killing or halting the spread of bacteria or viruses, some drugs may identify and kill cancerous cells in the body and some other drugs may replace missing substances or hormones or vitamins.

(3) Ideal drug produces no by-products :

Ideal drug is a hypothetical entity which does not produce any harmful by-products during the curing process. But the conventional drugs may produce adverse drug reactions in some living bodies due to the interaction of drug and its by-products with body cells.

(4) No repetition of the same disease again :

As per our assumption, when the ideal drug is inhaled, it has the ability to cure the diseases instantaneously and the drug cures the disease in such a way that it will never appear again in that living being, i. e., no repetition of the same disease again.

(5) No therapies and rest required after recovery :

Usually in practical drugs based curing, once the disease is cured the therapy should continue for some time for complete curing and during such time the patient is advised to take rest by the doctors. On the other hand, in the case of ideal drugs, no rest to the patient is required due to the fact that the disease completely cures instantaneously.

(d) Environmental Characteristics :

(1) No side effects so that it should be safe for users, and environment :

The ideal drug acts only on diseased cells and does not produce any harmful chemical during its action so that it has no side effect and hence is assumed to be safe to the users and environment.

(2) No environmental degradation :

Since the ideal drug is not producing any harmful chemical as the by-product, there is no excretion of harmful chemicals occurs from the body to the environment. As a result, the environment is not affected by the excreted drug discharge.

(3) Location independency :

Ideal drug yields same result of complete curing of diseases in any location around the world and in any time after the disease is started. The geographical factors and physical factors like temperature and pressure will not affect the expected performance of the ideal drug.

(4) Solutions to all health problems :

As per the definition of the ideal drug, it is always effective and gives quick solutions to any kind of diseases from a headache to cancer and hence solves all the health problems of living beings.

3.8. 5. Challenges & Opportunities in Achieving Ideal Drug System :

As mentioned earlier, the concept of the ideal drug is purely hypothetical and looks strange but it gives appropriate direction for future research. This model gives the idea of the required quality improvement of various properties of the drug in order to cure the diseases and the

opportunities and challenges in future research. The ideal drug model sets the goal of every researcher to decide their objectives while choosing the research topic related to drug discovery.

(1) Opportunities :

Ideal drug concept and characteristics based on the system model provides the following opportunities to drug researchers and drug manufacturers :

- Improve the quality of the drug by setting new objectives.
- Setting the target for the researchers to improve input, process, output, and environmental characteristics of the drugs.
- Continuous improvement opportunity by planning and researching in an identified characteristic.
- Focused research on issues related to the effectiveness of the drug, safety to patients, selectivity in drug action, decreased side effects, low cost, wide accessibility, less time for the cure, etc.
- To think on the realization of an Ideal drug with input characteristics like having any type of physical state, independent on dosage, scalability, affordability in terms of material usage for patients, and abundant and freely available ingredients usage.
- To also think and use the system process characteristics mentioned above while planning the drug discovery process.
- Drug manufacturing companies get new opportunity to use this model to re-define their objectives and enhance their R & D activity along with R & D budget.
- The consumers/patients also get the opportunity to have access to improved drugs to cure their diseases.

(2) Challenges :

Apart from opportunities, the ideal drug concept imposes many challenges for drug researchers, drug manufacturers, patients, health industry and even for the entire society. The individual characteristics under different headings like input, process, output, and environmental sections of the ideal drug system are really posing challenges for conventional thinkers and for the entire health industry. Converting these challenges into an opportunity to realize ideal characteristics of the drug at least individually if not altogether is the new goal of the health science research. The following are some of the challenges for drug researchers and drug manufacturers :

- The researchers face new challenges in their attempt to realize the ideal drug characteristics.

- The challenge of developing a material to be used as an ingredient to realize ideal drug.
- Manufacturing the drug using such ingredients which can possess ideal drug characteristics.
- The challenge of convincing the drug manufacturing companies to invest in attempting to realize the ideal drugs.
- Challenge on handling heavy resistance to be observed from the health science & pharmacy community as they see it as a threat for their profession.

3.8. 6. Nanotechnology as Universal Technology :

Nanotechnology is expected as a technology of the 21st century to solve many problems of society both at primary and secondary level [25-29]. Nanotechnology allows many fields of science and technologies to converge to single integrated technology and offers a new way to solve problems of society both at fundamental and applied levels. Such convergence ability of nanotechnology from many fields to single field leads to an increase in *interdisciplinary* research at the nanoscale. Many nanotechnology interdisciplinary groups for interdisciplinary research are formed in this century all over the world during recent years to accelerate the research and development in nanotechnology and related areas. Nanotechnology has solutions of many problems of agriculture to get nutritious food to every living being of the world, potable water for drinking and irrigation, renewable energy for essential human activities, many new and essential consumer durable systems, and better healthcare facilities. Nanotechnology is expected to change the definition and principle of functioning of many products and services provided by various industries to their customers as general purpose technology [195]. It is expected that the effect of Nanotechnology (NT) along with another already matured technology called Information Communication and Computation Technology (ICCT) is enormous in future days in the society on lifestyle of human beings and these two technologies are expected to solve many problems and requirements of the society and hence named them as Universal Technologies [195]. Being one of the Universal technologies, nanotechnology has huge hope in solving all the problems of living beings related to health sciences. Many problems in medical sciences have already anticipated solutions at least at conceptual level using nanotechnology and ICCT. In the next section, we have discussed the anticipated breakthroughs of nanotechnology solutions in health and medical science problems and hence the possibility of realizing the ideal drug characteristics using nanobiotechnology in future years.

3.8. 7. Possibility of realizing Ideal Drug using Nanotechnology :

Nanotechnology being a general-purpose technology of 21st century and growing as universal technology has solution in the process of developing ideal solutions to health and medical sciences problems. Nanotechnology is evolving as a new hope to create and utilization of materials and tools at nanometer scale and influencing number of industries in health and medical sciences including in particularly pharmaceutical industry. Nanotechnology tools and techniques developed for different industry sectors along with biotechnology ideas have potential opportunities in achieving ideal drug characteristics in pharmaceutical industry. It is also believed that nanotechnological tools suitable for improving the characteristics of drugs towards ideal drug are exotic, disruptive, and futuristic so that may take long time in terms of several hundred years for commercialization. Currently nanoparticles and nanodevices such as nanobiosensors and nanobiochips, are used to discover new drugs or to improve the characteristics of existing drug in pharmaceutical research industry. This include :

- Some nanosubstances like fullerenes are considered as potential drugs for the future healthcare industry.
- The nanoparticle based drug delivery systems allows to target drugs to specific areas of the body [272].
- The medical imaging technique is expected to utilize drug delivery systems to illuminate to any cellular functions including tumors, or the brain in the body [273].
- The nano scale drug particles can reach inaccessible areas in the body such as inflamed tissues due to their improved permeability and retention effect.
- New nano-scale drug carriers are developed using dendrimers, to increase the possibility of increasing therapeutic index of drug molecules [274].
- The nanotechnology based long acting injectable therapies for HIV treatment [275].
- The nanomaterial based systems are used as carriers of antibiotics for infectious diseases [276].
- Various nanoparticles, and nanofibers and nanoporous scaffolds are used in the fabrication scaffolds for nanoengineering scaffolds to replaced and re-grow damaged tissues and organs [277].
- Silica based mesoporous nanomaterials with surface reactive functionalities are used for bone tissue engineering [278].
- Use of nanomedicine for managing diabetics [279].

Based on such many possibilities discovered till now, there is a hope that many more diseases may find optimal curing solutions in future days using nanotechnology based techniques.

3.8.8. Current Research Agendas in Nanotechnology based Drug Research :

Nanotechnology is a useful tool to improve the selective delivery of drug to the specific site of action. Recent developments in nanotechnology to engineer nanoparticles with desired physicochemical properties have been projected as a new line of defense against many diseases. Table 3.19 summarizes some of the current research agendas in nanotechnology based drug research.

Table 3.19: Some of the current research agendas in Nanotechnology based Drug research

S. No.	Type of disease	Nanotechnology based solution	Reference
1	Bone related disease	Development of nanomaterials for bone-targeted drug delivery	Cheng, H. et al. (2017) [280]
2	Tissue regeneration, drug delivery and pharmaceuticals	Electrosprayed nanoparticles and electrospun nanofibers based on natural materials	Sridhar, R., et al (2015) [281]
3	Oncologic Disease	Nanomedicine	Brown, P. D., et al. (2015) [282]
4	Cancer therapy	Nanotechnology-based chemotherapy	Coccia, M. et al. (2015) [283] Singh, D. et al (2017) [284]
5	Neural regeneration	Nanotechnology-based approaches for guiding neural regeneration	Shah, S. et al (2015) [285]
6	Liver tissue engineering	Primary liver cells cultured on carbon nanotube substrates	Che Abdullah et al (2014) [286]
7	Treatment of melanoma	Nanoparticle-mediated drug delivery	Mundra, V. et al (2015) [287]
8	Drug delivery	Synthetic micro/nanomotors	Gao, W. et al (2014) [288]
9	Treatment and eradication of HIV/AIDS	Nanodrug formulations to enhance HIV drug exposure in lymphoid tissues and cells	Shao, J. et al (2016) [289]
10	Delivery of peptide nucleic acids (PNAs).	Nanotechnology based solutions	Gupta, A. et al (2016) [290]
11	Controlled drug release	Pharmaceutical nanocarriers	Lee, J. H. et al (2015) [291]
12	Smart drug delivery in cancer therapy	Ph-sensitive polymeric nanoparticles	Lim, E. K., et al (2018) [292]
13	Alzheimer's disease therapy	Nanotechnology approach	Ansari, S. A. et al (2017) [293]
14	Parkinson's disease	Nanotechnology-mediated nose to brain drug delivery	Kulkarni, A. D., et al (2015) [294]
15	Tuberculosis treatment	Nanotechnology-Based approach in tuberculosis treatment	Nasiruddin, M., et al (2017) [295]

16	Drug delivery platform	Biofunctionalized nanoparticles-based drug delivery platform	Bose, R. J. et al (2016) [296]
17	Preclinical imaging & drug delivery	DNA nanomaterials	Jiang, D. et al (2016) [297]
18	Cancer metastasis treatment	Nanotechnology-based intelligent drug design	Gao, Y. et al (2014) [298]
19	HIV AIDS treatment	Nanotechnology: a magic bullet	Kumar, L. et al (2015) [299]
20	Antibacterial Agents	Silver Nanoparticles	Franci, G. et al (2015) [300]
21	New method for potent drug development	Biological nanomotors	Pi, F. et al (2016) [301]
22	Broad-spectrum treatment of viral infections	Nanomedicine for infectious disease applications	Jackman, J. et al (2016) [302]
23	Eradicating HIV reservoirs	Nanotechnology approach	Cao, S. et al (2018) [303]
24	Ocular surface diseases	Role of nanotechnology in control of human diseases	Rai, M. et al (2016) [304]
25	Coronary artery disease	Nanotechnology in diagnosis and treatment	Karimi, M. et al (2016) [305]
26	Treatment of tuberculosis	Nanotechnology as a delivery platform	Choudhary, S. et al (2015) [306]
27	Brain cancer and Alzheimer's disease	Nano-enabled drug delivery systems	Ma, J. et al (2015) [307]

3.8.9. ABCD Listing of Nanotechnology in Drug Discovery :

(1) Advantages :

- Nanotechnology has given rise to promising new therapies and diagnostic tools for a wide range of diseases, especially cancer.
- The most important advantage offered by nanotechnology is the ability to specifically target organs, tissues, and individual cells.
- Nanotechnology-based drug delivery systems improve delivery of photosensitizers which are poorly water-soluble and facilitates them to reach intracellular sites of action.
- Nanotechnology systems can be designed and developed for the sustained release of drugs from the matrix and drug delivery to a specific target.
- Nanotechnology based drugs increase absorption, bioavailability, and controlled release of the drug at the site of administration.
- Provides faster, smaller, and highly sensitive diagnostic tools & techniques.

(2) Benefits :

- Nanotechnology in oncology offers selectively killing the tumor cells without harming healthy cells.
- The ability of nanotechnology to specifically target organs, tissues, and individual cells, ultimately leads to decrease the systemic side effects and hence improves the therapeutic index of drug molecules.
- The sustainable drug release properties of the nanotechnology systems enable the improvement of the bioavailability of drugs, can reduce the dosage and frequency of administration, and may solve the problem of non-adherence to prescribed therapy.
- Increased effectiveness of the drug, safety to patients, and selectivity in drug action,
- Nanotechnology based drugs provide decreased side effects, low cost, wide accessibility, less time for the cure, etc.
- Help to solve many unsolved health problems.

(3) Constraints :

- The process of detection, quantification, and removal of toxin part from nanoformulations while using them as drugs or carriers of drugs.
- It is predicted that nanomaterials used as the drug may give damage to lungs or any other organs in the body.
- Large-scale manufacturing and costs of nanomedicines are also important issues to be addressed.
- The research on drugs based on nanotechnology is under planning and development stage so that awareness about the consequence is yet to be created.

(4) Disadvantages :

- The safety issues of nanomaterial based drugs are not clear and yet to be convinced to the society.
- The cost associated with nanotechnology based research is presently high so that the cost of nanomedicines are accordingly high.
- Superspeciality research in nanotechnology based drug development is rare due to less number of experts in the field.

Table 3.20 : Comparison of Conventional drug and Nanotechnology based drug in terms of Ideal System Characteristics.

S. No.	Ideal Drug Characteristics	Conventional Drug	NT based Drug
1	Any type of physical state	Yes	Yes
2	Independent on dosage		

3	Scalable system	No	Yes
4	Affordability for patients in terms of material usage	No	Yes
5	Ingredients used are abundant and freely available	No	Possible
6	Non-toxic, biocompatible, and biodegradable	No	Possible
7	No side effects	No	Possible
8	Selectivity in its action	No	Possible
9	Rate of release is instantaneous and controllable	No	Possible
10	Drug release has no relationship with the drug action	No	Possible
11	Drug release is as per required therapeutic amount	No	Yes
12	No carrier is required to take drug to reaction site	No	Yes
13	Delivery system should be easy, simple, and cost effective	No	Possible
14	Drug should be easily eliminated from the body by simple metabolic processes after its action	No	Possible
15	Drug will not get accumulated in any part of the body causing inflammation	No	Possible
16	100 % effective in curing the disease	No	Possible
17	100 % safe for the living body	No	Possible
18	Shows broad spectrum of efficacy	No	Possible
19	Cures the disease completely	Possible	Possible
20	Cures diseases immediately	No	Possible
21	Produces no by-products	No	Possible
22	No repetition of same disease again	No	Possible
23	No therapies and rest required after recovery	No	Possible
24	No side effects	No	Possible
25	No environmental harm and degradation	No	Possible
26	Location independence	Possible	Yes
27	Solutions to all types of health problems	No	Possible

3.9 CONCLUSION :

The various properties of Ideal technology are identified, classified and analysed in the form of a model. A suitable possible practical technology is identified to realize most of the properties of Ideal technology. The characteristics and opportunities of nanotechnology are identified and analysed and the possibility of realization of Ideal technology using nanotechnology. It is found that nanotechnology being a general purpose technology can provide solutions almost all basic and high level problems like hypothetical Ideal technology. Hence nanotechnology is future technology expected to solve all problems of human beings

and elevate the human life to such a comfortable level towards ubiquitous and omnipotent like God.

Technology has affected the society and its surroundings in many ways and helped to develop more advanced economies including today's global economy. Science has contributed many technologies to the society which include Aircraft technology, Automobile technology, Biotechnology, Computer technology, Telecommunication technology, Internet technology, Renewable energy technology, Atomic & Nuclear technology, Nanotechnology, Space technology etc. have changed the lifestyle of the people and provided comfortability. In order to sustain this comfortness of people in the society, they have to worry about the sustainability of the surrounding environment. In this paper, we propose how the technologies can be made sustainable by adding green component so that they can avoid environmental degradation and converted into green technologies to provide a clean environment for future generations. The paper also discusses the opportunities and challenges for green technology for agriculture, green technology for potable water, green technology for renewable energy, green technology for buildings, green technology for aircraft and space exploration, green technology for education, green technology for food & processing, and green technology for health and medicine in 21st century.

Developing capability of producing an abundant amount of potable water is one of the basic requirements of civilized society and can be addressed using nanotechnology. In this paper, we have used a method of research where the ideal system is predicted by means of its various characteristics and analysed the possibility of improving the real systems towards ideal systems using suitable technology. Accordingly, the ideal water purifier system is proposed based on its anticipated input, system, output, and environmental characteristics and discussed how these characteristics can be achieved using a practical system developed using nanotechnology. The advantages, benefits, constraints, and disadvantages of such nanotechnology-based system are analysed from the user point of view using the ABCD listing framework. Based on the analysis, it is found that a practical water purifier system using nanotechnology-based filters are capable to improve the performance towards ideal water purifier performance.

The effect of nanotechnology innovations on Indian automobile sector in order to solve the problems in automobile efficiency, durability, cost, and environmental pollution are discussed. Nanotechnology based solutions for Auto-Components, Auto-Engines, Auto-Tyres, Auto-Electronics, Auto-Seat Materials, Auto-Bodies, Aeroplanes, Space Crafts, and Rockets are analysed. Based on applications and benefits of nanotechnology in different areas of

automobile industry, the opportunities to realize the vision and roadmap of the country and possible impact of these innovations on economical, political and renewable energy sector in India are discussed.

The nanotechnology supported energy sources, distribution lines, energy storage systems, and energy utilising systems are becoming important and popular among the customers due to potential advantages of nanotechnology in electrical energy generation and storage. The clean energy without environmental degradation, at almost zero cost, is expected to solve energy problem of the world through the concept called ubiquitous energy. The impact of nanotechnology on seven energy sectors including solar energy, wind energy, nuclear energy, oil-fuel based energy, artificial photosynthesis, energy storage and effective energy management to promote nanotechnology based energy as ubiquitous energy system along with possible business opportunities are discussed and reviewed. Finally, the advantages, benefits, constraints and disadvantages of nanotechnology in the energy sector from business service providers and customers point of view are identified and listed.

The concept of ideal energy source using system model is developed in order to study the ultimate objectives of the energy system research and development. Based on system model, the input characteristics, system/process characteristics, output characteristics, and environmental characteristics of ideal energy system are predicted, listed, and discussed. The 35 identified characteristics are analysed and compared with renewable practical electrical energy systems and possibility of developing optimum energy system close to ideal system in terms many characteristics using suitable technology are discussed. The concept and characteristics of such predicted hypothetical ideal energy system allows researchers to think innovatively to improve the practical energy systems by identifying suitable technology and design. Though the ideal energy system is a hypothetical model, it gives ideas and sets challenges to realize it through innovative research. In this chapter, we have also discussed the possibility of realizing various predicted properties of ideal energy system by segregating them as input properties, system requirements, output properties, and environmental expectations. The realization opportunity or to decrease the gap between present conventional energy system and ideal energy system are analysed using the most hopeful universal technology of 21st century called nanotechnology. A conceptual model ofan energy system using various processes based on nanotechnology is presented and the advantages, benefits, constraints, and disadvantages of using nanomaterials for solar cells in order to improve the conversion efficiency, decrease the cost, and increase the durability. It is also proposed and analysed the

possibility of using some nonlinear dye-sensitized nanocomposite doped polymer films in the process of designing highly efficient, low cost solar energy to electric energy converters. This predictive analysis model opens up various research possibilities of nanomaterials usage in developing optimum energy systems towards the objective of achieving ideal energy systems. A comparison of the properties of the ideal energy system with nanotechnology based electrical energy system is made and is based on the predictive analysis of the possible features of nanotechnology and its various anticipated processes.

Similarly, the ultimate objective of health science is precaution and prevention of all types of diseases of living animals including human beings. Both prevention and curing of diseases need suitable drug/medicine system. The drugs presently used for different diseases have many limitations and need to be improved in terms of their ability to cure the disease completely. In this paper, we have defined a so-called ideal drug system which can help the researchers and decision makers in the drug industry to redefine their objective in research and development in the pharmaceutical industry. The drug system which can cure any diseases instantaneously is called ideal drug or ideal medicine. Based on the exact expectations of the properties from a drug system as a medicine to cure all diseases, we tried to identify the characteristics of an ideal drug which can cure all diseases in the universe. Further, we also discussed the challenges and opportunities to realize such an ideal drug which can cure all the diseases. Further, we also analysed the possibility of using nanotechnology which is emerging as universal technology to realize the possibility of developing ideal drug and in this context, on some of the research agendas focussed on solving various diseases using nanotechnology are analysed. The advantages, benefits, constraints, and disadvantages of using nanotechnology in drug research with the goal of improving them towards an ideal drug system are also listed. Finally, the comparison is made between conventional drugs and nanotechnology based drugs in terms of Ideal System Characteristics. This paper is on futuristic research along with new knowledge creation and analysis based new interpretation of nanotechnology in medicinal drugs [308-316].

REFEENCES :

[1] Casey, V., & Richardson, I., (2004). A practical application of the IDEAL model. *Software Process: Improvement and Practice*, 9(3), 123-132.

[2] Aithal, P. S., (2016). Review on Various Ideal System Models Used to Improve the Characteristics of Practical Systems. *International Journal of Applied and Advanced Scientific Research*, 1(1), 47-56. DOI :http://doi.org/10.5281/zenodo.159749.

[3] Martin, F. G. (1996). Ideal and real systems: A study of notions of control in undergraduates who design robots. In Y. Kafai and M. Resnick (Eds.), Constructionism in Practice: Rethinking the Roles of Technology in Learning. pp. 297-322, Mahwah, NJ: Lawrence Erlbaum, 1996.

[4] Jaeschke, M., &Schley, P. (1995). Ideal-gas thermodynamic properties for natural-gas applications. *International journal of thermophysics*, 16(6), 1381-1392.

[5] https://www.globalspec.com/reference/47042/203279/ideal-gas-properties. Retrieved on 10/11/2018.

[6] http://www.preservearticles.com/201012302076/characteristics-of-an-ideal-fuel.html. Retrieved on 10/11/2018.

[7] Eom, B. H., Day, P. K., LeDuc, H.G., &Zmuidzinas, J. (2012). A wideband, low-noise superconducting amplifier with high dynamic range. Nature Physics, 8(8), 623.

[8] Knuuttila, T., & Boon, M. (2011). How do models give us knowledge? The case of Carnot's ideal heat engine. European journal for philosophy of science, 1(3), 309.

[9] Aithal, P. S., &Shubhrajyotsna Aithal, (2015). Ideal Technology Concept & its Realization Opportunity using Nanotechnology, *International Journal of Application or Innovation in Engineering & Management (IJAIEM)*, 4(2), 153 – 164. DOI: http://doi.org/10.5281/zenodo.61591.

[10] Aithal, P. S., and Shubhrajyotsna Aithal, (2016). Opportunities & Challenges for Green Technology in 21st Century. *International Journal of Current Research and Modern Education (IJCRME)*, 1(1), 818-828. DOI : http://doi.org/10.5281/zenodo.62020.

[11] Maslow, A. H. (1943). A theory of human motivation. *Psychological review*, *50*(4), 370.

[12] Synan, J. F., MacMahon, J. D., & Vincent, G. P. (1944). Chlorine Dioxide-a Development in Treatment of Potable Water. *Water Works & Sewerage*, *91*(12), 423-6.

[13] Shubrajyotsna Aithal & Aithal, P. S. (2018). Concept of Ideal Water Purifier System to Produce Potable Water and its Realization Opportunities using Nanotechnology. *International Journal of Applied Engineering and Management Letters (IJAEML)*, 2(2), 8-26. DOI: http://dx.doi.org/10.5281/zenodo.1323714.

[14] http://www.ibef.org/industry/india-automobiles.aspx. Retrieved on 10/11/2018.

[15] http://forbesindia.com/blog/business-strategy/indian-automotive-industry-the-road-ahead/#ixzz42wPsU3nR. Retrieved on 10/11/2018.

[16] Krishnaveni, M. and Vidya, R. (2015). Growth of Indian Automobile Industry.*International Journal of Current Research & Academic Review*, 3(2), 110-118.

[17] Stella, M. A. J., & Rajeshwari, D. (2012). Impact of nanotechnology in automobile industry. *ZENITH International Journal of Business Economics & Management Research*, 2(12), 298-302.

[18] Malani, A. S., Chaudhari, A. D., &Sambhe, R. U. (2015). A Review on Applications of Nanotechnology in Automotive Industry. World Academy of Science, Engineering and Technology, *International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering*, 10(1), 36-40.

[19] Presting, H., & König, U. (2003). Future nanotechnology developments for automotive applications. *Materials Science and Engineering: C*, 23(6), 737-741.

[20] Aithal, P. S. & Shubrajyotsna Aithal, (2016). Nanotechnological Innovations & Business Environment for Indian Automobile Sector : A Futuristic Approach. *International Journal of Scientific Research and Modern Education (IJSRME)*, 1(1), 296-307. DOI :http://doi.org/10.5281/zenodo.161090.

[21] Qualities of an ideal source of energy, https://www.studyadda.com/ncert-solution/10th-science-sources-of-energy/232/26014. referred on 25/10/2018.

[22] Aithal, P. S. & Shubhrajyotsna Aithal (2018 November). The Concept & Characteristics of Ideal Energy System and its Realization Constraints. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *2*(2), 127-137. DOI: https://doi.org/10.5281/zenodo.1487702.

[23] Architha Aithal & P.S. Aithal (2018). The Concept of Ideal Drug & its Realization Opportunity using Nanopharmaceutical Research Scenario. *International Journal of Health Sciences and Pharmacy*. 2(2), 11 – 26. DOI :http://doi.org/10.5281/zenodo.1469963.

[24] Aithal, P. S., Shubhrajyotsna Aithal, (2015). A review on Anticipated Breakthrough Technologies of 21st Century. *International Journal of Research & Development in Technology and Management Sciences*, *21*(6), 112 – 133. DOI :http://doi.org/10.5281/zenodo.61617.

[25] Aithal P. S. & Shubhrajyotsna Aithal, (2016). Business Strategy for Nanotechnology based Products & Services. *International Journal of Management Sciences and Business Research (IJMSBR)*, *5*(4),139-149.DOI :http://doi.org/10.5281/zenodo.161127.

[26] Aithal, P. S. & Shubhrajyotsna Aithal, (2016). Nanotechnology Innovations & Business Opportunities in Renewable Energy Sector. *International Journal of Engineering Research and Modern Education (IJERME)*, *1*(1), 674-692. DOI : http://doi.org/10.5281/zenodo.160905.

[27] Aithal, P. S. and Shubrajyotsna Aithal, (2016). Nanotechnology Innovations and Commercialization – Opportunities, Challenges & Reasons for Delay. *International Journal of Engineering and Manufacturing (IJEM),* 6(6), 15-25. DOI : http://doi.org/10.5281/zenodo.161161, DOI: http://doi.org/10.5815/ijem.2016.06.02.

[28] Shubhrajyotsna Aithal & Aithal, P. S. (2018). The Realization Opportunity of Ideal Energy System using Nanotechnology Based Research and Innovations. *International Journal of Advanced Trends in Engineering and Technology*, *3*(2), 1-15. DOI : http://doi.org/10.5281/zenodo.2531876.

[29] Aithal P. S. & Shubhrajyotsna Aithal, (2018). Nanotechnology based Innovations and Human Life Comfortability – Are we Marching towards Immortality ? *International Journal of Applied Engineering and Management Letters (IJAEML)*, *2*(2), 71-86. DOI : https://doi.org/10.5281/zenodo.1451498.

[30] F. G. Martin, (1996). Ideal and Real systems: A study of notions of control in undergraduates who design robots. In Y., Kafai and M. Resnick (Eds.), Constructionism in Practice: Rethinking the Roles of Technology in Learning. pp. 297-322, Mahwah, NJ: Lawrence Erlbaum, 1996.

[31] Aithal P. S. and Shubhrajyotsna Aithal, (2014). Ideal education system and its realization through online education model using mobile devices, Proceedings of IISRO Multi Conference 2014, Bangkok, 7/01/2014, 140 - 146, ISBN No. 978-81-927104-33-13.

[32] Rogers, E. M. (1995). 'Diffusion of Innovation', *The Free Press*, NY.

[33] Morgan, R. M. and Hunt, S. D. (1994). The commitment-trust theory of relationship marketing. *Journal of Marketing*, 58, (7), 20–38.

[34] Hazeltine, B. & Bull, C. (1999). Appropriate Technology: Tools, Choices, and Implications, New York, Academic Press. 3, 270. ISBN 0-12-335190-1.

[35] Akubue, Anthony (2000). Appropriate Technology for Socioeconomic Development in Third World Countries. *The Journal of Technology Studies*, *26*(1), 33–43.

[36] Todaro, M. Smith, S. (2003). Economic Development. Boston, Addison Wesley, pp. 252–254. ISBN 0-273-65549-3.

[37] Pearce, J. Albritton, S. Grant, G. Steed, G. &Zelenika, I. (2012). A new model for enabling innovation in appropriate technology for sustainable development. *Sustainability: Science, Practice, & Policy*, 8(2), 42-53.

[38] O'Driscoll, C., MacCormac, D., Deegan, M., Mtenzi, F. & B. O'Shea, (2008). RFID: an ideal technology for ubiquitous computing?. In Ubiquitous Intelligence and Computing, pp. 490-504, Springer Berlin Heidelberg.

[39] H. Li, C. Xu, & K. Banerjee, Carbon nanomaterials: The ideal interconnect technology for next-generation ICs. IEEE Design and Test of Computers, 27(4), pp. 20-31, 2010.

[40]Drexler, Eric, Engines of Creation: The Coming Era of Nanotechnology, Doubleday, 1986, ISBN 0-385-19973-2.

[41] Drexler, Eric, Nanosystems: Molecular Machinery, Manufacturing, and Computation. New York, 1992 John Wiley & Sons. ISBN 0-471-57547-X.

[42] http://www.foresight.org/challenges/energy.html, Providing Renewable Clean Energy, Challenges & Problems, [Accessed: December 12, 2014].

[43] Kawabata, S. Niwa, M. & Yamashita, Y. (1999). A guide line for manufacturing "ideal fabrics", *International Journal of Clothing Science and Technology*, 11(2/3), 134-144.

[44] http://foresight.org/challenges/health.html, Improving Health and Longevity, Challenges & Problems, [Accessed: December. 12, 2014]. (General Internet site)

[45] Vries, De.Imar, (2005). Mobile telephony: Realising the dream of ideal communication?. Mobile world, Springer London, pp. 9-28.

[46] Banich, M. & Wilson, B. (1993). Imagining the ideal information technology, Women, information technology, and scholarship, pp.67.

[47] Gardiner, K. M. (1984). Characteristics of an ideal Manufacturing System, In ASME conference CIM and Robotics.

[48] Guo, I. J. (2004). Recent progress in nanoimprint technology and its applications. *Journal of Physics D: Applied Physics*, 37(11), pp. R123.

[49] Hsiao, F. S. H. Lian, W.S. Lin, S.P. Lin, C. J. Lin, Y. S. Cheng, E. C. H. & Wu, S.C. (2011). Toward an ideal animal model to trace donor cell fates after stem cell therapy: Production of stably labeled multipotent mesenchymal stem cells from bone marrow of transgenic pigs harboring enhanced green fluorescence protein gene. *Journal of animal science*, *89*(11), 3460-3472, 2011.

[50] Sridhar Acharya P & Aithal, P. S. (2015). Innovations in Effective Management of Energy using Green Technology. *International Journal of Conceptions on Management and Social Sciences*, 3(2), 18 - 22.

[51] Aithal, P. S. and Priti Jeevan, (2016). Strategic Rethinking of Management Education: Green MBA Model. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 55-73.

[52] Aithal, P. S & Preethi Rao, (2016). How Service Industries Can Transform themselves into Green Business Industries. *International Journal of Management Sciences and Business Research (IJMSBR)*, 5(4), 150-158.

[53] Han, W., & Liu, L. C., (2009). Discussion on Green Education in Universities. *Journal of Daqing Normal University*, *1*, 39.

[54] Guoliang Wu, (2011). A New Concept of Green Education: The Cultivation Model for Successful and Practical Talents. *International Forum of Teaching & Studies*, 7(1), 45-48.

[55] Aithal, P. S. (2015). Concept of Ideal Business & Its Realization Using E-Business Model. *International Journal of Science and Research (IJSR)*, 4(3), 1267 - 1274.

[56] Aithal, P. S. (2015). Mobile Business as an Optimum Model for Ideal Business. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 146-159.

[57] Aithal, P. S. (2016). The concept of Ideal Strategy & its realization using White Ocean Mixed Strategy, *International Journal of Management Sciences and Business Research (IJMSBR)*, 5(4), 171-179.

[58] Aithal, P. S., (2015). Concept of Ideal Business & Its Realization Using E-Business Model. *International Journal of Science and Research (IJSR)*, 4(3), 1267 – 1274.DOI :http://doi.org/10.5281/zenodo.61648.

[59] Prithi Rao and Aithal P.S. (2016). Green Education Concepts & Strategies in Higher Education Model. *International Journal of Scientific Research and Modern Education (IJSRME)*, *1*(1), 793-802. 2016.

[60] Boye, J. I. & Arcand, Y., (2013). Current Trends in Green Technologies in Food Production and Processing. *Food Eng Rev*, 5(1), 1-17. DOI:10.1007/s1 2393-012-9062-z.

[61] Chandrashekara M, Avadhesh Yadav (2017). Water desalination system using solar heat: A review. *Renewable and Sustainable Energy Reviews*, 67, 1308-1330, DOI : https://doi.org/10.1016/j.rser.2016.08.058.

[62] Sharon, H. & Reddy, K. S. (2015). A review of solar energy driven desalination technologies. *Renewable and Sustainable Energy Reviews*, 41, 1080-1118. DOI : https://doi.org/10.1016/j.rser.2014.09.002.

[63] Hillie, T., & Hlophe, M. (2007). Nanotechnology and the challenge of clean water. *Nature nanotechnology*, *2*(11), 663.

[64] Trivedy, R. K. (1970). Low cost and energy saving technologies for water and wastewater treatment. *I Control Pollution*, *23*(2), 403-411.

[65] Gehrke, I., Geiser, A., & Somborn-Schulz, A. (2015). Innovations in nanotechnology for water treatment. *Nanotechnology, Science and Applications*, *8*, 1–17. DOI : http://doi.org/10.2147/NSA.S43773.

[66] Mamadou, D., Duncan, J. S., Savage, N., Street, A., &Sustich, R. C. (2008). *Nanotechnology applications for clean water*. William Andrew Publishing.

[67] Hillie, T., & Hlophe, M. (2007). Nanotechnology and the challenge of clean water. *Nature Nanotechnology*, *2*(11), 663-664.

[68] Savage, N., & Diallo, M. S. (2005). Nanomaterials and water purification: opportunities and challenges. *Journal of Nanoparticle research*, *7*(4), 331-342.

[69] Diallo, M., Street, A., Sustich, R., Duncan, J., & Savage, N. (2009). *Nanotechnology Applications for Clean Water: Solutions for Improving Water Quality*. William Andrew.

[70] Gu, Z., & Deng, B. (2007). Use of iron-containing mesoporous carbon (IMC) for arsenic removal from drinking water. *Environmental Engineering Science*, *24*(1), 113-121.

[71] Smith, A. (2006). Opinion: Nanotech–the way forward for clean water?. *Filtration & separation*, *43*(8), 32-33.

[72] Howell, J. A. (2004). Future of membranes and membrane reactors in green technologies and for water reuse. *Desalination*, *162*, 1-11.

[73] Zhang, T. C., Surampalli, R. Y., Lai, K. C., Hu, Z., Tyagi, R. D., & Lo, I. M. (2009). Nanotechnologies for water environment applications. Reston, VA: American Society of Civil Engineers.

[74] Kim, S. J., Ko, S. H., Kang, K. H., & Han, J. (2010). Direct seawater desalination by ion concentration polarization. *Nature Nanotechnology*, *5*(4), 297-301.

[75] Gehrke, I., Geiser, A., & Somborn-Schulz, A. (2015). Innovations in nanotechnology for water treatment. *Nanotechnology, science and applications*, *8*, 1.

[76] Bhattacharya, S., Saha, I., Mukhopadhyay, A., Chattopadhyay, D., & Chand, U. (2013). Role of nanotechnology in water treatment and purification: potential applications and implications. *Int J Chem Sci Technol*, *3*(3), 59-64.

[77] Das, R., Ali, M. E., Hamid, S. B. A., Ramakrishna, S., & Chowdhury, Z. Z. (2014). Carbon nanotube membranes for water purification: a bright future in water desalination. *Desalination*, *336*, 97-109.

[78] Upadhyayula, V. K., Deng, S., Mitchell, M. C., & Smith, G. B. (2009). Application of carbon nanotube technology for removal of contaminants in drinking water: a review. *Science of the total environment*, *408*(1), 1-13.

[79] Sylvester, P., Westerhoff, P., Möller, T., Badruzzaman, M., & Boyd, O. (2007). A hybrid sorbent utilizing nanoparticles of hydrous iron oxide for arsenic removal from drinking water. *Environmental Engineering Science*, *24*(1), 104-112.

[80] Li, Q., Mahendra, S., Lyon, D. Y., Brunet, L., Liga, M. V., Li, D., & Alvarez, P. J. (2008). Antimicrobial nanomaterials for water disinfection and microbial control: potential applications and implications. *Water research*, *42*(18), 4591-4602.

[81] Wong, M. S., Alvarez, P. J., Fang, Y. L., Akçin, N., Nutt, M. O., Miller, J. T., & Heck, K. N. (2009). Cleaner water using bimetallic nanoparticle catalysts. *Journal of Chemical Technology and Biotechnology*, *84*(2), 158-166.

[82] Mahendra, S., Li, Q., Lyon, D. Y., Brunet, L., & Alvarez, P. J. (2009). Nanotechnology-enabled water disinfection and microbial control: merits and limitations. In *Nanotechnology Applications for clean water* (pp. 157-166).

[83] Peng, X., Jin, J., Nakamura, Y., Ohno, T., & Ichinose, I. (2009). Ultrafast permeation of water through protein-based membranes. *Nature nanotechnology*, *4*(6), 353-357.

[84] Gollavelli, G., Chang, C. C., & Ling, Y. C. (2013). Facile synthesis of smart magnetic graphene for safe drinking water: heavy metal removal and disinfection control. *ACS Sustainable Chemistry & Engineering*, *1*(5), 462-472.

[85] Zhang, X., Qian, J., & Pan, B. (2016). Fabrication of novel magnetic nanoparticles of multifunctionality for water decontamination. *Environmental science & technology*, *50*(2), 881-889.

[86] Mayo, J. T., Yavuz, C., Yean, S., Cong, L., Shipley, H., Yu, W., ... & Colvin, V. L. (2007). The effect of nanocrystalline magnetite size on arsenic removal. *Science and Technology of Advanced Materials*, *8*(1-2), 71.

[87] Liga, M. V., Bryant, E. L., Colvin, V. L., & Li, Q. (2011). Virus inactivation by silver doped titanium dioxide nanoparticles for drinking water treatment. *Water research*, *45*(2), 535-544.

[88] Lin, S., Huang, R., Cheng, Y., Liu, J., Lau, B. L., & Wiesner, M. R. (2013). Silver nanoparticle alginate composite beads for point-of-use drinking water disinfection. *Water research*, *47*(12), 3959-3965.

[89] Bhatnagar, A., Kumar, E., & Sillanpää, M. (2010). Nitrate removal from water by nano-alumina: Characterization and sorption studies. *Chemical Engineering Journal*, *163*(3), 317-323.

[90] Heidarpour, F., Ghani, W. W. A. K., Fakhru'l-Razi, A., Sobri, S., Heydarpour, V., Zargar, M., & Mozafari, M. R. (2011). Complete removal of pathogenic bacteria from drinking water using nano silver-coated cylindrical polypropylene filters. *Clean Technologies and Environmental Policy*, *13*(3), 499-507.

[91] Dankovich, T. A., &Gray, D. G. (2011). Bactericidal paper impregnated with silver nanoparticles for point-of-use water treatment. *Environ. Sci. Technol*, *45*(5), 1992-1998.

[92] Roy, E., Patra, S., Karfa, P., Madhuri, R., & Sharma, P. K. (2017). Role of Magnetic Nanoparticles in Providing Safe and Clean Water to Each Individual. In *Complex Magnetic Nanostructures* (pp. 281-316). Springer International Publishing.

[93] Gupta, A. K., Ghosal, P. S., & Dubey, B. K. (2017). Hybrid Nanoadsorbents for Drinking Water Treatment: A Critical Review. *Hybrid Nanomaterials: Advances in Energy, Environment, and Polymer Nanocomposites*, 199.

[94] Anadão, P. (2017). Nanocomposite filtration membranes for drinking water purification. In *Water Purification* (pp. 517-549).

[95] Tomar, V. (2017). Elimination of hazardous fluoride from drinking water using Th–Mn nanoadsorbent. *Int J Nano Med &Eng*, *2*(7), 131-140.

[96] Liu, C., Kong, D., Hsu, P. C., Yuan, H., Lee, H. W., Liu, Y., ... &Maraccini, P. A. (2016). Rapid water disinfection using vertically aligned MoS2 nanofilms and visible light. *Nature nanotechnology*, *11*(12), 1098-1104.

[97] Antwi, D. M. B., & Acheampong, M. A. (2016). Modification of Titanium Dioxide Nanoparticles for Phosphate Removal from Waste water. *Journal of Applied Science, Technology & Management*, *1*(1), 18-36.

[98] Bolisetty, S., & Mezzenga, R. (2016). Amyloid–carbon hybrid membranes for universal water purification. *Nature nanotechnology*, *11*(4), 365.

[99] Sharma, V. K., McDonald, T. J., Kim, H., & Garg, V. K. (2015). Magnetic graphene–carbon nanotube iron nanocomposites as adsorbents and antibacterial agents for water purification. *Advances in colloid and interface science*, *225*, 229-240.

[100] Wang, Y., Liu, L., Hong, J., Cao, J., & Deng, C. (2018). A novel Fe (OH) 3/g-C3N4 composite membrane for high efficiency water purification. *Journal of Membrane Science*, 564, 372-381. DOI :https://doi.org/10.1016/j.memsci.2018.07.027.

[101] Heiranian, M., Farimani, A. B., &Aluru, N. R. (2015). Water desalination with a single-layer MoS_2 nanopore. *Nature communications*, *6*, 8616.

[102] Kou, J., Zhou, X., Lu, H., Wu, F., & Fan, J. (2014). Graphyne as the membrane for water desalination. *Nanoscale*, *6*(3), 1865-1870.

[103] Duan, L., Zhao, Q., Liu, J., & Zhang, Y. (2015). Antibacterial behaviour of halloysite nanotubes decorated with copper nanoparticles in a novel mixed matrix membrane for water purification. *Environmental Science: Water Research & Technology*, *1*(6), 874-881.

[104] Santhosh, C., Kollu, P., Doshi, S., Sharma, M., Bahadur, D., Vanchinathan, M. T., ..& Grace, A.N. (2014). Adsorption, photodegradation and antibacterial study of graphene–Fe3O4 nanocomposite for multipurpose water purification application. *RSC Advances*, *4*(54), 28300-28308.

[105] Soyekwo, F., Zhang, Q., Gao, R., Qu, Y., Lin, C., Huang, X., ... & Liu, Q. (2017). Cellulose nanofiber intermediary to fabricate highly-permeable ultrathin nanofiltration membranes for fast water purification. *Journal of Membrane Science*, *524*, 174-185.

[106] Surendhiran, D., Sirajunnisa, A., & Tamilselvam, K. (2017). Silver–magnetic nanocomposites for water purification. *Environmental Chemistry Letters*, *15*(3), 367-386.

[107] Pandey, N., Shukla, S. K., & Singh, N. B. (2017). Water purification by polymer nanocomposites: an overview. *Nanocomposites*, *3*(2), 47-66.

[108] Wang, Z., Wu, A., Colombi Ciacchi, L., & Wei, G. (2018). Recent Advances in Nanoporous Membranes for Water Purification. *Nanomaterials*, *8*(2), 65. DOI : https://doi.org/10.3390/nano8020065.

[109] Thakur, S., Govender, P. P., Mamo, M. A., Tamulevicius, S., & Thakur, V. K. (2017). Recent progress in gelatin hydrogel nanocomposites for water purification and beyond. *Vacuum*, *146*, 396-408.

[110] Masheane, M. L., Nthunya, L. N., Sambaza, S. S., Malinga, S. P., Nxumalo, E. N., Mamba, B. B., & Mhlanga, S. D. (2017). Chitosan-based Nanocomposite Beads for Drinking Water Production. In *IOP Conference Series: Materials Science and Engineering*, 195(1), p.12004. IOP Publishing.

[111] Azzouz, I., Habba, Y. G., Capochichi-Gnambodoe, M., Marty, F., Vial, J., Leprince-Wang, Y., & Bourouina, T. (2018). Zinc oxide nano-enabled microfluidic reactor for water purification and its applicability to volatile organic compounds. *Microsystems & Nanoengineering*, *4*, 17093.

[112] Carraro, M., Bonchio, M., Modugno, G., &Fiorani, G. (2017). Nanosized metal oxides (NMOs) and polyoxometalates (POMs) for antibacterial water treatment. In *Application of Nanotechnology in Membranes for Water Treatment* (pp. 169-188). CRC Press.

[113] Antwi, D. M. B., & Acheampong, M. A. (2016). Modification of Titanium Dioxide Nanoparticles for Phosphate Removal from Waste water. *Journal of Applied Science, Technology & Management*, *1*(1), 18-36.

[114] Davis, J. M. (2007). How to assess the risks of nanotechnology: learning from past experience. *Journal of nanoscience and nanotechnology*, *7*(2), 402-409.

[115] Jones, R. (2007). Can nanotechnology ever prove that it is green?.*Nature Nanotechnology*, *2*(2), 71.

[116] Tiede, K., Hanssen, S. F., Westerhoff, P., Fern, G. J., Hankin, S. M., Aitken, R. J., ... & Boxall, A. B. (2016). How important is drinking water exposure for the risks of engineered nanoparticles to consumers?.*Nanotoxicology*, *10*(1), 102-110.

[117] Handy, R. D., & Shaw, B. J. (2007). Toxic effects of nanoparticles and nanomaterials: implications for public health, risk assessment and the public perception of nanotechnology. *Health, Risk & Society*, *9*(2), 125-144.

[118] Lee S. F., and Ko, A. S. O., (2000). Building Balanced Scorecard with SWOT Analysis, and Implementing, Sun Tzu's The Art of Business Management Strategies' on QFD Methodology. *Managerial Auditing Journal* 15 (1–2), 68–76.

[119] Aithal, P. S. and Suresh Kumar, P. M. (2015). Applying SWOC Analysis to an Institution of Higher Education. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 231-247. DOI :http://doi.org/10.5281/zenodo.163425.

[120] Gupta, A. (2013). Environment & PEST analysis: an approach to external business environment. *International Journal of Modern Social Sciences*, *2*(1), 34-43.

[121] Aithal, P. S., Shailashree, V.T. Suresh Kumar, P. M. (2015). A New ABCD Technique to Analyze Business Models & Concepts. *International Journal of Management, IT and Engineering (IJMIE)*, *5*(4), 409 – 423. DOI : http://doi.org/10.5281/zenodo.61652.

[122] Aithal, P. S., (2016). Study on ABCD Analysis Technique for Business Models, business strategies, Operating Concepts & Business Systems. *International Journal in Management and Social Science*, *4*(1), 98-115. DOI : http://doi.org/10.5281/zenodo.161137.

[123] Porter, M. E. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance.* New York: The Free Press.

[124] Aithal, P. S., (2017). ABCD Analysis as Research Methodology in Company Case Studies. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, *2*(2), 40-54. DOI: http://dx.doi.org/10.5281/zenodo.891621.

[125] Architha Aithal, and Aithal, P. S., (2017). ABCD Analysis of Task Shifting – An optimum Alternative Solution to Professional Healthcare Personnel Shortage. *International Journal of Health Sciences and Pharmacy (IJHSP)*, *1*(2), 36-51. DOI: http://dx.doi.org/10.5281/zenodo.1038975.

[126] Aithal, P. S. & Suresh Kumar, P. M. (2016). Opportunities and Challenges for Private Universities in India. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 88-113. DOI : http://doi.org/10.5281/zenodo. 161157.

[127] Padmanabha Shenoy, & Aithal, P. S., (2016). A Study on History of Paper and possible Paper Free World. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 337-355. DOI : http://doi.org/10.5281/zenodo. 161141.

[128] Aithal, P. S., (2015). Comparative Study on MBA Programmes in Private & Public Universities - A case study of MBA programme plan of Srinivas University. *International Journal of Management Sciences and Business Research (IJMSBR)***,** *4*(12), 106-122. DOI : http://doi.org/10.5281/z enodo.163884.

[129] Aithal P. S., & Shubhrajyotsna Aithal (2016). Impact of On-line Education on Higher Education System. *International Journal of Engineering Research and Modern Education (IJERME), 1*(1), 225-235. DOI :http://doi.org/ 10.5281/zenodo.161113.

[130] Aithal P. S., and Suresh Kumar P. M., (2016). Analysis of Choice Based Credit System in Higher Education. *International Journal of Engineering Research and Modern Education (IJERME)*, *1*(1), 278-284. DOI **:** http://doi.org/ 10.5281/zenodo.161046.

[131] Varun Shenoy and Aithal, P. S., (2016). Changing Approaches in Campus Placements - A new futuristic Model, *International Journal of Scientific Research and Modern Education (IJSRME)*, *1*(1), 766 – 776. DOI :http://doi.org /10.5281/zenodo.160966.

[132] Prithi Rao, and Aithal, P. S. (2016). Green Education Concepts & Strategies in Higher Education Model. *International Journal of Scientific Research and Modern Education (IJSRME)*, *1*(1), 793-802. DOI :http://doi.org/ 10.5281/zenodo.160877.

[133] Aithal, P. S. & Shubhrajyotsna Aithal (2016). Ekalavya Model of Higher Education – an Innovation of IBM's Big Data University. *International Journal of Current Research and Modern Education (IJCRME)*, *1*(2), 190-205. DOI: http://dx.doi.org/10.5281/zenodo.198704**.**

[134] Pantzali M. N., Mouza A. A., Paras S.V. (2009). Investigating the efficacy of nanofluids as coolants in plate heat exchangers (PHE). *Chem Eng Sci.*, *64*(3), 290– 300.

[135] Kotnarowska, D., & Wojtyniak, M. (2007). Nanotechnology application to automotive coating manufacturing. *Journal of KONES*, 14, 253-258.

[136] Kang, H. Y. (2010). A review of the emerging nanotechnology industry: materials, fabrications, and applications. *Department of Toxic Substances Control Pollution Prevention and Green Technology, California*, *64*.

[137] Hartmut Presting, Ulf König, (2003). Future nanotechnology developments for automotive applications, *Materials Science and Engineering: C*, 23(6-8), 737–741.

[138] Margarida C. Coelho, GuilherminaTorrão, Nazanin Emami, and José Grácio, (2012). Nanotechnology in Automotive Industry: Research Strategy and Trends for the Future—Small Objects, Big Impacts. *Journal of Nanoscience and Nanotechnology*, *12*(8), 6621-6630.

[139] Giftson Felix, D., Siva Kumar, G. (2014). Nano particles in Automobile Tires. *IOSR Journal of Mechanical and Civil Engineering*, 11(4), 07-11.

[140] Edward Wallner, Bruce Myers, D.H.R Sarma, Richard Parker and David Ihms, (2010). Nanotechnology Applications in Future Automobiles, SEA International, Downloaded from http://www.123seminarsonly.com/Seminar-Reports/d 032/71906092-Nano.pdf.

[141] Aithal P. S., (2015). Mobile Business as an Optimum Model for Ideal Business. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 146-159.

[142] Aithal P. S., & Shubhrajyotsna Aithal (2015). An Innovative Education Model to realize Ideal Education System. *International Journal of Scientific Research and Management (IJSRM)*, 3(3), 2464 - 2469.

[143] Aithal P. S., (2015). Concept of Ideal Banking and Realization of it using Ubiquitous Banking. *Proceedings of National Conference Recent Trends in Management, IT & Social Science*, pp. 205-213, ISBN: 978-81-929306-7-1.

[144] Sridhar Acharya P., and Aithal P. S., (2016). Concepts of Ideal Electric Energy System FOR production, distribution and utilization. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 367-379.

[145] Varambally K. V. M., and Aithal P. S., (2009). Mobile Business Technology and Business Proliferation of Banks – A futuristic Approach. *Amity Business Review – an Indian Journal*, 10(1), 9 – 25.

[146] Aithal P. S. & Shubhrajyotsna Aithal, (2016). Impact of On-line Education on Higher Education System. *International Journal of Engineering Research and Modern Education (IJERME)*, *I*(1) 225-235.

[147] Du, J., Du, Z., Hu, J. S., Pan, Z., Shen, Q., Sun, J., and Wan, L. J., (2016). Zn–Cu–In–Se Quantum Dot Solar Cells with a Certified Power Conversion Efficiency of 11.6%. *Journal of the American Chemical Society*, 138(12), 4201-4209.

[148] Stelzner T., Pietsch M., Andrä G., Falk F., Ose E., and Christiansen S. (2008). Silicon nanowire-based solar cells. *Nanotechnology*, 19(29), 295203.

[149] Yang, Y., Zhao, J., Cui, C., Zhang, Y., Hu, H., Xu, L., & Tang, W. (2016). Hydrothermal growth of ZnO nanowires scaffolds within mesoporous TiO_2photoanodes for dye-sensitized solar cells with enhanced efficiency. *Electrochimica Acta*, 196, 348-356.

[150] Hao-Lin Feng, Wu-Qiang Wu, Hua-Shang Rao, Long-Bin Li, Dai-Bin Kuang and Cheng-Yong Su, (2015). Three-dimensional hyper branched TiO2/ZnO hetero structured arrays for efficient quantum dot-sensitized solar cells. *J. Mater. Chem. A*, 3(28), 14826-14832.

[151] VipinrajSugathan, Elsa John, K. Sudhakar (2015). Recent improvements in dye sensitized solar cells: A review. *Renewable and Sustainable Energy Reviews*, 52, 54–64.

[152] Zhenwei Ren, Jin Wang, Zhenxiao Pan, Ke Zhao, Hua Zhang, Yan Li, Yixin Zhao, Ivan Mora-Sero, Juan Bisquert, and Xinhua Zhong, (2015). Amorphous TiO_2 Buffer Layer Boosts Efficiency of Quantum Dot Sensitized Solar Cells to over 9%. *Chem. Mater.*, 27(24), 8398–8405.

[153] Tzu-mingChien, PrathameshPavaskar, Wei Hsuan Hung, Stephen Cronin, Sheing-Hui Chiu, Sz-Nian Lai. (2015). Study of the plasmon energy transfer processes in dye sensitized solar cells. *Journal of Nanomaterials - Special issue on Nano- and Biomaterials for Sustainable Development*, 2015.

[154] Acik, M., & Darling, S. B. (2016). Graphene in perovskite solar cells: device design, characterization and implementation. *Journal of Materials Chemistry A*, 4(17), 6185-6235.

[155] Australian National University. Glowing nanomaterial to drive new generation of solar cells. Science Daily. (2016). Retrieved July 3, 2016 from www.sciencedaily.com/releases/2016/04/160418095909.htm

[156] Sergey S. Kruk, Zi Jing Wong, Ekaterina Pshenay-Severin, Kevin O'Brien, Dragomir N. Neshev, Yuri S. Kivshar, Xiang Zhang. (2016). Magnetic hyperbolic optical metamaterials. *Nature Communications*, *7*, 11329.

[157] Zarazúa, I., Esparza, D., López-Luke, T., Ceja-Fdez, A., Reyes-Gomez, J., Mora-Seró, I., & de la Rosa, E. (2016). Effect of the electrophoretic deposition of Au NPs in the performance CdS QDs sensitized solar Cells. *Electrochimica Acta*, 188, 710-717.

[158] Huang, F., Hou, J., Zhang, Q., Wang, Y., Massé, R. C., Peng, S., ... & Cao, G. (2016). Doubling the power conversion efficiency in CdS/CdSe quantum dot sensitized solar cells with a ZnSe passivation layer. *Nano Energy*, 26, 114-122.

[159] Merugula, Laura A., Vikas Khanna, and Bhavik R. Bakshi. (2010). Comparative Life Cycle Assessment: Reinforcing wind turbine blades with carbon nanofibers. *Proceedings of the 2010 IEEE international symposium on sustainable systems and technology*, pp. 1-6. IEEE, 2010.

[160] Greco, A., Mistry, K., Sista, V., Eryilmaz, O., & Erdemir, A., (2011). Friction and wear behaviour of boron based surface treatment and nano-particle lubricant additives for wind turbine gearbox applications. *Wear*, 271(9), 1754-1760.

[161] Liang, F., Gou, J., Kapat, J., Gu, H., & Song, G., Multifunctional nanocomposite coating for wind turbine blades. *International Journal of Smart and Nano Materials*, 2(3), 120-133.

[162] Ma, Peng-Cheng, and Yi Zhang. (2014). Perspectives of carbon nanotubes/polymer nanocomposites for wind blade materials. *Renewable and Sustainable Energy Reviews*, 30, 651-660.

[163] Ng, K. W., Lam, W. H., &Pichiah, S. (2013). A review on potential applications of carbon nanotubes in marine current turbines. *Renewable and Sustainable Energy Reviews*, 28, 331-339.

[164] Tananaev, I. G., Sarychev, G. A., Myasoedov B. F. (2016). Nanomaterials in nuclear engineering and radioecology. *Nanotechnologies in Russia*, *11*(1–2), 63-72.

[165] Lamar O. Mair, (2015). Nuclear Power and Nanomaterials: Big Potential for Small Particles. *Federation of American Scientists, Public Interest Report*, 68(1), https://fas.org/wp-content/uploads/2015/02/ Nuclear-Power-and-Nanomaterials-Winter-2015.pdf.

[166] Zi-Jie Li, Lin Wang, Li-Yong Yuan, Cheng-Liang Xiao, Lei Mei, Li-Rong Zheng, Jing Zhang, Ju-Hua Yang, Yu-Liang Zhao, Zhen-Tai Zhu, Zhi-Fang Chai, and Wei-Qun Shi, (2015). Efficient removal of uranium from aqueous solution by zero-valent iron nanoparticle and its graphene composite. *Journal of Hazardous Materials*, 290, 26.

[167] Petrunin V. F., (2015). Development of Nanomaterials for Nuclear Energetics. *Physics Procedia*, 72, 536-539.

[168] Park K. J., Jung D., (2007). Enhancement of nucleate boiling heat transfer using carbon nanotubes. *Int J Heat Mass Transfer*, 50, 4499-4502.

[169] Pavía-Sanders, A., Zhang, S., Flores, J. A., Sanders, J. E., Raymond, J. E., &Wooley, K. L. (2013). Robust magnetic/polymer hybrid nanoparticles designed for crude oil entrapment and recovery in aqueous environments.*ACS nano*, 7(9), 7552-7561.

[170] Flores, J. A., Pavía-Sanders, A., Chen, Y., Pochan, D. J., & Wooley, K. L. (2015). Recyclable hybrid inorganic/organic magnetically active networks for the sequestration of crude oil from aqueous environments. *Chemistry of Materials*, 27(10), 3775-3782.

[171] Hashemi, R., Nassar, N. N., & Almao, P. P. (2014). Nanoparticle technology for heavy oil in-situ upgrading and recovery enhancement: Opportunities and challenges. *Applied Energy*, 133, 374-387.

[172] Diana N. H. Tran, ShervinKabiri, Ting Rui Sim and DusanLosic, (2015). Selective adsorption of oil–water mixtures using polydimethylsiloxane (PDMS)–graphene sponges.*Environ. Sci.: Water Res. Technol*., *1*, 298-305.

[173] Zhu, K., Shang, Y. Y., Sun, P. Z., Li, Z., Li, X. M., Wei, J. Q., & Zhu, H. W., (2013). Oil spill cleanup from sea water by carbon nanotube sponges. *Frontiers of Materials Science*, 7(2), 170-176.

[174] Hwang, Chih-Chau. (2014). Carbon Nanomaterials for Detection, Assessment and Purification of Oil and Natural Gas.*Doctoral Thesis, Rice University*. http://hdl.handle.net/1911/77165.

[175] Jiexi Wang, Qiaobao Zhang, Xinhai Li, DaguoXu, Zhixing Wang, Huajun Guo, Kaili Zhang, (2014). Three-dimensional hierarchical Co3O4/CuO nanowire hetero structure arrays on nickel foam for high-performance lithium ion batteries.*Nano Energy*, 6, 19-26.

[176] Guo, W., Xue, X., Wang, S., Lin, C., & Wang, Z. L. (2012). An integrated power pack of dye-sensitized solar cell and Li battery based on double-sided TiO2 nanotube arrays. *Nano letters*, 12(5), 2520-2523.

[177] Zhang LL, Zhao XS. (2009). Carbon-based materials as super capacitor electrodes. *Chem. Soc. Rev*., 38, 2520-2531.

[178] Maryam Moradi, Zheng Li, Jifa Qi, Wenting Xing, Kai Xiang, Yet-Ming Chiang, and Angela M. Belcher, (2015). Improving the Capacity of Sodium Ion Battery Using a Virus-Templated Nanostructured Composite Cathode, *NanoLett.*, 15(5), 2917–2921.

[179] Kwang Sup Eom, Jaehan Jung, Jung Tae Lee, Valentin Lair, Tapesh Joshi, Seung Woo Lee, Zhiqun Lin, Thomas F. Fuller, (2015). Improved stability of nano-Sn electrode with high-quality nano-SEI formation for lithium ion battery, *Nano Energy*, 12, 314–321.

[180] Gust, D., Moore, T. A., & Moore, A. L. Solar fuels via artificial photosynthesis. *Accounts of chemical research*, 42, No.12, pp. 1890-1898, 2009.

[181] http://web.stanford.edu/group/mota/education/Physics%2087N%20Final%20 Projects/ Group%20Gamma/photo.htm#_ednref3.

[182] Imahori, H., Mori, Y., &Matano, Y. (2003). Nanostructured artificial photosynthesis. *Journal of Photochemistry and Photobiology C: Photochemistry Reviews*, 4(1), 51-83.

[183] 51. Ryu, J., Lee, S. H., Nam, D. H., & Park, C. B. (2011). Rational Design and Engineering of Quantum-Dot-Sensitized TiO_2 Nanotube Arrays for Artificial Photosynthesis. *Advanced Materials*, 23(16), 1883-1888.

[184] Liao, L., Zhang, Q., Su, Z., Zhao, Z., Wang, Y., Li, Y., & Cai, X. (2014). Efficient solar water-splitting using a nanocrystalline Co Ophotocatalyst. *Nature nanotechnology*, 9(1), 69-73.

[185] Gust, D., Moore, T. A., & Moore, A. L. (2009). Solar fuels via artificial photosynthesis. *Accounts of chemical research*, 42(12), 1890-1898.

[186] Aithal P. S., Shailashree V. T., & Suresh Kumar P. M. (2015). Application of ABCD Analysis Model for Black Ocean Strategy. *International Journal of Applied Research (IJAR)*, 1(10), 331 - 337.

[187] Aithal P. S., Shailashree V. T., & Suresh Kumar P. M. (2016). ABCD analysis of Stage Model in Higher Education. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 11-24.

[188] Aithal P. S., Shailashree V.T., & Suresh Kumar P. M. (2016). Analysis of NAAC Accreditation System using ABCD framework. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 30 - 44.

[189] Aithal P. S., Shailashree V. T., & Suresh Kumar P. M. (2016). Application of ABCD Analysis Framework on Private University System in India. *International Journal of Management Sciences and Business Research (IJMSBR)*, 5(4), 159-170.

[190] Aithal P. S., Shailashree V. T., & Suresh Kumar P. M. (2016). The Study of New National Institutional Ranking System using ABCD Framework. *International Journal of Current Research and Modern Education (IJCRME)*. 1(1), 389 – 402.

[191] Qualities of an ideal source of energy, https://www.studyadda.com/ncert-solution/10th-sciencesources-of-energy/232/26014 referred on 25/10/2018.

[192] Aithal, P.S. & Shubhrajyotsna Aithal, (2016). Opportunities & Challenges for Green Technology in 21st Century. *International Journal of Current Research and Modern Education (IJCRME)*, 1(1), 818-828. DOI : http://doi.org/10.5281/zenodo.62020.

[193] Aithal, P. S., & Shubhrajyotsna Aithal, (2015). A review on Anticipated Breakthrough Technologies of 21st Century. *International Journal of Research & Development in Technology and Management Sciences*, 21(6), 112 – 133. DOI: http://doi.org/10.5281/zenodo.61617.

[194] Aithal P. S. & Shubhrajyotsna Aithal, (2018). Nanotechnology based Innovations and Human Life Comfortability –Are we Marching towards Immortality? *International Journal of Applied Engineering and Management Letters (IJAEML)*, 2(2), 71-86. DOI: https://doi.org/10.5281/zenodo.1451498.

[195] Aithal, P. S. and Shubhrajyotsna Aithal. (2018). Study of various General-Purpose Technologies and their contribution towards developing Sustainable Society.*International Journal of Management, Technology, and Social Sciences (IJMTS)*, 3(2), 16-33. DOI: http://doi.org /10.5281/zenodo.1409476.

[196] Aithal, P. S. (2016). Nanotechnology Innovations & Business Opportunities: A Review. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 182-204. DOI: http://doi.org/10.5281/zenodo.161153.

[197] Aithal P. S & Shubhrajyotsna Aithal, (2016). Business Strategy for Nanotechnology based Products & Services. *International Journal of Management Sciences and Business Research (IJMSBR)*, 5(4), 139-149, DOI: http://doi.org/10.5281/zenodo.161127.

[198] Aithal, P. S.&Shubrajyotsna Aithal, (2016). Nanotechnology Innovations and Commercialization – Opportunities, Challenges & Reasons for Delay. *International Journal of Engineering and Manufacturing (IJEM)*, 6(6), 15-25, DOI: http://doi.org/10.5281/zenodo.161161, DOI: http://doi.org/10.5815/ijem.2016.06.02.

[199] Aithal, P. S & Shubhrajyotsna Aithal, (2016). A New Model for Commercialization of Nanotechnology Products and Services. *International Journal of Computational Research and Development*, 1(1), 84-93. DOI: http://doi.org/10.5281/zenodo.163536.

[200] Aithal, P.S. & Shubhrajyotsna Aithal (2018). The Concept & Characteristics of Ideal Energy System and its Realization Constraints. *International Journal of Applied Engineering and Management Letters (IJAEML)*, 2(2), 127-137. DOI: https://doi.org/10.5281/zenodo.1487702.

[201] Aithal P. S & Shubhrajyotsna Aithal, (2018). Factor & Elemental Analysis of Nanotechnology as Green Technology using ABCD Framework. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, 3(2), 57-72. DOI: https://doi.org/10.5281/zenodo.1451490.

[202] Das, T. K., &Prusty, S. (2013). Graphene-based polymer composites and their applications. *Polymer-Plastics Technology and Engineering*, 52(4), 319-331.

[203] Kwong, C. Y., Choy, W. C. H., Djurišić, A. B., Chui, P. C., Cheng, K. W., & Chan, W. K. (2004). Poly (3-hexylthiophene): TiO2 nanocomposites for solar cell applications. *Nanotechnology*, 15(9), 1156.

[204] Liu, R. (2014). Hybrid organic/inorganic nanocomposites for photovoltaic cells. *Materials*, 7(4), 2747-2771.

[205] Grätzel, M. (2014). The light and shade of perovskite solar cells. *Nature materials*, 13(9), 838.

[206] Song, J., Zheng, E., Wang, X. F., Tian, W., & Miyasaka, T. (2016). Low-temperature-processed ZnO–SnO2 nanocomposite for efficient planar perovskite solar cells. *Solar Energy Materials and Solar Cells*, 144, 623-630.

[207] Han, G. S., Song, Y. H., Jin, Y. U., Lee, J. W., Park, N. G., Kang, B. K., ... & Jung, H. S. (2015). Reduced graphene oxide/mesoporous TiO_2 nanocomposite-based perovskite solar cells. *ACS applied materials & interfaces*, 7(42), 23521-23526.

[208] Liu, T., Bai, X., Miao, C., Dai, Q., Xu, W., Yu, Y., ... & Song, H. (2014). Yb2O3/Au upconversion nanocomposites with broad-band excitation for solar cells. *The Journal of Physical Chemistry C*, 118(6), 3258-3265.

[209] Huang, W. J., De Valle, S. A., Kana, J. B. K., Simmons-Potter, K., & Potter Jr, B. G. (2015). Integration of CdTe–ZnO nanocomposite thin films into photovoltaic devices. *Solar Energy Materials and Solar Cells*, 137, 86-92.

[210] Rath, T., Edler, M., Haas, W., Fischereder, A., Moscher, S., Schenk, A & Meischler, D. (2011). A direct route towards polymer/copper indium sulfide nanocomposite solar cells. *Advanced energy materials*, 1(6), 1046-1050.

[211] O'Hayre, R., Nanu, M., Schoonman, J., Goossens, A., Wang, Q., & Grätzel, M. (2006). The influence of TiO_2 particle size in $TiO_2/CuInS_2$ nanocomposite solar cells. *Advanced Functional Materials*, 16(12), 1566-1576.

[212] Maier, E., Rath, T., Haas, W., Werzer, O., Saf, R., Hofer, F & Amenitsch, H. (2011). $CuInS_2$–Poly (3-(ethyl-4-butanoate) thiophene) nanocomposite solar cells: Preparation by an in-situ formation route, performance and stability issues. *Solar energy materials and solar cells*, 95(5), 1354-1361.

[213] Beek, W. J., Wienk, M. M., & Janssen, R. A. (2006). Hybrid solar cells from regioregular polythiophene and ZnO nanoparticles. *Advanced Functional Materials*, 16(8), 1112-1116.

[214] Shanmugam, M., Bansal, T., Durcan, C. A., & Yu, B. (2012). Molybdenum disulphide/titanium dioxide nanocomposite-poly 3-hexylthiophene bulk heterojunction solar cell. *Applied Physics Letters*, 100(15), 153901.

[215] Zhao, D., & Yang, C. F. (2016). Recent advances in the TiO_2/CdS nanocomposite used for photocatalytic hydrogen production and quantum-dot-sensitized solar cells. *Renewable and Sustainable Energy Reviews*, 54, 1048-1059.

[216] Nogueira, A. F., Durrant, J. R., & De Paoli, M. A. (2001). Dye-sensitized nanocrystalline solar cells employing a polymer electrolyte. *Advanced Materials*, 13(11), 826-830.

[217] Dinari, M., Momeni, M. M., & Goudarzirad, M. (2016). Dye-sensitized solar cells based on nanocomposite of polyaniline/graphene quantum dots. *Journal of materials science*, 51(6), 2964-2971.

[218] Singh, E., &Nalwa, H. S. (2015). Graphene-based dye-sensitized solar cells: a review. *Science of Advanced Materials*, 7(10), 1863-1912.

[219] Chen, H., Liu, T., Ren, J., He, H., Cao, Y., Wang, N., & Guo, Z. (2016). Synergistic carbon nanotube aerogel–Pt nanocomposites toward enhanced energy conversion in dye-sensitized solar cells. *Journal of Materials Chemistry A*, 4(9), 3238-3244.

[220] Rutkowska, I. A., Marszalek, M., Orlowska, J., Ozimek, W., Zakeeruddin, S. M., Kulesza, P. J., &Grätzel, M. (2015). Nanocomposite Semi-Solid Redox Ionic Liquid Electrolytes with Enhanced Charge-Transport Capabilities for Dye-Sensitized Solar Cells. *Chem Sus Chem*, 8(15), 2560-2568.

[221] Pandikumar, A., Suresh, S., Murugesan, S., &Ramaraj, R. (2015). Dual Functional TiO2–Au Nanocomposite Material for Solid-State Dye-Sensitized Solar Cells. *Journal of nanoscience and nanotechnology*, 15(9), 6965-6972.

[222] Yun, S., Freitas, J. N., Nogueira, A. F., Wang, Y., Ahmad, S., & Wang, Z. S. (2016). Dye-sensitized solar cells employing polymers. *Progress in Polymer Science*, 59, 1-40.

[223] Kowsari, E., & Chirani, M. R. (2017). High efficiency dye-sensitized solar cells with tetra alkyl ammonium cation-based ionic liquid functionalized graphene oxide as a novel additive in nanocomposite electrolyte. *Carbon*, 118, 384-392.

[224] Boro, B., Gogoi, B., Rajbongshi, B. M., &Ramchiary, A. (2017). Nano-structured TiO_2/ZnO nanocomposite for dye-sensitized solar cells application: A review. *Renewable and Sustainable Energy Reviews*. *81*, 2264-2270.

[225] Sharma, S., Siwach, B., Ghoshal, S. K., & Mohan, D. (2017). Dye sensitized solar cells: From genesis to recent drifts. *Renewable and Sustainable Energy Reviews*, 70, 529-537.

[226] Usui, H., Matsui, H., Tanabe, N., &Yanagida, S. (2004). Improved dye-sensitized solar cells using ionic nanocomposite gel electrolytes. *Journal of Photochemistry and Photobiology A: Chemis*, 164(1-3), 97-101.

[227] Baxter, J. B., &Aydil, E. S. (2005). Nanowire-based dye-sensitized solar cells. *Applied Physics Letters*, 86(5), 053114.

[228] Yu, J., Fan, J., & Cheng, B. (2011). Dye-sensitized solar cells based on anatase TiO_2 hollow spheres/carbon nanotube composite films. *Journal of Power Sources*, 196(18), 7891-7898.

[229] Muduli, S., Game, O., Dhas, V., Vijayamohanan, K., Bogle, K. A., Valanoor, N., & Ogale, S. B. (2012). TiO2–Au plasmonic nanocomposite for enhanced dye-sensitized solar cell (DSSC) performance. *Solar Energy*, 86(5), 1428-1434.

[230] Paulose, M., Shankar, K., Varghese, O. K., Mor, G. K., Hardin, B., & Grimes, C. A. (2006). Backside illuminated dye-sensitized solar cells based on titania nanotube array electrod. Nanotechnology, 17(5), 1446.

[231] Manthina, V., Correa Baena, J. P., Liu, G., & Agrios, A. G. (2012). ZnO–TiO2 nanocomposite films for high light harvesting efficiency and fast electron transport in dye-sensitized solar cells. *The Journal of Physical Chemistry C*, 116(45), 23864-23870.

[232] Cao, Y., Bai, Y., Yu, Q., Cheng, Y., Liu, S., Shi, D., ... & Wang, P. (2009). Dye-sensitized solar cells with a high absorptivity ruthenium sensitizer featuring a 2-(hexylthio) thiophene conjugated bipyridine. *The Journal of Physical Chemistry C*, 113(15), 6290-6297.

[233] Stathatos, E., Lianos, P., Jovanovski, V., & Orel, B. (2005). Dye-sensitized photo electro chemical solar cells based on nanocomposite organic–inorganic materials. *Journal of Photochemistry and Photobiology A: Chemistry*, 169(1), 57-61.

[234] Han, H. W., Liu, W., Zhang, J., & Zhao, X. Z. (2005). A Hybrid Poly (ethylene oxide)/Poly (vinylidene fluoride)/TiO2 Nanoparticle Solid-State Redox Electrolyte for Dye-Sensitized Nanocrystalline Solar Cells. *Advanced Functional Materials*, 15(12), 1940-1944.

[235] Yang, B., Zuo, X., Chen, P., Zhou, L., Yang, X., Zhang, H & Chen, X. (2015). Nanocomposite of tin sulfide nanoparticles with reduced graphene oxide in high-efficiency dye-sensitized solar cells. *ACS applied materials & interfaces*, 7(1), 137-143.

[236] Shubrajyotsna Aithal, Aithal, P. S. and Bhat, G. K. (2011). Optical Nonlinearity of Dye-doped Polymer Film using Z-scan Technique, Second International Conference on Photonics 2011, 17-19 October 2011, Le Meridian, Kota Kinabalu, Malaysia, IEEE Xplore ISBN 978-1-61284-265-3, pp. 62-66 (2011). DOI: http://doi.org/10.1109/ICP.2011.6106884,

[237] Shubrajyotsna Aithal, Aithal, P. S. and Bhat, G. K. (2011). Study of nonlinear absorption in a dye doped polymer film due to frequency up-converted fluorescence, Proceedings of the International Conference on Laser, Material Science and Communication, Dept. of Physics, University of Burdwan, West Bengal, Ed. U. Chatterjee and P.K. Chakrabarti, ISBN: 978-93-80813-14-1, pp. 107-109. DOI: http://doi.org/10.5281/zenodo.62033.

[238] Shubhrajyotsna Aithal, Aithal, P. S. and Bhat, G. K. (2011). Nonlinear Absorption Studies of Disperse Orange Doped Polymer Film, Trends in Optics and Photonics II, Proceedings of International Conference on Trends in Optics and Photonics, December 7-9, 2011, Kolkata, India. Editors: Ajay Ghosh and Debesh Choudhury, ISBN 978-81-908188-1-0, P. 132-137. DOI: http://doi.org/10.5281/ zenodo.62034.

[239] Shubrajyotsna Aithal, Aithal, G. K. and Bhat, G. K. (2012). Phase Conjugation in Two Photon Absorbing Dye films by Degenerate Four-wave Mixing, 3rd International Conference on Photonics 2012, 1-3 October 2012, Penang, Malaysia. Published in IEEE Xplore ISBN: 978-1-4673-1463-3, pp - 235-239. DOI http://doi.org/10.1109/ICP.2012.6379868.

[240] Shubrajyotsna Aithal, Aithal, P. S. & Bhat, G. K. (2012). Study of Degenerate Four-Wave Mixing in Disperse Orange Dye-doped Polymer Film. *Advanced Materials Research Journal*, 584, 526-530. DOI: http://doi.org/10.4028/www.scientific.net/AMR.584.526.

[241] Shubrajyotsna Aithal, Aithal, P. S. (2012). Study of Phase Conjugated wave in DASPB dye-doped polymer films. In Proceedings of Photonics Global Conference (PGC), Singapore, 2012 (pp. 1-5). IEEE. ISBN: 978-1-4673-2513-4, DOI: http://doi.org/10.1109/PGC.2012.6458057.

[242] Shubrajyotsna Aithal, Aithal, P. S. & Bhat, G. K. (2013). Degenerate four-wave mixing in DASPB dye-doped polymer film, published in Part IV Quantum Optics, Chapter 12, Advances in Laser Physics and Technology, Edited by Man Mohan, Anil Kumar Maini, Aranya A. Bhattacherjee and Anil K. Razdan under the imprint of Foundation Books, Cambridge University Press India Pvt Ltd. 2013, pp. 179 - 195, ISBN: 978-93-844634-1-0., DOI : http://doi.org/10.5281/zenodo.62048.

[243] Shubhrajyotsna Aithal, Aithal, P. S. and Bhat, G. K. (2013). Study of Optical Limiting and Optical Phase Conjugation in DASPB dye-doped polymer films. *GSTF Journal of Physics and Applications (JPA)*, 1(1), 15-24. DOI: http://doi.org/10.5176/2335-6901_1.1.3.

[244] Shubhrajyotsna Aithal, Aithal, P. S. and Bhat, G. K. (2015).Comparative Study on Azo dye-doped Polymer Films for Optical Phase Conjugation. *International Journal of Science and Research (IJSR)*, 4(4), 436-441. DOI: http://doi.org/10.5281/zenodo.61724.

[245] Shubrajyotsna Aithal, Aithal, P. S. and Bhat, G. K. (2015) A Review on Sustainable Organic Materials for Optical Limiting Technology. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 527-544. DOI: http://doi.org/10.5281/zenodo.62032.

[246] Shubhrajyotsna Aithal, Aithal, P. S. & G.K. Bhat, (2016). A Review on Organic Materials for Optical Phase Conjugation & All-optical Switches. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 222-238, DOI: http://doi.org/10.5281/zenodo.62027.

[247] Shubhrajyotsna Aithal and Aithal P. S., (2016), ABCD analysis of Dye doped Polymers for Photonic Applications. *IRA-International Journal of Applied Sciences*, 4(3), 358-378. DOI: http://dx.doi.org/ 10.21013/jas.v4.n3.p1.

[248] Shubrajyotsna Aithal, & Aithal, P. S., Bhat,G. K. (2016). Characteristics of Ideal Optical Limiter and Realization Scenarios using Nonlinear Organic Materials – A Review. *International Journal of Advanced Trends in Engineering and Technology (IJATET)*, *1*(1), 73-84. DOI: http://doi.org/10.5281/ zenodo.240254.

[249] Shubrajyotsna Aithal, Aithal, P. S. & Bhat, G. K. (2016). Literature Review on Organic Materials for Third Harmonic Optical and Photonic Applications. *International Journal of Advanced Trends in Engineering and Technology (IJATET)*, 1(1), 151-162. DOI: http://doi.org/10.5281/zenodo.240647.

[250] Shubrajyotsna Aithal, Aithal, P. S. & Bhat,G. K. (2016). Type 1 & Type 2 Optical Limiting Studies in Disperse Orange-25 Dye-doped PMMA-MA Polymer Films using CW Laser. *International Journal of Applied and Advanced Scientific Research (IJAASR)*, *1*(1), 196-208. DOI: http://doi.org/10.5281/ zenodo.208184.

[251] Prasad, P. N., and Williams, D. J. (1991). Introduction to Nonlinear Optical Effects in molecules and Polymers. John Wiley & Sons, New York.

[252] Tomov, I. V., VanWonterghem, B., Dvornikov, A. S, Dutton, T. E., and Rentzepis, P. M. (1991). Degenerate four-wave mixing in azo-dye-doped polymer films./. *Opt. Soc. Am. B*, 8, 1477-1482.

[253] Mohajerani, E. and Mitchell, G. R. (1993). Temperature optimisation of optical phase conjugation in dye doped polymer films. *Opt. Commun*. 97, 388-396.

[254] Molecular Nonlinear Optics: Materials, Physics and Devices; Zyss, J., Ed.; Academic Press: Boston, 1994; p 129.

[255] Cheng, L-T.; Tam, W.; Stevenson, S. H.; Meredith, G.; Rikken, G.; Marder, S. R. (1991). Experimental investigations of organic molecular nonlinear optical polarizabilities. 1. Methods and results on benzene and stilbene derivatives. *J. Phys. Chem*., 95, 10631-10643.

[256] Shubrajyotsna Aithal, Aithal, P. S. and Bhat, G. K. (2016). CW Optical Limiting Study in Disperse Yellow Dye-doped PMMA-MA Polymer Films. *IRA-International Journal of Applied Sciences*, 5(3), 129-146. DOI: http://dx.doi.org/10.21013/jas.v5.n3.p4.

[257] Shubrajyotsna Aithal, Aithal, P. S. and Bhat, G. K. (2016). Study of Low Power Degenerate Four-Wave Mixing in Disperse Yellow Dye-doped Polymer Film. *International Journal of Engineering Research and Modern Education (IJERME)*, *1*(2), 200-209. DOI: http://doi.org/10.5281/zenodo.1987 16.

[258] Shubrajyotsna Aithal, Aithal, P. S. & Bhat,G. K. (2017). Study of Third Order Optical Nonlinearity in DASPB Dye-doped Polymer Films using CW Laser. *Saudi Journal of Engineering and Technology (SJEAT)*, *2*(1), 32-48. DOI: http://doi.org/10.21276/sjeat.2017.2.1.4.

[259] Shubrajyotsna Aithal, & Aithal P. S. (2017). Research Opportunities for Use of Organic Dyes & Dye-doped Polymers in Optoelectronics and Photonics. *International Journal of Engineering Research and Modern Education (IJERME)*, 2(1), 90-97. DOI: http://doi.org/10.5281/zenodo.546772.

[260] Shubrajyotsna Aithal, Aithal, P. S. and Bhat, G. K. (2017). Study of Third Order Optical Nonlinearity in Disperse Orange-25 Dye-doped Polymer Films using CW Laser. *International Journal of Applied Engineering & Management Letters*, *1*(1), 18-35. DOI: http://dx.doi.org/10.5281/zenodo.818692.

[261] Shubrajyotsna Aithal, Aithal, P. S. and G. K. Bhat, (2017). Study of Nonlinear Optical Properties of Disperse Yellow-7 Dye-doped Polymer Films using CW Laser. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *1*(1), 45-62. DOI: http://dx.doi.org/10.5281/zenodo. 821082.

[262] Nalwa, H. S., Miyata, S. Nonlinear Optics of Organic Molecules and Polymers, CRC Press, Boca Raton, 1997.

[263] Sadashivappa, G., & Sharvari, N. P. (2015). Nanoantenna–a review. *International Journal of Renewable Energy Technology Research*, 4(1), 1-9.

[264] Sabaawi, A. M., Tsimenidis, C. C., & Sharif, B. S. (2013). Overview of nanoantennas for solar rectennas. *Rectenna Solar Cells* (pp. 231-256). Springer, New York, NY.

[265] Vakil, A., &Bajwa, H. (2014). Energy harvesting using Graphene based antenna for UV spectrum. In Systems, Applications and Technology Conference (LISAT), IEEE Long Island (pp. 1-4). IEEE.

[266] Reynaud, C. A., Duché, D., Ruiz, C. M., Palanchoke, U., Patrone, L., Le Rouzo, J & Charaï, A. (2017). Toward a nanoimprinted nanoantenna to perform optical rectification through molecular diodes. *Journal of Nanoparticle Research*, 19(12), 394.

[267] Shank, J., Kadlec, E. A., Jarecki, R. L., Starbuck, A., Howell, S., Peters, D. W., & Davids, P. S. (2018). Power generation from a radiative thermal source using a large-area infrared rectenna. *Physical Review Applied*, 9(5), 054040.

[268] http://theartofmed.wordpress.com/2015/05/8/introduction-to-pharmacology-icharacteristics-of-drugs/. Retrieved on 10/10/2018.

[269] http://hubpages.com/education/Characteristics-of-Drug. Retrieved on 5/10/2018.

[270] Kubinyi, H. (2003). Drug research: myths, hype and reality. *Nature Reviews Drug Discovery*, 2(8), 665.

[271] Tiwari, G., Tiwari, R., Sriwastawa, B., Bhati, L., Pandey, S., Pandey, P., & Bannerjee, S. K. (2012). Drug delivery systems: An updated review. *International journal of pharmaceutical investigation*, 2(1), 2.

[272] Lata, S., Sharma, G., Joshi, M., Kanwar, P., & Mishra, T. (2017). Role of nanotechnology in drug delivery. *Int J Nanotechnol Nanosci.*, 5, 1-29.

[273] Kunjachan, S., Ehling, J., Storm, G., Kiessling, F., & Lammers, T. (2015). Noninvasive imaging of nanomedicines and nanotheranostics: principles, progress, and prospects. *Chemical reviews*, *115*(19), 10907-10937.

[274] Valavanidis, A., & Vlachogianni, T. (2016). Engineered nanomaterials for pharmaceutical and biomedical products new trends, benefits and opportunities. *Journal of Pharma Reports*, *1*(1), 1-8. DOI :http://doi.org/10.4172/jpr.1000105.

[275] Owen, A., & Rannard, S. (2016). Strengths, weaknesses, opportunities and challenges for long acting injectable therapies: insights for applications in HIV therapy. *Advanced drug delivery reviews*, 103, 144-156.

[276] Qasim, M., Lim, D. J., Park, H., & Na, D. (2014). Nanotechnology for diagnosis and treatment of infectious diseases. *Journal of nanoscience and nanotechnology*, 14(10), 7374-7387.

[277] Tasciotti, E., Cabrera, F. J., Evangelopoulos, M., Martinez, J. O., Thekkedath, U. R., Kloc, M., ... & Ferrari, M. (2016). The emerging role of nanotechnology in cell and organ transplantation. *Transplantation*, 100(8), 1629.

[278] Walmsley, G. G., McArdle, A., Tevlin, R., Momeni, A., Atashroo, D., Hu, M. S., ... & Wan, D. C. (2015). Nanotechnology in bone tissue engineering. *Nanomedicine: Nanotechnology, Biology and Medicine*, 11(5), 1253-1263.

[279] Veiseh, O., Tang, B. C., Whitehead, K. A., Anderson, D. G., & Langer, R. (2015). Managing diabetes with nanomedicine: challenges and opportunities. *Nature Reviews Drug Discovery*, 14(1), 45.

[280] Cheng, H., Chawla, A., Yang, Y., Li, Y., Zhang, J., Jang, H. L., & Khademhosseini, A. (2017). Development of nanomaterials for bone-targeted drug delivery. *Drug discovery today*, *22*(9), 1336-1350.

[281] Sridhar, R., Lakshminarayanan, R., Madhaiyan, K., Barathi, V. A., Lim, K. H. C., & Ramakrishna, S. (2015). Electrosprayed nanoparticles and electrospun nanofibers based on natural materials: applications in tissue regeneration, drug delivery and pharmaceuticals. *Chemical Society Reviews*, *44*(3), 790-814.

[282] Brown, P. D., & Patel, P. R. (2015). Nanomedicine: a pharma perspective. *Wiley Interdisciplinary Reviews: Nanomedicine and Nanobiotechnology*, *7*(2), 125-130.

[283] Coccia, M., & Wang, L. (2015). Path-breaking directions of nanotechnology-based chemotherapy and molecular cancer therapy. *Technological Forecasting and Social Change*, *94*, 155-169.

[284] Singh, D., Minz, A. P., & Sahoo, S. K. (2017). Nanomedicine-mediated drug targeting of cancer stem cells. *Drug discovery today*, *22*(6), 952-959.

[285] Shah, S., Solanki, A., & Lee, K. B. (2015). Nanotechnology-based approaches for guiding neural regeneration. *Accounts of chemical research*, *49*(1), 17-26.

[286] Che Abdullah, C. A., Lewis Azad, C., Ovalle-Robles, R., Fang, S., Lima, M. D., Lepró, X., ... & Sear, R. P. (2014). Primary liver cells cultured on carbon nanotube substrates for liver tissue engineering and drug discovery applications. *ACS applied materials & interfaces*, *6*(13), 10373-10380.

[287] Mundra, V., Li, W., &Mahato, R. I. (2015). Nanoparticle-mediated drug delivery for treating melanoma. *Nanomedicine*, *10*(16), 2613-2633.

[288] Gao, W., & Wang, J. (2014). Synthetic micro/nanomotors in drug delivery. *Nanoscale*, *6*(18), 10486-10494.

[289] Shao, J., Kraft, J. C., Li, B., Yu, J., Freeling, J., Koehn, J., & Ho, R. J. (2016). Nanodrug formulations to enhance HIV drug exposure in lymphoid tissues and cells: clinical significance and potential impact on treatment and eradication of HIV/AIDS. *Nanomedicine*, *11*(5), 545-564.

[290] Gupta, A., Bahal, R., Gupta, M., Glazer, P. M., & Saltzman, W. M. (2016). Nanotechnology for delivery of peptide nucleic acids (PNAs). *Journal of Controlled Release*, *240*, 302-311.

[291] Lee, J. H., & Yeo, Y. (2015). Controlled drug release from pharmaceutical nanocarriers. *Chemical engineering science*, *125*, 75-84.

[292] Lim, E. K., Chung, B. H., & Chung, S. J. (2018). Recent advances in ph-sensitive polymeric nanoparticles for smart drug delivery in cancer therapy. *Current drug targets*, *19*(4), 300-317.

[293] Ansari, S. A., Satar, R., Perveen, A., & Ashraf, G. M. (2017). Current opinion in Alzheimer's disease therapy by nanotechnology-based approaches. *Current opinion in psychiatry*, *30*(2), 128-135.

[294] Kulkarni, A. D., Vanjari, Y. H., Sancheti, K. H., Belgamwar, V. S., Surana, S. J., &Pardeshi, C. V. (2015). Nanotechnology-mediated nose to brain drug delivery for Parkinson's disease: a mini review. *Journal of drug targeting*, *23*(9), 775-788.

[295] Nasiruddin, M., Neyaz, M., & Das, S. (2017). Nanotechnology-Based approach in tuberculosis treatment. *Tuberculosis research and treatment*, *2017*, 1-12.DOI : https://doi.org/10.1155/2017/4920209.

[296] Bose, R. J., Lee, S. H., & Park, H. (2016). Biofunctionalized nanoparticles: an emerging drug delivery platform for various disease treatments. *Drug discovery today*, *21*(8), 1303-1312.

[297] Jiang, D., England, C. G., & Cai, W. (2016). DNA nanomaterials for preclinical imaging and drug delivery. *Journal of Controlled Release*, *239*, 27-38.

[298] Gao, Y., Xie, J., Chen, H., Gu, S., Zhao, R., Shao, J., & Jia, L. (2014). Nanotechnology-based intelligent drug design for cancer metastasis treatment. *Biotechnology Advances*, *32*(4), 761-777.

[299] Kumar, L., Verma, S., Prasad, D. N., Bhardwaj, A., Vaidya, B., & Jain, A. K. (2015). Nanotechnology: a magic bullet for HIV AIDS treatment. *Artificial cells, nanomedicine, and biotechnology*, *43*(2), 71-86.

[300] Franci, G.; Falanga, A.; Galdiero, S.; Palomba, L.; Rai, M.; Morelli, G.; Galdiero, M. (2015). Silver Nanoparticles as Potential Antibacterial Agents. *Molecules*, *20*, 8856-8874.

[301] Pi, F., Vieweger, M., Zhao, Z., Wang, S., & Guo, P. (2016). Discovery of a new method for potent drug development using power function of stoichiometry of homomeric biocomplexes or biological nanomotors. *Expert opinion on drug delivery*, *13*(1), 23-36.

[302] Jackman, J. A., Lee, J., & Cho, N. J. (2016). Nanomedicine for infectious disease applications: innovation towards broad-spectrum treatment of viral infections. *Small*, *12*(9), 1133-1139.

[303] Cao, S., & Woodrow, K. A. (2018). Nanotechnology approaches to eradicating HIV reservoirs. *European Journal of Pharmaceutics and Biopharmaceutics*. (in press).

[304] Rai, M., Ingle, A. P., Gaikwad, S., Padovani, F. H., & Alves, M. (2016). The role of nanotechnology in control of human diseases: perspectives in ocular surface diseases. *Critical reviews in biotechnology*, *36*(5), 777-787.

[305] Karimi, M., Zare, H., Bakhshian Nik, A., Yazdani, N., Hamrang, M., Mohamed, E., ... & Hamblin, M. R. (2016). Nanotechnology in diagnosis and treatment of coronary artery disease. *Nanomedicine*, *11*(5), 513-530.

[306] Choudhary, S., & Devi, V. K. (2015). Potential of nanotechnology as a delivery platform against tuberculosis: current research review. *Journal of Controlled Release*, *202*, 65-75.

[307] Ma, J., Porter, A. L., Aminabhavi, T. M., & Zhu, D. (2015). Nano-enabled drug delivery systems for brain cancer and Alzheimer's disease: research patterns and opportunities. *Nanomedicine: Nanotechnology, Biology and Medicine*, *11*(7), 1763-1771.

[308] Aithal, P. S. & Shubhrajyotsna Aithal, (2015). Ideal Technology Concept & its Realization Opportunity using Nanotechnology. *International Journal of Application or Innovation in Engineering & Management (IJAIEM)*, 4(2), 153 – 164. DOI: http://doi.org/10.5281/zenodo.61591.

[309] Aithal, P. S. and Shubhrajyotsna Aithal, (2016). Opportunities & Challenges for Green Technology in 21st Century. *International Journal of Current Research and Modern Education (IJCRME)*, 1(1), 818-828. DOI : http://doi.org/10.5281/zenodo.62020.

[310] Aithal, Shubrajyotsna & Aithal, P. S. (2018). Concept of Ideal Water Purifier System to Produce Potable Water and its Realization Opportunities using Nanotechnology. *International Journal of Applied Engineering and Management Letters (IJAEML)*, 2(2), 8-26. DOI: http://dx.doi.org/10.5281/zenodo.1323714.

[311] Aithal, P. S. & Shubrajyotsna Aithal, (2016). Nanotechnological Innovations & Business Environment for Indian Automobile Sector : A Futuristic Approach. *International Journal of Scientific Research and Modern Education (IJSRME)*, 1(1), 296-307. DOI : http://doi.org/10.5281/zenodo.161090.

[312] Aithal, P. S. & Shubhrajyotsna Aithal, (2016). Nanotechnology Innovations & Business Opportunities in Renewable Energy Sector. *International Journal of Engineering Research and Modern Education (IJERME)*, 1(1), 674- 692. DOI : http://doi.org/10.5281/zenodo.160905.

[313] Aithal, P. S. & Shubhrajyotsna Aithal (2018). The Concept & Characteristics of Ideal Energy System and its Realization Constraints. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *2*(2), 127-137. DOI: https://doi.org/10.5281/zenodo.1487702.

[315] Aithal, P. S. & Shubhrajyotsna Aithal (2018 November). The Realization Opportunity of Ideal Energy System using Nanotechnology Based Research and Innovations. *International Journal of Advanced Trends in Engineering and Technology*, *3*(2), 1-15., DOI : http://doi.org/10.5281/zenodo.2531876.

[316] Architha Aithal & Aithal, P. S. (2018). The Concept of Ideal Drug & its Realization Opportunity using Nanopharmaceutical Research Scenario. *International Journal of Health Sciences and Pharmacy*, 2(2), 11 – 26. DOI : http://doi.org/10.5281/zenodo.1469963.

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CHAPTER 4 :

IDEAL BUSINESS SYSTEM & ITS REALIZATION OPPORTUNITY

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ABSTRACT :
In this chapter the concept of an ideal business model &its realization opportunity using E-Business model is discussed. The chapter also contains the suggestion as mobile business as an optimum model for ideal business, business strategy for nanotechnology based products & services, and nanotechnology innovations and commercialization – opportunities, challenges & reasons for delay along with a new model for the commercialization of nanotechnology products and services are proposed and analysed.

4.1 INTRODUCTION :

The word 'Ideal system' refer to the system which has ideal characteristics i.e., perfect in every way. It is what the mind pictures as being perfect. The concept of ideal engine, ideal switch, ideal semiconductor devices like ideal diodes, transistors, etc. have been defined and taken as standards to improve the quality and performance of such practical devices or systems. It is found that, by keeping such hypothetical device or systems in mind, researchers have continuously improved the characteristics/properties of practical devices / systems to upgrade their performances. Hence ideal properties of a device or a system can be used to upgrade or improve its properties towards reaching 100% efficiency. By comparing the properties/characteristics of a practical device/system with its ideal counterpart, one can find out the possible modifications in that device /system towards reaching the objective of achieving such an ideal device. The simple definition of Business is a system of doing any activity with a profit motivation. This includes selling and/or purchasing any products/services with an objective of usually long term profit. A sustainable successful business involves 'Ease of Use'. Some of the characteristics of a business are :

(1) **Creation of utilities :**

Business makes goods more useful to satisfy human wants. It adds time, place, form and possession utilities to various types of goods. In the words of Roger, "a business exists to create and deliver value satisfaction to customers at a profit". Business enables people to satisfy their

wants more effectively and economically. It carries goods from place of surplus to the place of scarcity (place utility). It makes goods available for use in future through storage (time utility).

(2) **Dealings in goods and services:**

Every business enterprise produces and/or buys goods and services for selling them to others. Goods may be consumer goods or producer goods. Consumer goods are meant for direct use by the ultimate consumers, e.g., bread, tea, shoes, etc. Producer goods are used for the production of consumer or capital goods like raw materials, machinery, etc. Services like transport, warehousing, banking, insurance, etc. may be considered as intangible and invisible goods. Services facilitate buying and selling of goods by overcoming various hindrances in trade.

(3) **Continuity in dealings:**

Dealings in goods and services become business only if undertaken on a regular basis. For instance, if a person sells his old scooter or car it is not business though the seller gets money in exchange. But if he opens a shop and sells scooters or cars regularly, it will become business. Therefore, regularity of dealings is an essential feature of business.

(4) **Sale, transfer or exchange:**

All business activities involve transfer or exchange of goods and services for some consideration. The consideration called price is usually expressed in terms of money. Business delivers goods and services to those who need them and are able and willing to pay for them. For example, if a person cooks and serves food to his family, it is not business. But when he cooks food and sells it to others for a price, it becomes business. According to Peter Drucker "any organisation that fulfils itself through marketing a product or service is a business".

(5) **Profit motive:**

The primary aim of business is to earn profits. Profits are essential for the survival as well as growth of business. Profits must, however, be earned through legal and fair means. Business should never exploit society to make money.

The term business is commonly referred as doing anything with profit motivation. Organizations involved in business always develop their objective on sustainable profit for long term through formulating proper strategy. The term strategy in business management is viewed as long term or shortcut systematic plan to ensure winning in the process of reaching the objectives of the organization. The organizations which are involved in business of both products and services have similar objectives of earning profit for sustainable growth and expansion. The various strategies followed by organizations for sustainability and growth in

their business model are competitive/red ocean strategy [1], monopoly/blue ocean strategy [2], environmental care/Green ocean strategy [3], unethical/black ocean strategy [4, 5] or mixed /white ocean strategy [6]. Business organizations can sustain in their business based on using these strategies until there is a drastic change in features of products/services or in the business model. For example, due to advents in technology, the classical business model called brick and mortar model is changed to click and mortar model. Similarly, it is anticipated that the breakthrough of nanotechnology is going to change the features of products and services in almost all areas in the society. The nanotechnology is expected to be the general purpose technology [7] and is going to affect both basic needs and the aspirations of human life. The applications of nanotechnology in different identified areas provide lots of business opportunities. It includes Food, Medicine, Cleaner water, Better quality air, Electronics, Fuel Cells, Solar Cells, Batteries, Space Travels, Chemical sensors, Sporting goods, Fabrics, Cleaning products, Energy, Environment, Health, and Lifespan increase. These applications of nanotechnology in the society are expected to change the definition of civilization in the future generations and going to change the features and various products and the services so that business organizations may have to worry on developing new strategies for continuing in the business.

4.2. CONCEPT OF IDEAL BUSINESS & ITS REALIZATION OPPORTUNITY

The simple definition of Business is a system of doing things with a profit motivation. This includes selling and/or purchasing any products/services with an objective of usually long term profit. A sustainable successful business involves 'Ease of Use'.

4.2.1 PROPERTIES OF IDEAL BUSINESS

An Ideal business system shall have characteristics which can be predicted and classified. Based on various factors which decides the ideal business system characteristics, a model consisting of the input conditions, output conditions, market conditions and system requirements, is derived by a qualitative data collection instrument namely focus group method [8,9]. The block diagram of such a system is shown in Fig. 4.1

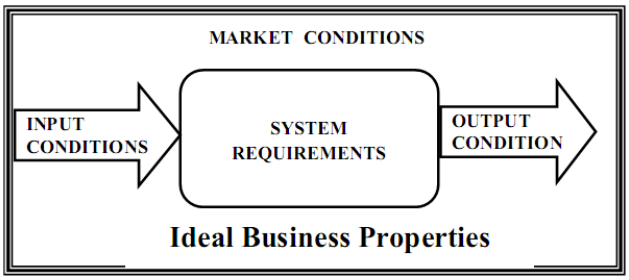

Fig. 4.1 : Classifications of Ideal Business Properties.

A. Market Conditions

(1) The Ideal Business sells its products/services to the entire world rather than a single neighborhood and hence it has an unlimited global market.

(2) The Ideal Business offers a product/service, which enjoys an inelastic demand in the market. (inelastic refers to a product that people need or desire almost at any price.)

(3) The Ideal Business markets a product/service that cannot be easily copied. This means that the product/service is an original or, at least, it is something that can be copyrighted or patented.

B. Input Conditions

(4) The Ideal Business has minimal labour requirements. The fewer personnel, the better is the business.

(5) The Ideal Business operates on a low overhead. It does not need an expensive location. It does not need large amounts of electricity, or advertising, or legal advice, or high-priced employees, or a large inventory.

(6) The Ideal Business does not require big cash outlays or major investments in equipment or product. In other words, it does not require huge capital.

C. System Requirements

(7) The Ideal Business is relatively free of all kinds of government regulations or restrictions.

(8) The Ideal Business is portable or easily moveable. This means one can shift his business and himself anywhere he wants to.

(9) The Ideal Business satisfies its owner's intellectual needs. There is nothing like being fascinated with what he does.

(10) The Ideal Business leaves enough free time to its owner. In other words, it doesn't require his labour and attention of 12, 16, or 18 hours a day.

(11) The Ideal Business is one in which the income is not limited by personal output (Leverage). In the Ideal-Business, one can have 10,000 customers as easily as can have one."

(12) The ideal Business will not have any liability after sales.

(13) The ideal Business will not have problems like seasonality, perishability and price drop.

D. Output Conditions

(14) In ideal Business the demand is always very high than supply and the efficiency of production is always 100%.

(15) The ideal Business will be sustainable for long time.

Any business which has the above properties is considered as ideal business and the conventional business called brick and mortar business has serious drawbacks/limitations in terms of the above properties.

4.2.2 Challenges to Achieve ideal business

To realize the Ideal Business in practice, we need to identify a product or service which is intangible in nature. The business should be monopoly and controlled by any place in the world. The product/service and the business models should be chosen in such a way as it should have properties, at least close to Ideal Business.

4.3. POSSIBLE SOLUTION THROUGH E-BUSINESS MODEL

An intangible product/service marketed through E-business model is the possible solution while approaching towards Idealization of the business. A ubiquitous E-Business model using intangible product/service is most suitable for elevation to Ideal business. Most of the properties discussed in Fig. 1 of Ideal business can be compared to the properties of E-business using mobile devices. A block diagram of customer oriented E-business model using mobile device is shown in Fig. 4.2 [10].

In this model, based on user request, the mobile device identifies the user through physical possession of the device, passwords, or biometrics such as voice recognition (path 1). The mobile banking service provider authenticates the transaction request from the device via either subscriber identification (as with existing phones) or cryptographic mechanisms such as digital signatures or secure protocols, like the Wireless Transport Layer Security Specification through private network service provider PNSP (path 2). The users can perform secured operations on account balance or loan account statement, transfer money between two accounts in the same bank (internal transaction), loan payment, or payment of electricity, water, phone, credit card and cellular phone/pager bills, through the bank (path 3). The financial transaction can be also performed between the mobile banking service provider and the merchant for m-commerce payment through PNSP (path3a) and/ or other financial institution(s) for bill payments or interbank transfer through PNSP (path 3b) and may involve secure payment protocols such as Internet Keyed Payments/Secure Electronic Transactions, or iKP/SET [11].

After completion of requested transaction, the mobile banking service provider delivers a confirmation of transaction to the user (path 4). In today's mobile phones, authorization is via subscriber identification mechanisms, which do not provide non-repudiation. However, in future, mobile consumers might also use a secure mobile signing device, to avoid disputes. This device may allow high-value transactions, as well as paying mobile operators who are not completely trusted (such as when roaming). Mobile communication mechanisms (such as GSM) allow the foreign (visited) network to authenticate the user with information from the home network. Charging requires prior agreements between the visited and the home networks. Designers of the Universal Mobile Telecommunications System (UMTS) recognized the difficulty of establishing agreements in advance among visited networks and all home networks [12]; thus, UMTS includes mechanisms for dynamic negotiation and setup of roaming agreements between a visited network and a home network. Roaming agreements seek to establish fees and ensure operator trustworthiness. Operators are trusted to deliver payments in time; foreign (remote) operators are also trusted to not overcharge visiting customers. A secure signing mobile device can prevent fraud (overcharging) by foreign network providers, thereby allowing more automated and variable roaming agreements. Operators can also use the final payments protocol [13], to extend pair-wise trust relationships into global trust relationships, allowing automated, secure, low-cost universal roaming.

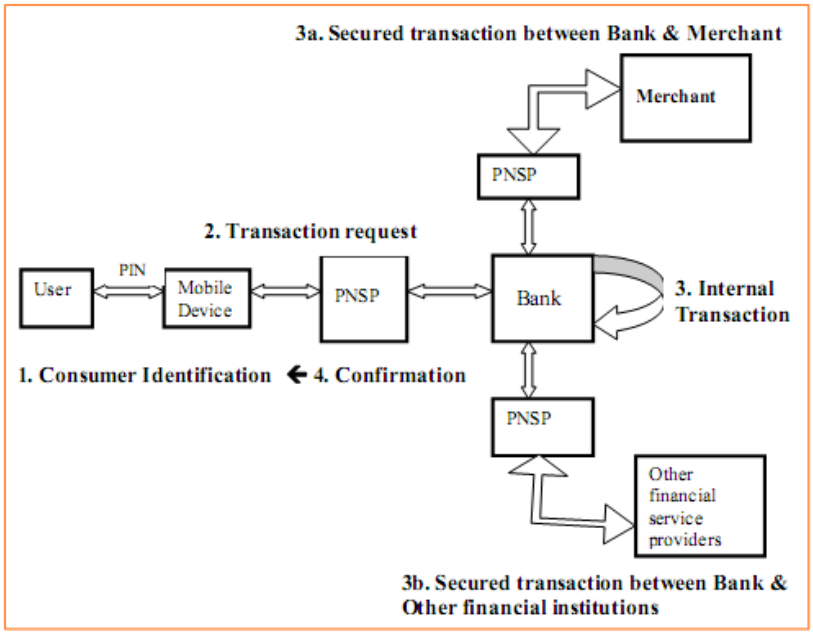

Fig. 4.2 : Customer oriented E-business model using mobile device.

4.4. MOBILE BUSINESS AS AN IDEAL BUSINESS

A. Features of E-Business Using Mobile Devices

E-Business using mobile devices called mobile business, promising unlimited information, entertainment, and business, and gives users the ability to access the Internet from any location at any time, the capability to pinpoint an individual mobile terminal user's location, the functionality to access information at the point of need, and a need-based data/information update capability. Mobile business has features not available to traditional e-business, some of which are :

1. Ubiquity: Through mobile devices, business entities are able to reach customers anywhere at any time. On the other hand, users can also get any information they are interested in, whenever they want regardless of where they are, through Internet-enabled mobile devices. In this sense, mobile business makes a service or an application available wherever and whenever such a need arises.

2. Personalization: An enormous number of information, services, and applications are currently available on the Internet, and the relevance of information users receive is of great importance. Since owners of mobile devices often require different sets of applications and services, mobile business applications can be personalized to represent information or provide services in ways appropriate to the specific user.

3. Flexibility: Because mobile devices are inherently portable, mobile users may be engaged in activities, such as meeting people or traveling, while conducting transactions or receiving information through their Internet-enabled mobile devices.

4. Dissemination: Some wireless infrastructures support simultaneous delivery of data to all mobile users within a specific geographical region. This functionality offers an efficient means to disseminate information to a large consumer population.

B. Mobile business Value Chain

Transport, basic enabling service, transaction support, presentation service, personalization support, user application, and content aggregators are the seven links in the mobile business value chain. The transport link maintains and operates the infrastructure and equipment to guarantee data communication between mobile users and application. Basic enabling service link provide services such as server hosting, data backup, and system integration. The Transaction support link provides the mechanism for assisting transactions, for security, and for billing users. The presentation service link converts the content of Internet-based applications to a wireless standard suitable for the screens of mobile devices. The

Personalization support link gathers users' personal information, which enables personalized applications for individual users. The Content aggregators link provide information in a category or search facilities to help users find their way around the Internet. Finally, the user applications link used to carry out mobile business transactions for mobile consumers. The following sectors will get benefit under m-business transformation [14, 15] :

1. Banking industry: Possible facilities that could be offered include Account Balance Enquiries, Last 'n' transactions, Utility Bills Payment, Cheque clearing notifications, Inter account Transfers, Statement and Cheque book requests, Access to Portfolio management and other share dealing services.
2. Share market industry: Mobile phone-based stock trading allows users to receive instant updates on market information. The system allows to users to identify which stock they are interested in and what levels of alert they want. The warnings are then sent to the user's handset, and then they can buy or sell immediately without going to a computer.
3. Shopping: Many mobile service providers are planned to launch services that promote shopping using mobile. Fabmart, Zee marketing are few examples. Customers can pay for their purchases through their mobile phone bills. Text message shopping is already in use to buy books, CD etc., at bargain rate.
4. Building and construction materials industry: The fragmented nature, geographical spread and multiplicity of levels in the distribution structure for most products in this industry offers unique challenges and opportunities for e-business & m-business initiatives. M-business adaptation in this sector would be driven by factors such as improving brand building and customer services, penetrating markets in the semi-urban and rural pockets, improved dealer management, and ensuring timely supplies and services.
5. Metal industry: M-business adaptation in the metal sector would be primarily driven by working with lower inventories and adapting IT techniques and catering the customers through remote devices. This will increase market coverage and widen distribution reach, improved dealer management and controlling cost at every stage of the value chain. Metals, as commodity, also provide considerable scope for on-line tendering and auction applications.
6. Office automation industry: The Indian office automation industry is another potential candidate to adopt m-business strategies to its sales and service. The major benefits would be improved customer service, wider market coverage, and marketing and procurement costs reductions.

7. Packaging industry: The packing industry is another potential sector for adopting m-business. Handling order taking and order placement through mobile, the package industries can improve supply efficiency, customer service and market coverage.

8. Indian engineering industry: Engineering industry with huge annual turnover is another potential candidate for m-business implementation. Front-end activities like enhanced customer service and receiving new order, and back-end activities like enhanced vendor communication and booking purchases can emerge key priority areas in this industry.

9. Electrical and electronics industry: Implementing e-business and m-business in these industries is expected to result in improved sales and customer service through better information dissemination.

10. Chemical industry: Chemical and Petro-chemical industries are considered on-line business is a cost reduction tool. By adopting these strategies they would improve supply chain efficiency and reduce marketing / procurement costs.

11. Hotels and tourism industries: Booking hotel rooms and resorts at any time, at any place can be done through m-business options.

12. Pharmaceutical industry: Pharmaceutical industry views m-business as a tool that would aid community building, and to smaller extent, reduce costs through better supply chain management. They also expect to use this medium to provide people with more information on diseases and the products used to cure them.

13. Logistics industries: Both transportation and warehousing parts of logistics are potential candidates for m-business implementation due to the fact of increase in products sold on-line. The need to move a large volume of small parcels and the increase in customer expectations.

14. Auto –components industry: The auto-component industry is another prominent candidate for m-business implementation. Due to the increasing competition in the domestic market and threat of imports, necessitating widening of market reach, and exploring export markets.

15. Lottery and Betting: All on-line lotteries and betting can accept the bets through the message delivered by SMS. The M-business technology allows not only mobile betting but also, using a mobile video-phone, be able to watch the actual race while moving on the road or while travelling in an aeroplane.

16. Mobile positioning services: With mobile positioning services your phone could become a personal tracking device, allowing your family friends and employer to know where you are

at all times. Mobile positioning integrates with satellite positioning systems and let people tell others where they are.

C. Benefits of Mobile Business from Customers Point of view

The benefit from the customers' point of view is accessing services at anywhere, any time and any extent of time. These features significantly save the valuable time of the customer [16]. The main advantages of m-business services for the customers are listed as follows :

(1) Ubiquity : Through mobile devices, business applications are able to reach customers anywhere at any time. On the other hand, users can also get any information they are interested in, whenever they want regardless of where they are, through Internet-enabled mobile devices. In this sense, mobile business makes a service or an application available wherever and whenever such a need arises. Communication can take place independent of the users location. The advantages presented from the omnipresence of information and continual access to business will be exceptionally important to time-critical applications.

(2) Personalization : An enormous number of business information, services, and applications are currently available on the Internet, and the relevance of information users receive is of great importance. Since owners of mobile devices often require different sets of applications and services, mobile business applications can be personalized to represent information or provide services in ways appropriate to the specific user. Additionally, personalized content is paramount in operating mobile devices because of the limitation of the user interface. Relevant information must always be only a single "click" away, since web access with any existing wireless device is not comparable to a PC screen either by size, resolution or "surfability". Therefore, subscriber profile ownerships is a key element in m-business success, as it will allow selectively targeted m-business applications. As such, the mobile database becomes a primary factor of m-business success by compiling personalized data bases and providing personalized services. One example, is the SIM (Subscriber Identification Module) smartcards which serve as a mobile database allowing the user to run applications and operate secure transactions. Such personalized information and transactions, via mobile devices, offer the greatest potential for the customization necessary for long-term success.

(3) Reduced costs : This is due to availing and using various products and services by number of customers online. The transaction fee charged by banking service providers for financial services is much cheaper than conventional retail banking transaction fees. The heavy competition and the price war between mobile service providers also reduced mobile service usage cost.

(4) Flexibility :Because mobile devices are inherently portable, mobile users may be engaged in activities, such as meeting people or traveling, while doing business, conducting transactions, or receiving information through their Internet-enabled mobile devices.

(5) Increased comfort : Many customers secretly hate their business service provider/banks because of punitive charges, inconvenient opening hours and unhelpful branch staff. In mobile business due to quick and continuous access, purchases and transactions can be made 24 hours a day, without requiring the physical interaction with the service provider.

(6) Time saving : The main benefit from the mobile business customers' point of view is significant saving of time by the automation of purchasing & banking services processing and introduction of an easy maintenance tools for managing customer's money. Since the response of the medium is very fast, the customer can wait till the last minute before purchasing and concluding a fund transfer.

(7) Convenience :The ability and accessibility provided from wireless devices will further allow m-business to differentiate its abilities from conventional business and e-business. People will no longer be constrained by time or place in conducting business activities. Rather, m-business could be accessed in a manner which may eliminate some of the labour of life's activities. For example, consumers waiting in line or stuck in traffic will be able to handle daily transactions/purchases through m-business applications. Consumers may recognize a special comfort which could translate into an improved quality of life.

(8) Better cash management : Mobile business facilities speed-up cash cycle and increases efficiency of business processes as large variety of cash management instruments are available on internet sites of banks. For example, it is possible to manage companies short term cash via online or mobile banking like investments in over-night, short and long term deposits, in commercial papers, in bonds and equities, in money market funds etc. In mobile business, customers can download the features of product/services or their history of different accounts and do a what –if analysis on their own mobile device, before affecting any transaction on the web or through mobile service providers. This will lead to better funds management.

TABLE 4.1 : Comparison of Conventional Business and online Business in terms of Ideal Business Characteristics.

S. No.	Ideal Business Characteristics	Conventional Business	Online Business
1	The Ideal Business sells its products/services to the entire world and hence it has an unlimited global market.	No	Yes
2	The Ideal Business offers a product/service, which enjoys an inelastic demand.	No	Yes

3	The Ideal Business sells a product/service that cannot be easily copied. i.e., it is something that can be copyrighted or patented.	No	Yes
4	The Ideal Business has minimal labor requirements.	No	Yes
5	The Ideal Business operates on a low overhead.	No	Yes
6	The Ideal Business does not require big cash outlays or major investments in equipment or product.	No	Yes
7	The Ideal Business is relatively free of all kinds of government regulations or restrictions.	No	Yes
8	The Ideal Business is portable or easily moveable.	No	Yes
9	The Ideal Business satisfies your intellectual needs.	No	Yes
10	The Ideal Business leaves you with free time.	No	Yes
11	The Ideal Business is one in which your income is not limited by your personal output (Leverage).	No	Yes
12	The ideal Business will not have any liability after sales.	No	Yes
13	The ideal Business will not have problems like seasonality, perishability and price drop	No	Yes
14	In ideal Business the demand is always very high than supply and the efficiency of production is always 100%.	No	Yes
15	The ideal Business will be sustainable for long time.	No	Yes

D. Comparison of Mobile Business Properties with that of Ideal Business

The system properties like - free from Government regulations, portability, and satisfying our intellectual needs, availability of free time, independency of income with personal output, no liability after sales, and no headache like problems of seasonality, perishability and price drop; the market conditions like - unlimited global market, inelastic demand, and copyright/patenting opportunities of ideal business also can be realizable using mobile business properties for intangible products/services. The input properties like - minimal labor requirements, low overhead, and low capital requirement; the output conditions like – high efficiency, and sustainable for long time, of ideal business also realizable to certain extent using mobile business properties for intangible products/services as shown in Table 4.1. Thus e-business using mobile devices called mobile business is a suitable business model for profit maximization and approaches to hypothetical Ideal business model.

E. Analysis of some possible Products/ Services for Ideal Business

Mobile business using various mobile devices for some of the products/services is suitable candidate for having ideal business characteristics. The products/services which are intangibles in nature used in mobile business transactions are most suitable candidates to follow almost all the characteristics of an ideal business model. Small business of selling the software products, e-books, e-music or any similar product/service will give the advantages of the Ideal Business properties.

4.5 MOBILE BUSINESS AS AN OPTIMUM MODEL FOR IDEAL BUSINESS

4.5.1ANALYSIS OF IDEAL BUSINESS CHARACTERISTICS

Ideal Business characteristics can be explained based on their effectiveness in improving the qualities and benefits of the business [16]. The characteristics mentioned in ideal business model are further discussed below :

(1) Unlimited Global Market :

Any business will sustain for long period by providing service to larger number of customers. Ideal business model eyeing at global market can sell its products/services to the global market rather than selling to a single neighbourhood market which has only limited customers.

(2) Inelastic demand :

The products/services are chosen in such a way that they can be killer application products/services. Such monopoly products/services available to the global market enjoys inelastic demand so that the service provider can sell them almost at any prize.

(3) Monopoly nature :

The product/service in ideal business environment is developed in such a way that it has unique features in terms of its technology, usability, innovativeness, cost/price or any other advantages. Also, the ideal business product/service that cannot be easily copied. This means that the product/service is an original or, at least, it is something that can be copyrighted or patented.

(4) Minimum Labour requirement :

Any business can sustain for longer period by decreasing the cost. By decreasing the cost of various resources used in the business, the organization can increase its profit. Ideal business, through its characteristics, should decrease its expenditure to minimum level and one of such possibility is minimum Labour dependent. The fewer personnel, the better is the business.

(5) Low overhead :

The total cost of any business is the sum of Fixed cost and Variable cost. The fixed cost involves initial investment on the business and maintenance cost. By decreasing initial investment without compromising with quality, the business can decrease its overall cost. As per our definition, the Ideal Business operates on a low overhead. It does not need an expensive location. It does not need large amounts of electricity, or advertising, or legal advice, or high-priced employees, or a large inventory.

(6) Low cash outflows :

Out of various resources used in any business capital investment like investment on machinery, buildings, equipment and other infrastructures which need huge capital. On the other hand the

Ideal Business does not require big cash outlays or major investments in equipment, buildings or product based on the nature of its products/services. In other words, it does not require huge capital.

(7) Free of Government Regulations :

Many business firms are facing problems due to Government regulations based on the nature on business, the environmental issues and the neighbouring community issues. These regulations sometime make the business organisation as nonprofit or to shut down. The Ideal Business is relatively free of all kinds of government regulations or restrictions so that can do sustainable business operations for longer period.

(8) Portability :

The conventional business models have uncertainty in their efforts of providing continued service to the customers due to various reasons including natural calamities. This problem can be solved in Ideal Business model due to its portability or easily movability. This means one can take his business and himself anywhere he wants to.

(9) Satisfying intellectual needs :

In conventional business, the organization grows due to the collective efforts of the executive team and it may not satisfy the intellectual needs of the individual executive. However, Ideal Business satisfies its owner's intellectual needs. There is nothing like being fascinated with what he does.

(10) Less time consumption :

The conventional business practices are engaging the owner with busy schedules. Usually, the business owners hardly get time for their leisure. On other hand, Ideal Business leaves enough free time to its owner. In other words, it doesn't require his labour and attention of 12, 16, or 18 hours a day.

(11) Potential opportunity for high income :

The primary objective of any business is large profit. There is nothing wrong in expecting huge profit for honest efforts. One of the advantages of Ideal Business is possibility of ensuring large profits. In Ideal Business the income is not limited by personal output (Leverage) and one can have 10,000 customers as easily as can have one. This is mainly due to intangible nature of products/services.

(12) No liability after sales :

Since the products/services in ideal business enjoys monopoly, and they are mostly being intangible, there is nothing like providing after sales service and assuring warranty for service.

If the delivered product/service is non-functional, immediately it can be replaced. Hence the ideal Business will not have any liability after sales.

(13) Low risk on price variation :

All conventional business has uncertainty due to competition, non-availability of various resources used or fluctuations in their prices due to environmental factors like seasonality, perishability and price drop. Ideal Business will not have such problems.

(14) Hundred percent efficiency :

Efficiency of a system is defined as the ratio of output to input of the system. It can be also be defined based on the ability of the system to balance demand and supply. In conventional systems, as demand increases, it is difficult to balance the supply. But in Ideal Business the demand is always very high and the supply can be increased easily for suitable types of products/services to maintain the efficiency of production is always 100%.

(15) Longer Sustainability :

One of the challenges of any practical business is long time sustainability. Most of the products/services follows shorter life-cycle due to various reasons like changes in technology, invention of new products/services with better features, changes in perception of customers etc. The ideal Business on other hand will be sustainable for long time due to its monopoly nature.

4.5.2 MOBILE BUSINESS AS AN IDEAL BUSINESS

A. Features of E-Business Using Mobile Devices

E-Business using mobile devices called mobile business, promising unlimited information, entertainment, and business, and gives users the ability to access the Internet from any location at any time, the capability to pinpoint an individual mobile terminal user's location, the functionality to access information at the point of need, and a need-based data/information update capability. Mobile business has features not available to traditional e-business, some of which are :

1. Ubiquity: Through mobile devices, business entities are able to reach customers anywhere at any time. On the other hand, users can also get any information they are interested in, whenever they want regardless of where they are, through Internet-enabled mobile devices. In this sense, mobile business makes a service or an application available wherever and whenever such a need arises.

2. Personalization: An enormous number of information, services, and applications are currently available on the Internet, and the relevance of information users receive is of great

importance. Since owners of mobile devices often require different sets of applications and services, mobile business applications can be personalized to represent information or provide services in ways appropriate to the specific user.

3. Flexibility: Because mobile devices are inherently portable, mobile users may be engaged in activities, such as meeting people or traveling, while conducting transactions or receiving information through their Internet-enabled mobile devices.

4. Dissemination: Some wireless infrastructures support simultaneous delivery of data to all mobile users within a specific geographical region. This functionality offers an efficient means to disseminate information to a large consumer population.

B. Mobile business Value Chain

Transport, basic enabling service, transaction support, presentation service, personalization support, user application, and content aggregators are the seven links in the mobile business value chain. The transport link maintains and operates the infrastructure and equipment to guarantee data communication between mobile users and application. Basic enabling service link provide services such as server hosting, data backup, and system integration. The Transaction support link provides the mechanism for assisting transactions, for security, and for billing users. The presentation service link converts the content of Internet-based applications to a wireless standard suitable for the screens of mobile devices. The Personalization support link gathers users' personal information, which enables personalized applications for individual users. The Content aggregators link provide information in a category or search facilities to help users find their way around the Internet. Finally, the user applications link used to carry out mobile business transactions for mobile consumers [14].

C. Benefits of Mobile Business from Customers Point of view

The benefit from the customers' point of view is accessing services at anywhere, any time and any extent of time. These features significantly save the valuable time of the customer. The main advantages of m-business services for the customers are listed as follows :

(1) Ubiquity : Through mobile devices, business applications are able to reach customers anywhere at any time. On the other hand, users can also get any information they are interested in, whenever they want regardless of where they are, through Internet-enabled mobile devices. In this sense, mobile business makes a service or an application available wherever and whenever such a need arises. Communication can take place independent of the users location. The advantages presented from the omnipresence of information and continual access to business will be exceptionally important to time-critical applications.

(2) Personalization : An enormous number of business information, services, and applications are currently available on the Internet, and the relevance of information users receive is of great importance. Since owners of mobile devices often require different sets of applications and services, mobile business applications can be personalized to represent information or provide services in ways appropriate to the specific user. Additionally, personalized content is paramount in operating mobile devices because of the limitation of the user interface. Relevant information must always be only a single "click" away, since web access with any existing wireless device is not comparable to a PC screen either by size, resolution or "surfability". Therefore, subscriber profile ownerships is a key element in m-business success, as it will allow selectively targeted m-business applications. As such, the mobile database becomes a primary factor of m-business success by compiling personalized data bases and providing personalized services. One example, is the SIM (Subscriber Identification Module) smartcards which serve as a mobile database allowing the user to run applications and operate secure transactions. Such personalized information and transaction feeds, via mobile devices, offer the greatest potential for the customization necessary for long-term success.

(3) Reduced costs : This is due to availing and using various products and services by number of customers online. The transaction fee charged by banking service providers for financial services is much cheaper than conventional retail banking transaction fees. The heavy competition and the price war between mobile service providers also reduced mobile service usage cost.

(4) Flexibility : Because mobile devices are inherently portable, mobile users may be engaged in activities, such as meeting people or traveling, while doing business, conducting transactions, or receiving information through their Internet-enabled mobile devices.

(5) Increased comfort : Many customers secretly hate their business service provider/banks because of punitive charges, inconvenient opening hours and unhelpful branch staff. In mobile business due to quick and continuous access, purchases and transactions can be made 24 hours a day, without requiring the physical interaction with the service provider.

(6) Time saving : The main benefit from the mobile business customers' point of view is significant saving of time by the automation of purchasing & banking services processing and introduction of an easy maintenance tools for managing customer's money. Since the response of the medium is very fast, the customer can wait till the last minute before purchasing and concluding a fund transfer.

(7) Convenience : The ability and accessibility provided from wireless devices will further allow m-business to differentiate its abilities from conventional business and e-business. People will no longer be constrained by time or place in conducting business activities. Rather, m-business could be accessed in a manner which may eliminate some of the labour of life's activities. For example, consumers waiting in line or stuck in traffic will be able to handle daily transactions/purchases through m-business applications. Consumers may recognize a special comfort which could translate into an improved quality of life.

(8) Better cash management : Mobile business facilities speed-up cash cycle and increases efficiency of business processes as large variety of cash management instruments are available on internet sites of banks. For example, it is possible to manage companies short term cash via online or mobile banking like investments in over-night, short and long term deposits, in commercial papers, in bonds and equities, in money market funds etc. In mobile business, customers can download the features of product/services or their history of different accounts and do a what –if analysis on their own mobile device, before affecting any transaction on the web or through mobile service providers. This will lead to better funds management.

D. Comparison of Mobile Business Properties with that of Ideal Business

The system properties like - free from Government regulations, portability, and satisfying our intellectual needs, availability of free time, independency of income with personal output, no liability after sales, and no headache like problems of seasonality, perishability and price drop; the market conditions like - unlimited global market, inelastic demand, and copyright/patenting opportunities of ideal business also can be realizable using mobile business properties for intangible products/services. The input properties like - minimal labor requirements, low overhead, and low capital requirement; the output conditions like – high efficiency, and sustainable for long time, of ideal business also realizable to certain extent using mobile business properties for intangible products/services as shown in Table 4.2. Thus e-business using mobile devices called mobile business is a suitable business model for profit maximization and approaches to hypothetical Ideal business model.

TABLE 4.2 : Comparison of Conventional Business and Mobile Business in terms of Ideal Business Characteristics.

S. No.	Ideal Business Characteristics	Conventional Business	Mobile Business
1	The Ideal Business sells its products/services to the entire world and hence it has an unlimited global market.	No	Yes
2	The Ideal Business offers a product/service, which enjoys an inelastic demand.	No	Yes

3	The Ideal Business sells a product/service that cannot be easily copied. i.e., it is something that can be copyrighted or patented.	No	Yes
4	The Ideal Business has minimal labour requirements.	No	Yes
5	The Ideal Business operates on a low overhead.	No	Yes
6	The Ideal Business does not require big cash outlays or major investments in equipment or product.	No	Yes
7	The Ideal Business is relatively free of all kinds of government regulations or restrictions.	No	Yes
8	The Ideal Business is portable or easily moveable.	No	Yes
9	The Ideal Business satisfies your intellectual needs.	No	Yes
10	The Ideal Business leaves you with free time.	No	Yes
11	The Ideal Business is one in which your income is not limited by your personal output (Leverage).	No	Yes
12	The ideal Business will not have any liability after sales.	No	Yes
13	The ideal Business will not have problems like seasonality, perishability and price drop	No	Yes
14	In ideal Business the demand is always very high than supply and the efficiency of production is always 100%.	No	Yes
15	The ideal Business will be sustainable for long time.	No	Yes

E. Analysis of some possible Products/ Services for Ideal Business

Mobile business using various mobile devices for some of the products/services is suitable candidate for having ideal business characteristics. The products/services which are intangibles in nature used in mobile business transactions are most suitable candidates to follow almost all the characteristics of an ideal business model. Small business of selling the software products, e-books, e-music or any similar product/service will give the advantages of the Ideal Business properties.

4.6 BUSINESS STRATEGY FOR NANOTECHNOLOGY BASED PRODUCTS & SERVICES

The following nano-technology product have huge business opportunities [17]:

(1) Any agricultural product which supports improvement in agricultural crop yield.

(2) Any product which controls crop diseases.

(3) Any product which avoids the usage of pesticides.

(4) Any product which simplifies agricultural production work.

(5) Any Product which decreases the cost of agricultural production .

(6)) Any Product which decreases the cycle time of the crops.

(7)) Any Product which lowers the water requirement for irrigation and other resources.

(8) Any product which supports to removal of dissolved salts from salty water.

(9) Removal of micro pollutants.

(10) Water softening and wastewater treatment.

(11) Any food product with nano- additives to enhance taste and flavour.

(12) Any nanotech based food and drink package to tracking, quality monitoring and anti-counterfeiting.

(13) Any product with nano-encapsulated nutrients and supplements to improve the health condition.

(14) Any Cosmetics product with better performance.

(15) Any nanotechnology based packaging which keeps food items fresh for long period.

(16) Any nanotechnology based food item which decreases the hungriness of human beings without affecting their normal life.

(17) Any product which keeps teeth white and strong.

(18) Any product based on nanotechnology which growths hair selected places of the human body like head.

(19) Any product based on nanotechnology which improves the quality of games and sports materials.

(20) Any nanotechnology food product prepared artificially.

(21) Any product based on nanotechnology to clean the air of the atmosphere.

(22) Products for nanotechnology based energy solutions through more efficient lighting, fuel cells, hydrogen storage, solar cells, locally distributed power generation, and decentralized generation and storage by reinventing the power grid.

(23) Nanotechnology based long-life cheaper cloths with no wrinkle, stain, or allow the growth of bacteria.

(24) Any products like anti-microbial socks, underwear and sporting apparel, wind and water proof jackets, wrinkle and stain resistant suits, casual wear and swimsuits that protect against UV rays.

(25) Nanotechnology based fabrics which is water and stain resistant, insulates against heat or chill, dirt rinses off in rain, and reduces odours and bad smell.

(26) Nanotechnology based construction materials with properties like energy efficiency, ultra high strength, extra durability, and
extremely lightweight.

(27) Nano-modified cement for improving concrete properties, performance and durability.

(28) Nanotechnology based medicine for diseases like HIV/AIDS, Ebola, Cancer, and the Avian Flu.

(29) Products like nanorobots which can slow or reverse the aging process, and life expectancy.

(30) Products like nanorobots which can perform cosmetic surgery, rearranging the atoms of human body to change ears, nose, eye color or any other physical feature of human beings as per their wish to alter.

(31) Any nano-system which build various products with molecular-level precision with virtually no chemical waste and pollution.

(32) Any nanotech based product made by more efficient and lighter materials for automotive and aircraft systems, High performance tyres for automobiles, efficient and non-platinum based catalytic converters, novel more efficient fuel and power sources, etc.

(33) Any low cost nanotechnology products which increases the performance of memory, displays, processors, solar powered components, and embedded intelligence systems.

(34) Any nanotech product which improves the efficiency of home entertainment electronics, 3D televisions, performance of videogames etc.

(35) Any nanotech system which supports preparation of drugs containing nano-sized active ingredients.

(36) Any breakthrough drug delivery systems based on nanotechnology that allow deposition of medications in previously inaccessible areas of the body, and improved diagnostic tests and medical devices.

(37) Nano-photonics based computer systems with infinite storage ability, infinite bandwidth, and infinite processing ability at tremendous speed.

(38) Nanotech based materials and devices which supports low cost and secured space exploration like propulsion fuels, coatings, structural materials, smart uniforms, electronics and life support environments.

(39) Nanotechnology based 3D printer systems which allow to replicate anything, including diamonds, water and food.

(40) Nanotechnology supported system for removal of a substance called lipofuscin from certain types of non-dividing cells, including the brain, heart, liver, kidneys and eyes to extend the human lifespan.

The following nano-technology based services have attractive business opportunities :

(1) Advertising services using nanotechnology to decrease environmental foot print.

(2) Nanotech supported Banking and Insurance services by improving security & information storage ability.

(3) Retailing service can be supported by high speed and secured technology based on nano devices

(4) Using nano-electronic devices tourism service can be improved by using increased speed of communication.

(5) The quality of transportation services can be improved using nanotech based communication and tracking, online reservation, etc.

(6) Hospitality and food services can be also improved using nanotech based food processing, food packaging, food delivery, clean water supply, reduce, reuse, and recycle waste etc.

(7) Entertainment and Recreation services can be improved using nanotech based energy, electronic equipment, Entertainment equipment and Recreation systems.

(8) Mass communication & Media services can be improved using nanotech based communication and storage devices, e-media, etc.

(9) Nanotechnology based health diagnosis, Health therapy and health information service will support to improve quality HealthCare services.

(10) Electronic Communication services get support by nanotech based electronic devices to improve the bandwidth and authentication, electronic documents etc.

(11) Nanotechnology based IT hardware components improves the quality of IT enabled services.

(12) Nanotechnology helps to improve online education services with improved multi-media based education.

(13) Nanotechnology based opportunities improves the public utility services related to rainwater, waste and recycling, water and waste water, toxics, community and energy.

(14) Nanotechnology in Real Estate & Leasing service improves ICT which improves the quality of services in various real estate and leasing processes.

(15) Nanotechnology based innovations in food processes, water and waste management, energy and health management improves the public administration services.

(16) The various resources used in defence services are improved in terms of their quality using nanotechnology.

(17) Nanotechnology based control of greenhouse gases emission improves the quality of various business support services.

(18) Nanotechnology supported marketing concepts based on reducing, recycling and re-using resources improves the benefits of marketing services.

(19) Using the general purpose technology characteristics of nanotechnology, the quality of many professional services can be improved.

(20) Nanotechnology based environmental sustainability and decreasing environmental degradation improves the quality of social services in the society.

Any business organization which focus on research and development in above products and services and capable to market them has opportunity for sustainable growth for long time.

4.6.1. DEVELOPING A GLOBAL STRATEGY FOR NANOTECHNOLOGY BUSINESS

(1) First entry advantage for R &D : An organization which identifies the opportunity in above discussed products and services and invests for developing such products or services will get first movers advantage due to the fact that the new product or service developer can patent such discoveries/innovations.

(2) Identifying new areas of Nanotechnology Applications : While investing on R & D, and developing the product or services, the organizations have to use blue ocean strategy to develop unique products or services in new but essential area of application in the society.

(3) Focusing on Solutions to Basic Need Problems Area : While considering the market size, the products and services developed using nanotechnology addressing basic needs of the people of the society have better market opportunities so that such organization can prosper quickly.

(4) Focusing on Solutions to Luxurious Problems Area : Organizations can also plan their strategy to identify the possible products and services related to the comfortability of the users. Such products or services can be sold at premier price to increase the profitability of the organization.

(5) Developing low cost products and services in Basic Need Problems Area : Since the business organizations have social responsibility, they have to plan to develop products related to the basic needs of the people as well as luxurious products or services for the comfortability of the people. Such low cost strategy is important in improving the brand image of the organization.

(6) Developing Premier Products and services in Luxury Area : The products or services identified should be developed through

focussed research in the field either by self-investment or through collaboration to get the first movers advantage.

(7) Identifying new applications of developed Products & Services : The organizations can also focus on identifying new

applications of the products or services developed through their innovative strategy.

(8) Focusing on Environmental benefits by Greening the Products and Services : The organizations doing business in nanotechnology based products/services have to focus on environment and the negative effect of the technology. Organizations have to monitor the dangerous effect of their product/services to take care of future generations.

(9) Studying and avoiding side effects and social impact of developed Products and services : To know the side effects of the developed products/services before marketing them, the organization should do enough testing systematically. In case of medicinal products, proper clinical trials have to be organized to test the consequences of the side effects.

(10) Studying the business environment for developed products to follow suitable business strategy : While identifying the opportunity through business analysis and developing the products/services for production and marketing, the organization should select its business strategy by using either competitive or red ocean strategy, monopoly or blue ocean strategy, environmental sustainability or green ocean strategy, or the combination of them called white ocean mixed strategy so that organization can realize its objective of doing long time profit by winning its challenge. Apart from the business strategy, the organization can follow global strategy to expand its market to entire world. The key aspects of such global strategy include:

1. Treating the global market as the domestic market for standard products.
2. Creating a global marketing mix, which at the same time recognises regional and national differences, such as differences in language and tastes in providing services.
3. Creating global production and distribution systems, e.g. super-factories covering major areas of the world.
4. Concentrating on power-brands - the most successful brands and products. Because the global market is so large there are substantial benefits to be gained from economies of large scale production, marketing and distribution. Rather than producing thousands of different products it makes sense to narrow down the range to a much smaller number in order to support these brands across the globe.

4.6.2 FUTURE POSSIBILITIES OF NANOTECHNOLOGY INNOVATIONS

(1) Nanomachines are devices built from individual atoms. Some researchers believe that nanomachines will one day be able to enter living cells to fight disease. They also hope to one day build nanomachines that will be able to rearrange atoms in order to construct new objects. If they succeed, nanomachines could be used to literally turn dirt into food and perhaps eliminate poverty.

(2) Nanotechnology has the potential to completely revolutionise all the three key aspects of healthcare sector-Diagnosis, prevention and Treatment. It can completely change the healthcare sector for the next generation. Nanotechnology will help medical professionals in today's most excruciating medical issues, such as repairing of damaged organs, diagnosis and treatment of cancer cells, removal of obstruction in brain and it can help in better drug delivery system.

(3) By using nanotechnology system, it is possible to measure hundreds of complicated factors simultaneously, avoiding the risk of losing samples waiting days for lab results, and lab mess-ups. Nano filters are able to remove the smallest of known viruses.

Nanotechnologically made, antimicrobial coating is another promising area for preventing diseases. Nanotechnology can help design certain drugs that very difficult to manufacture because of structural constraints by using a controlled manufacturing system at the atomic and molecular level. Nanotechnologically, the drugs can be designed such as to eliminate the toxic part of it and leave the "effective" one.

(4) Nanotechnology can be used for solar photocatalysis of water and CO_2 in which carbon dioxide of atmosphere can be reduced and hydrogen can be separated to use as hydrogen fuel using solar energy. This technology of Photoreduction of CO_2 with water to form hydrocarbon (methane, methanol, etc.) is very beneficial due to negative CO_2 foot print which cleans the environment and also supports sustainable transportation using the existing infrastructure for hydrogen fuel distribution.

(5) Nanotechnology can be used for both in vivo and in vitro biomedical research and applications. Nano particles can be used in targeting tumor cells at initial stage. Particles like den trine, quantum dots and fullerene. Nanotechnology can be used to develop "signature protein" to treat cancer.

4.7 NANOTECHNOLOGY INNOVATIONS AND COMMERCIALIZATION

4.7.1 Failure to Achieve Estimated Timeline of Commercialization - New Proposal

Timeline for nanotechnology innovations is predicted in various literature as shown in table 1. The earlier prediction of nanotechnology timeline is given by Roco in the year 2004 and the new prediction based on last 15 years development is also given in Aithal et.al during 2015 [1] is listed in table 4.3. Based on this new roadmap, we have completed the first generation of passive nanostructures by 2015 and just entered the second generation of active nanostructures which may long last till 2020. The third generation of nanosystems which include assemblies of nanotools work together to achieve a final goal may be completed by the year 2035 and the

fourth generation of molecular nanosystems which involves the intelligent design of molecular and atomic devices, leading to unprecedented understanding and control over the basic building blocks of all natural and man-made things by the year 2050. This prediction is made based on present systematic investments on nanotechnology based product innovations by developing countries along with developed countries, and the multinational companies and also by studying the universities efforts worldwide on developing nanotechnology graduates, postgraduates and based on the promises shown by research personnel all over the world and the efforts being done by world top research centres including NASA in the process of creating breakthroughs in nanotechnology. If this prediction goes reality like the development of various generations of computers happened during the end of 20th century, the dream of nanotechnology-based super civilization is going to be a reality after the year 2050 itself.

Table 4.3 : Anticipated Timeline of Nanotechnology Innovations

Nanotech Generation	Development	Examples	First Prediction by Roco 2004 [3]	Recent Prediction by Aithal 2015 [1]
First Generation	Passive Nanostructures Ex: Coatings, nanoparticles, nanostructured metals, polymers, ceramics.	Nanomaterials, including nanotubes and nanolayers.	2000 - 2005	2000 - 2015
Second Generation	Active Nanostructures Ex: 3D transistors, amplifiers, targeted drugs, actuators, adaptive structures.	Change their state during use, responding in predictable ways to the environment.	2005 - 2010	2015 – 2020
Third Generation	Nanosystems Ex: Guided assembling; 3D networking and new hierarchical architectures, robotics.	Assemblies of nanotools work together to achieve a final goal.	2010 – 2015	2020 – 2035
Fourth Generation	Molecular Nanosystems Ex: Molecular devices 'by design', atomic design, Gene therapy.	Involves the intelligent design of molecular and atomic devices, leading to "unprecedented understanding and control over the basic building blocks of all natural and man-made things.	2015 - 2020	2035 - 2050
Fifth Generation	Singularity	Growth rate in NT applications become infinite.	2020 - 2015	Beyond 2050

4.7.2 Commercialization of Nanotechnology

Technology commercialization is the process of converting ideas into products for businesses and consequentially, creating demands for the products and jobs for the people. Commercialization of nanotechnology from research to economically viable product is particularly vulnerable to the "Valley of Death" point of commercialisation graph compared to any other technologies due to the reasons related to a product focus, market engagement, scale up and product development [18]. From a business perspective, the essential elements for the successful commercialization of a specifically directed nanotechnology include innovative

products, market size, market potential, and the current economic scenario and accordingly using qualitative data collection instrument namely focus group method [8], we have developed a model for successful nanotechnology commercialization process as shown in fig. 4.3 which include ten steps to develop standard products/services.

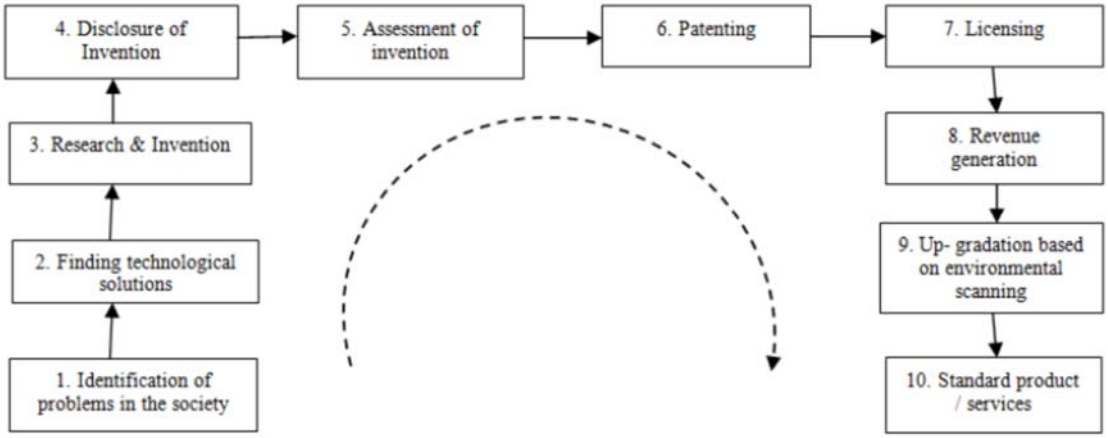

Fig. 4.3: Steps Required in Successful Nanotechnology Commercialization Model.

(a) Steps in Nanotechnology Commercialization Model:

1. Identification of Problems in the society: When an organization is planning to encash opportunities in nanotechnology-based business, it has to carry out a market survey and has to arrive at the conclusion on which product in which area has better demand, easy to develop, produce and market with low initial investment and sustainability.

2. Finding technological solutions through Ideas & Concepts: After identifying the possible products based on nanotechnology, the firm should do a technological feasibility study of producing such product with requited features.

3. Research & Invention – Product development, design, modelling & simulation: Once the firm understands that identified product is feasible to develop, it has to invest in indigenous research or collaborate with existing research organizations to develop the product.

4. Disclosure of Invention: Soon after the product is developed in R & D section of the firm, enough publicity should be given through various types of campaigns to create local and global demand.

5. Assessment of invention: Parallelly, the firm should make an assessment of the features of the products, reproducibility of the properties, reliability on the performance etc.

6. Patenting: In order to protect the intellectual property right of the invention, the firm should get protection by applying for a patent on the product/processes.

7. Licensing: Based on the patent right, the firm has to plan its strategy and take the decision to produce the product either directly under its own brand or by licensing to other firms spread globally.

8. Revenue generation: Through creating demand as well as its pricing strategy the firm has to decide its revenue generation model to realize its objective of maintaining long term profit.

9. Up gradation based on environmental scanning: Based on feedback from the stakeholders, and monitoring its environmental effects, the firm has to continuously upgrade the performance of the product and monitor its quality & performance.

10. Standard product / services: By standardizing the product/service, the firm can implement and develop technical standards which help to maximize compatibility, interoperability, repeatability, safety, or quality. It can also facilitate commoditization of the product.

Any firm which plans to do business using nanotechnology products/services gets success by following the above steps of our nanotechnology commercialization model.

(b) Opportunities for Nanotechnology Commercialisation:

1. Huge expectation from the society: By knowing the advantages and benefits of nanotechnology, people are waiting for the breakthrough of nanotechnology products in all areas of the consumer requirements in the society.

2. Opportunity for new innovative product development : Based on substantial advantages and hence expected huge demand for nanotech products, there are almost infinite number of opportunities for new product development in different areas of the society.

3. Opportunity for both small business and mega business players based on their investment capacity : Since nanotechnology products varying from simple cosmetic product to screen infrared rays from skin to artificial food products to self-generating molecular motors, depending on the interest and capability of firm, it can focus a particular type of product so that both small business firms and mega business firms have opportunity in nanotechnology product development and marketing.

4. Opportunity for new product development for entrepreneurs in their existing field itself so that they can use their experience: Being general purpose technology, nanotechnology provides scope for existing firms to upgrade their products/services. Hence, the existing entrepreneurs can plan to improve their products by improving them using nanotechnology features for improved performance.

5. The new discoveries and innovations get patent protection to commercialize their inventions. So that the investment of the firms will not be wasted due to their right to get patent protection for their inventions.

6. The new technology gives an opportunity to explore new business and sustainable earnings through the use of systematic commercialisation process.

4.7.3 Challenges for Nanotechnology Commercialization

New inventions based on new technology, usually attract attention due to their ingenuity, but a product must also be useful and compelling, enabling it to be used in everyday life. The objective of the firm is to identify a market for its new products [19]. From a business perspective, the steps to be followed for the successful commercialization of a nanotechnology-based product include market size, market potential, and the economic scenario of the countries and the people who use such products [20]. Common challenges faced by nanotechnology firms are:

(i) Time Lag: The average time delay between research, completion, and commercialization of a nanotechnology product can lie between three to five years [21, 22]. The banks and other financial funding agencies, find this time lag to be a major detriment due to the fact of the block of their capital [23].

(ii) Valley of Death: This is the gap between a positive scientific result of a researcher and obtaining supporting funds for commercialization and prototyping of the product [23]. Since the cost of

commercialization is very high compared to the invention cost of the product, usually, the scientist who invented the product may not have the interest in commercialization, but the firms invested for such research have to spend to encash its business opportunity.

(iii) Lack of infrastructure: Nanotechnology product based research is expensive and requires costly instruments. The lack of infrastructure retards the progress of new product invention.

(iv) Lack of standard for evaluation: A major obstacle for developing nano-products is the lack of standards for evaluation of performance at different stages of research. Because of this, normalizing standards by which nanotechnologies can be evaluated are lacking which affects the patenting process.

(v) Bureaucratic delays: Patent policies take up to thirty-six months to respond to a single application, a serious problem when even a slight delay can be detrimental. Due to lack of a coherent policy on technology transfer from universities to start-up businesses and a considerable red tape must be dealt with for any such transfer using black ocean strategy [4].

(vi) Dearth of funding: Since the research in nanotechnology is capital intensive due to the state-of-the-art instruments requirement, firms face challenges in obtaining funding. Thus, commercialization of nanotechnology products requires huge investments which small to medium firms cannot be secure easily.

(vii) Lack of trained professionals: The lack of sufficiently trained scientists, engineers, technicians, and researchers in the field is another barrier [23]. This is mostly due to lack of addition of nanoscience and technology in the engineering and science syllabus.

(viii) Pseudo Environmentalist: The speculation in environmental, health and safety issues of nanotechnology-based products, there is much debate about effects of nanotechnology might have on surroundings. Pseudo-environmentalists take this as an opportunity for fighting against the technology and do negative publicity to pressurize the firms to demand ransom.

(ix) Public support: Public support is always favourable due to their expectation towards any emerging technology, including nanotechnology. As a result, firms who invest in new technology to provide better high-tech products to them gets a higher brand image and public sentiments in their favour but small firms and start-ups that currently constitute a major chunk of nanotechnology product firms do not have such advantage [24-28].

(x) Sustainability in the market: The final challenge for the firms is maintaining the sustainability of the commercialized product or service for the longer time to get the return on investment and expected profits through planning and executing proper marketing strategy.

4.7.4 Nanotechnology and Corporate Business Strategy

Corporate strategy of an organization is a long-term plan to ensure success in its business. The organizations are following various strategies to ensure business sustainability either expanding their business globally, or by adding values to their existing business, or by expanding to new products or services which have potential opportunities in the future market. The various corporate strategies followed by organizations are broadly divided into five categories as Red ocean strategy, Blue ocean strategy, Green ocean strategy, Black ocean strategy, or White ocean mixed strategy as explained below:

(a) Nanotechnology gives the competitive advantage for Red Ocean strategy players [1] by improving their product features using NT research. Since nanotechnology products are comparatively new and rarely available in the market, the competition is proportionately less.

(b) Nanotechnology supports to develop new monopoly products for Blue Ocean strategy players [2] by inventing revolutionary new patented products using NT research. By identifying new applications of existing nanotechnology products or by inventing new avenues of

developing innovative products with the patent right, nanotechnology firms can follow blue ocean strategy.

(c) NT supports to develop new sustainable products for Green Ocean strategy players [3] by taking care of environmental degradation through NT research. The existing business firms can develop a strategy to improve the features of their products to make them environmental friendly which is the part of their corporate social responsibility. The new firms shall develop processes of manufacturing and the end products to be marketed as environmental friendly by erasing the carbon footprint using nanotechnology.

(d) Nanotechnology supports to develop new sustainable products for White Ocean strategy players [6] by strong collaboration and competition; address multi-stakeholders and responsible development by avoiding any unpredictable danger, threat and risk to living beings through NT research.

(e) Nanotechnology based products have substantial advantages in wars and military operations including weapons and weapon carrier systems so that many firms doing military weapons business use black ocean strategy [4] to get huge orders from bureaucrats and politicians who have the deciding power of purchase.

4.8 NEW MODEL FOR COMMERCIALIZATION OF NANOTECHNOLOGY PRODUCTS AND SERVICES

4.8.1. Nanotech Products & Services:

Various nanotechnology based products and services are entering the market but proper planned strategy of commercialization by companies can create better market demand and hence better return on investment [29-32]. Some of the nanotechnology based products which can help to solve basic problems of the people are:

(1) Products Related to Food and Food Packages:

- Food processing Nanofilters using nanomaterials.
- Nanocarrier systems for delivery of nutrients and supplements in the form of liposomes or biopolymer-based nanoencapsulated substance.
- Inorganic additives such as silver, iron, silica, titanium dioxide, selenium, platinum, calcium, magnesium in nanoformare available for supplements, nutraceuticals, and food and feed applications.
- A range of ecological finished barrier coating formulations of nanomaterials, used in the production of paper or cardboard destined for packaging with specific barrier requirements.

- Plastic polymers with nanoclay such as gas barrier, nanosilver, and nanozinc oxide for antimicrobial action, and nanotitanium nitride for strength.
- Different types of nanomaterial-based coatings are available for food preparation surfaces and for coating food preparation machinery.
- Nanosensors used to detect pesticides on fruit and vegetables.
- Nanoparticles encapsulated products are available to deliver vitamins or other nutrients in food and beverages without affecting the taste or appearance.
- Nanoparticle emulsioned ice-cream which improve the texture and uniformity of the ice-cream.
- Silver based nano-engineered food packaging provides biodegradable protection against leakage, gas penetration, and pathogen entrance into foods.
- Carbon dioxide sensor developed based on polyaniline boronic acid conductive polymer nanoparticles for food safety applications including monitoring grain spoilage.
- Nanotechnology based thermochromic or photochromic inks invented for marketing, brand protection or product safety to include covert tags on labels for smart food packaging.
- Nanolaminate edible coatings are available to cover food consists of more than one layer.
- Nanosensors have great potential to hasten the speed of detection, identification and quantification of pathogens, spoilage substances and proteins that cause allergies in food. Nanosensors are usually placed in food packages to monitor the internal and external conditions of the food.
- Active food packaging using metallic and metallic oxide nanoparticles in nanocompositeused to improve the shelf-life of foods.

(2) Products Related to Drinking & Potable Water:

- Portable water filtration products to clean water to produce drinking water.
- Nano-zero valent iron is used for remediation of groundwater contaminated with chlorinated hydrocarbon fluids and perchlorates.
- Nanocomposite membranes consisting of nanofillers, is produced as a new group of filtration materials comprising mixed matrix membranes and surface-functionalized membranes.
- Electro spinning produced nanofibers are used in water and wastewater treatment.

- Product consists of a combined water treatment process comprising photocatalysis and ceramic membrane filtration, with high capacity of several million cubic meters per day in particular for the degradation of volatile organic compounds.
- Nanotechnology based sea water desalinator produces drinking water from Sea water using nanotechnology based sea water desalinator.
- Drinking water from sewage using nanofilters.
- Nanotech based graphene treatment plant from sewage systems to develop nanotech based graphene treatment plant.

(3) Products Related to Renewable Energy & Storage:

- Solar-driven photocatalytic hydrogen production using nanotechnology principles.
- High efficiency electricity generation with metal nanoparticle based dye-sensitized solar cells.
- Nanomaterial based lithium ion rechargeable batteries for electric energy storage, and solid-state hydrogen storage.
- TiO2 and cadmium sulfide based nanostructures show efficient catalysts for water conversion into oxygen and hydrogen for hydrogen fuel cells.
- Carbon Nanotubes (CNTs), grapheme, and carbon-metal oxide composites are used for long life batteries and electrochemical supercapacitors.
- Nanomaterial based artificial photosynthesis for production of energy and hydro-carbons.
- Nanotechnology based photovoltaic cells and organic light emitting devices based on quantum dots as well as carbon nanotubes in composite film coatings are used for solar cells. It can enable cost effective solar and fuel cells with higher efficiency.
- Silicon-Lead Selenide (Si-PbSe) Quantum dots nanosystem based organic solar cells.
- Nanostructured high temperature superconductors for low loss power transmission.
- Nanostructured fillers in component of high voltage power lines for high electrical insulation.
- Epoxy made of carbon nanotubes used in rotor blades of wind power plants for improved strength of rotor blade parts.
- Nanomaterial products which acts as better catalyst in production of petrol from Crude oil to improves the efficiency of fuel production.

- Nanomaterial products based on heat absorbing sensors to converts waste heat in computers, automobiles, homes, power plants, etc., to usable electrical power.
- Nanocoating as anti-reflection layers on solar cells for increasing the energy yield.

(4) Products Related to Consumer Products & Cosmetics: About 1,600 consumer products based on nanotechnology are already available in the market [33]. These products are mainly belonging to following categories:

- Nano-sunscreens to protect the skin from UV rays.
- Anti-aging skin cream.
- Hair growth products using liposomes and ethosomes.
- Hard nanoparticles, such as silicon dioxide, can be used to build up scratch resistant coatings.
- Nanoparticulate coating for corrosion protection.
- Nano-coatings anti-fingerprint coating.
- Sunscreen made with zinc oxide nanoparticles.
- Anti-aging skin cream containing proteins enclosed in liposome nanoparticles
- Skin care creams that delivers nutrients to deeper layers of the skin by using nanoemulsions.
- Skin care products using nanoemulsions and liposomes.
- Antibacterial cleaning products using silver nanoparticles.
- Spray on film containing titanium oxide nanoparticles to kill bacteria and reduces odors.
- Liquid cleaner using nanoparticles called micelles to remove oils and dirt.
- Spray on liquid containing nanoparticles which form a hydrophobic film to repel water and dirt.
- Silver nanoparticles used in household appliances such as clothes, washer, or refrigerator to kill bacteria and to reduce odors.
- Nanocomposite barrier film to prevent air loss from tennis balls, etc.
- Tennis racquet frames containing silicon dioxide nanoparticles to increases strength, stability, and power.
- Epoxy containing carbon nanotubes coating the skin of kayaks to increases abrasion resistance.
- Resin containing buckyballs (fullerenes) are also used to make badminton racquets to increase power and stability.

- Ski wax made with nanocomposites to increases gliding performance and maximum speed.
- Bicycle parts made with carbon nanotubes increases stiffness without weight increase.
- Fishing rods made with a epoxy resin (called NSi) made with silica nanoparticles to increase the strength without weight increase.
- Fabric enhanced with nanowhiskers for water and stain resistant.
- Fabric enhanced with nanopores insulates against heat or chill.
- Fabric enhanced with some kind of nanoparticles supports dirt rinses off in rain, similar to property of the lotus plant.
- Fabric enhanced with silver nanoparticles reduces odors.

(5) Products Related to Pharmaceutics & Medicine:

- Nanosilver dressings to prepare wound healing material.
- Semiconductor nanocrystals fluorescent biological labels be used as fluorescent probes in biological staining and diagnostics as superior to existing fluorophores.
- Nanotechnology implants can monitor the body chemistry of patients and trigger drug release at a specific location inside the body. Biological implants and nanoelectronic devices can be used to enhance sight for the vision impaired and hearing for those who are hard of hearing.
- Nanoproducts for non-invasive or minimally invasive surgical tools, gene chips and biochemical sensors for early detection and prevention of diseases.
- Nanotech in regenerative medicine to eventually develop into treatments to replace or repair organs.
- Nanoparticle based drug delivery.
- Polymeric micelle nanoparticles to deliver drugs to tumors.
- Quantum dots for medical imaging.
- Bucky balls to block inflammation by trapping free radicals
- Nanoemulsions for nasal delivery to fight viruses (such as the flu and colds) or through the skin to fight bacteria.
- Nanoparticle cream for delivery of nitric oxide gas to treat infection.
- Nanoparticles that target tumor cells, when irradiated by x-rays the nanoparticles generate electrons which cause localized destruction of the tumor cells.
- AuroShell particles (nanoshells) for thermal destruction of cancer tissue.

- Diagnostic testing using gold nanoparticles to detect low levels of proteins indicating particular diseases.
- Drugs called nanoviricides developed to attack virus particles.
- Nanoparticle based synthetic vaccines.
- Antimicrobial wound dressings using silver nanocrystals.
- Dendrimer nanoparticles for use in drug delivery.
- Medical gauze containing aluminosilicate nanoparticles which help blood clot faster in open wounds.
- Detection of early-stage Alzheimer's disease using Gold nanoparticles.

(6) Products Related to Automobiles & Space Applications:

- Nanoparticle enforced wheel tires.
- Nanoengineered thermoplastic materials used in chassis parts to reduce weight.
- Nanotechnology batteries and fuel cells for electric/ hydrogen powered automobiles.
- Automobile interiors using dirt-repellent and antimicrobial textiles and surfaces, nanoparticulate air filters anti-glare coatings of mirrors, and instruments made by nanomaterials.
- Nano-structured coatings in automobile engines.
- Lightweight, flexible spacesuits using nanomaterials.
- Nutrient transport between bone tissue and the vascular system using nanotechnology to prevent bone deterioration during the space exploration.
- Radiation shielding is an area of key importance for space exploration.
- Anti-glare coatings on automobiles.
- Automobile bodies using nanosteel to reduce weight.
- Nano-varnish for stable value and scratch resistance.
- Nano-filters for clean air in automobile interiors.

(7) Products Related to Industrial Engineering:

- Nano-cement for improvement of strength, durability and monitoring.
- Steel cables can be strengthened using carbon nanotubes for industry applications.
- Nanoparticle based wood coatings for environmental protection.
- Nanotech based self-cleaning glasses and heat resistant glasses.
- Lithography.
- Integrated chips using miniaturisation of small mechanical moving devices (MEMS).

(8) Products Related to Information Communication & Computation Technology (ICCT):

- Light emitting diodes and Laser diodes based on nanocrystal quantum dots.
- Flash memory products.
- Latest computer hard disk drives & high speed processors.
- CMOS integrated circuits using sub-22nm geometry.
- Magnetoresistive Random Access Memory (MRAM).
- Intel's Integrated circuits with nano-sized features.
- Computer, mobile phone, and camera displays organic light-emitting diodes, or OLEDs.
- Conductive inks for printed electronics for RFID/smart cards/smart packaging.
- Antimicrobial/antibacterial coatings on mouse/keyboard/cell phone casings.

(9) Nanotechnology Services: Nanotechnology services [14] include:

- Innovations in displays boards for Advertising using nanotech integrated circuits and light emitting devices.
- Innovations in security & information storage for banking and financial services using nanotechnology based surveillance and storage devices.
- Innovation in information collection and storage, Online business in insurance services using nanotechnology supported information communication technology (ICT).
- Improved product features using high speed and secured technology based on nano devices in retailing services.
- Increased speed of communication using nanoelectronic devices in tourism business.
- Nanotech based communication and tracking, online reservation etc. in transportation service.
- Nanotech based communication, identification and tracking in distribution services.
- Nanotech based food processing, food packaging, food delivery, clean water supply, reduce, reuse, and recycle waste etc. in hospitality and food services.
- Nanotech based energy, electronic equipment, entertainment equipment and recreation systems in entertainment and recreation services.
- Nanotech based communication and storage devices, e-media etc. in mass communication & media services.

- Nanotechnology based health diagnosis, Health therapy and health information service in healthcare.
- Nanotech based electronic devices to improve the bandwidth and authentication, electronic documents etc. in Electronic Communication services.
- Nanotechnology based IT hardware components improves the quality of IT enabled services.
- Nanotechnology helps to improve online services including education services. Nanotechnology also helps to improve multi-media based education in education services.
- Nanotechnology based opportunities improves the public utility services related to rainwater, waste and recycling, water and waste water, toxics, community and energy.
- Nanotechnology improves ICT which improves the quality of services in various real estate and leasing processes in Public Administration services.
- Nanotechnology based innovations in food processes, water and waste management, energy and health management improves the public administration services.
- The various resources used in defence services are improved in terms of their quality using nanotechnology in defence services.
- Nanotechnology based control of greenhouse gases emission improves the quality of various business support services.
- Nanotechnology supported marketing concepts based on reducing, recycling and re-using resources improves the benefits of marketing services.
- Since nanotechnology is going to be general purpose technology, the quality of many professional services can be improved by using nanotech based innovations.
- Nanotechnology based environmental sustainability and decreasing environmental degradation improves the quality of social services in the society.

4.8.2 ABCD Listing of New Model:

This new commercialization model inspires the organizations to involve and invest on nanotechnology-based research by identifying the opportunities to solve issues related to both basic problems and problems on the comfortable life for human beings in the society. The identified opportunities have to be encashed by these interested organizations by setting their objectives to find technological solutions through investment on research and development. The results of their research and innovations are to be tested in the laboratory before

commercialization of inventions. To protect the intellectual property right of the invention, the firms initially go for applying the patent for their products/processes. After obtaining the patent, the firms decide on producing the products and try to create a global market and selling them to the global market based on demand either starting their own subsidiaries or by licensing other firms to produce these products in standard form. This commercialization model allows the firms to generate revenue and hence profit. Thus, a firm can get a return on investment with profit for solving the social problems on both basic and comfortability issues by following above commercialization model. This commercialization model has following advantages, benefits, constraints, and disadvantages [34-40].

(1) Advantages:

- Investment on research based on possible demand for new technology due to its ability to solve both basic problems in the society and problems related to comfortability of life.
- Companies get a new idea and opportunity to expand their business.
- New product development which has high demand universally.
- Patenting opportunity to protect intellectual property right of the invention.
- Licensing opportunity to get a return on investment.
- New products with multi-features, low price, and optimum performance.
- Nanotech products have long durability.
- Involvement of company in new product development through prototyping and then standardization.
- Commercialization of nanotechnology products is given priority and supported by many developed countries for the advancement of civilization.

(2) Benefits:

- Products developed based on society need and hence huge demand.
- Commercialization of indigenously developed product/service gives an opportunity for sustainable profit.
- Monopoly and global business opportunity through the patent.
- Opportunity to improve product features through innovation after prototyping till standardization.
- Organizational sustainability in competitive and uncertain business environment.

- New brand creation or brand stabilization in new technology area through innovative nanotech products.
- Mass production or licensed production leads to global business and global marketing which in turn gives better profit.
- The society gets the benefit of using advanced products at affordable price and hence support for the advancement of civilization.
- Government subsidy and tax benefits for research and commercialization of nanotechnology products & services.

(3) Constraints:

- Investment in research & development for new product/service invention.
- Breakthrough in research for new sustainable and useful product.
- Involving innovative & creative scientists by hiring them.
- Protecting the intellectual property right of the invention through patenting.
- Market size, market potential for the invented product and the economic scenario of the countries and the people who are prospective customers.
- Educating the people to use nanotech products and on safety issues.
- Standardization of the product/service for global acceptance.
- Identifying competitive firm for licensing.
- Lack of Government supports in many countries due to the fear of unknown environmental degradation and side effects of these products.

(4) Disadvantages:

- Huge initial investment for developing an innovative product based on a survey on demand in the society.
- The risk in investment on research & development in nanotechnology due to possible failure on inventing breakthrough products/services.
- Speculation in environmental, health, and safety issues of nanotechnology-based products usage.
- Commercialization of the product may need further standardization.
- The possibility of licensing firm's involvement in unethical practices which affects the profit and the brand name of the parent firm.
- Any delay in any stage of product/service commercialization facilitates the competitors to overtake.

4.9 CONCLUSION

(1) The various properties of Ideal business are identified and classified.

(2) A suitable business model is identified to realize most of the properties of Ideal Business.

(3) Various E-business models are used to study the possibility of realization of Ideal Business.

(4) It is found that ubiquitous E-Business called mobile business with intangible product/service can have most of the Ideal business properties.

Also, in this chapter, important nanotechnology features and their usage in industry, various products and services based on nanotechnology innovations and Business Strategy for them are identified. Applications & benefits of NT in Agriculture, Food packing & Clean water, in Renewable Energy & Storage, and in Medicine are discussed. Various Business Opportunities for New Nanotechnology based Products and Services, Developing a global strategy for Nanotechnology Business including PEST analysis model and ABCD analysing framework. Finally, some of the Future possibilities of nanotechnology innovations are mentioned and discussed.

Based on research results and publications, it is understood that nanotechnology is going to be the general purpose technology to support and solve major problems of the human beings and the society due to its potential ability to find amicable solutions at micro-level and expanding it to macro-level. The importance of nanotechnology is analyzed by listing advantages, benefits, constraints, and disadvantages in solving social and technological problems in the society. It is found that nanotechnology commercialization is lagging behind due to many reasons and hence failed to follow the expected generations in its growth stages. But as per new predictions, nanotechnology is developing to solve almost all problems of human life by 2050 by reaching the stage of singularity in which growth rate in NT applications become infinite. In this paper, we have developed a commercialization model for nanotechnology products and services and discussed the opportunities, challenges, and possible corporate business strategies for nanotechnology commercialization.

Our analysis based on research results and publications, it is understood that nanotechnology is going to be the general purpose technology to support and solve major problems of the human beings and the society due to its potential ability to find amicable solutions at micro-level and expanding it to macro-level. It is found that nanotechnology commercialization is lagging behind due to many reasons and hence failed to follow the expected generations in its growth stages. But as per new predictions, nanotechnology is developing to solve almost all problems

of human life by 2050 by reaching the stage of singularity in which growth rate in NT applications become infinite. In this paper, we made a detailed analysis of nanotechnology applications in different fields based on business organizations point of view. Based on the business perspective, we have developed a new model nanotechnology products/services commercialization model and analyzed it based on organizational and customer's perspectives. The paper also contains a detailed discussion on the opportunities and challenges for nanotechnology commercialization. In terms of time lag, the valley of death, lack of infrastructure, lack of a standard for evaluation, bureaucratic delays, the dearth of funding, and lack of trained professionals, brand image, and public support. Finally, we have discussed the advantages, benefits, constraints, and disadvantages of this new commercialization model in terms of nanotechnology products market potential [41-45].

REFERENCES :

[1] Porter, M. E. (1997). Competitive strategy. *Measuring Business Excellence*, 1(2), 12-17.

[2] Kim W. C., and Mauborgne R. (2004). Blue Ocean Strategy: How to Create Uncontested Market Space and Make the Competition Irrelevant. *Harvard Business Review*, 71-81.

[3] Hou.Shengtian (2007) Green ocean strategy: Obtaining sustainable competitive advantage, Beijing: Tsinghua University Press, pp. 183-197.

[4] Aithal P. S., Suresh Kumar P. M., (2015). Black Ocean Strategy - A Probe into a New type of Strategy used for Organizational Success. *GE International Journal of Management Research*, 3(8), 45 - 65. DOI : http://doi.org/10.5281/zenodo.163423.

[5] Aithal, P. S., Shailashree V. T., & P.M. Suresh Kumar, (2015). Application of ABCD Analysis Model for Black Ocean Strategy. *International Journal of Applied Research (IJAR)*, 1(10), 331 - 337, DOI : http://doi.org/10.5281/zenodo.163424.

[6] Aithal, P. S. (2016). The concept of Ideal Strategy & its realization using White Ocean Mixed Strategy. *International Journal of Management Sciences and Business Research (IJMSBR)*, 5(4), 171-179.DOI :http://doi.org/10.5281/zenodo.161108.

[7] Aithal, P. S. and Shubhrajyotsna Aithal. (2018). Study of various General-Purpose Technologies and their contribution towards developing Sustainable Society, *International Journal of Management, Technology, and Social Sciences (IJMTS)*, *3*(2), 16-33. DOI :http://doi.org/10.5281/Zenodo.1409476.

[8] Rogers, E.M., (1995). ' Diffusion of Innovation', The Free Press, NY.

[9] Morgan, R. M. and Hunt, S. D. (1994). The commitment-trust theory of relationship marketing. *Journal of Marketing*, 58, 20–38, 1994.

[10] Varambally, K. V.M. & Aithal, P.S. (2009). Mobile Business Technology and Business Proliferation of Banks - A Futuristic Approach. *Amity Business Review*, 10(1), 9 – 25.

[11] MacGregor, R., Ezvan, C. and Liquori, L. (1997). Secure Electronic Transactions: Credit Card Payment on the Web in Theory and Practice. SG24- 4978-00 Redbook, IBM, International Technical support Organization, Raleigh, NC, July 2, 1997; see www.redbooks.ibm.com/

[12] Horn, G. and Preneel, B. (1998). Authentication and payment in future mobile systems. In Proceedings of the European symposium on Research in Computer Security (ESORICS'98) Lecture notes in Computer Science (LouvainJa- Neuve, Belgium, Sepl.6-8), Springer Verlag, pp. 277-293.

[13] Herzberg, A. (2003). Payments and banking with mobile personal devices. *Communications of the ACM*, 46(5), 53-58.

[14] Aithal P. S. and Varambally, K.V.M. (2006). Security Issues in Online Financial Transactions with Special Reference to Banking Industry," In Quality in Service Sector and Managerial Challenges-Allied Publisher Pvt. Ltd. 2006, ISBN:81-7764-992-2, pp. 103-114, 2006.

[15] Aithal, P. S. (2015). Concept of Ideal Business & Its Realization Using E-Business Model. *International Journal of Science and Research (IJSR)*, 4(3), 1267 – 1274.DOI :http://doi.org/10.5281/zenodo.61648.

[16] Aithal, P. S. (2015). Mobile Business as an Optimum Model for Ideal Business. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 146-159. DOI :http://doi.org/10.5281/zenodo.163880.

[17] Aithal P. S. & Shubhrajyotsna Aithal, (2016). Business Strategy for Nanotechnology based Products & Services. *International Journal of Management Sciences and Business Research (IJMSBR)*, 5(4), 139-149.DOI :http://doi.org/10.5281/zenodo.161127.

[18] Craig B., Richard M., Grant E., and Darren M., (2013). Success factors to a nanotech-enabled whole product, in Nanotechnology Commercialisation edited by Takuya Tsuzuki, *Pan Stanford Publishing Pvt. Ltd*. p. 171.

[19] Mazzola L. (2003). Commercializing nanotechnology. *Nature Biotechnology*, 21, 1137-43.

[20] Hobson D. W. (2009). Commercialization of nanotechnology. *Wiley Interdiscip Rev NanomedNanobiotechnol*, 1, 189-202.

[21] Beer C., Foldbjerg R., Hayashi Y., Sutherland D. S., Autrup H. (2012). Toxicity of silver nanoparticles - nanoparticle or silver ion? *Toxicology Letters*, 208, 286-292.

[22] Patra J. K., Gouda S. (2013). Application of nanotechnology in textile engineering: An overview. *J. Engineering Techn Res,* 5, 104-111.

[23] McNeil R.D, Lowe J, Mastroianni T, Cronin J, Ferk D. (2007). Barriers to nanotechnology commercialization. *U.S. Department of Commerce Technology Administration*.

[24] Naseri R, Davoodi R. (2011). Commercialization of nanotechnology in developing countries. *3rd International Conference on Information and Financial Engineering*, Singapore, IACSIT.

[25] Mazumder S, Sarkar D, Puri I.K. (2014). Nanotechnology Commercialization: Prospects in India. *J Mater Sci Nanotechnol*, 2014; 2(2): 201.

[26] Waitz, A., &Bokhari, W. (2003). Nanotechnology commercialization best practices. *White Paper, Quantum Insight, Menlo Park, CA. available at http://www. Quantum insight. com/papers/030915_commercialization. pdf, last accessed*, *7*(12), 2016.

[27] Aithal P. S. and Shubrajyotsna Aithal (2016). Nanotechnological Innovations & Business Environment for Indian Automobile Sector: A Review. *International Journal of Scientific Research and Modern Education*, 1(1), 296-307.

[28] Aithal P. S. and Shubhrajyotsna Aithal (2016). Nanotechnology Innovations & Business Opportunities: A Review. *International Journal of Management, IT and Engineering*,6 (1), 182-204.

[29] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4294021/

[30] http://www.azonano.com/article.aspx?ArticleID=4069

[31] Aithal, P. S. & Shubhrajyotsna Aithal, (2016). Nanotechnology Innovations & Business Opportunities in Renewable Energy Sector. *International Journal of Engineering Research and Modern Education (IJERME)*, 1(1), 674-692. DOI : http://doi.org/10.5281/zenodo.160905

[32] http://www.understandingnano.com/nanotechnology-skin-care-cosmetics.html

[33] Vance, M. E., Kuiken, T., Vejerano, E. P., McGinnis, S. P., Hochella, M. F., Jr., Rejeski, D. and Hull, M. S. (2015). Nanotechnology in the real world: Redeveloping the nanomaterial consumer products inventory. *Beilstein Journal of Nanotechnology*, 6, 1769-1780. DOI: http://dx.doi.org/10.3762/bjnano. 6.181.

[34] Aithal, P. S. (2016). Study on ABCD Analysis Technique for Business Models, Business strategies, Operating Concepts & Business Systems. International Journal in Management and Social Science, 41), 98-115. DOI: http://doi.org/10.5281/zenodo.161137.

[35] Aithal, P. S., Shailashree, V. T., & Suresh Kumar, P. M. (2016). ABCD analysis of Stage Model in Higher Education. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 11-24. DOI: http://doi.org/10.5281/zenodo.154233.

[36] Aithal P. S., Shailashree V. T., & Suresh Kumar P. M., (2015). Application of ABCD Analysis Model for Black Ocean Strategy. *International Journal of Applied Research (IJAR)*, 1(10), 331 - 337. DOI: http://doi.org/10.5281/zenodo.163424.

[37] Aithal, P. S., Shailashree, V. T. & Suresh Kumar, P. M. (2016). Analysis of NAAC Accreditation System using ABCD framework. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 30 – 44. DOI :http://doi.org/10.5281/zenodo.154272.

[38] Shubhrajyotsna Aithal & Aithal, P. S., (2016). ABCD analysis of Dye doped Polymers for Photonic Applications. *IRA-International Journal of Applied Sciences*, 4(3), 358-378. DOI: http://dx.doi.org/10.21013/jas.v4.n3.p1.

[39] Aithal, P. S., Shailashree, V. T. & Suresh Kumar, P.M. (2016). The Study of New National Institutional Ranking System using ABCD Framework. *International Journal of Current Research and Modern Education (IJCRME)*, 1(1), 389 – 402. DOI: http://doi.org/10.5281/zenodo.161077.

[40] Aithal, P. S., Shailashree, V. T. & Suresh Kumar, P. M. (2016). Application of ABCD Analysis Framework on Private University System in India. *International Journal of Management Sciences and Business Research (IJMSBR)*, 5(4), 159-170. DOI: http://doi.org/10.5281/zenodo.161111.

[41] Aithal, P. S., (March 2015). Concept of Ideal Business & Its Realization Using E-Business Model. *International Journal of Science and Research (IJSR)*, 4(3), 1267 – 1274. DOI : http://doi.org/10.5281/zenodo.61648.

[42] Aithal, P. S. (2015). Mobile Business as an Optimum Model for Ideal Business. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 146-159, DOI : http://doi.org/10.5281/zenodo.163880.

[43] Aithal P. S. & Shubhrajyotsna Aithal, (April 2016). Business Strategy for Nanotechnology based Products & Services. *International Journal of Management Sciences and Business Research (IJMSBR)*, 5(4), 139-149, DOI : http://doi.org/10.5281/zenodo.161127.

[44] Aithal, P. S. and Shubrajyotsna Aithal, (November 2016). Nanotechnology Innovations and Commercialization – Opportunities, Challenges & Reasons for Delay. *International Journal of Engineering and Manufacturing (IJEM),* 6(6), 15-25, DOI : http://doi.org/10.5281/zenodo.161161, DOI: http://doi.org/10.5815/ijem.2016.06.02.

[45] Aithal, P. S. & Shubhrajyotsna Aithal, (2016). A New Model for Commercialization of Nanotechnology Products and Services. *International Journal of Computational Research and Development,* 1(1), 84-93. DOI : http://doi.org/10.5281/zenodo.163536.

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CHAPTER 5

IDEAL EDUCATION SYSTEM & ITS REALIZATION OPPORTUNITY

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ABSTRACT :
In this chapter, the concept and characteristics of the ideal education system and its realization opportunity through online open education model using mobile devices are proposed and analysed. The chapter also consists of discussion on the impact of On-line education on higher education system and how Smart Library Model can be used as Universal Library for future generation education systems.

5.1 INTRODUCTION :

Education is the most important thing for any country to develop and prosper. Education moulds the character and intelligence of individuals. It also provides the talent and motivation to every person. The conventional education system at higher education level is analog to brick and mortar type business system, where a student get systematic education from college/University by physically attending required courses regularly (Full time/part Time). However, the conventional education system has many drawbacks and lot of improvements are expected in future days. To improve any present systems, it is normal practice that such systems have to be compared with an hypothetical, predicted system of that kind called "Ideal system". The word 'Ideal system' refers to the system which has ideal characteristics i.e., perfect in every way. It is what the mind pictures as being perfect. The concept of ideal engine, ideal switch, ideal voltage source, ideal current source, ideal semiconductor devices like ideal diodes, ideal transistors, amplifiers etc. have been defined and taken as standards to improve the quality and performance of such practical devices or systems. It is found that, by keeping such hypothetical devices or systems in mind, researchers have continuously been improving the characteristics/properties of practical devices / systems to upgrade their performances. Hence ideal properties of a device or a system can be used to upgrade or improve its properties towards reaching 100% efficiency. By comparing the properties/characteristics of a practical device/system with its ideal counterpart, one can find out the possible modifications in that device /system towards reaching the objective of achieving such an ideal system [1].

In this chapter, we have presented an Ideal Education System model by considering various characteristics under 4 categories such as Input conditions, Systems requirements, Output conditions and Environmental & social conditions, and analyzed these characteristics with an objective to achieve the goal. We have also studied the possibility of realizing our Ideal Education System Model through Online Education using Mobile devices. A comparison is made between Conventional Education Models and Online education Model using Mobile devices.

In this chapter, it is also proposed that the online education system is next generation education system and impact of online education system in higher education on development of science & society are analysed. The types of online education models and their importance are discussed. The advantages, benefits, constraints and disadvantages of online education systems are also discussed. The features some of the online portals are studied by considering some of the important online education models e.g., edX, Alison, NPTEL and UZity as case examples. Finally, the online education system is compared with a hypothetical system called "Ideal education system".

The concept of library in educational institutions is changing as the major constituents of library like physical books, hard copies of journals and newspapers are vanishing and a new format called e-format of these resources emerging through advents in computer science, information science and e-storage technology. The physical copies of books, journals and newspapers are thumbing and their electronic format do not need space for storage and single copy of such resource can be shared by any number of users so as the name of library has no longer validity. Hence libraries are now renamed as Resource Centres with online facility to provide resource sharing services to its registered users. Future libraries so called ‘Resource Centres’ do not need large reading rooms, large book/journal old volume storage area or even independent library building. Individual institutions also do not need independent libraries. There should be one Resource centre for a country or even only one for the entire world through which everybody can connect through ICT for uploading and downloading audio, text and video files so that equality in terms of accessibility to any of these types of resources can be maintained irrespective of gender, region, religion, economical background and the country origin of the users. The paper discusses the possibility of such transformation of Library into ‘Universal Resource Center’ and the consequences of such transformation to information sharing throughout the World and further changes in the model of costless higher education and extended opportunity for new knowledge creation. We also discuss how such transformed

Libraries as Universal Resource Centres may provide automated customized service for individuals ubiquitously by incorporating smart library model.

5.2. IDEAL EDUCATION SYSTEM AND ITS REALIZATION OPPORTUNITY :

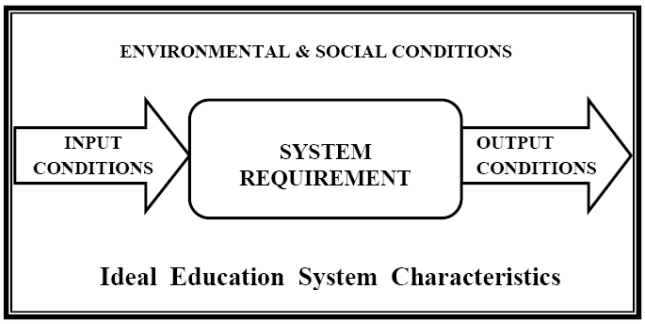

Fig. 5.1 : Classifications of an Ideal Education System Characteristics.

Education at its best will effectively prepare students for the working world. An ideal education system would not only prepare students for the working world but would also prepare them to become empowered to transform the working world to better suit the needs of the people. An Ideal education system shall have characteristics which can be predicted and classified. Based on various factors which decides the ideal education system characteristics, a model consisting of the input conditions, output conditions, system requirements, and social & environmental conditions is derived by a qualitative data collection instrument namely focus group method [2, 3]. The block diagram of such a system is shown in Fig. 5.1.

A. Social & environmental conditions :

(1) The Ideal Education provides education to the entire world rather than a single neighbourhood /Country and hence it has an unlimited global reachability.

(2) The Ideal Education offers courses of study, which enjoys an inelastic demand in the world market. (inelastic refers to a Course that people need or desire almost at any price.)

(3) The Ideal Education provides all types of courses in all field of specialization and imparts knowledge, skills and experience to all people irrespective of their age, gender, previous qualification, and country of origin.

(4) The Ideal Education system provides high quality education to everybody irrespective of their economic, social, linguistic and cultural background.

B. Input Conditions :

(5) The Ideal Education system need minimum instructors in identified courses and must utilize optimum service from them.

(6) The Ideal Education system operates on a low overhead. It does not need an expensive location, big campus and huge amount of infrastructure. Only a few Universities are required to provide quality education to the entire world.

(7) The Ideal Education system does not require major investments in equipment and other education & training systems or repetition of large number of universities in every state and every country. In other words, it does not require huge capital.

C. System Requirements :

(8) The Ideal Education system is relatively free of all kinds of government regulations or restrictions.

(9) The Ideal Education system is portable or easily moveable. This means a student registered for a course should get the service wherever he moves.

(10) The Ideal Education system satisfies its students intellectual needs. There are no constraints like compulsory subjects, minimum and maximum subjects.

(11) The Ideal Education system leaves enough free time to instructors as well as to students. In other words, it doesn't require attention/study of 12, 16, or 18 hours a day.

(12) The Ideal Education system is one in which the income of the university does not limit by personal output (Leverage). In the Ideal Education system, one can train 10,000 students as easily as can have one."

(13) The ideal Education system students can take exams any time, any number of times and results should be declared immediately. There is nothing like losing a year due to failure in examination.

(14) The ideal Education system will provide services to its registered students anywhere, any time and any amount of time. i.e., it is ubiquitous.

(15) In ideal system, the technology is used in such a way that all pedagogies of education system should be delivered effectively.

(16) An ideal education system provides all students with not only basic knowledge but also social skills and good behaviours.

D. Output Conditions :

(17) In ideal Education system, the demand for variety of courses is higher than supply and the efficiency of the system is always 100%.

(18) In ideal Education system, the students have a choice on alternative in terms of course/service providers.

(19) The ideal Education system will be sustainable for long time.

Any education system which has the above properties is considered as ideal education system and the conventional education systems called brick and mortar systems have serious drawbacks/limitations in terms of the above properties [4].

5.3 ANALYSIS OF THE CHARACTERISTICS :

Ideal Education System characteristics can be explained based on their effectiveness in improving the qualities and benefits of the education system in empowering & to reform the working world. The characteristics mentioned in ideal education system model are further discussed below :

(1) Global Reachability :

Any ideal system will sustain for longer period providing services to larger number of people. An Ideal Education system will be eyeing at global students and provides education to the entire world rather than a single neighbourhood /Country which has only limited students. Hence Ideal education system has an unlimited global reachability.

(2) Inelastic demand :

The Ideal Education offers all required and possible courses of study with highest quality and enhanced values, which enjoys an inelastic demand in the world market due to their benefits. In ideal education system, the benefits of education & training is always more than the cost incurred to avail it.

(3) Open Courses for everybody :

The Ideal Education System provides all types of courses in all field of specialization and imparts knowledge, skills and experience to all people irrespective of their age, gender, previous qualification and country of origin. This helps everybody in the world to have access to higher education in chosen area irrespective of his/her origin.

(4) High Quality Courses for everybody :

The Ideal Education system provides high quality education to everybody irrespective of their economic, social, linguistic and cultural background. The product/course in ideal education system is developed in such a way that it has unique features in terms of concepts, pedagogy, technology, understandability, innovativeness, cost/price or any other advantages.

(5) Minimum Instructors requirement :

Any education system can sustain for longer period by decreasing the cost. The Ideal Education system need minimum instructors in identified courses and must utilize optimum service from them for proper model of course delivery. Using a model of utilizing less, highly qualified,

experienced, innovative instructors to provide training, will minimize the expenditure of the system.

(6) Low overhead :

The total cost of any education system is the sum of Fixed cost and Variable cost. The fixed cost involves initial investment on the education system and the variable cost include maintenance cost. By decreasing initial investment without compromising with quality, the education system can decrease its overall cost. As per our definition, the Ideal education system operates on a low overhead. It does not need an expensive location, big campus and huge amount of infrastructure. Only few Universities are required to provide quality education to the entire world.

(7) Low investments :

Out of various resources used in any education system, capital investment like investment on land, buildings, equipment and other infrastructures need huge capital. On the other hand, the Ideal education system does not require big cash outlays or major investments in land, equipment, buildings and other education & training systems or repetition of large number of universities in every state and every country. In other words, it does not require huge capital.

(8) Free of Government Regulations :

Many conventional education systems are facing problems due to Government regulations based on the nature of education (basic, higher, professional etc.), the environmental issues and the neighbouring community issues. These regulations sometime make the educational systems as non-profit or to shut down. An Ideal system is relatively free of all kinds of government regulations or restrictions so that it can do sustainable services for longer period.

(9) Portability :

The conventional Education models have uncertainty in their efforts of providing continued service to the students due to various reasons including shifting from one country to another country or due to natural calamities. This problem can be solved in Ideal education model due to its portability or easy movability. This means a student registered for a course should get the service wherever he moves.

(10) Satisfying intellectual needs :

In conventional education, the organization grows due to the collective efforts of the instructors and students and it may not satisfy the intellectual needs of the individual students. However, Ideal education system satisfies the intellectual needs of every student. There are no constraints like compulsory subjects, minimum and maximum subjects etc.

(11) Less time consumption :

The Ideal Education system leaves enough free time to instructors as well as to students. Students can take the courses at any leisure time. They need not attend the courses every day and spend equal amount of time every day. Similarly, the instructors also need not engage with busy schedules. In other words, it doesn't require attention/study of 12, 16, or 18 hours every day. In addition, the students need not waste their time for unproductive activities like travel etc.

(12) Potential opportunity for high income :

The education systems must have profit for further progress. There is nothing wrong in expecting huge profit for honest efforts. One of the advantages of Ideal education system is possibility of ensuring large profits. The Ideal Education system is one in which the income of the university does not limit by personal output of its instructors (Leverage). In the Ideal Education system, one can have 10,000 students as easily as can have one." This is mainly due to intangible nature of courses/services and scalability.

(13) Repeated Opportunity for continuing education :

In ideal Education system, students need not be tensed due to heavy pressure during examination. The examinations are scientifically planned to test their understandability and intelligence. They can take exams any time, any number of times and results should be declared immediately. There is nothing like losing a year due to failure in examination.

(14) Ubiquitous :

The ideal Education system will provide services to its registered students anywhere, any time and any amount of time. i.e., it is ubiquitous. This is the major advantage of ideal educational system compared to conventional brick-and-mortar system.

(15) Technology dependent :

In ideal system, the technology is used in such a way that all pedagogies of education system should be delivered efficiently and effectively. Students should get opportunity to do experiments through simulation, group discussions/group activities through online communication models.

(16) All-round education :

An ideal education system provides all registered students with not only basic knowledge but also social skills and good behaviours. This will qualify them and empower to reform the working world.

(17) Hundred percent efficiency :

In ideal Education system, due to its global reachability to anybody and everybody, the demand for variety of courses is higher than supply and the efficiency of the system is always 100%.

(18) Choice of alternative Courses :

Depending upon the self interest, job demands, environmental factors, the students in ideal Education system have a choice of alternative in terms of course/service providers.

(19) Longer Sustainability :

The ideal Education system will be sustainable for long time due to its advantages like low cost, high quality, and ubiquity.

5.4 AN INNOVATIVE EDUCATION MODEL TO REALIZE IDEAL EDUCATION SYSTEM :

To realize the Ideal Education System in practice, we need to convert University Courses to intangible in nature. The education system should be online electronic (intangible) components and is controlled by any place in the world. The courses and the education model should be chosen in such a way as it should have characteristics, at least close to Ideal Education system model. This can be realized by online courses provided by virtual universities located anywhere in the world. In order to reach such online virtual courses to the students located anywhere, they should use mobile communicating devices so that the model will be perfectly ubiquitous [5].

An intangible course marketed through E-business model is the possible solution while approaching towards Idealization of the education. A ubiquitous E-Business model using intangible courses by virtual universities is most suitable for elevation to Ideal education system. Most of the characteristics discussed in Fig. 5.1 of Ideal Education system can be achieved through and compared to the properties of online Education using mobile devices.

A. Benefits of Online Mobile Education

The benefit from the student's point of view is accessing education services anywhere, any time and any extent of time. These features significantly save the valuable time of the student. The main advantages of online mobile education for the global students are listed as follows [6] :

(1) Ubiquity : Through mobile devices, education applications are able to reach students anywhere at any time. On the other hand, students can get any course they are interested in, whenever they want regardless of where they are, through Internet-enabled mobile devices. In this sense, mobile education makes a service or an application available wherever and whenever such a need arises. Communication can take place independent of the students and

universities location. The advantages presented from the omnipresence of information and continual access to university courses will be exceptionally important to time-critical applications.

(2) Personalization : An enormous number of education courses, services, and applications are currently available on the Internet, and the relevance of information received by users is of great importance. Since owners of mobile devices often require different sets of applications and services, mobile education applications can be personalized to represent information or provide services in ways appropriate to the specific students use. Additionally, personalized courses/content is paramount in operating mobile devices because of the limitation of the user interface. Relevant university courses must always be only a single "click" away, since web access with any existing wireless device is not comparable to a PC screen either by size, resolution or "surfability".

(3) Reduced costs : This is due to availing and using various courses and services by number of students online. The course fee charged by service providers/universities is much cheaper than fees of conventional education systems. The heavy competition and the price war between mobile service providers also reduced mobile service usage cost.

(4) Flexibility : Because mobile devices are inherently portable, students may be engaged in activities, such as working or travelling, while doing their study through their internet-enabled mobile devices.

(5) Increased comfort : Many students secretly hate the conventional education system because of punitive fees, inconvenient working hours and unhelpful university staff. In online mobile education system, due to quick and continuous access of interested and required courses from any global university, the service is available 24 hours a day, without requiring the physical interaction with the instructors.

(6) Time saving : The main benefit from the online mobile education system from student's point of view is significant saving of time by the automation of education services including access to study materials, video lectures, online assignment submission, online interaction/discussion with both instructors and peer students, online exam and evaluation etc. Since the response of the medium is very fast, the students can get their result soon after the examination.

(7) Convenience : The ability and accessibility provided in wireless devices will further allow online mobile education system to differentiate its abilities from conventional education systems. People who wants to study any course in any university will no longer be constrained

by time or place. Rather, it could be accessed in a manner which may eliminate some of the labour of life's activities. For example, students waiting in line or stuck in traffic will be able to access course materials/take an exam through online mobile education applications. Students may recognize a special comfort which could translate into an improved quality of life.

(8) Dissemination : Some wireless infrastructures support simultaneous delivery of data/information to all registered online mobile students within a specific geographical region. This functionality offers an efficient means to disseminate information to a large student population simultaneously.

B. Comparison of Conventional Education and Mobile Education

The system properties like - free of government regulations, portability, satisfying intellectual needs, less time consumption, potential opportunity for high income, repeated opportunity for continuing education, ubiquity, and technology dependence; Input Conditions like - minimum instructors requirement, low overhead, low investments; Output Conditions like - all-round education, hundred percent efficiency, choice of alternative courses, and longer sustainability; Social & environmental conditions like - global reachability, inelastic demand, open courses for everybody, and high quality courses for everybody of ideal education model are realizable to certain extent using online mobile education as shown in Table 5.1. Thus, online education using mobile devices called mobile education is a suitable education model for realizing our hypothetical Ideal business model.

Table 5.1 : Comparison of Conventional Education and online Mobile education in terms of Ideal System Characteristics.

S. No.	Ideal Education System Characteristics	Conventional Education	Online Mobile Education
1	Global Reachability	No	Yes
2	Inelastic demand	No	Yes
3	Open Courses for everybody	No	Yes
4	High Quality Courses for everybody	No	Yes
5	Minimum Instructor requirement	No	Yes
6	Low overhead	No	Yes
7	Low investments	No	Yes
8	Free of Government Regulations	No	Yes
9	Portability	No	Yes
10	Satisfying intellectual needs	No	Yes
11	Less time consumption	No	Yes
12	Potential opportunity for high income	No	Yes
13	Repeated Opportunity for continuing education	No	Yes

14	Ubiquity	No	Yes
15	Technology dependent	No	Yes
16	All-round education	Yes	Yes
17	Hundred percent efficiency	No	Yes
18	Choice of alternative Courses	No	Yes
19	Longer Sustainability	No	Yes

5.5 IMPACT OF ON-LINE EDUCATION ON HIGHER EDUCATION SYSTEM :

5.5.1 Next Generation Education:

Competency-Based Credit System (CBCS) is a significant improvement in education model. It provides an opportunity to personalize the learning in higher education by means of providing a proper direction while choosing the subjects, and in assessment. Competency-based programs allow students to demonstrate academic competence through a combination of assessment and documentation of experience to gain academic credit. It allows students to progress at their own pace, incorporates the process of prior learning assessment, to offer a logical framework for improving knowledge, skills and experience as per the demands of the industry to the extent decided by the institution. A student need not necessarily have to take predetermined subjects required and elective courses to be taught by approved faculty members. Rather, it would mean that a student has demonstrated a defined set of proficiencies and mastery of knowledge and content.

CBCS model is much effective for students who carry out higher education through 'learn-while-earn model' due to the fact that they get practical experience in their interested area, which can be converted into academic credits along with the theoretical and conceptual understanding of the subject. CBCS also works well for adults who are returning to school to complete programs of study after few years working experience and in such cases it has the potential to reduce costs shortening the duration and time to the completion of the course. Competency-based course design requires more proper planning of the courses than what is currently done for conventional Credit Based System. Conducting number of assessments to continuously measure the student mastery in a chosen subject is labour-intensive. Instead of offering periodic assessments per subject per semester of a course in Credit Based system, competency-based system requires to provide hundreds of opportunities to each student to test their understanding the subject. Along with determining the competency in the subject, these assessments are required to determine how quickly they can move through the curriculum, a fundamental requirement of the CBCS model [7]. Earning college credit by virtue of life experience runs afoul of classroom experience, which many educators believe to be sacred.

Designing and developing CBCS courses requires special tactics. Some institutions developed hundreds of formative assessments used to measure student progression to ensure that students have qualified the prescribed learning objectives and learning activities. In fact, this assessment capability of such institutions is going to be core capability to develop collaboration with other institutions only for effective assessment of human resources for industries [8]. The difficulty and constraints of CBCS model is preparing and supporting students learning at different paces due to their different capabilities unlike present classroom teaching. This has both pedagogical and administrative implications, as students learn same subject at different time based on their personal capability. How to provide this benefit to the students while accommodating variable time-to-completion? But the main ingredients of CBCS model is student centric independent learning in his/her own pace. For this, institutions need to be able to register and process students on an ongoing basis. This is technically simple, but not as easy as we imagine due to the fact of embedded nature of administrative systems in our institutions. Competency models recognize the value of experiential learning, in which students can develop and hone skill sets in real-world contexts. For instance, a student with a background in web design may be able to provide an institution with a portfolio that demonstrates mastery of computer coding or digital design. If coding or digital design is a discipline in which the institution gives credit, and the mastery demonstrated is sufficiently similar to that achieved in the classroom, then the institution may grant credit based on that portfolio. The logic of competency-based credit is compelling through individual learning or online learning or even traditional classroom based learning. Here, the process attaining the required level of competency can be different but reaching the level of competency is important. After all, colleges and universities hire most people to teach so that students learn. If students can achieve the desired learning in other ways, then why not provide them with the same credential as those who sat in the traditional classrooms with the traditional faculty members? In future days, if more higher educational institutions adopt competency-based models, more and more students will earn degrees from such institutions by taking the courses where they have earned competency and perhaps interact minimally with professors.

5.5.2 On-Line Education Models:

There are number of models developed on how to deliver education effectively using many tested pedagogy. All of these models may not end up thriving in the long-term, but the following models have potential for attracting the learners. These models are differing in terms of course design, pedagogy and the channel by which information is created and transmitted:

(1) Traditional full time classroom based face-to-face programs

(2) Traditional part-time classroom based programs

(3) Non-Profit Online Programs

(4) Profit-based Online Programs

(5) Online Competency-Based Education Model

(6) Open Education Practices

(7) Massively Open Online Courses, or MOOCs

(8) Flipped Classrooms

(9) Self-learning

(10) Complete online competency based Higher education through Mobile Devices.

5.5.3. Importance of Online Education System:

The benefit from the students' point of view is accessing education services anywhere, any time and any extent of time. These features significantly save the valuable time of the student. The main advantages of online mobile education for the global students are listed as follows [9]:

Ubiquity: Through mobile devices, education applications are able to reach students anywhere at any time. On the other hand, students can get any course they are interested in, whenever they want regardless of where they are, through Internet-enabled mobile devices. In this sense, mobile education makes a service or an application available wherever and whenever such a need arises. Communication can take place independent of the students and universities location. The advantages presented from the omnipresence of information and continual access to university courses will be exceptionally important to time-critical applications. Ubiquity is most supporting feature of competency based learning system.

Personalization: Huge number of education courses, services, and applications are currently available on Internet and the relevance of information received by users is of great importance. Since owners of mobile devices often require different sets of applications and services, mobile education applications can be personalized to represent information or provide services in ways appropriate to the specific students use. Additionally, personalized courses/content is paramount in operating mobile devices because of the limitation of the user interface. Relevant university courses must always be only a single "click" away, students can access required courses systematically where they have created competency to take assessment exercise.

Reduced Costs: This is due to availing and using various courses and services by number of students online. The course fee charged by service providers/universities is much cheaper than

fees of conventional education systems. The heavy competition and the price war between mobile service providers also reduced mobile service usage cost. So, online based CBCS model allows students to qualify in prescribed subjects by taking assessments from service provider through online, which decreases the cost of availing degrees based on online based evaluation procedure.

Flexibility: Because mobile devices are inherently portable, students may be engaged in activities, such as working or travelling, while doing their study through their internet-enabled mobile devices. The skills and experience they learned can be used for online assessment to get relevant degrees.

Increased Comfort: Many students secretly hate the conventional education system because of punitive fees, inconvenient working hours and unhelpful university staff. In online mobile education system, due to quick and continuous access of interested and required courses from any global university, the service is available 24 hours a day, without requiring the physical interaction with the instructors. So, online CBCS model has advantage of independent student centric learning and earning degree online without physically attending classes.

Time Saving: The main benefit from the online mobile education system for student's point of view is significant saving of time by the automation of education services including access to study materials, video lectures, online assignment submission, online interaction/discussion with both instructors and peer students, online exam and evaluation etc. Since the response of the medium is very fast, the students can get their result soon after the examination. CBCS model imparted online also has this benefit.

Convenience: The ability and accessibility provided in wireless devices will further allow online mobile education system to differentiate its abilities from conventional education systems. People who want to study any course in any university will no longer be constrained by time or place. Rather, it could be accessed in a manner which may eliminate some of the labor of life's activities. For example, students waiting in line or stuck in traffic will be able to access course materials/take an exam through online mobile education applications. Students may recognize a special comfort which could translate into an improved quality of life. Similarly, online CBCS model is most convenient to get college degree for working class people.

5.5.4 Online Competency-Based Education Model :

Competency-Based Credit System (CBCS) is a significant improvement in education model by designing a new evaluation system. It provides an opportunity to personalize the learning in

higher education by means of providing a proper direction while choosing the subjects, and its assessment. Competency-based programs allow students to demonstrate academic competence through a combination of assessment and documentation of experience to gain academic credit. It allows students to progress at their own pace, incorporates the process of prior learning assessment, to offer a logical framework for improving knowledge, skills and experience as per the demands of the industry to the extent decided by the institution. Competency-based Credit System (CBCS) works backwards within a course, starting with the desired outcomes through a learning objectives and relevant assessments, and then moving to the learning experiences that should lead students to the outcomes. Typically, there is a desire to include flexible pathways for the student to achieve the outcomes. CBCS can be implemented in various modalities, including face-to-face classroom, online education and hybrid models [10]. In CBCS the outcomes are more closely tied to job skills or employment needs, and the methods are typically self-paced. Some of the critical components of CBCS are as follows:

(1) Explicit learning outcomes with respect to the required skills and concomitant proficiency (standards for assessment).

(2) A flexible time frame to master these skills.

(3) A variety of instructional activities to facilitate learning.

(4) Criterion-referenced testing of the required outcomes.

(5) Certification based on demonstrated learning outcomes.

(6) Adaptable programmes to ensure optimum learner guidance.

CBCS may be offered on campus or off campus, in the classroom or online, accelerated or normally paced. The institutions offer CBCS define competencies that are expected of graduates and students demonstrate these competencies by successfully completing courses that relate to the required competencies. In some cases, institutions embed competency assessments into each course. Some institutions also offer the option of awarding credit for prior learning, through prior learning assessments. In the case of online CBCS, the program moves into a self-paced model. Some of the characteristics of online CBCS programmes are:

- Fully-online
- Self-paced
- Flexible to allow for retaking of assessments until competency demonstrated
- Flexible to allow passing of assessments up front and not even need instruction / activities, thus allowing credit for life experiences or prior learning assessments (PLA).

Currently emphasis and growth in CBCS is driven by the desire to provide lower-cost education options through flexible programs – lower cost is the driver. The investment community is not playing as big of a role in CBCS as they are in Massive Open Online Courses (MOOCs) like NPTEL, edx, Coursera, Udacity etc. This unique competency-based model will allow students to start classes anytime they like, work at their own pace, and earn credit for what they already know. Students can demonstrate college-level competencies – no matter where they learned the material – as soon as they can prove that they know it. By taking advantage of this high quality, high flexibility model, and by utilizing a variety of resources to help pay for their education, students will have new tools to accelerate their careers [10].

5.5.5. ABCD Listing of Online Education System:

The simple ABCD analysis model consists of listing advantages, benefits, constraints and disadvantages of the system [11-12]. For online education system the simple ABCD analysis is listed below:

Advantages:

(1) Convenience

(2) Choice based subjects

(3) No wastage of time

(4) Global quality

(5) Accessibility to global technology & education models

(6) Flexibility in time & learning

(7) Students from all over the world to service providers

(8) Acclaimed professors can reach global students.

(9) New courses, new pedagogy can be used to attract global students.

(10) Quality and brand based sustainability.

Benefits:

(1) Technology based innovations in examination system

(2) Earn while learn benefit

(3) Low fee opportunity

(4) High quality education at affordable or low cost.

(5) Learning courses are available at anytime, anywhere.

(6) International quality and international acceptability of certificates.

(7) Better earning opportunity for service providers.

(8) Better branding opportunity for service providers.

(9) By reaching global students, Professors can develop personal brand.

(10) New courses, new pedagogy can be popularized globally.

Constraints:

(1) Designing online courses in different subjects

(2) Identifying futuristic areas

(3) Finding and retaining suitable faculty

(4) Innovative examination and evaluation model

(5) Expenditure for online advertisement for marketing courses

(6) Checking the accreditation and quality of the programmes

(7) No human direct interaction unlike conventional classroom programmes

(8) Courses which need practicals are difficult even if run through simulations.

(9) Students may feel loneliness and sense of isolation if they are not working

(10) Less opportunity for interaction with teachers/instructors

Disadvantages:

(1) Lack of credibility of online courses.

(2) Low acceptability from industries while offering job.

(3) More hard work due to intensive assignments and pressure to maintain deadlines.

(4) Students have to be responsible for their own learning

(5) Global competition in a given subject for the students.

(6) Personality development in not possible due to no direct interaction with classmates.

(7) Less creativity and innovating ability due to less interaction with teacher/instructors.

(8) High initial investment for service providers.

(9) Only self-motivated students get benefit, but unmotivated students fails to complete the course.

(10) Online courses focus more on improving knowledge but conventional classroom based courses improves soft skills along with knowledge.

5.5.6. Case Examples of Online Education System:

In this section, we have discussed the impact of online education system in higher education by considering two next generation online education models e.g., edX, and Alison consortiums are discussed as case examples. ALISON - a service of free learning and certification through on-the-spot assessment making it possible to test anyone, on anything, at anytime, anywhere via the web. EDX - a non-profit online initiative created by founding partners Harvard and

MIT. Finally, the next generation online education system is compared with a hypothetical system called "Ideal education system".

(1) NPTEL:

NPTEL (National Programme on Technology Enhanced Learning), India is a joint initiative of the IITs and IISc. Through this initiative, NPTEL offer online courses and certification in various topics. These Online courses**:** Free for all, Certification examinations are offered for a nominal fee. Presently as on the February 2016, number of courses ongoing are 47 with duration of courses: 4 weeks, 8 weeks or 12 weeks. There are courses of 10 hours, 20 hours and 40 hours on different topics of different subjects. Each course contains video lectures, Assignments, and course end exams for registered participants. Participants can answer the assignments based on watching video lectures available for download [13].

(2) ALISON:

ALISON is an e-learning provider and academy founded in Galway, Ireland in 2007 by serial entrepreneur, Mike Feerick. Its stated objective is to enable people to gain basic education and workplace skills. The majority of ALISON's learners are located in the developing world with the fastest growing number of users in India. ALISON registered its 5 millionth learner in February 2015, making the online education provider one of the biggest MOOCs outside of the US. ALISON currently offers over 750 courses across certificate and diploma level in ten languages. ALISON is one of the world's largest free online learning platforms, providing 750 free courses at diploma and certificate level. The certificate level courses necessitate 1–2 hours study with the more rigorous diploma level offerings requiring 9–11 hours study on the part of the learner. ALISON note on their website that 'there is no time limit on completing a course, so learners can study entirely at their own pace' and that some of the courses such as the Microsoft Digital Literacy Program may take up to 20 hours to complete. One of ALISON's most popular courses ABC IT, a 15–20 hours training suite is cited by the New York Times as 'covering similar ground' to the International Computer Driving License without the cost of certification [14].

(3) EDX:

Founded in May 2012, by scientists from Harvard and Massachusetts Institute of Technology. Gerry Sussman, Anant Agarwal, Chris Terman, and Piotr Mitros**,** edX is a massive open online course (MOOC) provider. It hosts online university-level courses in a wide range of disciplines to a worldwide student body, including some courses at no charge. It also conducts research into learning based on how people use its platform. EdX differs from other MOOC providers,

such as Coursera and Udacity, in that it is a non-profit organization and runs on open-source software. EdX has been developed as open-source software and made available to other institutions of higher learning that want to make similar offerings. On June 1, 2013, edX open sourced its entire platform.

EdX currently has 272 courses, 140 soon starting courses, 64 upcoming courses, 226 self-paced courses and 365 archived courses. These courses are further classified as Introductory courses (538), Intermediate courses (241), and Advanced courses (62). Out of these courses, 706 courses are available in English language [15].

(4) UZITY:

Uzity is a virtual learning environment and course management system developed by Foradian Technologies. It is a collaboration platform for students, teachers, administrators and management of an institution. Uzity helps in knowledge management of the entire institution and functions as a repository of course, information and collaboration data. It is developed by the same team who developed Fedena. Uzity helps to invite teachers and students to collaborate and learn the contents of different courses. Students can ask questions specific to each topic and the answers can be given by teacher or other students. It allows uploading learning resources of different topics related to the course and also let to share the resources of other courses in the same organization. Uzity gives full control of designing and implementing the learning activities of an institution [16].

(5) Other Popular Free Online Courses:

Business Insider, India, [17] in its article on the 10 most popular free online courses for professionals, has listed the following 10 online courses professionals in different areas from IT to management.

1. Learning How to Learn: Powerful mental tools to help you master tough subjects — University of California, San Diego: In this course, Oakland University professor Barbara Oakley and Salk Institute professor Terrence Sejnowski use studies of brain chemistry to determine the best ways to approach a new subject, memorize facts, and deal with procrastination.

2. Mastering Data Analysis in Excel — Duke University: In this course Duke post-doctoral fellow Jana Schaich Borg and director of the Center for Quantitative Modeling Daniel Egger teach students how to use Excel to understand the concepts behind uncertainty-reduction and information-gain predictive models that data scientists use.

3. Programming for Everybody (Getting Started with Python) — University of Michigan: This is a Python course, from Michigan professor Charles Severance. It's part one of five, so consider this one if you're looking for a more thorough foundation.

4. Machine Learning — Stanford University: For the people who wants to learn about artificial intelligence, this is right course to start. Stanford associate professor and Coursera cofounder Andrew Ng uses case studies and programming exercises to illustrate some of the ways machines learn.

5. R Programming — Johns Hopkins University: This is a on line course in the Johns Hopkins data science package. It introduces students to the R programming language, which is the world's most popular language for data analysis.

6. The Data Scientist's Toolbox — Johns Hopkins University: This course is offered by Johns Hopkins professors Jeff Leek, Roger D. Peng, and Brian Caffo to give an overview of what exactly data scientists do, as well as to introduce students to some of their tools: version control, markdown, git, GitHub, R, and RStudio.

7. Tibetan Buddhist Meditation and the Modern World — University of Virginia: This course from University of Virginia professors David Francis Germano and Kurt R. Schaeffer takes a look at multiple Tibetan Buddhist meditation traditions from historical, religious, scientific, and practical purposes. It's a multi-layered introduction to the roots of an increasingly secularized practice.

8. An Introduction to Interactive Programming in Python (Part 1) — Rice University: Python is one of the world's top five programming languages and is used at organizations like Google, Yahoo, and NASA. It's a high-level language, but a novice can learn the basics relatively easily. Rice professors Joe Warren, Scott Rixner, John Greiner, and Stephen Wong keep the course interesting by having students use Python to build simple games like Pong and Asteroids.

9. Successful Negotiation: Essential Strategies and Skills — University of Michigan: This course is taught by Ross School of Business professor George Siedel around the world and says his research-based class is useful whether you're trying to secure a million-dollar investment in business or to lower the cost of cable bill.

10. Introduction to Financial Accounting — University of Pennsylvania: This course is taught by Wharton professor Brian J. Bushee including the basics of Accounting. By the end, participant will know how to confidently read an income statement, balance sheet, and statement of cash flows.

5.5.7. Ideal Education System:

Education at its best will effectively prepare students for the working world. An ideal education system would not only prepare students for the working world but would also prepare them to become empowered to transform the working world to better suit the needs of the people. An Ideal education system shall have characteristics which can be predicted and classified. Based on various factors which decides the ideal education system characteristics, a model consisting of the input conditions, output conditions, system requirements, and social & environmental conditions [18-20].

(1) The Ideal Education provides education to the entire world rather than a single neighbourhood /Country and hence it has an unlimited global reachability.

(2) The Ideal Education offers courses of study, which enjoys an inelastic demand in the world market. (Inelastic refers to a Course that people need or desire almost at any price.)

(3) The Ideal Education provides all types of courses in all field of specialization and imparts knowledge, skills and experience to all people irrespective of their age, gender, previous qualification and country of origin.

(4) The Ideal Education system provides high quality education to everybody irrespective of their economic, social, linguistic and cultural background.

(5) The Ideal Education system need minimum instructors in identified courses and must utilize optimum service from them.

(6) The Ideal Education system operates on a low overhead. It does not need an expensive location, big campus and huge amount of infrastructure. Only a few Universities are required to provide quality education to the entire world.

(7) The Ideal Education system does not require major investments in equipment and other education & training. systems or repetition of large number of universities in every state and every country. In other words, it does not require huge capital.

(8) The Ideal Education system is relatively free of all kinds of government regulations or restrictions.

(9) The Ideal Education system is portable or easily moveable. This means a student registered for a course should get the service wherever he moves.

(10) The Ideal Education system satisfies its students intellectual needs. There are no constraints like compulsory subjects, minimum and maximum subjects.

(11) The Ideal Education system leaves enough free time to instructors as well as students. In other words, it doesn't require attention/study of 12, 16, or 18 hours a day.

(12) The Ideal Education system is one in which the income of the university does not limit by personal output (Leverage). In the Ideal Education system, one can train 10,000 students as easily as can have one."

(13) The ideal Education system students can take exams any time, any number of times and results should be declared immediately. There is nothing like losing a year due to failure in examination.

(14) The ideal Education system will provide services to its registered students anywhere, any time and any amount of time. i.e., it is ubiquitous.

(15) In ideal system, the technology is used in such a way that all pedagogies of education system should be delivered effectively.

(16) An ideal education system provides all students with not only basic knowledge but also social skills and good behaviours.

(17) In ideal Education system, the demand for variety of courses is higher than supply and the efficiency of the system is always 100%.

(18) In ideal Education system, the students have a choice on alternative in terms of course/service providers.

(19) The ideal Education system will be sustainable for long time.

Any education system which has the above properties is considered as ideal education system and the conventional education systems called brick and mortar systems have serious drawbacks/limitations in terms of the above properties [18].

5.6 SMART LIBRARY MODEL FOR FUTURE GENERATION EDUCATION SYSTEM :

5.6.1. Effect of Information Communication Technology on Library Concept:

The concept of library in educational institutions are changing as the major constituents of library like physical books, hard copies of journals and newspapers are vanishing and a new format called e-format of these resources emerging through advents in computer science, information science and e-storage technology. The physical copies of books, journals and newspapers are thumbing and their electronic format do not need space for storage and single copy of such resource can be shared by any number of users so as the name of library has no longer validity. Hence libraries are now renamed as Resource Centres with online facility to provide resource sharing services to its registered users. Future libraries so called 'Resource Centres' do not need large reading rooms, large book/journal old volume storage area or even independent library building.

5.6.2. Present Status in Library Systems:

In the present system, there are many libraries in the country classified as public libraries and educational institutional libraries. These libraries provide information to the users in the form of books, newspapers, periodicals, magazines, and Journals both physical and through online services (figure. 5.2).

Advantages:

(1) Physical libraries are the repositories of books in different subjects, periodicals, newspapers, journals and their back volumes.

(2) Physical library provides reading room where users can study the information without any disturbance.

(3) Libraries provide book borrowing facility to the users so that users can take the books to their home for specified days.

(4) Physical libraries provide networking opportunity for the users with similar interested people in a given subject or in a given course.

(5) College libraries provide information to the students on any subject for their academic use.

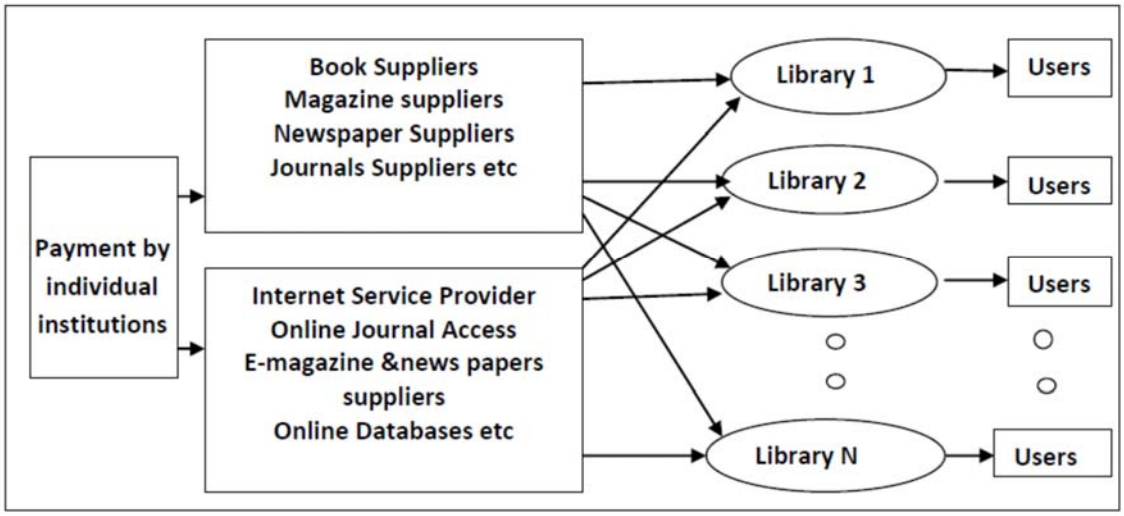

Fig. 5.2: The conceptual model of present library system

Benefits:

(1) Libraries are information resource centres. People can spend their leisure time either to enhance their knowledge or to read story books for recreation.

(2) Students get benefit of availability of information, research articles and databases related to in their chosen course.

(3) Libraries provide easy access to information to the users which reduce the cost of purchasing such resources individually by users.

Constraints:

(1) Restriction in information resources due to constraint in budget.

(2) Requirement of library building and space which cannot be expandable quickly based of enhanced demand.

(3) Maintaining physical copy of books in all subjects at a place is difficult and costly process.

Disadvantages:

(1) Cost of maintaining big libraries is high.

(2) Every user need different books at different time.

(3) Duplication of all physical books available in all subjects in every library is not possible for few users.

(4) Physical libraries cannot satisfy every users requirements.

The conceptual model of physical library system is shown in figure 5.2 where each libraries should have independent resources both physical and electronic resources to provide service to the users. Here lot of resources are underutilized or users may not get satisfactory information due to the constraints of the library. Even though several innovations and best practices like computerization of library, providing new library services through institutional website etc. are introduced in higher educational institutions [21, 22], complete digitization of library information is essential for future education systems.

5.6.3. Effect of Electronic & Optical Storage Technologies on Library Concept:

The advents in information communication technology, internet, and digitization of books, periodicals, newspapers, magazines, journals, video lectures, and most of the reference books, changed the concept of conventional libraries, and provided new model of library called Resource centres. These digital resources can be stored in the library using electronic and optical storage technology or subscribed online from such service providers to reduce and avoid storage of paper based books, journals and periodicals as old volumes. By introducing digital library concept, present libraries can reduce book storage space, provide easy search & access facility through the provision of various database search facility, and decreases the cost of maintenance of libraries in education institutions. Due to huge storage ability of computers, the concept of book stack system is vanishing and as a result, huge space requirement in the library building is also vanishing. Accordingly, the employees required in the library are also decreased. Individual institutions also do not need independent libraries. There should be one Resource centre for a country or even only one for the entire world through which everybody can connect through ICT for uploading and downloading audio, text and video files so that

equality in terms of accessibility to any of these types of resources can be maintained irrespective of gender, region, religion, economical background and the country origin of the users.

5.6.4. Revolutionary Changes in Library Systems – Smart Library:

Digital information storage technology and information communication technology together can revolutionize the concept of library system and can transform it into digital library. A country can take initiation in developing national electronic library system called smart library to cater the need of every citizen of the country. The conceptual model of Centralized National Smart Library System is depicted in figure 5.3.

In smart library, the entire library factions are automated and a central library will digitize all the information and provide such service to all public and educational & research institutional libraries in e-form. These local libraries should have electronic reading systems to retrieve any information based on search facility to the readers. Such local client libraries will become paperless systems. This concept changes local libraries as E-resource centres. A user can get access to any information through e-books, e-newspapers, e-magazines, e-journals and their back volumes through search facility. Such smart libraries have advantages in terms of reduced cost to maintain resourceful libraries without any physical copies of the resources. A developing country should have such smart libraries to cater the information need of their citizens. Depending on the model of smart library, either the national government can spend the expenditure of the National Central Smart library or through subscription fee to every local client libraries or users, the system can generate its revenue for maintenance. Table 5.2 contains the comparison of conventional physical libraries with national Smart library model.

In smart library system, the client libraries act as electronic information resource centres networked with National Smart Library through internet or private networks. Such client libraries functioning in Educational institutions by replacing conventional libraries can be called as Information Resource Centres (IRC). IRC will provide huge benefits to educational institutions as well as users (faculty members and students) due to unrestricted information availability and reduced cost. This new model will also remove the constraint of unequal sharing of library resources between rural and urban institutions.

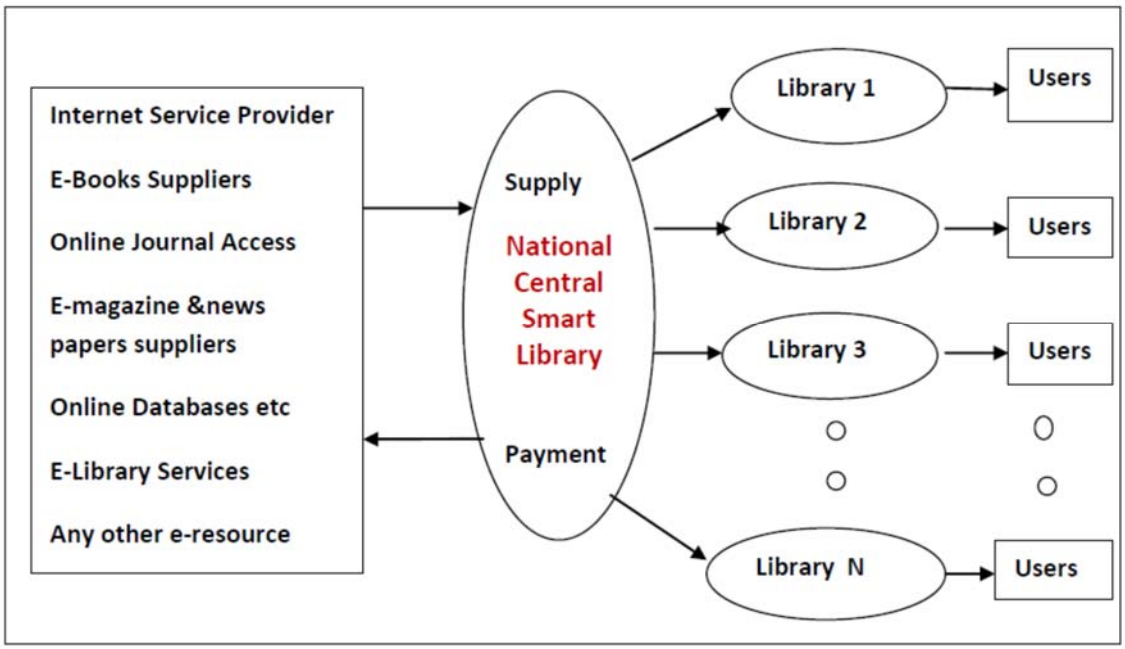

Fig 5.3: The conceptual model of Centralized National Smart Library system

Table 5.2: Comparison between Conventional library & National Smart library systems

S.No	Conventional Library	National e-library service through Smart Library
1	Huge physical infrastructure requirement	Small infrastructure required without any book storage facility
2	More employees required to maintenance	Less employees required to maintenance
3	Higher expenditure for providing more print books and journals in many subjects.	Fixed expenditure to individual Resource centres
4	Service available only during official working hours	Service can be provided 24 hours a day in the campus through wireless network.
5	Service quality is low due to non availability of many books and journals	Service quality is high due to availability of many books and journals on digital form through National network.
6	Latest editions of books and journals takes more time to reach.	Online books and journals are updated simultaneously throughout the country

5.6.5. Institutional Resource Centres:

All educational and research institutions can get the advantage of National Smart library, by becoming client library. Based on this model, students of every educational institution get equal opportunity for availing required information irrespective of their location in the country.

Advantages:

(1) All public libraries and educational institutional libraries will have access to equal amount of resources.

(2) No physical storage of books and other materials are required.

(3) No responsibility on purchase of new books and other resources periodically.

(4) Institutional resource centres act as electronic distribution centres in the premises of schools, colleges and in identified public places.

(5) Through high speed internet/private networks and computer terminals, IRC's provide access to huge depository of information available in National Smart Library systems through powerful search facility.

(6) Through wireless network, the IRC can extend its resource access facility to entire campus so that users can access IRC resources from Hostels, classrooms or any other places inside the campus.

(7) Removes the discrimination among the students based on geographical location and the students of public and private schools/colleges.

Benefits:

(1) Publics and students get access to quality and reliable information at their native place/school/college.

(2) The effort and the cost of developing and maintaining IRC is comparatively low.

(3) The benefit of accessibility of innumerable information at any time in any interested subject in audio, video and text form (multimedia) is available to every user.

(4) User can store the required information in their electronic storage drives for future use without any additional cost. This also avoids physical copies and contributes for sustainable environment.

(5) IRC provides complete solution to any type of users information resource requirements.

(6) Using advanced information communication technology, IRC supports equality in terms of information resource distribution in the society.

(7) Contributes fast national development by supporting the researchers to increase national research output.

(8) IRC supports and contributes for economical, social, political and scientific development of the country.

Constraints:

(1) Availability of high speed internet connectivity or private networks in the entire country.

(2) Decision and investment on creation of National Central Smart library by the country government.

(3) Changing the conventional brink and mortar libraries to click and mortar Information Resource Centre is difficult due to initial resistance from the users.

(4) Changing mindset of people initially to utilize new system.

(5) Educating the people to use new system.

(6) Changing the mindset of publishers to convert their publications for online open access system.

Disadvantages:

(1) High investment at initial stage

(2) Existing investment on physical resources are going to be waste

(3) The profit for publishers will decline.

5.6.6 Concept of Universal Resource Centre:

Universal resource centre is considered as an ideal library with ideal characteristics. It should contain all information for everybody from everywhere. Characteristics of an ideal business system [23, 24], an ideal education system [25-27], an ideal technology [18] are identified and discussed for realizing such systems in practice, Similarly, ideal characteristics of an energy system [28], a banking system [29], an ideal strategy [30] and an ideal software [31] are also studied. The Universal Resource Centre is a concept for integrated information system for entire world and even for entire universe to refer, retrieve, manipulate, store, and share any kind of information of any kind including academic, research and development, business, and governmental systems. Figure 5.4 shows the model of such Universal Resource Centre and table 5.3 lists the characteristic features of Universal Resource Centre.

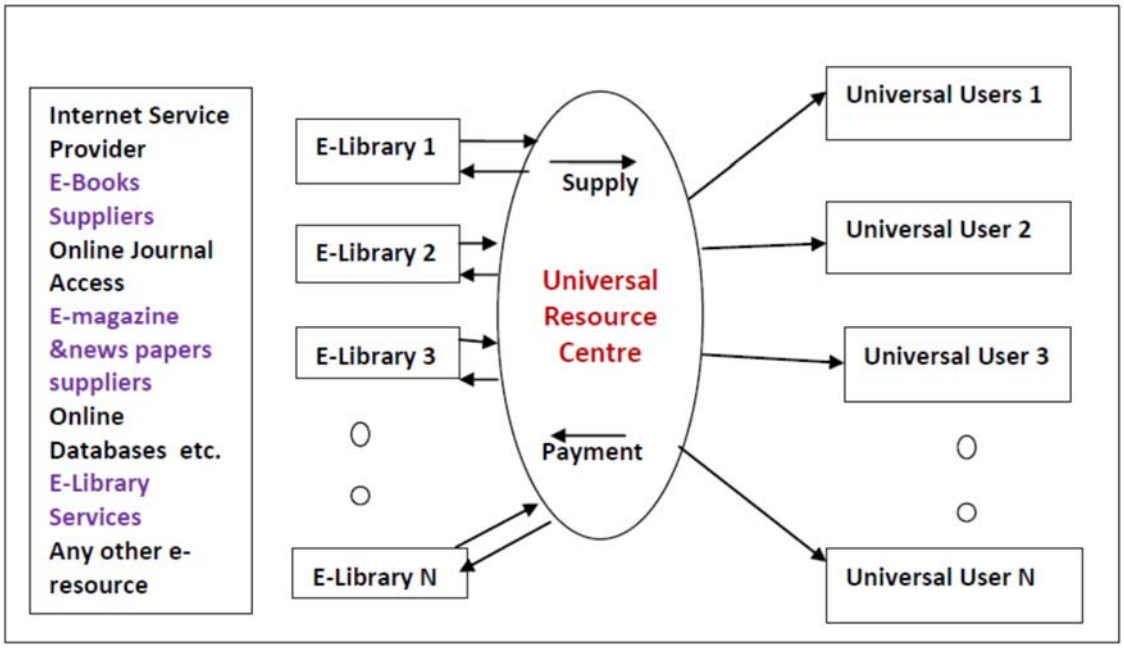

Fig. 5.4: The conceptual model of future e-library system (Universal Resource Centre)

Table 5.3: The characteristics of Universal Resource Centre compared to Ideal library.

S.No	Characteristics of Universal Resource Centre	Characteristics of Ideal Library
1	Universal information resources	Infinite information resources
2	Information Access to every registered candidate of the world at very nominal annual fee	Free information access to everybody in the universe
3	Data & Information uploading facility for every registered member	Data & Information uploading facility for every user
4	Advanced automated system with minimum employees	Advanced automated system with no employees
5	Inter-connected local libraries to provide universal service.	One library for entire universe

5.6.7. ABCD Listing of Universal Resource Centre:

ABCD listing is a model of qualitative [32-36] analysis. In this section, we have used ABCD analysis for qualitative listing of advantages, benefits, constraints and disadvantages from business service providers and customer's point of view.

Advantages:

(1) An integrated source of information for entire universe.

(2) A subscriber can get any information ubiquitously i.e., anywhere, any time and any amount of time in the entire universe.

(3) Every registered member can upload any piece of information.

(4) Sharing of information online through such smart system decreases inequality between people of different regions of different country due to the fact that information is intangible resource.

(5) URC supports paperless education system which supports environmental sustainability.

(6) Every country governments can pay the annual subscription charges so that information for education and research for individuals can be free.

(7) Bargaining power of users will improve and that of big publishers who have created a niche around them by creating artificial quality brand will break so that equality in information sharing without discrimination is possible.

(8) URS supports fast development of civilization in the world through equally shared knowledge.

(9) Educational and research organizations can save huge amount of money by avoiding their investment for developing and maintaining institutional libraries.

(10) Digital information can be copied and shared with any number of users without any additional expenditure through open access model.

Benefits:

(1) Easy access to information to everybody without individual expenditure.

(2) No discrimination for accessing and sharing the educational and research information between people of different countries, religions, race and genders.

(3) Customized information is available to users through powerful search machines.

(4) Users can avail and share information through their mobile device irrespective of their location.

(5) Countries can support their citizens to make use of relevant information for education and research so that they can maintain equality in terms of access to information. This will remove the divide between urban and rural.

(6) Everybody in the world will get same information which removes the barrier for quality research for developing countries compared to developed countries.

(7) Equal information sharing is possible for quality research which provides benefit to poor people of the entire world.

(8) Discrimination between researchers due to unavailability of reference information as well as their inability of publishing results quickly to the entire world can be eliminated.

Constraints:

(1) Sharing information between people of different countries is difficult due to the fact of different language.

(2) Research Information sharing is difficult due to proprietary rights like patents, copyrights etc.

(3) High speed internet accessibility in every location in developing countries is still a constraint.

(4) Everybody can access information using advanced technology only if they have adopted such technology and able to use information for their advancement.

(5) Information sharing for education and research between different countries is difficult unless the entire world is evolved as an integrated economic union.

(6) Many developed countries may not show keen interest in implementation of such system due to business reasons.

Disadvantages:

(1) The need of information for different people and for different purpose is different.

(2) Developing an integrated universal resource system is difficult due to resistance in sharing education and research related information between different countries.

(3) Realizing such model is difficult due to many constraints of technology, society, certain sections of business organizations.

(4) Decreases huge employment opportunity available in conventional library system due to universal automation.

(5) People perception of such system to adopt due to difference in culture, tradition of people of different countries.

5.6.8. Anticipated Time-Frame for Changes:

The national central smart library concept can be realized based on political decision of the central government. Strong visionary in at Countries Central government can take decision to create policies regarding providing free/subsidized digital information to every citizen of the country. Online open access information publication model that enables the dissemination of research articles to the global community without restriction through the internet. Thus, all articles published under open access can be accessed by anyone. The open access form of books, journals in all fields of society is essential for the development of civilization and equality among the countries. It is expected that all the journals and book publishers have to adopt new open access policy in the entire world by 2020. As a result, if the country governments are ready with high speed information communication technology to support

Central smart library and client Information Resource Centres, the National Smart libraries and free access to educational and research information to every citizen of the country by 2020. The time to realize Universal Resource Centre (URC) may require few more years (two to three years), due to copyright and payment issues between different countries for free information exchange.

5.7 CONCLUSION :

(1) The various characteristics of Ideal Education System are identified and classified.

(2) A suitable Online Mobile Education model is developed to realize most of the properties of Ideal Education System.

(3) Various E-business models are used to study the possibility of realization of Ideal Education System.

(4) It is found that ubiquitous E-Business called Online mobile education model can have most of the Ideal Education System characteristics.

(5) The impact of On-line education on higher education system are discussed. Online education has made rapid progress in the recent times, making it one of the most analysed and discussed subject in higher education system. In this paper, we have discussed the online education system as next generation education system and impact of online education system in higher education on development of science & society. The types of online education models and their importance are discussed. The advantages, benefits, constraints and disadvantages of online education systems are identified and discussed. The features of the online education portals are studied by considering some of the important online education models e.g., edX, Alison, NPTEL and UZity as case examples. Finally, the online education system is compared with a hypothetical system called "Ideal education system".

(6) It is concluded that a Smart Library Model can be used as Universal Library for of future generation education systems. Advances in information communication technology disclosed a new opportunity for innovation in conventional library models. Using the state-of-the-art technology, the countries can convert brick & mortar libraries in to click and mortar libraries to provide quick and complete information requirement to common man and the students of the entire country and the world without any discrimination. The proposed Universal Resource Centre is expected to be an innovation in advents of technology to share the intangible information resource between every human being of the world without any barrier [37-40].

REFERENCES :

[1] James P. Neelankavil, (1994). Corporate America's Quest for an Ideal MBA. *Journal of Management Development*, 13(5), 38 -52.

[2] Rogers, E.M., (1995), ' Diffusion of Innovation', *The Free Press*, NY.

[3] Morgan, R. M. and Hunt, S. D. (1994). The commitment-trust theory of relationship marketing. *Journal of Marketing*, 58, 20–38.

[4] Aithal, P. S. (2015). Mobile Business as an Optimum Model for Ideal Business. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 146-159, DOI : http://doi.org/10.5281/zenodo.163880.

[5] Varambally, K. V. M. & Aithal, P. S. (2009). Mobile Business Technology and Business Proliferation of Banks - A Futuristic Approach. *Amity Business Review*, 10(1), 9 – 25.

[6] Aithal, P. S. and Varambally, K. V. M. (2006). Security Issues in Online Financial Transactions with Special Reference to Banking Industry, Quality in Service Sector and Managerial Challenges-Allied Publisher Pvt. Ltd. ISBN:81-7764-992-2, pp. 103-114.

[7] Lado, A. A., Boyd, N. G., & Wright, P. (1992). A competency-based model of sustainable competitive advantage: Toward a conceptual integration. *Journal of management*, 18(1), 77-91.

[8] Rivenbark W. C. & Jacobson, W. S. (2010). Three Principles of Competency-Based Learning: Mission, Mission, Mission. *Journal of Public Affairs Education*, *20*(2), 181–192.

[9] Aithal P. S. & Shubhrajyotsna Aithal, (2015). An Innovative Education Model to realize Ideal Education System. *International Journal of Scientific Research and Management (IJSRM)*, 3(3), 2464 – 2469.

[10] Malan S. P. T. (2000). The 'new paradigm' of outcomes-based education in perspective, ISSN 0378-5254 *Tydskrif vir Gesinsekologie en Verbruikerswetenskappe*, Vol 28, pp. 22-28. http:// www.ajol.info/ index.php/jfecs/ article/viewFile/ 52788/41390

[11] Aithal P. S., Shailashree V. T., Suresh Kumar P. M., (2015a) A New ABCD Technique to Analyze Business Models & Concepts. *International Journal of Management, IT and Engineering (IJMIE)*, 5(4), 409 - 423.

[12] Aithal, P.S., (2016) Study on ABCD Analysis Technique for Business Models, business strategies, Operating Concepts & Business Systems. *International Journal in Management and Social Science*, 4(1), 98-115.

[13] http://nptel.ac.in/

[14] https://alison.com/course/

[15] https://www.edx.org/

[16] http://uzity.com/

[17] Richard Feloni (2015) The 10 most popular free online courses for professionals, Business Insider, India, http://www.businessinsider.in/The-10-most-popular-free-online-courses-for-professionals.

[18] Aithal P. S. and Shubhrajyotsna Aithal (2015). Ideal Technology Concept & its Realization Opportunity using Nanotechnology. *International Journal of Application or Innovation in Engineering & Management (IJAIEM)*, 4(2), 153 – 164.

[19] Aithal P. S. (2015). Concept of Ideal Business & Its Realization using E-Business Model. *International Journal of Science and Research (IJSR)*, 4(3), 1267 – 1274.

[20] Aithal P. S. and Shubhrajyotsna Aithal (2014). Ideal education system and its realization through online education model using mobile devices. *Proceedings of IISRO Multi Conference*, Bangkok, pp. 140 - 146, ISBN No. 978-81-927104-33-13.

[21] Aithal P. S. and Harischandra P. (2015). Quality Enhancement in Higher Education Institutions through Best Practices in Library: A Case of SIMS. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 489-505.

[22] Harischandra P., Shylesh S, and Aithal P. S. (2016). Information Technology Innovations in Library Management: A Case of SIMS. *International Journal of Current Research and Modern Education (IJCRME)*, 1(1), 657-676.

[23] Aithal P. S. (2015). Concept of Ideal Business & Its Realization Using E-Business Model, *International Journal of Science and Research (IJSR)*, 4(3), 1267 – 1274.

[24] Aithal P. S. (2015). Mobile Business as an Optimum Model for Ideal Business. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 146-159.

[25] Aithal P. S. and Shubhrajyotsna Aithal (2015). An Innovative Education Model to realize Ideal Education System. *International Journal of Scientific Research and Management (IJSRM)*, 3(3), 2464 - 2469.

[26] Aithal P. S. and Shubhrajyotsna Aithal, (2014) Ideal education system and its realization through online education model using mobile devices, Proceedings of IISRO Multi Conference 2014, Bangkok, 7/01/2014, pp. 140 - 146, ISBN No. 978-81-927104-33-13.

[27] Aithal P. S. & Shubhrajyotsna Aithal (2016). Impact of On-line Education on Higher Education System. *International Journal of Engineering Research and Modern Education (IJERME)*, 1(1), 225-235.

[28] Sridhar Acharya P. & Aithal P. S. (2016). Concepts of Ideal Electric Energy System FOR production, distribution and utilization. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 367-379.

[29] Aithal P. S. (2016). The concept of Ideal Strategy & its realization using White Ocean Mixed Strategy. *International Journal of Management Sciences and Business Research (IJMSBR)*, 5(4), 171-179.

[30] Aithal P. S. (2016). Concept of Ideal Banking and Realization of it using Ubiquitous Banking. Proceedings of National Conference on Changing Perspectives of Management, IT, and Social Sciences in Contemporary Environment, Manegma 2016, Vol. 14, pp-13-24, ISBN 978-93-5265-6523.

[31] Aithal P. S. and Priyeesh Pai V. (2016). Concept and Characteristics of Ideal Software and its Realization Scenarios. Proceedings of National Conference on Changing Perspectives of Management, IT, and Social Sciences in Contemporary Environment, Manegma 2016, Vol. 14, pp-25-35, ISBN 978-93-5265-6523.

[32] Aithal P. S. & Suresh Kumar, P. M. (2016). Opportunities and Challenges for Private Universities in India. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 88-113.

[33] Padmanabha Shenoy, and Aithal P. S. (2016). A Study on History of Paper and possible Paper Free World. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 337-355.

[34] Aithal, P.S., (2015). Comparative Study on MBA Programmes in Private & Public Universities - A case study of MBA programme plan of Srinivas University**.** *International Journal of Management Sciences and Business Research (IJMSBR)***,** 4(12), 106-122.

[35] Aithal P. S. and Suresh Kumar P. M. (2016). Analysis of Choice Based Credit System in Higher Education, *International Journal of Engineering Research and Modern Education (IJERME)*, 1(1), 278-284.

[36] Varun Shenoy and Aithal P. S. (2016). Changing Approaches in Campus Placements - A new futuristic Model. *International Journal of Scientific Research and Modern Education (IJSRME)*, 1(1), 766 – 776.

[37] Aithal P. S. and Shubhrajyotsna Aithal, (2014). Ideal education system and its realization through online education model using mobile devices, *Proceedings of IISRO Multi Conference 2014*, Bangkok, 7/01/2014, 140 - 146, ISBN No. 978-81-927104-33-13. DOI: http://doi.org/10.5281/zenodo.62059.

[38] Aithal P. S. and Shubhrajyotsna Aithal, (2015). An Innovative Education Model to realize Ideal Education System. *International Journal of Scientific Research and Management (IJSRM)*, 3(3), 2464 - 2469. DOI: http://doi.org/10.5281/zenodo.61654.

[39] Aithal, P. S. & Shubhrajyotsna Aithal, (2016). Impact of On-line Education on Higher Education System. *International Journal of Engineering Research and Modern Education (IJERME)*, 1(1), 225-235. DOI : http://doi.org/10.5281/zenodo.161113.

[40] Aithal, P. S. (2016). Smart Library Model for Future Generations. *International Journal of Engineering Research and Modern Education (IJERME)*, 1(1), 693-703. DOI : http://doi.org/10.5281/zenodo.160904.

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CHAPTER 6

IDEAL BANKING SYSTEM & ITS REALIZATION OPPORTUNITY

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ABSTRACT :
This Chapter contains the concept of ideal banking, its characteristics, realization of ideal banking concept based on ubiquitous banking using mobile devices, and a comparison of the ideal banking model with the mobile banking system.

6.1 INTRODUCTION :

A bank is a financial intermediary and creates money by lending money to a borrower, thereby creating a corresponding deposit on the bank's balance sheet. A banking system is a group or network of institutions that provide financial services to the society. These institutions are responsible for operating a payment system, providing loans, taking deposits, and helping with investments. Lending activities can be performed directly by loaning or indirectly through capital markets. After the advent of technology and its penetration to all business fields, the responsibility of banks is enhanced to provide better, speedy, and ubiquitous service to the customers so that it can create more money and hence profit. Banking business includes the business of receiving money on current or deposit account, paying and collecting cheques drawn by or paid in by customers, the making of advances to customers, and includes such other business as the Authority may prescribe for the purposes of Banking Act of the country. Banking business includes : receiving from the general public money on current, deposit, savings or other similar accounts repayable on demand or within certain days or with a period of call or notice of less than that period; and paying or collecting cheques drawn by or paid in by customers. Automation of banking processes is present day requirement and networking all the branches of the banks through Information communication technology is essential for decreasing the cost of the operation. Since banking functions involves the transaction of money between different accounts and due to advents of electronic commerce which need electronic money transactions and payments between different parties, security and authenticity are very important features of present banking operations [1]. The function of banks involves following:

(1) Payment of money by conducting checking or current accounts for customers, paying cheques drawn by customers on the bank and collecting cheques deposited to customers' current accounts.

(2) Banks also enable customer payments via other payment methods such as RTGS, Wire transfers or telegraphic transfer, and automated teller machines (ATMs).

(3) Banks borrow money by accepting funds deposited on current accounts, by accepting term deposits, and by issuing debt securities such as banknotes and bonds.

(4) Banks lend money by making advances to customers on current accounts, by making instalment loans, and by investing in marketable debt securities and other forms of money lending.

Banks have two types of products namely retail banking and business banking. Banks formulate various strategies in order to attract more deposits and lend it to genuine customers to get a better return and hence make more profit. A bank can generate revenue in a variety of different ways including interest, transaction fees and financial advice. The traditionally most significant method is via charging interest on the capital it lends out to customers. The bank profits from the difference between the level of interest it pays for deposits and other sources of funds, and the level of interest it charges in its lending activities. Based on such objective of a general banking system, the ideal concept of the banking system is developed. The ideal bank is a system with ideal banking characters. In this paper, a model of ideal banking system is proposed by considering the ideal characteristics expected under input conditions, output conditions, system requirements, and environmental conditions. The factors affecting these characteristics are identified using a qualitative data collection instrument namely focus group method. Finally, some of the possible technology supported models which support the concept of Ideal banking are identified and analyzed.

6.2. IDEAL BANKING CONCEPT AND CHARACTERISTICS :

A banking system consist of interconnected many branches and the customers registered in any branch can avail required services in any branch. The banking operations are controlled and monitored by a central bank of the country. A customer can avail designated service either online or physically entering to the bank branch. The simplest analogous model to a banking system is shown in figure 6.1. It represents the general banking functions discussed in the previous section by integrating various branches through appropriate networking technology. Based on networking of bank branches, a customer can avail any service from any branches of

the bank. Using the internet and wireless technology, a customer can avail banking services using electronic banking and mobile banking models.

The conventional model of the banking system can be improved in its performance without changing its objectives and functions using electronic communication technology so that the speed, quality, accuracy and convenience of banking services to its customers will improve to a great extent. To improve any present systems, it is normal practice that such systems have to be compared with a hypothetical, predicted system of that kind called "Ideal system". The word 'Ideal system' refers to the system which has ideal characteristics i.e., perfect in every way. It is what the mind pictures as being perfect. The concept of an ideal engine, ideal switch, ideal voltage source, ideal current source, ideal semiconductor devices like ideal diodes, ideal transistors, amplifiers etc. have been defined and taken as standards to improve the quality and performance of such practical devices or systems. It is found that, by keeping such hypothetical devices or systems in mind, researchers have continuously been improving the characteristics/properties of practical devices / systems to upgrade their performances. Hence, ideal properties of a device or a system can be used to upgrade or improve its properties towards reaching 100% efficiency. By comparing the properties/characteristics of a practical device/system with its ideal counterpart, one can find out the possible modifications in that device /system towards reaching the objective of achieving such an ideal system [2]. Ideal Banking System model by considering various characteristics under 4 categories such as Input conditions, Systems requirements, Output conditions and Environmental & social conditions, and analyzed these characteristics with an objective to achieve the goal.

An ideal banking system would not only prepare students for the working world but would also prepare them to become empowered to transform the working world to better suit the needs of the people. An Ideal banking system shall have characteristics which can be predicted and classified. Based on various factors which decide the ideal banking system characteristics, a model consisting of the input conditions, output conditions, system requirements, and social & environmental conditions is derived by a qualitative data collection instrument namely, focus group method [3, 4]. The block diagram of such a system is shown in Figure 6.1.

A. Social & environmental conditions :

(1) The Ideal Banking system provides banking services to the entire world rather than a single neighbour-hood town /Country and hence, it has an unlimited global reachability.

(2) The Ideal banking offers services to its customers, which enjoys an inelastic demand in the world market. (inelastic refers to a service that people need or desire almost at any price.)

(3) The Ideal banking system provides all types of banking services of both retail banking and business banking to all customers irrespective of their age, gender, previous qualification and country of origin.

(4) The Ideal Banking system provides high-quality banking services to everybody irrespective of their economic, social, linguistic and cultural background.

B. Input Banking Conditions :

(5) The Ideal Banking system needs minimum employees in identified areas of operation and must utilize optimum service from them.

(6) The Ideal Banking system operates on a low overhead. It does not need an expensive location, many branches, and huge amount of infrastructure. Only a few Universities are required to provide quality service to the entire world.

(7) The Ideal Banking system does not require major investments in equipment and other infrastructure or repetition of a large number of branches in every state and every country. In other words, it does not require huge capital.

C. System Requirements :

(8) The ideal banking system is relatively free of all kinds of government regulations or restrictions.

(9) The ideal banking system is portable or easily moveable. This means a customer registered in one bank should be able to get the services wherever he moves and in whichever city he lives.

(10) The ideal banking system satisfies its customers' intellectual needs. There are no constraints like minimum amount transaction, to be registered or avail services only in one bank, minimum and a maximum number of services availed per day.

(11) The ideal banking system leaves enough free time to service providers/bank employees as well as customers. In other words, it doesn't require attention/study of 12, 16, or 18 hours a day.

(12) The ideal banking system is one in which the income of the bank does not limit by a personal output (Leverage) of the bank workers. In the ideal banking system, a bank can provide any number of customers as easily as can have one.

(13) The ideal Banking system, customers can do transactions at anytime, any number of times and results should be declared immediately. There is nothing like wasting time in queue, travel time to the bank etc.

(14) The ideal Banking system will provide services to its registered customers anywhere, anytime and any amount of time. i.e., it is ubiquitous.

(15) In an ideal system, the technology is used in such a way that all services of the banking system should be delivered effectively.

(16) An ideal banking system provides all customers with not only basic knowledge of banking but also on authenticity and security for financial transactions.

D. Output Conditions :

(17) In the ideal banking system, the demand for a variety of services is higher than supply and the efficiency of the system is always 100%.

(18) In the ideal banking system, the customers have a choice of alternative in terms of service providers.

(19) The ideal banking system will be sustainable for a long time.

Any banking system which has the above properties is considered as ideal banking system and the conventional education systems called brick and mortar systems have serious drawbacks/limitations in terms of the above properties [5-8].

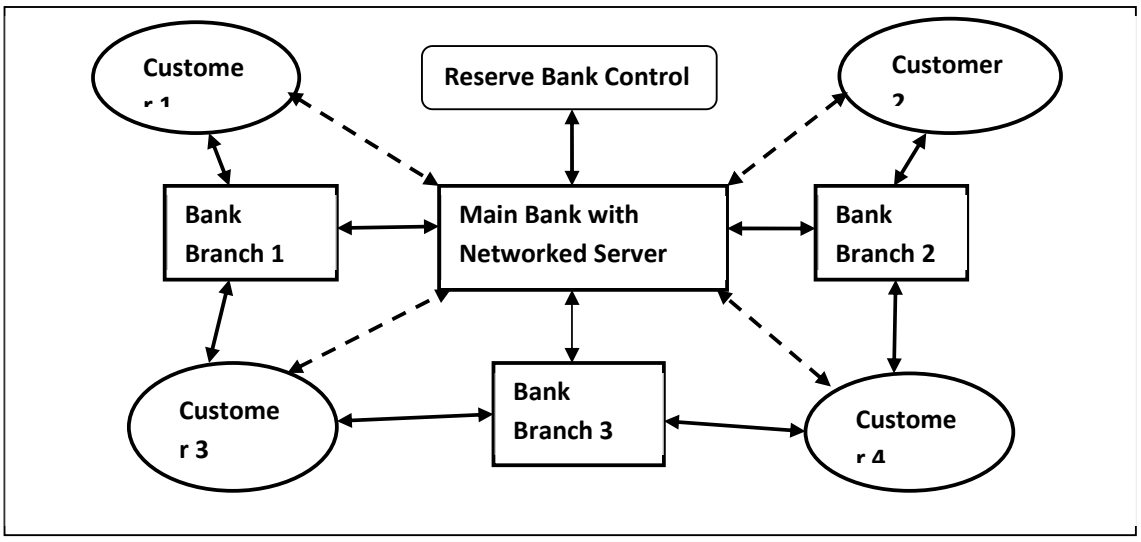

Fig. 6.1 : A General Banking System Model

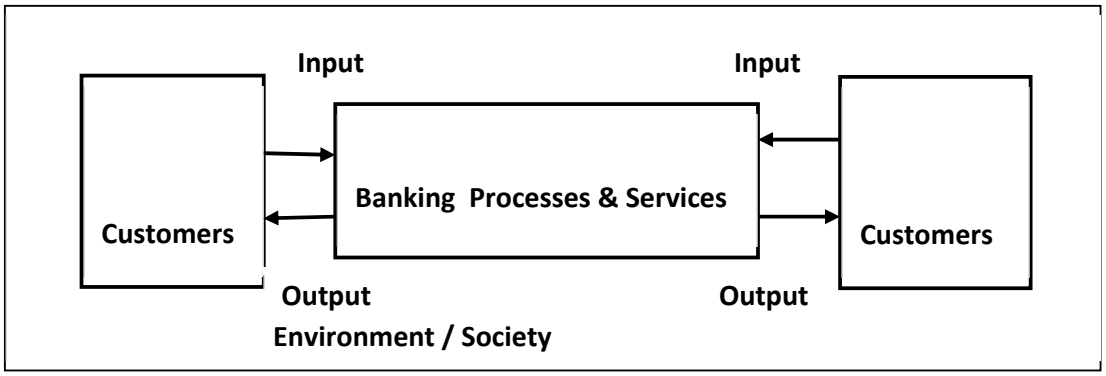

Fig. 6.2 : Characteristics of an Ideal Banking System

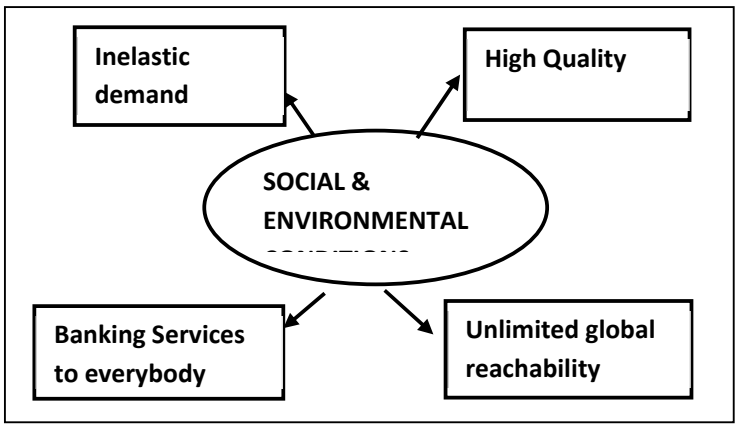

Fig. 6.3 : Block diagram representing Social & environmental conditions

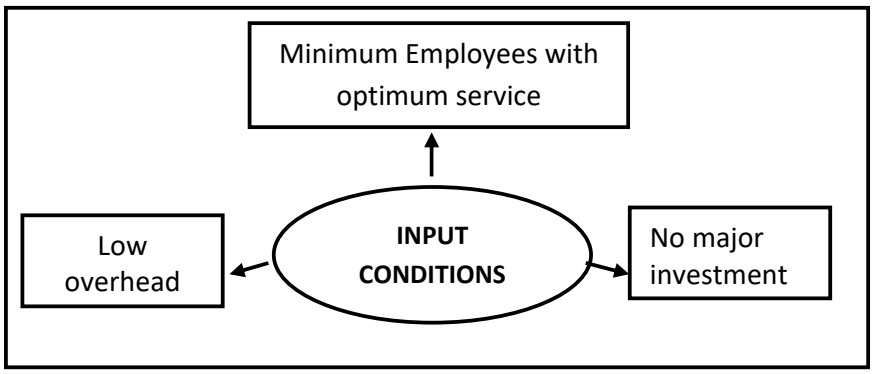

Fig. 6.4 : Block diagram representing Input conditions

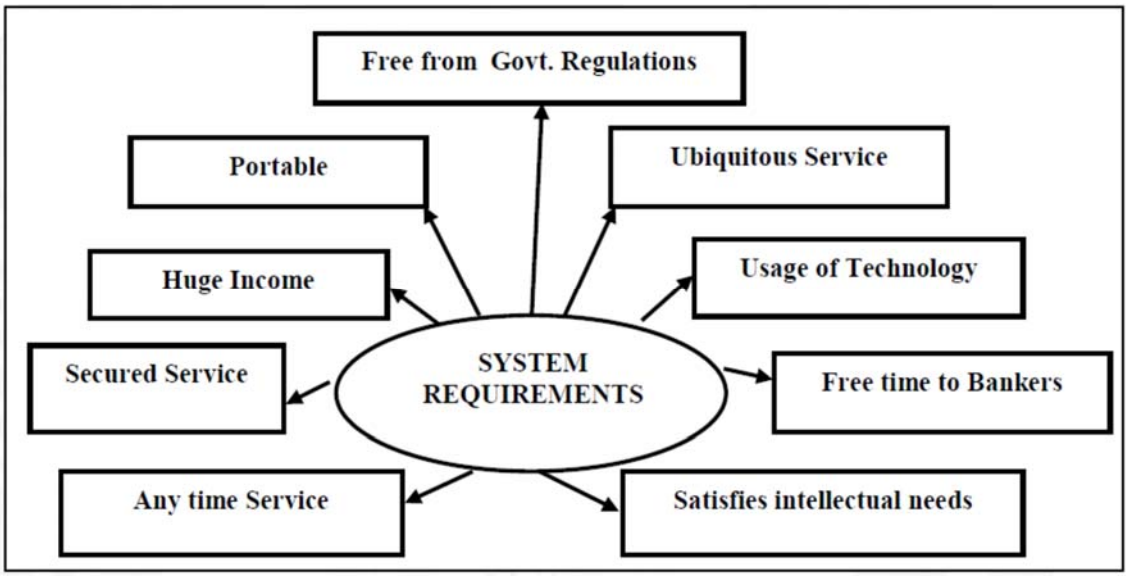

Fig. 6.5 : Block diagram representing System requirements

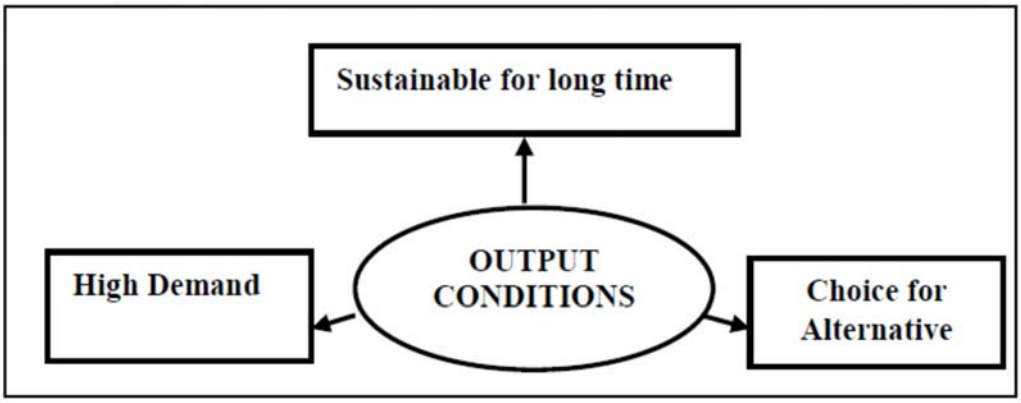

Fig. 6.6 : Block diagram representing Output conditions

6.3. ANALYSIS OF IDEAL BANKING CHARACTERISTICS :

The Ideal banking characteristics can be explained based on their effectiveness in improving the qualities of services and customers comfortability of availing it. The characteristics mentioned in ideal banking model are depicted in fig. 6.3 to fig. 6.6 and further discussed below [9-10] :

A. Social & environmental conditions

(1) Global Reachability : Any ideal system will sustain for longer period providing services to the larger number of people. The Ideal Banking system provides banking services to the entire world rather than a single neighbourhood town which has only limited number of customers. Hence, ideal banking system has an unlimited global reachability.

(2) Inelastic demand : The Ideal banking system offers all required and possible banking services with the highest quality and enhanced values to the customers, which enjoys an inelastic demand in the entire world due to their benefits. In the ideal banking system, the benefits of providing banking services to the customers are always more than the cost incurred to provide it. Similarly, for the customers, the benefits of the ideal banking services are always much more than the cost of availing it. A banking model can be called as an ideal only if it can decrease the distribution cost, distribution time, advertisement cost and production/servicing cost to a minimum level close to zero and capable of supporting the banking services to achieve inelastic demand. Such banking service becomes very attractive to all segments of global customers so that the customers desire to use it at any price which creates inelastic demand.

(3) Ubiquitous service to every customer :

Ubiquitous means being present everywhere simultaneously or existing everywhere at the same time. The very concept behind this is being everywhere and still being virtually inexistent or invisible. The aim of such banking service is to establish an environment where people can always be on-the-go and still carry information and power to solve their problems at their inconvenience, without being bound by the location of any particular technological device. Ubiquitous banking provides solutions and services at anytime, anywhere, any amount of time to the users. The Ideal banking system provides all types of banking services of both retail banking and business banking to all customers irrespective of their age, gender, previous qualification and country of origin due to its ubiquitous nature. This helps everybody in the world to have access to higher education in chosen area irrespective of his/her origin.

(4) Affordable to everybody :

Ideal banking should be so smart, so simple and so powerful that it works for everybody irrespective of their economic, social, linguistic and cultural background. Development and maintenance of such system should be simple, cost effective with fewer constraints for implementation. Hence, ideal banking is affordable to everybody so that it uses common techniques available in nature and manipulate effectively to the need of human being at an affordable cost. Thus, ideal banking system provides high-quality banking services to everybody irrespective of their economic, social, linguistic and cultural background.

B. Input Banking Conditions

(1) Minimum Employee Requirement :

Any system can sustain for a longer period by decreasing the cost. The ideal banking system needs minimum employees with specialized skills and must utilize optimum service from them

to provide optimum service to the customers. The ideal banking system needs minimum employees in identified areas of operation and must utilize optimum service from them.

(2) Low overhead cost :

The total cost of any system is the sum of Fixed cost and Variable cost. The fixed cost involves the initial investment on the development of the system and the variable cost includes maintenance cost of the system. By decreasing initial investment without compromising with quality and by minimizing the maintenance and service cost, the banking system can decrease its overall cost. As per our definition, the ideal banking system operates on a low overhead. It does not need an expensive location, big branch building and a huge amount of infrastructure. Only one office in any location is required to provide banking services to the entire world. Hence, the Ideal Banking system operates on a low overhead. It does not need an expensive location, many branches, and huge amount of infrastructure. Only a few banks are required to provide quality service to the entire world.

(3) Low investments :

Out of various resources used in any banking system, capital investment like investment on land, buildings, equipment and other infrastructures need huge capital. On the other hand, the ideal banking system does not require major investments in equipment and other infrastructure or repetition of a large number of branches in every state and every country. In other words, it does not require huge capital.

C. System Requirements

(1) Free of Government Regulations :

The ideal banking system is relatively free of all kinds of government regulations or restrictions. Many conventional business systems are facing problems due to Government regulations based on the nature of service provided, the environmental issues and the neighbouring community issues. These regulations sometimes make the banking systems as a nonprofit or to shut down. An ideal system is relatively free of all kinds of government regulations or restrictions so that it can do sustainable services for a longer period.

(2) Portability :

The ideal banking system is portable or easily moveable. This means a customer registered in one bank should be able to get the services irrespective of the location of the bank. A good business model should have characteristics to run the business location independent. The business should have the same level of difficulty and performance in terms of productivity, efficiency, effectiveness and hence revenue and profit even if it is performed any corner of the

world irrespective of its location and the physical, geographical, political, economical, and technical environment. The ideal banking should be perfectly portable or easily moveable from one location to other location based on the interest of its owner and should have the same level of difficulty everywhere. This means the bank should able to provide the specified services anywhere to its customers irrespective of its location.

(3) Satisfying intellectual needs of stakeholders:

The ideal banking system satisfies both its owners and customers' intellectual needs. There are no constraints like minimum amount transaction, to be registered or avail services only in one bank, minimum and a maximum number of services availed per day. There should be an opportunity for the owner to develop new services and the customers to surf new services like online trading for investment.

(4) Less time consumption :

The ideal banking system leaves enough free time to service providers/bank employees as well as customers due to the fact that all banking service decisions are automated and artificially controlled. In other words, it doesn't require attention/study of 12, 16, or 18 hours a day. In addition, the customers and employees need not waste their time for unproductive activities like travel etc.

(5) Potential opportunity for high income :

The ideal banking system is one in which the income of the bank does not limit by a personal output (Leverage) of the bank workers. In the ideal banking system, a bank can provide any number of services to any number of customers as easily as can have one. The banking systems must have profit for further progress. There is nothing wrong in expecting huge profit for honest efforts. One of the advantages of ideal banking system is the possibility of ensuring large profits. This is mainly due to intangible nature of banking services and scalability.

(6) Ubiquitous Service :

The ideal Banking system, customers can do transactions at any time, any number of times and results should be declared immediately. There is nothing like wasting time in queue, travel time to the bank etc.

(7) Anytime Service :

The ideal Banking system will provide services to its customers anywhere, anytime and any amount of time. i.e., it is ubiquitous so that customer need not weight either in the branch or in an online queue to avail service.

(8) Usage of Technology :

In an ideal system, the technology is used in such a way that all services of the banking system should be delivered effectively without any defect.

(9) Secured Service :

An ideal banking system provides all customers with not only basic knowledge of banking but also on authenticity and security for financial transactions. There will be no malpractice or miss function of any processes.

D. Output Conditions

(1) High Demand :

In the ideal banking system, since the quality is 100% and defects are zero, the demand for a variety of services is higher than supply and the efficiency of the system is always 100%.

(2) Choice for Alternative :

In the ideal banking system, the customers have a choice of alternative in terms of service providers so that the customer satisfaction will be 100%.

(3) Sustainable for a long time :

As per the definition, the ideal banking system will be sustainable for a long time with infinite demand, infinite serving ability, and infinite profit.

6. 4 REALIZATION OF IDEAL BANKING CONCEPT USING UBIQUITOUS BANKING :

6.4.1 ADOPTION OF COMPUTERS AND ICT IN BANKING SYSTEM

Information Technology (IT) in banking supports the automation of various processes, controls, and information production using computers, telecommunications, software and ancillary equipment such as automated teller machine (ATM) and debit/credit cards. It covers the harnessing of electronic technology for the information needs of a business at all levels of the organization. Irechukwu (2000) [11] lists some banking services that have been revolutionized through the use of ICT which includes account opening, account managing, customer account mandate, and transaction processing recording and intimating to customers. ITC has provided self-service banking facilities to the prospective customers to open a new account online. It also assists customers to validate their account numbers and receive instruction on when and how to receive their cheque books, credit, and debit cards. ICT deals with the physical devices and software that link various computer hardware components and transfer data from one physical location to another (Laudon and Laudon; 2001 [12]). ICT provided various electronic products and services in the banking industry which include Automated Teller Machine, smart cards, telephone banking, electronic funds transfer,

electronic data interchange, electronic home and office banking, SMS banking etc. ICT is effectively used in core banking system. A core banking system is the software developed and installed in a bank to support its most common transactions like making and servicing loans, opening new accounts, processing cash deposits and withdrawals, processing payments and cheques, calculating interest, customer relationship management (CRM) activities of the bank, managing customer accounts, maintaining minimum balances, interest rates, number of withdrawals allowed, intimating each transactions to the customers, establishing interest rates, maintaining records for all the bank's transactions etc.

6.4.2 Innovation in E-Banking : Mobile Banking as Ubiquitous Banking

(A) Mobile Banking – A new distribution Channel

Providing financial transactions through mobile devices is a new distribution channel for financial institutions. Using this new distribution channel, they can add further value to their financial services. One of the industries which seem to be more affected after inventing the internet and mobile communication technology is retail banking. It holds all the opportunities and threats connected with the mobile devices and the mobile communication technology. Many retail banks have a dense branch network, close relationships with their customers, and are mostly local businesses operating in one country or part of a country or selected location of the country only. However, their core services are perfectly digitizable and the new technology, therefore, has a potential for transferring all their banking business to mobile banking. This availability of new distribution channel is advantageous for banks for following reasons due to possibility of improving operation effectiveness and service differentiation :

1. The mobile banking distribution channel can offer the customers better service output online in the form of a broader and deeper assortment, less waiting time and higher market decentralization. This may attract new customers (Mols et al., 1999 [13]), increase the revenue of the innovative firms and consequently lead to higher profits to the bank over a long period of time.

2. The mobile banking distribution channels are more cost effective than telephone and branch based networks, and lower cost may lead to lower prices for the consumers. In such cases, seemingly loyal customers may change to the mobile banking distribution channels, and the banking firms that have invested in the wrong channels may end up with channels that turn out to be useless, i.e., investments which may be difficult to recover.

3. The mobile banking distribution channels may change the way in which financial institutions interact with their customers and may facilitate direct marketing, relationship marketing, and mass customization, thus increase customer loyalty.

4. The demand for usage of mobile banking channel is likely to increase in the future due to the increase in literacy and the availability of mobile phones at cheaper rate and fall in the cost of mobile communication charges. This will change the optimal distribution channel structure for the most retail banks and the mobile banking channel is going to be most preferred banking channel due to its ideal characteristics [14-15].

(B) Features of Mobile Banking :

M-banking is not just e-banking without fixed connections, but it is an entirely new way of designing and deploying a wide range of systems and solutions that are :

- Personal.
- Convenient.
- Easy to use.
- Always available.
- Accessible in real time.
- Location sensitive.

Various drivers moving mobile banking revolution forward include :

(1) Advancements in network technologies – Mobile network operators around the world are investing large sums of money in licenses and in building a new generation of networks. Network technologies that can support always-on connectivity will allow users to immediately send and receive voice and data services. At the same time, business investment is continuing apace in innovation at other levels of the network. Device manufacturers are creating prototypes of the products that might exist in the near future, and the race is on to create new standards for operating platforms.

(2) Falling costs for airtime and wireless devices - The cost of mobile devices and basic services such as voice and short messaging service (SMS) have plummeted. No longer is the mobile device a status symbol. It is becoming an intrinsic part of everyday life for millions of people.

(3) The ability to link elements in different value chains, in real time, to provide a dynamic, personalized service - Businesses those link services, many of which already exist independently, will streamline their customers' transactions. For example, linking aeroplane ticket purchases, car rental bookings, and hotel reservations, then communicating all the

information via messaging to mobile devices, would make travel planning easier. In order to offer these new services, businesses are beginning to enter into new alliances and partnerships, both within and outside their industries. This process in itself creates new possibilities and new business opportunities. M-business raises critical questions about strategic adaptation for every organization. It will herald the emergence of entirely new value chains and business models, not to mention new levels of personalized service. It will lead to new business alliances and a wave of convergence between industries. At a fundamental level, it will enable organizations to dynamically reconfigure their value chains and develop new relationships with employees, suppliers, customers, and competitors.

(4) The ability to tailor services to end-users' various needs — Taking one-to-one marketing to a higher level — will become a new source of competitive advantage. By changing the nature of communication and interaction, customer relationship management will take on a new dimension. M-business will also facilitate efficiency gains through workforce management. Mobile technologies offer the potential for tasks to be scheduled for the right worker, with the right set of tools, at the right location and at the right time. They also increase the likelihood that customer enquiries can be resolved on the first port of call.

The following value proposition attributes [16-17] differentiates m-banking from e-banking :

1. Ubiquity : Mobile devices offer users the ability to receive information and perform transactions from virtually any location on a real-time basis. M-banking users will have a presence everywhere, or in many places simultaneously, with a similar level of access available through fixed-line technology. Transactions can take place independent of the user's location. The advantages presented from the omnipresence of information and continual access to availing and providing banking services are exceptionally important to time-critical applications.

Mobile banking, for example, can leverage this value proposition by providing alert notifications, inquiries, and the information on financial transactions through SMS to users mobile device. As such, the real-time, everywhere presence of m-banking will offer capabilities uniquely beneficial to users. Financial services that are time and location sensitive, like any time purchase through credit card/debit card or any other electronic authentication system, are likely to benefit from businesses exploiting this value-added feature of mobile banking.

2. Convenience : The ability and accessibility provided from wireless devices will further allow m-banking to differentiate its abilities from e-banking. Customers should be no longer be constrained by time or place in accessing e-banking services. Rather, m-banking could be

accessed in a manner which may eliminate some of the labor of life's activities. For example, customers waiting in line or stuck in traffic will be able to pursue favorite Internet/SMS based banking activities or handle daily transactions through m-banking applications. Customers may recognize a special comfort which could translate into an improved quality of life. One opportunity to increase value lies in m-banking capabilities that allow customers to shop at where they are not located. This ability to obtain information and conduct transactions from any location is inherently valuable to bank customers. Hence, m-banking offers tremendous opportunities to banking service providers to expand a client base by providing value-added services to customers. By making services more convenient, the customer may actually become more loyal. Consequently, communication facilities within m-banking are key applications for the delivery of convenience.

3. Localization : Knowing the location of the mobile user creates a significant advantage for m-banking. Location-based offerings, via global positioning technology, are available on all mobile devices. Through GPS technology, financial service providers can accurately identify the location of the user. Utilizing this technology, m-banking providers will be better able to receive and send information relative to a specific location. Since mobile devices like cell phones are almost always on, vendors will know the location of their customers and can deliver promotions based upon the likely customer demands for that location. Location-specific information leverages the key value proposition of m-banking over traditional e-banking by supplying information relevant to the current geographic position of the user. M-banking providers will be able to both push and access information relevant to the user's specific location. Mobile websites may serve as points of consolidation of customer information and disseminate the relevant information for a particular location based on profile data built on the user's past behavior, situation, profile, and location. As such, real-time offers may become the "killer application" for M-banking.

4. Personalization : Mobile devices are typically used by a sole individual, making them ideal for individual-based target marketing. Mobile offers the opportunity to banking service providers to personalize messages to customers of various segments, based upon time and location. New developments in information technology and data-mining make tailoring messages to individual consumers practical and cost-effective.

5. Conditions of Usage : In the m-banking model, the mobile user may be engaged in another activity, like traveling, meeting people, etc., rather than sitting in front of his/her desktop terminal.

6. Adaptability : Mobile banking applications should be adapted to the environment of their clients. Adaptability is possible along various dimensions including the type of the device in use, the currently available communication bandwidth as well as location and time.

7. Broadcasting : Some wireless infrastructures, such as cellular architectures and satellite networks, support broadcasting (i.e., simultaneous delivery) of data to all mobile users inside a specific geographical region. Broadcasting of banking information offers an efficient means to disseminate information to a large customer population. This mode of operation can be used to deliver information of common interest to many users such as variation in interest rate, variation in stock prices, or for advertising new banking offers.

The security for the online financial transactions at both client side and the banks server side must be very important for fool proof transactions. It is estimated that the lack of security and the high level of fraud is made the people doubt on encashing advantages of online banking services.

The security threats on the client side may be due to the poor platform integrity, the multitude of default authentication and the arcane user interface. The security threats on the server side may be due to various system attacks like password cracking, screen emulators, data diddling, malicious code, distributed denial of service, physical perimeter penetration, and wireless intercepts. Compare to the internet based online banking, the online banking through the private network of mobile service providers and the user's personal mobile device is more secured. Hence, the primary concern on present day usage of mobile banking applications is due to the limited size and poor user interface of mobile devices than the security. Authentication between mobile phone users is indirectly provided by the calling and called party numbers and confidentiality of the transmitted information can be provided by encrypting the information flow between the communicating parties. Network operators are authenticating the users for billing purposes and to avoid fraud which will also help secured mobile banking through such networks. Users and banking service providers are interested in authenticating each other to avoid fraudulent transactions [18-19].

The various advantages for banks [20-21] by offering mobile banking distribution channel for their customers are :

(1) Banks can cut down their costs of providing service to the customers substantially.

(2) This new channel gives additional opportunity to the banks to cross-sell their other complex banking products and services such as vehicle loans, credit cards, etc.

(3) Mobile banking distribution channel offers the next surest way to achieve their growth. In developed countries, where mobile penetration is nearing saturation, mobile banking is helping banks to increase revenues from the now static subscriber base.

(4) The banks get an opportunity to simplify the complicated services and to make the usage easy to attract new customers and retain old ones.

Presently, many banks offer following services through mobile banking channel :

1. Account Balance Enquiry
2. Account Statement Enquiries.
3. Cheque Status Enquiry.
4. Cheque Book Requests.
5. Fund Transfer between Accounts.
6. Credit/Debit Alerts.
7. Minimum Balance Alerts.
8. Bill Payment Alerts.
9. Bill Payment.
10. Recent Transaction History Requests.
11. Information Requests like Interest Rates/Exchange Rates.

These services are classified as Push and Pull services with respect to the bank server. 'Push' service is when the bank sends out information to customers based upon an agreed set of rules. 'Pull' service is when the customer explicitly requests a service or information from the bank, so a request for last five transactions statement from a customer is a Pull based offering.

Another type classification is also used as Enquiry based service and Transaction based service. A request for customers bank statement is an enquiry based service and a request for funds transfer to some other account is a transaction-based service. Table 6.1 shows the difference between such categories of mobile banking services.

Table 6.1 : Classification of mobile banking Services

	Push Based	**Pull Based**
Transaction Based	-	Fund Transfer Bill Payment Other financial services like share trading.
Enquiry Based	Credit/Debit Alerts. Minimum Balance Alerts Bill Payment Alerts	Account Balance Enquiry Account Statement Enquiry. Cheque Status Enquiry. Cheque Book Requests. Recent Transaction History

(C) Characteristics of Mobile Banking System :

(1) The mobile banking system can provide banking services to the entire world rather than a single neighbourhood /Country and hence it has an unlimited global reachability.

(2) The mobile banking offers services to its customers, which enjoys an inelastic demand in the world market due to its inelastic expandable capability, and low expenditure to both service providers and customers. (inelastic refers to a service that people need or desire almost at any price.)

(3) The mobile banking provides all types of banking services of both retail banking and business banking to all customers irrespective of their age, gender, previous qualification and country of origin.

(4) The mobile banking system provides high-quality banking services to everybody irrespective of their economic, social, linguistic and cultural background.

(5) The mobile banking system needs minimum employees in identified areas of operation and must utilize optimum service from them.

(6) The mobile banking system operates on a low overhead. It does not need an expensive location, big building for customer service and the huge amount of infrastructure. Only a few branches are required to provide quality service to the entire country/world.

(7) The mobile banking system does not require major investments in equipment used in bank branches and other customer supporting systems provided in bank branches or repetition of a large number of branches in every city and villages. In other words, it does not require huge capital.

(8) The mobile banking system is relatively free of all kinds of government regulations or restrictions except Reserve/Federal bank regulations.

(9) By certain extent, the services of the mobile banking system are portable or easily shiftable. This means a customer registered in one bank should able to get the services wherever he moves and in whichever city he lives.

(10) The mobile banking system satisfies its customer's intellectual needs. There are no constraints like minimum amount transaction, to be registered or avail services only in one bank, minimum and a maximum number of services availed per day.

(11) The mobile banking system leaves enough free time to service providers/bank employees as well as customers. In other words, it doesn't require attention/duty of 12, 16, or 18 hours a day.

(12) The mobile banking system is one in which the income of the bank does not limit by the personal output (Leverage) of the bank workers. In the mobile banking system, a bank can provide any number of customers as easily as can have one.

(13) The mobile banking system, customers can do the transaction in any time, any number of times and transaction takes place immediately through banks main server. There is nothing like wasting time in queue, travel time to the bank, etc.

(14) The mobile banking system will provide services to its registered customers anywhere, anytime and any amount of time. i.e., it is ubiquitous.

(15) In the mobile banking system, the technology is used in such a way that all services of the banking system should be delivered effectively.

(16) Mobile banking system provides all customers with not only basic knowledge of banking but also on authenticity and security for financial transactions.

(17) In the mobile banking system, the supply of a variety of automated services is instantaneous and is equal to the demand and the efficiency of the system is always 100%.

(18) In the mobile banking system, the customers have a choice of alternative in terms of service providers.

(19) The mobile banking system will be sustainable for a long time due to its advantages and benefits to customers and service providers.

6.4.3 Ubiquitous Banking as Ideal Banking

The mobile banking system which is ubiquitous i.e., services available to the customers anytime, anywhere, any amount of time irrespective of a number of customers availing the service at a time, using wireless electronic/optical technology made the conventional brick and mortar banking system as ubiquitous banking. The automated banking services using computer technology and information technology supports to make banking services ubiquitous. Due to the massive growth of banking technologies with the aid of 5G mobile technology [22], the mobile banking services becoming more authenticated and secured. This has increased the confidence of the common man to use such services in day today's life. While referring table 6.2, it is understandable that major characteristics of the ideal banking system are comparable with the characteristics of the ubiquitous mobile banking system. Thus, ubiquitous nature of mobile banking system made it as the ideal banking system. Even though we could not realize ideal engine, ideal technology, and ideal education system in practice, we have almost reached the goal of banking system by elevating ubiquitous mobile banking system close to ideal banking system.

6.5 COMPARISON OF IDEAL BANKING MODEL WITH MOBILE BANKING SYSTEM :

The ideal banking characteristics are used to compare mobile banking features with the features of conventional brick and mortar branch banking system and are listed in table 6.2. Based on the comparison, it can be accepted that ubiquitous mobile banking shows almost all features of ideal banking except few exemptions.

Table 6.2 : Comparison of Mobile Banking Characteristics with Ideal banking Characteristics

S.No.	Ideal Banking Characteristics	Traditional Branch Banking	Mobile Banking
1	Unlimited global reachability	No	Possible
2	Banking services enjoy inelastic demand in the world market	No	Possible within a country
3	Provides all types of banking services to all customers.	Possible with limitations	Possible
4	Provides high-quality banking services to everybody irrespective of their economic, social, linguistic and cultural background	Not happening	Possible
5	Uses minimum employees in identified areas of operation and must utilize optimum service from them.	Not possible	Possible through automation
6	Operates on a low overhead.	Operational expenditure is high	Due to automation of services, overhead expenditure is low.
7	Does not require huge capital.	Requires comparatively huge capital	Due to automated online services, it requires comparatively less capital.
8	Relatively free of all kinds of government regulations or restrictions.	Govt. and RBI/FB regulations are applicable.	Govt. and RBI/FB regulations are applicable.
9	The services of ideal banking system are portable or easily shiftable.	Not possible	Possible
10	Satisfies its customer's intellectual needs.	No. Due to constraints of Physical bank branches.	Yes.
11	Leaves enough free time to service providers/bank employees as well as customers.	No free time	More free time due to automated services.
12	The income of the bank does not limit by the personal output (Leverage) of the bank workers.	Not applicable	Applicable due to automated online services
13	Customers can do transactions in any time, any number of times without wasting the time.	Not possible	Possible due to automated online services.

14	provides ubiquitous services.	Not possible	Possible due to automated online services.
15	All services of the banking system are delivered effectively.	Not possible	Possible using proper technology.
16	Provides all customers with not only basic knowledge of banking but also on authenticity and security for financial transactions.	Difficult to implement	Possible using proper technology.
17	The demand for a variety of services is higher than supply and the efficiency of the system is always 100%.	Always supply is less than demand.	Supply of variety of automated services is instantaneous and is equal to the demand and the efficiency of the system is always 100%.
18	The customers have a choice of alternative in terms of service providers.	Not much alternative.	The customers have choice of alternative.
19	The system is sustainable for a long time	Change is inevitable.	Sustainable for long time due to its advantages and benefits to customers and service providers.

6.6 CHAPTER CONCLUSION :

Banks are formulating various strategies in order to attract more deposits and lend it to genuine customers to get a better return and hence make more profit. Based on such objective of a general banking system, the ideal concept of a banking system is developed. The ideal bank is a system with ideal banking characters. In this paper, a model of an ideal banking system is proposed by considering the ideal characteristics expected under input conditions, output conditions, system requirements, and environmental conditions. The factors affecting these characteristics are identified using a qualitative data collection instrument namely focus group method. Finally, some of the possible technology supported models which support the concept of Ideal banking are identified and analyzed. Based on our analysis and discussion on comparing the features, ideal banking characteristics, and mobile banking characteristics are almost matching and hence it can be concluded that ubiquitous banking system based on mobile banking technology is a perfect model to realize ideal banking system [23-25].

REFERENCES :

[1] Sreelatha T and Chandra Sekhar (2012). Role of Technology in Indian Banking Sector. *International Journal of Management and Business Studies* (*IJMBS)*, 2(4), 36-40.

[2] Aithal P. S. and Shubhrajyotsna Aithal (2015). Ideal Technology Concept & its Realization Opportunity using Nanotechnology. *International Journal of Application or Innovation in Engineering & Management (IJAIEM)*, 4(2), 153 – 164.

[3] Rogers E. M. and Hunt S. D. (1994). 'Diffusion of Innovation', 1995, The Free Press, NY.

[4] Morgan R. M. and Hunt S. D. (1994). The commitment-trust theory of relationship marketing. *Journal of Marketing*, 58, 20–38.

[5] Aithal P. S. & Shubhrajyotsna Aithal (2015). An Innovative Education Model to realize Ideal Education System. *International Journal of Scientific Research and Management (IJSRM)*, 3(3), 2464 – 2469.

[6] Aithal P. S. (2015). Concept of Ideal Business & its Realization Using E-Business Model, *International Journal of Science and Research (IJSR)*, 4(3), 1267 – 1274.

[7] Aithal P. S. and Shubhrajyotsna Aithal (2014). Ideal education system and its realization through online education model using mobile devices. Proceedings of IISRO Multi-Conference 2014. Bangkok, pp. 140 - 146, ISBN No. 978-81-927104-33-13.

[8] Aithal P. S. (2015). Mobile Business as an Optimum Model for Ideal Business. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 146-159.

[9] Aithal, P. S. (2016). Ideal Banking Concept and Characteristics**.** *International Research Journal of Management, IT and Social Sciences (IRJMIS)*, 3(11), 46-55. DOI : http://dx.doi.org/10.21744/irjmis.v3i11.311.

[10] Aithal, P. S. (2016). Realization of Ideal Banking Concept using Ubiquitous Banking. *International Journal of Scientific Research and Modern Education (IJSRME)*, 1(2), 119-135. DOI: http://dx.doi.org/10.5281/Zenodo.164703.

[11] Irechukwu, G., (2000). Enhancing the Performance of Banking Operations Through Appropriate Information Technology. In: Information Technology in Nigerian Banking Industry, Spectrum Books, Ibadan, pp. 63-78.

[12] Laudon, D. P. and Laudon, J. P. (2001). Management Information Systems: Organisation and Technology in the Network Enterprises, 4th ed. Prentice Hall International in. U.S.

[13] Mols, N. P., Bukh, P. N. D. and Nielsen, J. F. (1999). Distribution Channel strategies in Danish retail Banking. *International Journal of Retail & Distribution Management*, 27(1), pp. 37-47.

[14] Aithal P. S. and Varambally K. V. M. (2006). Security Issues in Online Financial Transactions with Special Reference to Banking Industry. Quality in Service Sector and Managerial Challenges – Allied Publisher Pvt. Ltd, pp. 103- 114.

[15] Varambally, K. V. M. and Aithal, P. S., (2009). Mobile Business Technology and Business Proliferation of Banks – A futuristic Approach. *Amity Business Review*, 10 (1), 9 – 25.

[16] Aithal P. S., (2016). A Review on Opportunities and Challenges for Mobile Business Activities in India. *International Journal of Management, IT, and Engineering (IJMIE)*, 6(1), 124-148.

[17] Aithal P. S. (2016). A Review on various E-business and M-business models & Research Opportunities. *International Journal of Management, IT, and Engineering (IJMIE)*, 6(1), 275-298.

[18] Aithal P. S., and Varambally K. V. M. (2015). Customer Perspective on Online Mobile Banking in India - An Empirical Study. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 77-97.

[19] Aithal P. S. (2015). Biometric Authenticated Security Solution to Online Financial Transactions. *International Journal of Management, IT, and Engineering (IJMIE)*, 5(7), 455-464.

[20] Aithal P. S. (2015). Recommendations on Policy & Regulatory Guidelines for Mobile Banking in India. *International Journal of Management, IT, and Engineering (IJMIE)*, 5(7), 1-20.

[21] Aithal P. S., (2015) Factors Affecting Banker's Perspective on Mobile Banking. *International Journal of Management, IT, and Engineering (IJMIE)*, 5(7), 28-38.

[22] Krishna Prasad K., and Aithal P. S., (2015). Massive Growth of Banking Technology with the Aid of 5G Technologies. *International Journal of Management, IT, and Engineering (IJMIE)*, 5(7), 616-627.

[23] Aithal, P. S. (2016). Ideal Banking Concept and Characteristics. *International Research Journal of Management, IT and Social Sciences (IRJMIS)*, 3(11), 46-55. DOI : http://dx.doi.org/10.21744/irjmis.v3i11.311.

[24] Aithal, P. S. (2016). Realization of Ideal Banking Concept using Ubiquitous Banking, *International Journal of Scientific Research and Modern Education (IJSRME)*, 1(2), 119-135. DOI**:** http://dx.doi.org/10.5281/Zenodo.164703.

[25] Aithal, P. S. (2016). A Comparison of Ideal Banking Model with Mobile Banking System. *International Journal of Current Research and Modern Education (IJCRME)*, 1(2), 206-224. DOI: http://dx.doi.org/10.5281/Zenodo.198708**.**

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CHAPTER 7

IDEAL SOFTWARE & COMPUTING SYSTEM AND THEIR REALIZATION OPPORTUNITY

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ABSTRACT :
In this chapter, the concept of ideal software, its realization scenarios, and opportunity for realizing the ideal computing system using cloud computing model are proposed, discussed and analysed.

7.1 INTRODUCTION :

Automation of business processes improve an organization's overall workflow in terms of simplifying and improving the process, achieving greater efficiency, adapting to changing business needs, reducing human error, speedup the activities of processes, reduce the cost associated with completing particular process, and clarifying job roles and responsibilities. Automation of business process need software designed for that specific purpose. Developing software for various business processes is greater challenge and massive work and many organizations involved in software planning, design and development. Presently, the two broader classifications of software are general purpose and specific purpose application software. In this paper, we have considered the software as a model of a system. A model is a simplified representation of an operation, or is a process, or a system in which only the basic aspects or the most important features of a typical problem under investigation are considered. The objective of a model is to identify significant factors and interrelationships. The reliability of the solution obtained from a model, depends on the validity of the model representing the real system. A good model called ideal model must have the following characteristics:

- An ideal model should be capable of taking new formulations in to account without having any changes in its frame.
- Assumptions made in the model should be as small as possible.
- Variables used in the model must be less in number ensuring that it is simple and coherent.
- It should be open to parametric type of treatment.
- It should not take much time in its construction for any problem.

The significant advantages of using a model for a system are:

- Problems under consideration become controllable through a model.
- It provides a logical and systematic approach to the problem.
- It provides the limitations and scope of an activity of the system.
- It helps in finding useful tools that eliminate duplication of methods applied to solve the problems.
- It helps in finding solutions for research and improvements in a system.
- It provides an economic description and explanation of either the operation or the systems they represent.

Predictive Models predict facts and relationships among the various activities of the problem. These models do not have an objective function as a part of the model to evaluate decision alternatives. In this model, it is possible to get information as to how one or more factors change as a result of changes in other factors. Example of predictive
model is the model of an Ideal system.

Descriptive Models *d*escribe facts and relationships among the various activities of the problem. These models also do not have an objective function as a part of the model to evaluate decision alternatives. In this model also, it is possible to get information as to how one or more factors change as a result of changes in other factors. Example of descriptive model is the model of a real system.

Automation of business processes improves an organization's overall workflow in terms of simplifying and improving the process, achieving greater efficiency, adapting to changing business needs, reducing human error, speed-up the activities of processes, reduce the cost associated with completing the particular process and clarifying job roles and responsibilities. Automation of business process needs a computing device along with both hardware and software which are designed for that specific purpose. A designing and developing computer system for various computation processes has a greater challenge and massive work. In this paper, we have considered the ideal computer model as a system for ubiquitous computing anytime anywhere and any amount and discussed how it can be achieved with the help of cloud computing technology. This model supports to achieve Universal Automation in industrial and business processes in which computing resources can be accessed over the Internet from the cloud and supports the organizations to enhance their capacity dynamically without investing in new infrastructure, training new IT personnel, or purchasing new licensed software that are required for the automation of various processes. Cloud computing has profited many

organizations by decreasing IT expenses and permitting them to focus on their core business competencies and skills rather than IT infrastructure. The objective of a model is to identify significant factors and interrelationships to realize cloud computing model. The reliability of the solution obtained from a model depends on the validity of the model representing the real system. An ideal computing model with the support of cloud technology must have the following characteristics :

- An ideal model should be capable of taking new formulations into account without having any changes in its existing framework.
- Assumptions made in the model should be as less as possible.
- Variables used in the model must be less in number ensuring that it is simple and coherent.
- It should be open to the parametric type of treatment.
- It should not take much time in its construction for any problem.
- Infrastructures such as software applications, data storage and processing power of the system required to implement model should be supported by cloud technology.

The significant advantages of using a model for a system are:

- Problems under consideration become controllable through a model.
- It provides a logical and systematic approach to the problem.
- It provides the limitations and scope of an activity of the system.
- It supports scalability, flexibility, elasticity, efficiency, and supports outsourcing non-core activities of an organization.
- It offers an innovative business concept for organizations to adopt IT-enabled services without advance investment.

7.2. CONCEPT OF IDEAL SOFTWARE AND ITS REALIZATION SCENARIOS :

It is well known that we can improve the performance of any system by comparing it with a hypothetical, predicted system of that kind called "Ideal system" [1]. Ideal properties of a device or a system can be used to upgrade or improve its properties towards reaching 100% efficiency. By comparing the properties/characteristics of a practical device/system with its ideal counterpart, one can find out the possible modifications in that device /system towards reaching the objective of achieving such an ideal system [2]. Many systems like ideal gas, ideal fuel, ideal solution, ideal fluid, ideal engine, ideal switch, ideal voltage source, ideal current source, ideal diode, ideal transistor, and ideal amplifier are familiar to everybody since school

days. Recently, ideal business system [3-4], ideal education system [5-7], ideal technology system [8], ideal strategy [9], ideal energy source [10-12], ideal banking system [13-16], and ideal library system [17-21] are studied and their input, system, output and environmental characteristics are discussed.

Ideal software, by definition, is a general-purpose software model which can be used for any platform, any type of system, and application automation, without making modifications in the form of structure, coding by an external person/agency. Ideal software is a hypothetical system/instruction set, supported by artificial intelligence, optical neural networks & optical solutions, to modify the algorithms, instructions, and coding based on data processing requirements. Ideal Software is a predictive model and is hypothetical software product having ideal characteristics and is the ultimate goal of a software developer. Identifying ideal software characteristics give an idea on how present software can be improved further by knowing the gap between present software and ideal software. The concept of ideal software motivates software designers to continuously improve the software towards ideal. Software is a system which consists of set of instructions used to do certain pre-specified operations on input data and gives output in the form of result/decision. Thus, generally, software is a product with set of inputs, various set of instructions and execution of these instructions as processes and defined format of output which are results of the processed instructions on input data. A general software system is given in the figure 7.1.

While developing any kind of software product, the first and foremost objective is that it must meet all the requirements of the customer or end-user. Secondly, the cost of developing and maintaining the software should be low and the development of software should be completed in the specified time-frame. Presently, the software design and development is a major business in worldwide and there are enough opportunities and challenges in starting software companies to improve the quality of the software [22].

Fig. 7.1: Block diagram of a general software system

7.3. MODEL AND CHARACTERISTICS OF IDEAL SOFTWARE :

7.3.1 Ideal Software Model:

Ideal Software System consists of various characteristics under 4 categories such as Input conditions, Systems requirements, Output conditions and Environmental & social constraints, and analyzed these characteristics with an objective to achieve the goal of achieving universal automation system. Ideal software would not only automate the various industrial and business processes but would also improve the efficiency of the processes towards maximum value (infinity) to better suit the needs of the people. An ideal software shall have characteristics which can be predicted and classified. Based on various factors which decide the ideal software characteristics, a model consisting of the input conditions, output conditions, system requirements, and social & environmental constraints is derived by a qualitative data collection instrument namely, focus group method [3]. The block diagram of such a system is shown in figure 7.2.

Input: The various resources and qualities both tangible and intangible consumed while developing and using the software for the automation of various functions will come under input characteristics.

Processes: The various software system characteristics like operational characteristics, transition characteristics, revision Characteristics, performance characteristics and maintenance characteristics. For ideal system, these characteristics should lead to the corresponding parameters either zero or infinity depending on making the system ideal.

Output: The output characteristics like performance in achieving the goal are accuracy, correctness, reliability, sustainability, reusability, efficiency and readability.

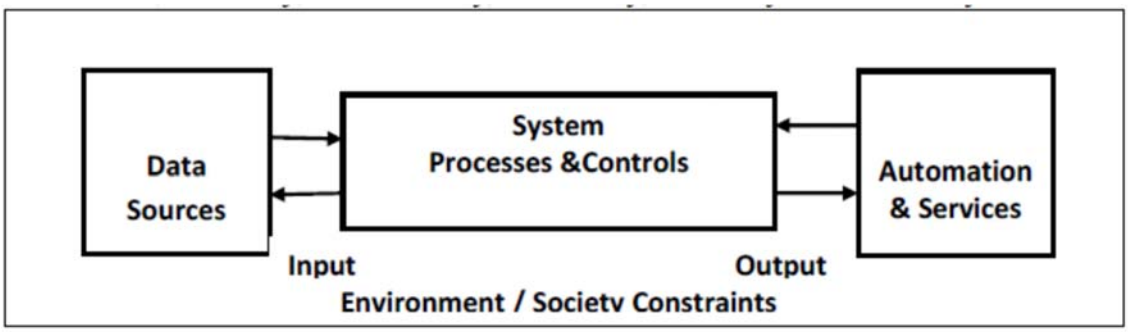

Fig. 7.2: Characteristics of an Ideal Software System

7.3.2 Ideal Software Characteristics:

The Quality factors of software can be determined using their input characteristics, operational characteristics, transition characteristics, revision characteristics and output characteristics. These characteristics are obvious and essential features expected from any project during development and implementation.

7.3.2.1 Input Characteristics:

The input characteristics of ideal software are listed in table 7.1. The prominent eight input characteristics are (1) Zero input resources, (2) Infinite selectivity, (3) Ubiquitous input acceptance, (4) Infinite input security, (5) Infinite reliability, (6) Infinite usability, (7) Infinite efficiency in data acceptance, and (8) Zero energy consumption at input.

Table 7.1: Description of various input characteristics of an ideal software

Sl. No.	Input characteristics	Description
1	Minimum Resources	Zero input resources except data & Instructions
2	Minimum Input	Minimum amount of data & Instructions as input
3	Input Selectivity	Select input data which is appropriate for process and eliminate redundancy and inconsistency
4	Ubiquitous input	Ubiquitous input data (Any time, any amount, any amount of time)
5	Security	With the increase in security threats nowadays, this factor is gaining importance. The input shouldn't have ill effects on software / hardware.
6	Reliability	The input should not have any defects. Not only this, it shouldn't fail while execution. Zero defects & errors prone data
7	Usability	Infinite usability of inputs
8	Efficiency	100% efficiency of data for getting accurate results
9	Short processing time	Select input which takes minimum time for processing
10	No input energy	Zero input energy for Processing & Storing and thus maximize performance of system

7.3.2.2 Software Process/ System Characteristics:

System characteristics include operational characteristics, transitional characteristics and maintenance characteristics [23].

(A) Operational Characteristics: These are functionality based factors and related to 'exterior quality' of software and this tells us how well software works in operations. It can be measured on following characteristics that are listed in Table 7.2. The ten prominent operational characteristics are (1) Zero budgets, (2) Full correctness, (3) Easy usability, (4) Perfect integrity, (5) 100% reliability, (6) 100% efficiency, (7) Infinite tolerance to security threats, (8) 100% safety against hazards, (9) Infinite functionality, (10) Perfect Robustness.

Table 7.2: Description of various operational characteristics of an ideal software

Sl. No.	Operational Characteristics	Description
1	Budget	Determines the cost and difficulty/ease to develop and maintain an software
2	Correctness	The software which we are making should meet all the specifications stated by the customer.

3	Usability	The amount of efforts or time required to learn how to use the software should be less. This makes the software user-friendly even for IT-illiterate people.
4	Integrity	Refers to the degree to which unauthorized access to the software or data can be prevented.
5	Reliability	The software product should not have any defects. Not only this, it shouldn't fail while execution.
6	Efficiency	This characteristic relates to the way software uses the available resources. The software should make effective use of the storage space and execute command as per desired timing requirements.
7	Security	With the increase in security threats nowadays, this factor is gaining importance. The software shouldn't have ill effects on data / hardware. Proper measures should be taken to keep data secure from external threats.
8	Safety	The software should not be hazardous to the environment/life.
9	Functionality	The capability of the software product to provide functions which meet stated and implied needs when the software is used under specified conditions (what the software does to fulfill needs).
10	Robustness	The degree to which the software can keep on functioning in spite of being provided with invalid data.

(B) Transitional Characteristics: Importance of any of these factors varies from application to application. In systems where, human life is at stake, integrity and reliability factors must be given prime importance. In any business related application usability and maintainability are key factors to be considered. Always remember in Software Engineering, quality of software is everything, therefore try to deliver a product which has all these characteristics and qualities. This aspect is important when the software is moved from one platform to another and various transition Characteristics of software are listed in Table 7.3. The four most prominent transaction characteristics of ideal software are (1) Perfect interoperability, (2) 100% reusability, (3) perfect portability, and (4) 100% performance guarantee.

Table 7.3: Description of various transitional characteristics of an ideal software

Sl. No.	Transitional Characteristics	Description
1	Interoperability	Interoperability is the ability of software to exchange information with other applications and make use of information transparently.
2	Reusability	If we are able to use the software code with some modifications for different purpose then we call software to be reusable.
3	Portability	Portability refers to the ability of an application to run on different platforms (operating systems) with or without minimal changes. Due to rapid development in the hardware and the software, nowadays platform change is a common phenomenon. Hence, if a program is developed for a particular platform, then the life span of the program is severely affected.
4	Performance	Software should perform reasonably well in regular and stressful scenarios.

(C) Maintenance Characteristics: This aspect briefs about how well software has the capabilities to maintain itself in the ever-changing environment and various maintenance characteristics of software are listed in table 7.4. The ten most prominent maintenance characteristics of ideal software are (1) Zero maintenance cost, (2) Perfect flexibility, (3) Perfect generality, (4) Infinite extensibility, (5) Infinite scalability, (6) Easy testability, (7) Highest modularity, (8) Best readability, (9) Easy documentation for anybody use, (10) Infinite tenant efficiency, and (11) Easy configurability.

Table 7.4: Description of various maintenance characteristics of an ideal software

Sl. No.	Maintenance Characteristics	Description
1	Maintainability	Maintenance of the software should be easy for any kind of user.
2	Flexibility	A software should be flexible enough to handle most of the changes without having to rewrite the entire program. Most of the programs are developed for a certain period and they require modifications from time to time. For example, in case of payroll management, as the time progresses, some employees may leave the company while some others may join. Hence, the payroll application should be flexible enough to incorporate all the changes without having to reconstruct the entire application.
3	Generality	Apart from flexibility, the software should also be general. Generality means that if software is developed for a particular task, then it should also be used for all similar tasks of the same domain. For example, if software is developed for a particular organization, then it should suit all the other similar organizations.
4	Extensibility	It should be easy to increase the functions performed by it.
5	Scalability	It should be very easy to upgrade it for more work (or for more number of users).
6	Testability	Testing the software should be easy.
7	Modularity	Any software is said to make of units and modules which are independent of each other. These modules are then integrated to make the final software. If the software is divided into separate independent parts that can be modified, tested separately, it has high modularity.
8	Readability	The program should be written in such a way that it makes other programmers or users to follow the logic of the program without much effort. If a program is written structurally, it helps the programmers to understand their own program in a better way. Even if some computational efficiency needs to be sacrificed for better readability, it is advisable to use a more user-friendly approach, unless the processing of an application is of utmost importance.
9	Documentation	Documentation is one of the most important components of an application development. Even if a program is developed following the best programming practices, it will be rendered useless if the end user is not able to fully utilize the functionality of the application. A well-documented application is also useful for other programmers because even in the absence of the author, they can understand it.

10	Multi-Tenant Efficiency	All the sites share the same instance of the software, providing a significant savings in server resource use, maintenance, and costs. Updates are rolled out instantly to customers, all at once.
11	Configurability	Each site's administration interface has variable configuration options including: network content access, simplified blog interface, Social Site (social media) extensions, and custom tool modules. These can be turned on or off on a per site basis with minimal effort and time.

7.3.2.3. Output Characteristics:

The output characteristics of ideal software are listed in table 7.5. The prominent eight output characteristics are (1) 100% accuracy, (2) Perfectly correct output, (3) Perfectly reliable output, (4) Long term sustainability, (5) Infinitely reusability, (6) 100% output efficiency at very low input, (7) Readability to everyone, and (8) Perfect satisfied user experience.

Table 7.5: Description of various output characteristics of an ideal software

S. No.	Output Characteristics	Description
1	Accuracy	Software should result in high accuracy output.
2	Correctness	Software result should meet all the requirements of end users.
3	Reliability	The software output should not have any defects which misleads in decision making.
4	Sustainability	Long period of sustainability.
5	Reusability	Same output can be able to take different inferences for decision making.
6	Efficiency	More output with the same input and Same output with less input
7	Readability	Result of software should be in simple readable form so that anyone can understand.
8	User Experience	Its user interface would immediately make sense to its users. It would be simplistic, elegant and something that is painless to use.

7.3.2.4 Environmental Characteristics:

The external environmental and market characteristics of ideal software are listed in table 7.6. The most prominent external characteristics are (1) Inelastic demand, (2) Infinite market for ideal software, (3) Infinite ability, (4) Cannot be copied by others/competitors, and (5) High quality service to every user.

Table 7.6 : Description of various environmental characteristics of an ideal software

Sl. No.	Environmental Characteristics	Description
1	Inelastic Demand	Inelastic demand refers to a software system that people need or desire almost at any price.
2	Infinite market	Unlimited global market due to its unique character of providing service to every automation system
3	Infinite ability to process inelastic demand	Ideal software has infinite ability to process inelastic demand from entire world due to its infinite capacity.

4	Cannot be copied	Ideal software cannot be copied by competitors. It can be protected by copyright /patent so that the developer of ideal software can enjoy its proprietary for long time.
5	High quality service to every user	Ideal software is expected to provide high quality service to every user so that it provides 100% satisfaction to external users.

7. 3.3 Ideal Software & Universal Automation:

Ideal software has infinite internal ability to automate any processes, applications, and systems. Ideal software system can automate industrial production systems, business service systems, form systems and even home applications. Such fully automated systems are possible using software systems having ideal characteristics developed with the help of artificial intelligence, optical neural networks & optical solutions, to modify the algorithms, instructions, and coding based on data processing requirements. Such automation system called universal automation systems can automate all processes in the society leaving the human beings free from work and challenges. Even though, developing complete ideal software is only the prediction, using technological advancement, one can develop software which can mimic the ideal characteristics in future days which leads further development of anticipated universal automation systems [24-27].

7.3.4 Possibility of Development of Ideal Software:

It is interesting to know how one can develop software which shows ideal characteristics. The possibility of development of such software using presently existing and future available technologies is a real challenge for software professionals and also the consequences of such software development on IT industry in the society.

Operating Systems:

- Operating systems will have to provide protocols, interfaces and resource managers that support easy consumption of services from the cloud as well as provisioning of cloud services.
- Operating systems need to efficiently exploit the compute power available from multi core and many-core processor architectures that are extended with various types of co-processors.
- Failure detection of hardware and platform software components and silent shutdown to support safe state of the system.
- Performance-optimized processor architectures to maximize computational throughput.

- Misbehaviour detection of application software components and restart or shutdown of affected components to increase robustness of the system.

Application Software:

- A rich interface definition language to specify application software component interfaces unambiguously.
- A hardware-independent programming interface for acceleration hardware to port application software components easily.
- Software must run on variety of platforms and it should be platform independent to support portability.
- Parallel programming models and patterns through the support of cloud computing environments in order to efficiently utilize underlying hardware and deliver comparable performance.
- The software must exploit the power saving features of the hardware and allow for large sleep cycles as much as possible.

Self-Modifying Software:

- Artificial Intelligence program, capable of developing its own programs, using a genetic algorithm implementation with self-modifying and self-improving code that performs a specific task.
- Verifying the authenticity of a program's code during execution through Selfcheck summing.

7.4 CONCEPT OF IDEAL COMPUTING AND OPPORTUNITY FOR REALIZE USING CLOUD COMPUTING MODEL :

Ideal computing system, by definition, is a general purpose computing model which can be used for any platform, any type of system, and application automation, without making modifications in the form of structure, coding by an external person/agency and computing resources such as software applications, data storage and processing power of the system. The ideal computing is a hypothetical system/device, supported by optical/quantum computing systems, artificial intelligence, optical neural networks & optical solutions, to provide the algorithms, instructions, and coding based on data processing requirements. Ideal computing system is a predictive model and is a hypothetical computing device having ideal characteristics and is the ultimate goal of computer and computation technology. Identifying ideal computing characteristics give an idea of how present computers can be improved further by knowing the gap between present computing systems and ideal hypothetical computing system. The concept

of ideal computing motivates computer designers to continuously improve the computing systems towards the ideal machine. The software is a system which consists of a set of instructions used to do certain pre-specified operations on input data and gives output in the form of result/decision. Thus, generally, a computing system is a product with a set of inputs, various software and hardware to process the input, and execution of the processes in a defined format of output which are results of the processed input data. While developing any kind of computing system, the first and foremost objective is that it must meet all the requirements of the customer or end-user. Secondly, the cost of developing and maintaining such computer should be low and the development of the internal structure, i.e., the design should be completed within the specified time-frame. At present, the design and development of sophisticated computing system with high speed, parallel processing capability is a major business in worldwide and there are enough opportunities and challenges in running such companies to improve the speed of processing and decreasing the manufacturing cost.

7.4.1. Ideal Computing System Model:

The block diagram of ideal computing system is shown in figure 7.3. It has mainly four sections as input section, processing section, output section and computing environment. An ideal computing system can take infinite input from infinite number of users and process such input data using ideal computing processor and presents the output information to those infinite number of users instantaneously or periodically as per computing environment. The computing processor section of the ideal computing system contains internally both hardware and software required to process any amount of data as per user requirement (fig. 7.4).

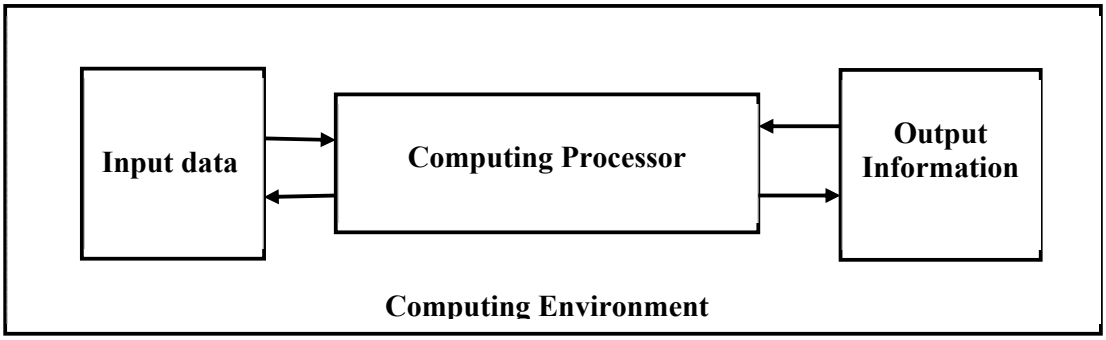

Fig. 7.3: Block diagram of Ideal Computing System

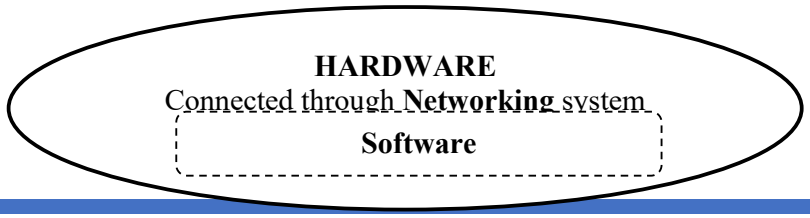

Fig. 7.4 : Subsystems of Computing process

Characteristics of Ideal Computing Processor:

The processing part of ideal computing system should provide the function of ideal software executed through ideal hardware. So that it can take any amount of input data and processes almost instantaneously for online processing or stores the input data and processes periodically using the flexible ideal software and presents the information to the user or for any other applications using the output part of the system. The computing processing part combined with both hardware and software must show ideal operational characteristics, ideal transactional characteristics, ideal maintenance characteristics, and other general characteristics of an ideal computing device which are further discussed below :

(A) Operational Characteristics: These are functionality based factors and related to 'exterior quality' of the computing system and this tells us how well system works in operations. It can be measured by characteristics such as (1) Zero budgets, (2) Full correctness, (3) Easy usability, (4) Perfect integrity, (5) 100% reliability, (6) 100% efficiency, (7) Infinite tolerance to security threats, (8) 100% safety against hazards, (9) Infinite functionality, and (10) Perfect Robustness.

(B) Transitional Characteristics: This aspect is important when the computing system is used to change the working platform from one platform to another and various transition Characteristics of the system includes characteristics like (1) Perfect interoperability of the software, (2) 100% reusability of the system, (3) perfect portability, and (4) 100% performance guarantee.

(C) Maintenance Characteristics: This aspect briefs about how well the computing system has the capabilities to maintain its characteristics in the ever-changing environment and various maintenance characteristics of its hardware and software are (1) Zero maintenance cost, (2) Perfect flexibility, (3) Perfect generality, (4) Infinite extensibility, (5) Infinite scalability, (6) Easy testability, (7) Highest modularity, (8) Best readability, (9) Easy documentation for anybody use, (10) Infinite tenant efficiency, (11) Easy configurability, and (12) Free from software based virus attack.

(D) Environmental Characteristics: The external environmental and market characteristics of ideal computing system are (1) Capability of managing inelastic demand, (2) Infinite market for ideal computing systems, (3) Infinite ability of computing, (4) Cannot be copied by others/competitors, and (5) High-quality service to every user.

(E) General Characteristics:

(a) The ideal computing system is relatively free from all kinds of government regulations or restrictions.

(b) The ideal computing system is portable or easily moveable. This means it can be implemented on any platform.

(c) The ideal computing system satisfies its user's intellectual needs. There are no constraints like minimum and a maximum number of processes can be processed per day.

(d) The ideal computing system is one in which the performance does not limit by a personal output (Leverage) of the user working with it. In the ideal computing system, a computer can provide service to any number of users offline or online as easily as it can have to one.

(e) The ideal computing system, users can process the data at any time, any number of times and results can be presented through the output immediately. There is nothing like wasting time in queue, or waiting time to process the data to get the required information due to fan-in and fan-out problem of practical hardware devices or due to the inadequacy of hardware system used in the system.

(f) The ideal computing system will provide services to its users anywhere, anytime and any amount of time. i.e., it is ubiquitous.

(g) In an ideal computing system, the technology is used in such a way that all processes and services of the system should be delivered effectively.

(h) An ideal computing system provides authenticity and security for all processing and transactions.

7.4.2. Possibility of realization of Ideal Computing using Cloud Computing:

Cloud computing is one of the advances in computer technology and is uses information communication technology as well. Due to the ubiquity of cloud computing facility with flexibility in scaling it has become an important topic of research and provides the value for computing processes in the business. The cloud computing model offers so-called Business Intelligence (BI) for any kind of business decisions via the Internet. However, in practice, to create BI environments to improve business decisions, a large capital layout is required to handle large volumes of data. Providing BI individually to business decisions of an organization by establishing such facility in the neighbourhood of such business also requires enormous processing power which places pressure on the business resources. Therefore, through cloud computing model, one can offer a rented hardware as well as software to process the data online. Thus, cloud computing model has three variations as Software as a Service (SaaS), Infrastructure-as-a-Service (IaaS) and Platform-as-a-Service (PaaS) to provide

ubiquitous computing service solutions to the business. The cloud computing solution to any business will allow companies to reduce their investment cost and maintenance cost for without compromising to have access to BI solution which will give the business an edge on their competition. It removes the need for organizations to install and run applications on their own computers or in their own data centers and eliminates the expense of hardware acquisition, installation, provisioning, and maintenance, as well as software licensing, and support. SaaS is most often implemented to provide business software functionality to enterprise customers at any required time and at low cost while allowing those customers to obtain the same benefits of commercially licensed, internally operated software without the associated complexity of installation, management, licensing, support, and high initial cost. The cloud computing solution provides virtualized computing resources over the Internet and it is a single tenant cloud layer service where the Cloud computing vendor's dedicated resources are only shared and benefited contracted clients at a pay-per-use fee basis. It reduces the need for huge initial investment on computing hardware such as data servers, networking devices, and processing power. The cloud computing solution provides hardware resources and software tools needed for application development to its users as a service. Here, software and development tools are hosted on the provider's servers and they deliver consumer with a platform including all the systems and technical environments comprising of the software development life-cycle components such as developing, testing, deploying, required tools and software applications for software development. Cloud computing service provider hosts the hardware and software requirements on its own infrastructure that are required by the automation of business process. So, it relieves users from installing hardware and software requirements to develop or run a new application on site [28-51].

Ever since advancements in the information technology world started taking place, cloud computing was the demanding technology that emerged as a boon for the business of all sizes. However, cloud model offers certain characteristics for the users so that they can avail maximum benefits in terms of monetarily as well as establishing a strong customer base. In this research, it is proposed and argued that the cloud computing model can be used in any practical computer system to realize ideal computing system characteristics (figure 7.5). Some of the **characteristic** features of cloud computing model which can make it as ideal processing partner for an ideal computing processor section are listed below:

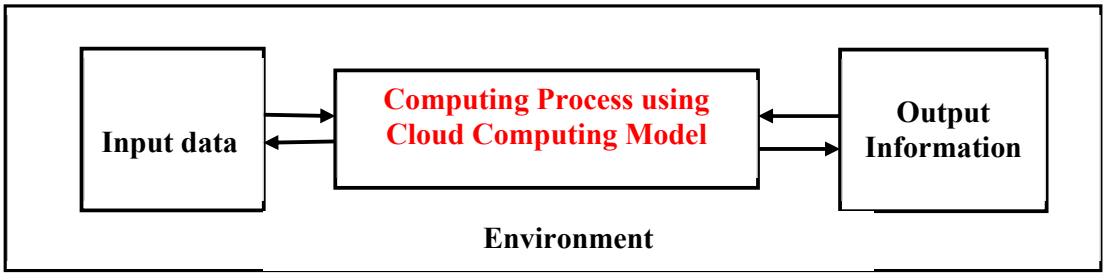

Fig. 7.5: Ideal Computing System using Cloud Computing

Characteristics of Cloud Computing Model:

(1) Cloud Model is Highly Scalable

Organizations can begin with a small deployment of cloud and can develop quickly, then scale it back if required. Additionally, the adaptability of cloud computing permits consumer organizations to utilize additional resources as required, empowering them to fulfill their necessities. It also improves employee coordination due to the fact that cloud computing model supports device independence to decrease the burdens of software and hardware applications, further supporting the scalability levels of a system.

(2) Cloud Model is Flexible

Cloud computing is one among very few technologies which provide a flexible work environment by expanding and growing the computation application facility for the entire globe. The emergence of cloud computing model provides a flexible platform for automating BI. The cloud model is divided into three platforms comprising of IaaS, PaaS, and SaaS, which further include three optional models like public cloud, private cloud, and hybrid cloud. The flexibility option of cloud computing technology has a major advantage to the business of all sizes and operates their daily tasks and work activities smoothly and efficiently.

(3) Cloud Model is Cost-Effective

Cloud computing technology offers the feature of device independence to its users so that the cost of infrastructure and IT communication are likely to go down. The existing businesses and the emerging businesses, by using cloud computing model can avoid purchasing and deploying software and hardware applications in their in-house IT infrastructures. This will end up with optimum spending and huge cost savings.

(4) Cloud Model is Pay as per Use

There are many one-time-payment or pay-as-you-use options available, which make it very reasonable for the consumer company. The consumer company can demand more cloud resources when required and can release when they are not in use.

(5) Cloud Model Unlimited Storage space

Storing information on the cloud gives consumer almost unlimited storage space. Hence, no more need to worry about running out of storage space.

(6) Cloud Model Supports green computing

The more efficient use of computer resources to help the environment and promote energy saving. Usage of ready-made computing resources tailored to an organization's needs certainly helps it to reduce electricity expenses. While it saves on electricity, it also saves on resources required to cool off computers and other components. This reduces the emission of dangerous materials into the environment.

(7) Cloud Model Supports Backup and Recovery

Services using multiple redundant backup sites, which can support business continuity and disaster recovery. Since all data is stored in the cloud, backing it up and restoring the same is relatively much easier than storing the same on a physical device. Hence, this makes the entire process of backup and recovery much simpler than other traditional methods of data storage.

(8) Cloud Model Supports Work from anywhere and Mobile Accessible

The access to the information is from anywhere using Internet connection with proper credentials and access rights. This convenient feature lets the user move beyond time zones and geographic location issues and increased productivity due to systems accessible in an infrastructure available from anywhere.

(9) Cloud Model Supports Quick Deployment

Cloud computing gives the benefit of quick deployment of sought or required setup. The whole framework setup can be completely functional within a couple of minutes, condition the correct sort of innovation that client needs are accessible. Programmed Software Integration is simple as user/decision maker needs to handpick those services and programming applications that are the best suit for that organization. Access to data is through APIs that does not require application installations on to PCs.

Table 7.7: Similarities between Ideal Computing Processor Model & Cloud Computing Model [28-51]

S. No.	Ideal Computing Processor Characteristics	Cloud Computing Model Characteristics
1	Ideal computing processor is a flexible elastic system in terms of its capability to support any amount of processing data between zero to infinity at any given time.	Cloud computing system has internal provision to vary the computing facilities depending on client requirement so that it can support any amount of processing data between zero to infinity at any given time.
2	Maintainability - Maintenance of both the software and hardware part of ideal	Maintenance of cloud computing system is given priority from vendor side and enough

	computing system should be easy and trouble free operation should be possible for any kind of users.	backup systems along with required software are always available for ubiquitous online service to any computing system so that trouble-free operation is possible.
3	Flexibility – Both hardware and Software parts of cloud computing system should be flexible enough to handle most of the changes in input and processing without having to modify any of the hardware and without rewriting the entire program.	Every business enterprise aims for a flexible work environment for being clear throughout their way in expanding and growing business branches across the globe through using flexible cloud computing system.
4	Scalability - It should be very easy to upgrade the system to more work depending on requirement instantaneously.	One of the advantages of cloud computing is organizations can begin with a small deployment of cloud and can develop quickly, then scale it back instantaneously if required.
5	Multi-Tenant Efficiency – In an ideal computing system, all the users share the same instance of the software, providing significant saving in server resource use, maintenance, and costs. Updates are rolled out instantly to users, all at once.	In cloud computing system, many registered customers can share computing resources in a public or private cloud simultaneously. Each tenant's data is isolated and remains invisible to other tenants.
6	Atomicity – Failures in the system should have provision to recover and restore the data.	Services using multiple redundant backup sites, which can support continuity of business and recovery of any disaster by instantaneous recovery of the data.
7	Ubiquitous – The ideal computing system provides ubiquitous services to process the huge number of data at anytime, anywhere, any amount of time.	In cloud computing system, the access to the information is from anywhere, anytime and any amount using Internet connection with proper credentials and access rights.

While realizing the ideal computing system, the input data from any number of sources should be processed by the ideal computing processor and which can be achieved by connecting the local computing processor to cloud computing system so that all ideal characteristics if cloud computing model can be utilized in the local computing processor to make it ideal computing processor. Figure 7.6 shows the concept and idea on how the local processors of low capabilities to cloud computing systems based on need and hence how to modify the capability and scalability along with other features of local processor towards ideal computing system.

7.4.3. Challenges to Achieve Ideal Computing using Cloud Computing:

The adoption and usage of cloud computing model by organizations for the optimum management of their computing resources as ideal computing are associated with numerous challenges because organizational users are still skeptical about its authenticity. The major challenges that the business will face when automating computing solution using Cloud Computing model are as follows:

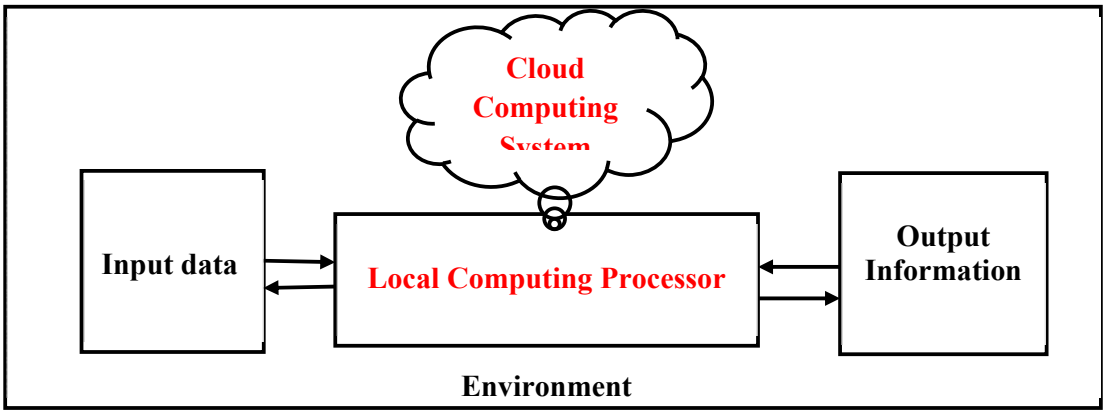

Fig. 7.6: Ideal Computing System consisting of Local computing processor combined with Cloud Computing system

(1) Security Challenges: The security aspects have played an important role in hindering the acceptance of Cloud computing. Storing organizational crucial data, executing them using a software on someone else's hard disk, and using someone else's processor appears daunting to many. Well-known security issues such as data loss, phishing, running remotely on a collection of machines will cause serious threats to organization's data and software. Moreover, the multi-tenancy model and the collective computing resources in cloud computing has introduced new security challenges that require advanced security techniques to tackle with. For example, hackers can set up a Cloud service and provide it to client organizations with more reliable infrastructure services at a relatively cheaper price for them to start an attack.

(2) Costing Model Challenges: Migration to the Cloud model can significantly reduce the infrastructure cost, but it does raise the cost of data communication, i.e. the cost of shipping an organization's data to and from the public and community Cloud and the cost per unit of computing resource used is likely to be higher in many cases. This cost is particularly prominent if the consumer organization uses the hybrid cloud deployment model where the organization's data is distributed amongst a number of public/private/community clouds.

(3) Pricing Model Challenges: The flexible computing resource pool has made the cost investigation significantly more convoluted than standard data centers, which often calculates their cost based on utilization of static computing. Moreover, creating virtual server has become the unit of cost analysis for the client organizations rather than the underlying physical server. For cloud computing facility providers, the cost of developing architecture in which a single instance of a software application serves multiple customers within their offering can be very substantial. Which include: reconstruction of the software that was originally used for single-customer, the cost of providing new features that allow for intensive customization of

software, performance and security enhancement for concurrent multi-user access, and dealing with complexities induced by the above changes using required software. Consequently, cloud computer facility providers need to consider the exchange between the provision of multi-occupancy and the cost reduction yielded by multi-occupancy such as reduced overhead through paying off, reduced number of on-site software licenses, etc. Therefore, a strategic and feasible charging model for cloud computing facility provider is critical for the gainfulness and supportability of SaaS cloud providers in a cloud environment.

(4) Service Level Agreement (SLA) Challenges:

In spite of the fact that cloud consumer organizations do not have control over the fundamental computing resources, they do need to guarantee the quality, accessibility, dependability, and performance of provided resources when consumer organizations have relocated their core business activities onto their entrusted cloud. In other words, it is essential for consumer organizations to obtain a guarantee from service providers on service delivery. Usually, these are given through Service Level Agreements (SLAs) negotiated between the providers and users of cloud. The issue in this is the definition of SLA details in such a way that has suitable level of granularity, specifically the trade-offs amongst articulacy and multifaceted nature, so they can cover a large portion of the client's desires and is generally easy to be weighted, confirmed, assessed, and implemented by the resource allocation and management mechanism on the cloud. In addition, different types of cloud offerings (IaaS, PaaS, and SaaS should characterize distinctive SLA meta specifications. This also causes a number of implementation issues for the cloud providers. Furthermore, advanced SLA mechanisms need to always consider and incorporate user feedback and customization highlights into the SLA assessment framework.

(5) Cloud Interoperability Issue Challenges:

At present, each cloud offering has its own way on how cloud clients, applications, and users collaborate with the cloud, leading to the "Foggy Cloud" phenomenon. This extremely prevents the advancement of cloud ecosystems by constraining vendor locking, which restricts the ability of users to choose from alternative vendors/offering simultaneously in order to improve resources at different levels within an organization. More importantly, proprietary cloud application programming interface makes it extremely hard to coordinate cloud services with an organization's own existing legacy frameworks. The primary aim of interoperability is to understand the flawless transfer of data across clouds and between cloud and local applications of an organization which works as client. There are a number of levels where the

interoperability is essential for cloud computing for smooth functioning. First, need to optimize the IT asset and computing resources of the organization often need to keep in-house IT assets and capabilities associated with their core competencies while outsourcing marginal functions and activities on the cloud. Second, more important for the purpose of optimization is an organization may need to outsource a number of marginal functions to cloud services offered by different service providers. Standardization emerges to be a good solution for interoperability problem. However, as cloud computing just begins to take off, the interoperability issue has not shown up on the pressing agenda of major industry cloud vendors [28-51].

7.4.4. Suggestions

✓ To safeguard server failure, Public Cloud service providers should implement strong data replication mechanisms to distribute customer's data across the globe in various geographies so that cloud based ideal server concept for ideal computing can be achieved.

✓ All communications with cloud computing processors which acts as processor parts of ideal computing system should be protected using encryption and key management because Services can be accessed through a thin client, laptop or mobile phone and data is easily accessible through these channels and transferred across multiple networks when your cloud service provider is extremely far away from your location.

✓ In cloud computing part of an ideal computing system, to prevent offline attacks disk encryption can be used to encrypt all the data including user files on the disk which helps to keep data secured.

✓ Data stored in IaaS infrastructure in public cloud system should be monitored using robust logging and reporting system to keep track the location of information, who has accessed it, in which machines are handling it and which storage arrays are responsible for it.

✓ The use of virtual processing system act as a mechanism in the PaaS layer in Cloud computing. Virtual machines must be safeguarded against different harmful security attacks such as cloud malware. So during the data transfer over network channels, it is necessary to maintain the integrity of applications and enforce accurate authentication checks for the secured data transfer.

✓ In Software as a service model of cloud computing system, the applications are accessed using web browsers over the Internet, therefore, web browser security is crucially important. Security architect needs to consider various methods of securing SaaS applications such as Web Services (WS) security, Extendable Markup Language (XML) encryption, Secure Socket

Layer (SSL) and the available methods and facilities used in enforcing protection to data transmitted over the Internet.

7.5 CONCLUSION :

Ideal systems are those systems which have ideal characteristics. In any ideal system, their characteristics are divided into four categories as input characteristics, system characteristics, output characteristics, and environmental characteristics. In this paper, we have tried to develop ideal software concept by identified its characteristics. Further these characteristics are divided into four categories. The input characteristics identified are Zero input resources, Infinite selectivity, Ubiquitous input acceptance, Infinite input security, Infinite reliability, Infinite usability, Infinite efficiency in data acceptance, and Zero energy consumption at input. The operational system characteristics identified are Zero budget, Full correctness, Easy usability, Perfect integrity, 100% reliability, 100% efficiency, Infinite tolerance to security threats, 100% safety against hazards, Infinite functionality, Perfect Robustness. The transition system characteristics identified as Perfect interoperability, 100% reusability, perfect portability, and 100% performance guarantee. The maintenance system characteristics are found to be Zero maintenance cost, Perfect flexibility, Perfect generality, Infinite extensibility, Infinite scalability, Easy testability, Highest modularity, Best readability, Easy documentation for anybody use, Infinite tenant efficiency, and Easy configurability.

The output characteristics identified are 100% accuracy, Perfectly correct output, Perfectly reliable output, Long term sustainability, Infinitely reusability, 100% output efficiency at very low input, Readability to everyone, and Perfect satisfied user experience. The identified environmental characteristics are Inelastic demand, Infinite market for ideal software, Infinite ability, cannot be copied by others/competitors, and High-quality service to every user. Even though ideal software is a hypothetical assumption and difficult to realize in practice, by knowing its characteristics, one can improve the characteristics of developed software towards ideal level. This will disclose an opportunity to software developers to continuously improve the quality of the software.

The objective of every computing system is to improve efficiency, scalability, multitasking, and generality of functioning so that it can be operated satisfactorily for any variation in input and operating environment. Improving efficiency of performance of any device from present level to ideal level is the challenge for the researchers and continuous improvement is required in the performance of such device/systems until their characteristics are elevated towards ideal characteristics. In this paper, we have proposed, designed and discussed the characteristics of

an ideal computing system which can be realized in practice using new emerging computing model to be used as the ideal computing processor section. This idea allows the designer to realize the most of the expected ideal computing system characteristics in practice. The paper also contains an elaborated discussion on challenges and suggestions while achieving ideal computing system using cloud computing model [52-53].

REFERENCES:

[1] Von Bertalanffy, L. (1968). General systems theory. New York, 41973, 40.

[2] Aithal, P. S., (2016). Review on Various Ideal System Models Used to Improve the Characteristics of Practical Systems. *International Journal of Applied and Advanced Scientific Research*, 1(1), 47-56. DOI: http://doi.org/10.5281/zenodo.159749.

[3] Aithal P. S. (2015). Concept of Ideal Business & Its Realization Using E-Business Model, *International Journal of Science and Research (IJSR)*, 4(3), 1267 - 1274.

[4] Aithal P. S. (2015). Mobile Business as an Optimum Model for Ideal Business. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 146-159.

[5] Aithal P. S. and Shubhrajyotsna Aithal (2015). An Innovative Education Model to realize Ideal Education System. *International Journal of Scientific Research and Management (IJSRM)*, 3(3), 2464 - 2469.

[6] Aithal P. S. and Shubhrajyotsna Aithal (2014). Ideal education system and its realization through online education model using mobile devices. *Proceedings of IISRO Multi Conference* 2014, Bangkok, 7/01/2014, pp. 140 - 146, ISBN No. 978-81-927104-33-13.

[7] Aithal P. S. & Shubhrajyotsna Aithal (2016). Impact of On-line Education on Higher Education System. *International Journal of Engineering Research and Modern Education (IJERME)*, 1(1), 225-235.

[8] Aithal P. S. and Shubhrajyotsna Aithal (2015). Ideal Technology Concept & its Realization Opportunity using Nanotechnology. *International Journal of Application or Innovation in Engineering & Management (IJAIEM)*, 4(2), 153 – 164.

[9] Aithal P. S. (2016). The concept of Ideal Strategy & its realization using White Ocean Mixed Strategy. *International Journal of Management Sciences and Business Research (IJMSBR)*, 5(4), 171-179.

[10] Sridhar Acharya P. and Aithal P. S. (2016). Concepts of Ideal Electric Energy System for production, distribution and utilization. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 367-379.

[11] Aithal, P. S. & Shubhrajyotsna Aithal (2018). The Concept & Characteristics of Ideal Energy System and its Realization Constraints. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *2*(2), 127-137. DOI: https://doi.org/10.5281/zenodo.1487702.

[12] Shubhrajyotsna Aithal & Aithal, P. S. (2018). The Realization Opportunity of Ideal Energy System using Nanotechnology Based Research and Innovations. *International Journal of Advanced Trends in Engineering and Technology*, *3*(2), 1-15. DOI : http://doi.org/10.5281/zenodo.2531876.

[13] Aithal P. S. (2016). Concept of Ideal Banking and Realization of it using Ubiquitous Banking, *Proceedings of National Conference on Changing Perspectives of Management, IT, and Social Sciences in Contemporary Environment*, Manegma 2016, SIMS, Mangalore, India, Vol. 14, pp-13-24, ISBN 978-93-5265-6523.

[14] Aithal, P. S. (2016). Ideal Banking Concept and Characteristics. *International Research Journal of Management, IT and Social Sciences (IRJMIS)*, *3*(11), 46-55. DOI : http://dx.doi.org/10.21744/irjmis.v3i11.311.

[15] Aithal, P. S. (2016). Realization of Ideal Banking Concept using Ubiquitous Banking, *International Journal of Scientific Research and Modern Education (IJSRME)*, *1*(2), 119-135. DOI: http://dx.doi.org/10.5281/zenodo.164703.

[16] Aithal, P. S. (2016). A Comparison of Ideal Banking Model with Mobile Banking System. *International Journal of Current Research and Modern Education (IJCRME)*, *1*(2), 206-224. DOI: http://dx.doi.org/10.5281/zenedo.198708**.**

[17] Aithal P. S. (2016). Concept of Smart Library Models for Future Generations. *Proceedings of National Conference on Changing Perspectives of Management, IT, and Social Sciences in Contemporary Environment*, Manegma 2016, SIMS, Mangalore, India, Vol. 14, pp-50-62, ISBN 978-93-5265-6523.

[18] Aithal P. S. and Shubhrajyotsna Aithal, (2014). Ideal education system and its realization through online education model using mobile devices, *Proceedings of IISRO Multi Conference 2014*, Bangkok, 7/01/2014, 140 - 146, ISBN No. 978-81-927104-33-13. DOI: http://doi.org/10.5281/zenodo.62059.

[19] Aithal P. S. and Shubhrajyotsna Aithal, (2015). An Innovative Education Model to realize Ideal Education System. *International Journal of Scientific Research and Management (IJSRM)*, *3*(3), 2464 - 2469. ISSN: 2321-3418, DOI: http://doi.org/10.5281/zenodo.61654.

[20] Aithal, P. S. & Shubhrajyotsna Aithal, (2016). Impact of On-line Education on Higher Education System. *International Journal of Engineering Research and Modern Education (IJERME)*, 1(1), 225-235. ISSN: 2455 – 4200. DOI : http://doi.org/10.5281/zenodo.161113.

[21] Aithal, P. S. (2016). Smart Library Model for Future Generations. *International Journal of Engineering Research and Modern Education (IJERME)*, 1(1), 693-703. ISSN: 2455 – 4200. DOI : http://doi.org/10.5281/zenodo.160904.

[22] Aithal P. S., Padmanabha Shenoy and Priyanka Neelam (2015). Opportunities & Challenges in Starting Software Company in Developing Countries. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 201-214.

[23] Penna Sparrow (2011). Characteristics of a Good Software, Referred from http://www.ianswer4u.com/2011/10/characteristics-of-good-software.html.

[24] Valeriy Vyatkin, (2013). Software Engineering in Industrial Automation: State-of-the-Art Review. *IEEE Transactions on Industrial Informatics*, 9(3), 1234 – 1249.

[25] Vogel-Heuser, Birgit; Diedrich, Christian; Fay, Alexander; Jeschke, Sabine; Kowalewski, Stefan; et al., (2014). Challenges for Software Engineering in Automation, *Journal of Software Engineering and Applications*, 7(5), 440-451.

[26] Tariq Samad, Leveraging the Web: A Universal Framework for Building Automation, 2007 American Control Conference, New York, NY, pp. 4382 – 4387. 9-13 July 2007, ISSN 0743-1619.

[27] Julien Chouinard, Software for Next Generation Automation and Control, 4th IEEE International Conference on Industrial Informatics, Singapore, 16-18 Aug. 2006, pp. 886 – 891.

[28] Gens, F. (2009). New IDC IT Cloud Services Survey: Top Benefits and Challenges, IDC eXchange, viewed 18 February 2010.

[29] Brodkin, J. (2008). Gartner: Seven cloud-computing security risks. Infoworld, 2008, 1-3.

[30] European Network and Information Security Agency. (2009). Cloud Computing: Benefits, risks and recommendations for information security. ENISA.

[31] Kandukuri, B. R., & Rakshit, A. (2009, September). Cloud security issues. In Services Computing, 2009. SCC'09. IEEE International Conference on (pp. 517-520). IEEE.

[32] Kresimir, P., and H. Zeljko (2010). Cloud computing security issues and challenges. PROC Third International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services, pp. 344-349.

[33] Grobauer, B., Walloschek, T., & Stocker, E. (2011). Understanding cloud computing vulnerabilities. IEEE Security & Privacy, 9(2), 50-57.

[34] Subashini, S., & Kavitha, V. (2011). A survey on security issues in service delivery models of cloud computing. Journal of network and computer applications, 34(1), 1-11.

[35] Ramgovind, S., Eloff, M. M., & Smith, E. (2010, August). The management of security in cloud computing. In 2010 Information Security for South Africa (pp. 1-7). IEEE.

[36] Almorsy, M., Grundy, J., & Müller, I. (2010, November). An analysis of the cloud computing security problem. In Proceedings of APSEC 2010 Cloud Workshop, Sydney, Australia, 30th Nov.

[37] Cloud Security Alliance (CSA). Available: http://www.cloudsecurityalliance.org [Mar.19, 2010]

[38] Puthal, D., Sahoo, B. P. S., Mishra, S., & Swain, S. (2015, January). Cloud computing features, issues, and challenges: a big picture. In Computational Intelligence and Networks (CINE), 2015 International Conference on (pp. 116-123). IEEE.

[39] Hussein, N. H., & Khalid, A. (2016). A survey of Cloud Computing Security challenges and solutions. International Journal of Computer Science and Information Security, 14(1), 52.

[40] Arnold, S. (2009). Cloud computing and the issue of privacy. KM World, 14-22.

[41] Global Netoptex Incorporated. "Demystifying the cloud. Important opportunities, crucial choices." pp 4-14. Available: http://www.gni.com [Dec. 13, 2009].

[42] Lenk, A., Klems, M., Nimis, J., Tai, S., & Sandholm, T. (2009, May). What's inside the Cloud? An architectural map of the Cloud landscape. In Proceedings of the 2009 ICSE Workshop on Software Engineering Challenges of Cloud Computing (pp. 23-31). IEEE Computer Society.

[43] Weinhardt, C., Anandasivam, A., Blau, B., & Stosser, J. (2009). Business models in the service world. IT Professional Magazine, 11(2), 28.

[44] Jensen, M., Schwenk, J., Gruschka, N., & Iacono, L. L. (2009, September). On technical security issues in cloud computing. In 2009 IEEE International Conference on Cloud Computing (pp. 109-116).

[45] Leavitt, N. (2009). Is cloud computing really ready for prime time. Growth, 27(5), 15-20.

[46] Jensen, M., Schwenk, J., Gruschka, N., & Iacono, L. L. (2009, September). On technical security issues in cloud computing. In 2009 IEEE International Conference on Cloud Computing (pp. 109-116).

[47] Soghoian, C. (2010). Caught in the cloud: Privacy, encryption, and government back doors in the web 2.0 era. J. on Telecomm. & High Tech. L., 8, 359.

[48] Aithal, P. S. & Pai, V. T. (2016). Concept of Ideal Software and its Realization Scenarios. *International Journal of Scientific Research and Modern Education (IJSRME)*, 1(1), 826-837. DOI : http://doi.org/10.5281/zenodo.160908.

[49] Pai V. T. & Aithal, P. S., (2017). A Review on Security Issues and Challenges in Cloud Computing Model of Resource Management. *International Journal of Engineering Research and Modern Education (IJERME)*, 2(1), 65-70. DOI : http://doi.org/10.5281/zenodo.546323.

[50] Vaikunth Pai T. & Aithal, P. S., (2017). Cloud Computing Security Issues - Challenges and Opportunities. *International Journal of Management, Technology, and Social Sciences (IJMTS),* 1(1), 33-42. DOI: http://dx.doi.org/10.5281/zenodo.569920.

[51] Aithal, P. S. & Priyesh Pai, T. (2017). Opportunity for Realizing Ideal Computing System using Cloud Computing Model. *International Journal of Case Studies in Business, IT and Education (IJCSBE), 1*(2), 60-71. DOI: http://dx.doi.org/10.5281/zenodo.1094995.

[52] Aithal, P. S., & Vaikuth Pai, T., (2016). Concept of Ideal Software and its Realization Scenarios. *International Journal of Scientific Research and Modern Education (IJSRME)*, 1(1), 826-837. DOI: http://doi.org/10.5281/zenodo.160908.

[53] Aithal, P. S. & Priyesh Pai, T. (2017). Opportunity for Realizing Ideal Computing System using Cloud Computing Model. *International Journal of Case Studies in Business, IT and Education (IJCSBE),* 1(2), 60-71. DOI: http://dx.doi.org/10.5281/zenodo.1094995.

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CHAPTER 8

ANALYSIS OF SYSTEMS & TECHNOLOGY USING ABCD FRAMEWORK

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ABSTRACT :
In this chapter, a new ABCD framework as to analyse business models, concepts, technology, systems, and strategies is proposed, developed, and used to analyse nanotechnology as green technology. The framework analyses advantages, benefits, constraints, and disadvantages (ABCD) of a system or concept from different stakeholder point of view. The chapter also contains the Factor & Elemental Analysis of nanotechnology as green technology using ABCD framework.

8.1 INTRODUCTION :

A business model or functional system is a set of process/activities that results in sustainable profit through desired revenue and customer value. The business model spells out how a company makes money by specifying its position in the value chain. The business model combines the roles and relationships among a firm's customers, allies, and suppliers; the major flows of product, services, information, and money; and the major benefits to the participants. The model includes eight ingredients of business as : value proposition, revenue model, market opportunity, competitive environment, competitive advantage, market strategy, organizational development, and management team. The model also includes the business elements such as customer management (including value proposition); product and service portfolio, processes, and activities; required resources, suppliers and business networks; and financial viability (including revenue sources). Most of the business models are developed and monitored based on their advantages and disadvantages to the organization to fulfil its objectives and their benefits to the stakeholders. This also include the constraints of doing business in competitive business environment.

● According to the first school of thought proposed by Timmers's [1] a business model is an architecture for product, service and information flows including a description of the various business actors and their roles; and a description of the potential benefits for the various business actors; and a description of the sources of revenue" (Timmers, 1998, p.4). Rappa (2001) [2] suggests a business model is a method of doing business by which a company can

sustain development. This definition directly spells out how a company makes money in the market. The business model is categorized into nine generic forms, which include brokerage, advertising, infomediary, merchant, manufacturer, affiliate, community, subscription and utility. Thus, although the differences of the above two classifications are noticeable, these taxonomies share some common features.

● In the second school of thought, the emphasis of defining business model has gradually shifted from business model taxonomy to the components or elements of business models (Pateli and Giaglis, 2004) [3]. Linder and Cantrell (2000) [4] understand a business model as an organization's core logic for creating value. Further, they decompose a business model into sub-models that link together, which includes Pricing Model, Convenience Model, Commodity-plus Model, Experience Model, Channel Model, Intermediary Model, Trust Model, and Innovation Model. Hamel (2000) [5] defines a business model as the business concept implemented in practice, which is a radical innovation that can lead to the value creation and the change of the rules governing the industry. Instead of giving the simple lists of business model components, this definition includes a real-life description of business model elements including customer interface, core strategy, strategic resource, and value network.

● The third school of thought began to model the components of business model in the form of reference models or ontology. Gordijn, Akkermans and van Vliet (2001) [6] propose a business model ontology that focuses on the linkage between business and information technology. This ontology specifies value flows between business actors.

● The fourth school of thought is concerned with identifying criteria for either assessing the feasibility and profitability of business models or evaluating a business model in various applications.

Hamel (2000) [5] has identified four factors that determine a business model's value potential: efficiency, uniqueness, fit, profit booster, respectively. Afuah and Tucci (2003) [7] define three levels of measurement for the performance of a business model, which includes: the profitability of a firm comparing to its competitors; a firm's profit margin and market share; business model component attributes. Around this value-centered theme, they provide a framework that attributes the value creation of a business model to eight elements. Some perceive the business model as an abstract business concept that describes the logic of make profits for a company (Linder and Cantrell, 2000 [4]; Hamel, 2000 [5]; Timmers, 1998 [1]; Rappa, 2001 [2]), while others link it with strategy, business processes as well as business information systems (Afuah and Tucci, 2003) [7]. Different criteria have been used to

decompose or categorize business models. However, value and value creation are the common foci. Moreover, in general, in examining the mechanism of value creation for a business model, people consider firm's capability and the firm boundary. This is based on taking into account the specific environment and information technology characteristics.

The success or failure of a business model, strategy, operational concept or business system depends on various determinant issues like (1) the organization, (2) the business operations, (3) various stake holders, (4) the environment/society, (5) the Technology, and (6) the strategy the organization follows and any analyzing framework should address these pertinent issues and related underline factors. Accordingly, the business model or strategy, or working concept or business system can be analyzed using these issues by finding the various factors affecting the business. Technology is a one of the main factors which affects the business model.

Technology is an application of science to develop various products and processes, tangible or intangible, to solve problems of the people in the society. Technology provides many business opportunities to people where the business is doing anything with profit motivation [8]. There are many different technologies emerged in the society in order to improve the business processes for producing new products or services. The research and developments in science and technology continuously improve the technology or create new technologies. There are many specific-purpose and general-purpose technologies already available and some more are emerging as research progress [9]. Out of many definitions for the research process in both natural sciences and philosophical sciences, the most popular two definitions are (1) Creating new knowledge, and (2) Interpretation of existing knowledge in a new way through the suitable method of analysis. Creating new knowledge mainly focus on creating new science, new technology, new product or service, new process used to produce product or service, creating new way of doing things both theoretically and experimentally. Interpretation of existing knowledge in a new way so that it can support new concept/idea/strategy/solution is also considered as research. For this, a proper analysis tool/framework is required. Such an analysis framework should study and interpret a given concept, idea, system, strategy, technology, solution etc. in a systematic form and in detail using various determining issues and affecting factors [10].

Technology analysis is a scientific, interactive, and communicative process that aims to contribute to the formation of public opinion on societal aspects of that technology. There are many analysis frameworks used to interpret concepts, ideas, technologies, models, systems, solutions to any problems, strategies, products or services of an organization, resources, etc.

Analysing a technology includes the study of development of that technology, its cost-benefits from the stakeholders point of view, its strength, weakness, opportunities and challenges (SWOC) [11-12], its advantages, benefits, constraints, and disadvantages to the stakeholders (ABCD) [10, 13], its external analysis using political, economic, social, technological, environmental, and legal (PESTEL) framework [14-15], its performance analysis etc. Out of them, recently developed analysis framework called ABCD analysis framework is flexible to use in both qualitative and quantitative manner [10, 13, 16-19]. ABCD analysis method allows the researcher to interpret the given concepts, ideas, technologies, models, systems, solutions of any problems, strategies, products or services of an organization, resources including material, machine, men, money, and information, systematically by considering various determinant issues related to the problem under analysis. The various determinant issues like organizational issue, product issue, customer issue, government issue, and environmental/ societal issues are identified and the affecting factors under the constructs Advantages, Benefits, Constraints, and Disadvantages are determined for identified key attributes [12-13]. The ABCD analysing framework is also suitable for analysing a technology to study various affecting factors for different stakeholders including organization which adopted that technology for producing products through suitable processes under given constructs. In this chapter, we have used ABCD analysing framework for the first time to analyse nanotechnology which is a general-purpose technology and also a green technology considered as a boon to the mankind due to its usefulness in solving all basic and advanced problems in the society to an optimum level which is very close to the ideal level.

8.2 VARIOUS TECHNIQUES FOR BUSINESS MODEL ANALYSIS :

A business model is a set of propositions that creates customer value through sustainable and desired outcome. The business model explains how an organization generates profit by specifying its position in the value chain. Identifying suitable business models that enhance customer value and revenue, analyzing the model systematically is the current challenge for organizations. A model in business management is a simplified representation of an operation, or a process in which only the basic aspects or the most important features of a typical problem under investigation are considered. Many types of analysis frameworks are available [20]. According to Wu (1992) [21], good framework should guide toward a method or solution uniquely suitable to the particular situation in question. Lee and Ko (2000) [22] proposed a framework for strategic business analysis by integrating SWOT (strengths, weaknesses, opportunities, and threats), balanced score card [23] and quality function deployment.

Although many analytical techniques, such as SWOT, SLEPT (social, legal, economic, political, technical) [24], and the BSC (Balanced Score Card) analysis, can be used to identify an organization's strategic needs, none provides a direct mechanism to prioritize the needs and convert them into operational processes or to then translate those processes into a specification that can be used to develop or acquire supportive software systems. In contrast to this, other analytical techniques such as Porter's (1985) [25] Value Chain Analysis (VCA), facilitate the analysis of processes within a company but do not provide an easy mechanism to link these to high-level business objectives. A business model is a theory that is continually being tested in the marketplace [26]. Therefore, a good business model remains essential to every organization, whether it is a new venture or an established player [27]. A business model describes the customers, products, sales channels and the revenue structure of an enterprise, the position of an enterprise within its value network and the nature of its business relationships, and the underlying economic logic of an enterprise [28-29]. Kagermann and Österle (2006) [28] predict that in future business model innovation is more important for business success than product innovation. The business model concept is not used consistently both in research and in business practice [15], [30] because the dynamic characteristics of a business model are difficult to predict, value networks are full of interdependencies, and such networks often display complex feedback dynamics [31-32]. A consistent method to analyze the structure, behaviour and the dynamics of a business model should allow to identify possible optimizations governing the business models, to assess the impact of innovative changes and to identify critical success factors before the changes are implemented within a particular environment. Various techniques are used to analyze individual characteristics or organizational effectiveness & strategies in a given environment like SWOT analysis, SWOC analysis, PEST analysis, McKinsey 7S framework, ICDT model, Portor's five force model etc. But there is a need for simple but systematic analyzing technique for business model's analysis. The paper is a discussion on a new technique namely ABCD analysing framework adopted for studying a given business model, business strategy, concept/idea or on a business system. ABCD is an acronym that stands for Advantages, Benefits, Constraints, and Disadvantages. Application of ABCD analysis results in an organized list of a business advantages, benefits, constraints, and disadvantages in a systematic matrix. This includes how various issues should be identified for models/concepts/systems based on a generalized framework and then how to derive a specific framework for either a business model or a concept or a system specifically. A general guideline is given on how to identify various factors affecting these determinant

issues based on the four constructs advantages, benefits, constraints and disadvantages. Finally, ABCD analysing framework is compared with other known business model frameworks like SWOT, **Competitive Profile Matrix (**CPM**)** analysis, EFE & IFE Matrices, BCG analysing frameworks, Porter's Five Forces Model, and PESTLE Analysis. The entire framework is divided under various issues/area of focus under various issues, deployment factors affecting the business/concept in terms of advantages, benefits, constraints, and disadvantages, and suitable critical effective elements. This analyzing technique being simple, gives guideline to identify and analyze the effectiveness of any business model and new concepts developed.

While applying ABCD framework for a system, one has to be careful in identifying major issues governing/ related to the system. The issues should all the dimensions such as organization, operation, administration, actors within the organization and dependent on the organization, the technology and the business environment. Once the issues for analysing are identified, the various factors affecting these issues have to be discovered through focus group discussion under four identified constructs advantages, benefits, constraints and disadvantages of ABCD framework. Finally, the constituent critical elements for each affecting factor should be identified and listed under ABCD constructs. The importance of the system/model/concept can be discussed based on comparing constructs which is based on analyzing the factors affecting in each construct. Weightage to each factor affecting various constructs can be given based on importance of identified constituent critical elements. By comparing the weightage, one can decide the usefulness of the system/ model/concept.

8.3 LITERATURE REVIEW ON ABCD FRAMEWORK :

Recently, Aithal P.S. et. al. (2015) [33] developed ABCD analyzing framework to analyze any business model/strategy/concept/system and to study its effectiveness in providing value to its stake holders and sustainable profit through expected revenue generation. Application of ABCD analysis results in an organized list of a business advantages, benefits, constraints, and disadvantages in a systematic matrix. The entire framework is divided under various issues/area of focus and various business deployment factors affecting the business/concept can be identified and analyzed under each issue by identifying suitable critical effective element. This analyzing technique being simple, gives guideline to identify and analyze the effectiveness of any business model, business strategy, business concept/idea, and business system.

Reshma et. al. (2015) [34-35], have analyzed the characteristics of "Working from Home" e-business model using ‘ABCD Analysis Technique'. Based on various factors which decides the Working from Home system, a model of various factors and their constituent critical elements

affecting under organizational objectives, employers' point of view, employees' point of view, customers/students point of view, environmental/societal point of view and system requirements are derived by a qualitative data collection instrument namely focus group method. It is found that the factors supporting advantages and benefits are more effective compare to constraints and disadvantages of this model, so that working from home model may become more popular from the prospective of employers and employees in the organization in the future.

ABCD analysis framework have been used for analysis of a business strategy called 'Black ocean strategy' [36-37]. The advantages, benefits, constraints, and disadvantages of black ocean strategy on organizational issues, administrative issues, employee's issues, business issues, external environmental issues and operational issues for an organization are identified and analyzed by identifying various affecting factors and their constituent critical elements.

ABCD analysis framework was used for analysis of NAAC Accreditation System [38]. The advantages, benefits, constraints, and disadvantages of NAAC Accreditation System on organizational issues, Faculty performance Issues, Students development/ progression Issues, Social/Environmental/Community engagement issues, Infrastructure and Learning resources issues, and strategic issues like Innovations Creativity and Best Practices are identified and analyzed by identifying various affecting factors and their constituent critical elements.

ABCD analysis framework has been used for analysis of a concept "Higher Education Stage Model". The characteristics of the concept are evaluated based on identifying and analyzing the advantages, benefits, constraints, and disadvantages. The result supported the logic of using ABCD analyzing technique in any concept/idea performance evaluation [39-40].

8.4 STRUCTURE OF ABCD ANALYSIS FRAMEWORK :

Advantages, Benefits, Constraints and Disadvantages (ABCD) of a System can be used to analyze and understand the model/system in an effective way. As per this analysis technique [33], the effectiveness of a business model/strategy/ concept/system can be studied by identifying and analyzing the advantages, benefits, constraints, and disadvantages of various affecting factors by considering various determinant issues as shown in fig. 8.1. The various factors contributing under the four identified constructs like advantages, benefits, constraints, and disadvantages are derived by a qualitative data collection instrument namely focus group method [41-42], and the constituent critical elements supporting these factors are identified.

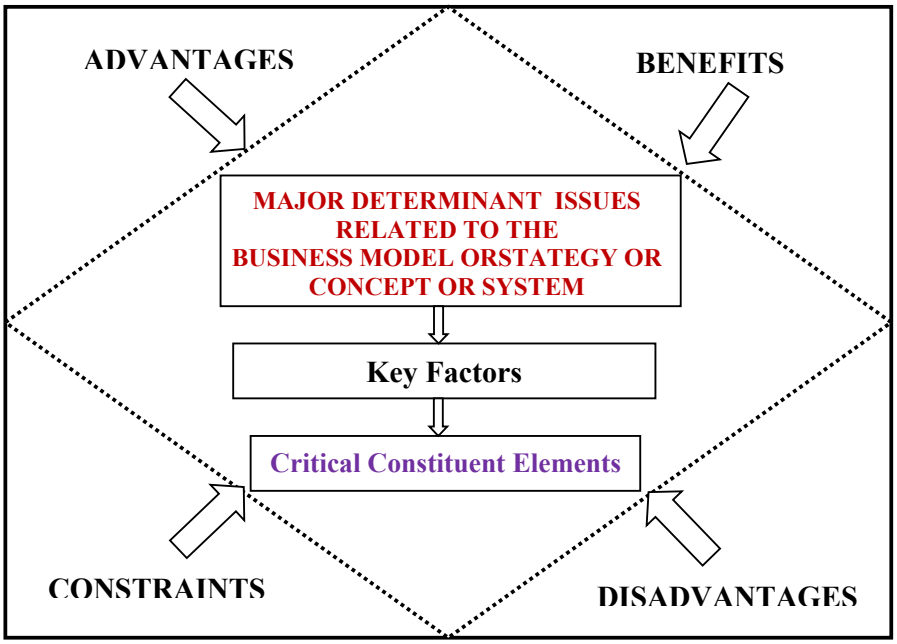

Fig. 8.1 : Block diagram of issues affecting the Business model, or Concept or System as per ABCD framework.

(a) Determinant Issues to be Identified :

(i) For Business Models

Followings may be the determinants of a general business model :

1. Organizational Issues
2. Operational Issues
3. Employees Issues
4. Administrative issues
5. Customers Issues
6. Technological issues
7. Strategic Issues
8. Environmental & Social issues etc.

(ii) For Business Strategy

Followings may be the determinants of a general business strategy :

1. Organizational Issues
2. Business Issues
3. Operational Issues
4. Stakeholders Issues
5. Administrative issues

6. Users/customers Issues
7. Technological Issues
8. Environmental & Social Issues
9. Financial Issues etc.

(iii) For Operating Concepts/Ideas

Followings may be the determinants of a general business ideas/operating concepts :

1. Organizational Issues
2. Business Issues
3. Idea Implementation Issues
4. Operational Issues
5. Stakeholders Issues
6. Administrative issues
7. Users Issues
8. Technological issues
9. Environmental & Social issues etc.

(iv) For Business/functional Systems

Followings may be the determinants of a general business/functional systems :

1. System Requirement Issues
2. Operational Issues
3. Input Issues
4. Output Issues
5. Performance Issues
6. Users Issues
7. Technological Issues
8. Environmental & Social Issues
9. Issues on Innovative Processes etc.

(b) Finding Factors Affecting:

After finalizing the "determinant issues" of the business model/strategy/concept/system for analysis, the various affecting factors for each determinant issue should be determined based on focus group method under all the four ABCD constructs of this model : advantages, benefits, constraints, and disadvantages. The result can be listed as suitable tables for each issue with affecting factors for each construct. The various possible affecting factors for different chosen determinant issues for given business model/strategy/concept/system are listed in Table 8.1.

Table 8.1 : List of determinant issues and their possible affecting factors

S. No.	Determinant Issues	Affecting factors
1	Organizational issues	Organisational policy, procedure, structure, rules, regulation, goals, vision, mission, objectives, values, long term strategy, short term strategy, risk, innovation, sustainability and organisational culture.
2	Operational issues	Structure, systems, processes, policies, alignment, investment, infrastructure, resources. Quality issues, control & management issues, work culture issues, wastages and delay issues.
3	Employees issues	Attracting talented workforce, retaining workforce, motivating employees, developing and training the work force, maintaining performance standards, diversified employees, motivated work force, learning work culture, HR, policy, procedure and strategy.
4	Administrative issues	Rules, regulation, procedure, resources, infrastructure, easy of transaction, documentation, cost & expenditure incurred time keeping, law enforcement, governance etc.
5	Customer issues	Demographic details, consumption patterns, changes, products, services, pricing promotion, customer delight, customer service, loyalty, contentment, customer grievance handling etc.
6	Technological issues	Research latest technology, up gradation, integration issues, back-up and disaster, recovery challenges, security risks, strategic IT planning, technological change, cost and investment issues with technology, user friendliness etc.
7	Strategic issues	Affecting factors for Strategic issues include factors related to firm's corporate strategy, organizational strategy, operating strategy, competitive strategies or monopoly strategies, brand-building strategies, marketing strategies, growth strategies etc.
8	Environmental & social issues	Strategy, values, ethics, risk & risk oversight, financial performance, external reporting, reliability of information, stake holder relations, consideration of nature & environment, environmental citizenship.
9	Business issues	Nature of business, scope of business, business objectives, leadership, culture, values and ethics in business, system, style and structure.
10	Stakeholder issues	customer's employees, suppliers, vendor relationships, shareholders, the public and society, law, regulation, business code, brand, safety and quality considerations.
11	User issues	Easy of understanding, Flexibility, ecofriendly, procedures, quality, time, and cost consideration.
12	Input issues	Resources, land, labor, capital, technology, Assets, data and information, money, Skill, Know –how, machinery etc.

13	Issues on innovative processes	Profitability, costs, efficiency, productivity, employee job satisfaction, customer satisfaction, learning culture, risk taking behavior,out of the box thinking etc.

As per ABCD analysis framework, all these affecting factors should be categorized under advantages, benefits, constraints and disadvantages. Each factor of above determinant issues includes constituent critical elements which vary depending on person who analyze the model.

(c) Identifying Constituent Critical Elements :

As per ABCD analysis framework, all these affecting factors should be categorized under advantages, benefits, constraints and disadvantages. Each factor of above determinant issues includes constituent critical elements which vary depending on person who analyze the model. Constituent critical elements (CCE) are those characteristics, conditions, or variables which when maintained and sustained, can have significant impact on the factor affecting that particular determinant issue.The critical constituent elements can be tabulated for affecting factors for all four constructs : advantages, benefits, constraints and disadvantages as separate tables.

8.5 ADVANCED ABCD ANALYSIS :

At the most, ABCD analysis is qualitative and considered to be only a reference to further quantitative analysis. Based on "prioritization of factors" we can further improve the analysis method as advanced ABCD analysing technique. An advanced ABCD goes a step further to make it quantitative.

In a simple ABCD, advantages and disadvantages or benefits and constraints are equal to each other therefore a minor disadvantage can balance a major advantage. Without prioritization, some factors might be given too much or too little emphasis and the most relevant factors might simply be overlooked. The aim of advanced ABCDis to identify the most significant factors of the analysis from all the items listed on it. How to perform it?

Step 1. Identify the various issues.

Step 2 Identify various factors affecting on these issues under the constructs advantages, benefits, constraints, and disadvantages.

Step 3. Prioritize the factors affecting by evaluating importance, weightage and score.

While Prioritizing the factors and the constitutional critical elements, the factors affecting under advantages, benefits, constraints, and disadvantages are evaluated on 3 categories:

- **Importance**. Importance shows how important is a construct for the identified determinant issue. For a given analysis, either advantage, or benefit or constraint or disadvantage may be

more important than others. A number from 0.01 (not important) to 1.0 (very important) should be assigned to each construct. The sum of all weights should equal 1.0 (including all four constructs).

- **Rating**. A score from 1 to 3 is given to each factor to indicate whether it is a major (3) or a minor (1) construct. The same rating should be assigned to all the constructs where 1 would mean a low priority to the construct and 3 a high priority to the construct.
- **Score**. Score is a result of importance multiplied by rating. It allows prioritizing the constructs. The researcher should rely on the most important advantages and benefits and try to convert the constraints and disadvantages in to the opportunities.

Their evaluation includes:

- **Importance**. It shows to what extent the external factor might impact the business model/strategy/concept/system. Again, the numbers from 0.01 (no impact) to 1.0 (very high impact) should be assigned to each item. The sum of all weights should equal 1.0.
- **Probability**. Probability of occurrence is showing how likely the opportunity or threat will have any impact on business model/strategy/concept/system. It should be rated from 1 (low probability) to 3 (high probability).
- **Score**. Importance multiplied by probability will give a score by which the researcher must be able to prioritize the affecting factors. The researcher should pay attention to the factors having the highest score and ignore the factors that will not likely affect the business model/strategy/concept/system.

8.6 ABCD ANALYSIS IN EXPLORATORY RESEARCH :

Exploratory research is research conducted for a problem that has not been clearly defined. It often occurs before we know enough to make conceptual distinctions or posit an explanatory relationship [43]. Exploratory research helps determine the best research design, data collection method and selection of subjects. It should draw definitive conclusions only with extreme caution. Given its fundamental nature, exploratory research often concludes that a perceived problem does not actually exist. Exploratory research often relies on secondary research such as reviewing available literature and/or data, or qualitative approaches such as informal discussions with consumers, employees, management or competitors, and more formal approaches through in-depth interviews, focus groups, projective methods, case studies or pilot studies. The Internet allows for research methods that are more interactive in nature. For example, RSS feeds efficiently supply researchers with up-to-date information; major search engine search results may be sent by email to researchers by services such

as Google Alerts; comprehensive search results are tracked over lengthy periods of time by services such as Google Trends; and websites may be created to attract worldwide feedback on any subject. Exploratory research investigates into a problem or situation which provides insights to the researcher. The research is meant to provide details where a small amount of information exists. It may use a variety of methods such as trial studies, interviews, group discussions, experiments, or other tactics for the purpose of gaining information. When the purpose of research is to gain familiarity with a phenomenon or acquire new insight into it in order to formulate a more precise problem or develop hypothesis, the exploratory studies (also known as formulative research) come in handy. If the theory happens to be too general or too specific, a hypothesis cannot be formulated. Therefore an exploratory research helps to gain experience that will be helpful in formulative relevant hypothesis for more definite investigation as suggested by Sue Greener, JoeMartelli (2015) [44].

ABCD analysis framework supports exploratory research by identifying various affecting factors under different constructs and identifying constituent critical elements using a suitable method out of the available methods such as trial studies, interviews, group discussions, focus group methods, experiments, or other tactics for the purpose of gaining information. The information gathered can be used for prioritizing the factors and the constituent critical elements.

8.7 ABCD ANALYSIS IN EMPIRICAL RESEARCH :

Empirical research is research using empirical evidence. It is a way of gaining knowledge by means of direct and indirect observation or experience. Empiricism values such research more than other kinds. Empirical evidence (the record of one's direct observations or experiences) can be analyzed quantitatively or qualitatively. Through quantifying the evidence or making sense of it in qualitative form, a researcher can answer empirical questions, which should be clearly defined and answerable with the evidence collected (usually called data). Research design varies by field and by the question being investigated. Many researchers combine qualitative and quantitative forms of analysis to better answer questions which cannot be studied in laboratory settings, particularly in the social sciences and in education. The word empirical means information gained by experience, observation, or experiment. The central theme in scientific method is that all evidence must be empirical which means it is based on evidence. In scientific method the word "empirical" refers to the use of working hypothesis that can be tested using observation and experiment. Empirical research is based on observed and

measured phenomena and derives knowledge from actual experience rather than from theory or belief. Key characteristics to look for :

- Statement about the methodology being used.
- Research questions to be answered.
- Definition of the group or phenomena being studied.
- Process used to study this group or phenomena, including any controls or instruments such as tests or surveys.

ABCD analysis framework supports empirical research by developing a methodology to identify working hypothesis that can be tested either by using observation and experiment or through a suitable instrument such as tests or surveys, to collect the data and to find the relationship between the constituent critical elements and the corresponding affecting factors under different constructs for each identified issue. By analyzing the Business model/strategy/concept/system, one can develop a research model to prioritize the factors and the constituent critical elements.

8.8 COMPARISON OF ABCD FRAMEWORK WITH OTHER ANALYSIS TOOLS :

(a) ABCD and SWOT :

SWOT analysis is a framework that allows managers to synthesize insights obtained from an internal analysis of the company's strengths and weaknesses with those from an analysis of external opportunities and threats. Strengths are those factors that give an edge for the company over its competitors. Weaknesses are those factors that can be harmful if used against the firm by its competitors. Opportunities are favourable situations which can bring a competitive advantage. Threats are unfavourable situations which can negatively affect the business. The comparison of ABCD analysing framework and SWOT analysing framework is given in table 8.2.

Table 8.2 : Comparison of ABCD and SWOT analysing frameworks.

S. No.	ABCD Analysis Framework	SWOT Analysis Framework
1	ABCD is a mnemonic denoted A for Advantages, B for Benefits, C for Constraints, and D for disadvantages.	SWOT is a mnemonic denoted S for Strength, W for Weakness, O for Opportunities, and T for Threats.
2	Used as a tool for analysing business models, operating concepts/ideas, business strategies, business/ functional systems.	Used as a tool by organizations and individuals to know their ability of doing their business by knowing internal and external factors which have, or may have, an impact on business.

3	The framework contains various factors different determinant issues under four constructs advantages, benefits, constraints and disadvantages and then identifying constituent critical elements.	The framework allows managers to synthesize insights obtained from an internal analysis of the company's strengths and weaknesses with those from an analysis of external opportunities and threats.
4	Constituent critical elements(CCE) are those characteristics, conditions, or variables which when maintained and sustained, can have significant impact on the factor affecting that particular determinant issue.	SWOT can be done by one person or a group of members that are directly responsible for the situation assessment in the company. Basic swot analysis is done fairly easily and comprises of only few steps: Step 1. Listing the firm's key strengths and weaknesses. Step 2. Identifying opportunities and threats.
5	Each of the factors may be different to different kinds of Determinant issues for business models, operating concepts/ideas, business strategies, business/functional systems.	SWOT is widely accepted tool due to its simplicity and value of focusing on the key issues which affect the firm. The aim of swot is to identify the strengths and weaknesses that are relevant in meeting opportunities and threats in particular situation.
6	It is possible to classify an affecting factor under advantage, disadvantage, benefit, or constraints easily.	It is hard to tell if a characteristic is a strength (weakness) or not. *For example*, firm's organizational structure can be a strength, a weakness or neither!
7	Can be used for quantitative study through prioritization of factors and constituent critical elements.	Can be used for quantitative study through prioritization of factors by identifying importance, giving ratings and calculating the score of strengths and weaknesses. Opportunities and threats are prioritized slightly differently by identifying importance, probability and score.

(b) ABCD and CPM :

Competitive Profile Matrix (CPM) analysis is a framework tool that compares the firm and its rivals and reveals their relative strengths and weaknesses. In order to better understand the external environment and the competition in a particular industry, firms often use CPM. The comparison of ABCD analysing framework and CPM analysing framework is given in table 8.3.

Table 8.3 : Comparison of ABCD and CPM analysing frameworks.

S. No.	ABCD Analysis Framework	CPM Analysis Framework
1	ABCD is a mnemonic denoted A for Advantages, B for Benefits, C for Constraints, and D for disadvantages.	**Competitive Profile Matrix** (CPM) analysis compares the firm and its rivals and reveals their relative strengths and weaknesses.

2	Used as a tool for analysing business models, operating concepts/ideas, business strategies, business/functional systems.	The matrix identifies a firm's key competitors and compares them using industry's critical success factors.
3	The framework contains various factors affecting different determinant issues under four constructs advantages, benefits, constraints and disadvantages and then identifying constituent critical elements.	The analysis reveals company's relative strengths and weaknesses against its competitors, so a company would know, which areas it should improve and, which areas to protect.
4	Constituent critical elements(CCE) are those characteristics, conditions, or variables which when maintained and sustained, can have significant impact on the factor affecting that particular determinant issue.	Critical success factors (CSF) are the key areasvary between different industries or even strategic groups and include both internal and external factors.
5	Each of the factors may be different to different kinds of Determinant issues for business models, operating concepts/ideas, business strategies, business/functional systems.	The more critical success factors are included the more robust and accurate the analysis is.
6	Can be used for quantitative study through prioritization of factors and constituent critical elements.	Can be used for quantitative study through Prioritization. Each critical success factor is given weightage and factors are rated. Score is calculated by multiplying weight and rating.

(c) ABCD and EFE & IFE Matrices :

The internal and external factor evaluation matrices have been introduced by Fred R. David in his book 'Strategic Management [45, 33]. Internal Factor Evaluation (IFE) Matrix is a strategy tool used to evaluate firm's internal environment and to reveal its strengths as well as weaknesses. External Factor Evaluation (EFE) Matrix is a strategy tool used to examine company's external environment and to identify the available opportunities and threats. The comparison of ABCD analysing framework and CPM analysing framework is given in table 8.4.

Table 8.4 : Comparison of ABCD and EFE & IFE Matrix frameworks.

S. No.	ABCD Analysis Framework	EFE & IFE Matrices Analysis Framework
1	ABCD is a mnemonic denoted A for Advantages, B for Benefits, C for Constraints, and D for disadvantages.	Internal Factor Evaluation (IFE) Matrix is a strategy tool used to evaluate firm's internal environment and to reveal its strengths as well as weaknesses. External Factor Evaluation (EFE) Matrix is a strategy tool used to examine company's

		external environment and to identify the available opportunities and threats.
2	Used as a tool for analysing business models, operating concepts/ideas, business strategies, business/functional systems.	Both tools are used to summarize the information gained from company's external and internal environment analyses. The summarized information is evaluated and used for further purposes, such as, to build SWOT analysis or IE matrix.
3	The framework contains various factors affecting different determinant issues under four constructs advantages, benefits, constraints and disadvantages and then identifying constituent critical elements.	Even though, the tools are quite simplistic, they do the best job possible in identifying and evaluating the key affecting factors.
4	Constituent critical elements (CCE) are those characteristics, conditions, or variables which when maintained and sustained, can have significant impact on the factor affecting that particular determinant issue.	When using the EFE matrix we identify the key external opportunities and threats that are affecting or might affect a company simply by analysing the external environment with the tools like PEST analysis, Porter's Five Forces, or Competitive Profile Matrix. When using the IFE matrix, Strengths and weaknesses are used as the key internal factors in the evaluation.
5	Each of the factors may be different to different kinds of Determinant issues for business models, operating concepts/ideas, business strategies, business/functional systems.	The general rule is to identify 10-20 key external factors and additional 10-20 key internal factors, but you should identify as many factors as possible.
6	Can be used for quantitative study through prioritization of factors and constituent critical elements.	Can be used for quantitative study through Prioritization of factors. Each key factor should be assigned a weight, rating, weighted scores & total weighted score.

(d) ABCD and BCG Matrix :

BCG matrix (or growth-share matrix) is a corporate planning tool, which is used to portray firm's brand portfolio or SBUs on a quadrant along relative market share axis (horizontal axis) and speed of market growth (vertical axis) axis. BCG matrix is a framework created by Boston Consulting Group to evaluate the strategic position of the business brand portfolio and its potential. The comparison of ABCD analysing framework and BCG analysing framework is given in table 8.5.

Table 8.5 : Comparison of ABCD and BCG analysing frameworks.

S. No.	ABCD Analysis Framework	BCG Matrix Framework
1	ABCD is a mnemonic denoted A for Advantages, B for Benefits, C for Constraints, and D for disadvantages.	Boston Consulting Group's (BCG) growth-share matrix is a corporate planning tool, which is used to portray firm's brand portfolio in the form of a graph on a quadrant along relative market share axis (horizontal axis) and speed of market growth (vertical axis) axis.
2	Used as a tool for analysing business models, operating concepts/ideas, business strategies, business/functional systems.	Developed as a business tool, which uses relative market share and industry growth rate factors to evaluate the potential of business brand portfolio and suggest further investment strategies.
3	The framework contains determining various factors affecting under different determinant issues under four constructs advantages, benefits, constraints and disadvantages and then identifying constituent critical elements.	The framework is used to evaluate the strategic position of the business brand portfolio and its potential. It classifies business portfolio into four categories based on industry attractiveness (growth rate of that industry) and competitive position (relative market share). These two dimensions reveal likely profitability of the business portfolio in terms of cash needed to support that unit and cash generated by it.
4	Constituent critical elements (CCE) are those characteristics, conditions, or variables which when maintained and sustained, can have significant impact on the factor affecting that particular determinant issue.	The general purpose of the analysis is to help understand, which brands the firm should invest in and which ones should be divested.
5	Each of the factors may be different to different kinds of Determinant issues for business models, operating concepts/ideas, business strategies, business/functional systems.	There are four quadrants into which firms brands are classified: (1) Dogs hold low market share compared to competitors and operate in a slowly growing market. (2) Cash cows are the most profitable brands and should be "milked" to provide as much cash as possible. (3) Stars operate in high growth industries and maintain high market share. Stars are both cash generators and cash users. (4) Question marks are the brands that require much closer consideration.
6	Can be used for quantitative study through prioritization of factors and constituent critical elements.	Being a qualitative method can be used for finding proportion of business revenue generated by each brand.

(e) ABCD and Porter's Five Forces Model :

Porter's five forces model is an analysis tool that uses five forces to determine the profitability of an industry and shape a firm's competitive strategy [46]. It is a framework that classifies and analyzes the most important forces affecting the intensity of competition in an industry and its profitability level. These forces determine an industry structure and the level of competition in that industry. The stronger competitive forces in the industry are the less profitable it is. The comparison of ABCD analysing framework and BCG analysing framework is given in table 8.6.

Table 8.6 : Comparison of ABCD and Porter's Five Forces analysing frameworks.

S. No.	ABCD Analysis Framework	Porter Five Forces Analysis Framework
1	ABCD is a mnemonic denoted A for Advantages, B for Benefits, C for Constraints, and D for disadvantages.	The five forces model is an analysis tool that uses five forces to determine the profitability of an industry and shape a firm's competitive strategy.
2	Used as a tool for analysing business models, operating concepts/ideas, business strategies, business/functional systems.	The tool is very useful in formulating firm's strategy as it reveals how powerful each of the five key forces is in a particular industry.
3	The framework contains various factors affecting different determinant issues under four constructs advantages, benefits, constraints and disadvantages and then identifying constituent critical elements.	The framework that classifies and analyzes the most important forces affecting the intensity of competition in an industry and its profitability level. These forces determine an industry structure and the level of competition in that industry. The stronger competitive forces in the industry are the less profitable it is. An industry with low barriers to enter, having few buyers and suppliers but many substitute products and competitors will be seen as very competitive and thus, not so attractive due to its low profitability.
4	Constituent critical elements (CCE) are those characteristics, conditions, or variables which when maintained and sustained, can have significant impact on the factor affecting that particular determinant issue.	It is every strategist's job to evaluate company's competitive position in the industry and to identify what strengths or weakness can be exploited to strengthen that position. The tool is very useful in formulating firm's strategy as it reveals how powerful each of the five key forces is in a particular industry.

5	Each of the factors may be different to different kinds of Determinant issues for business models, operating concepts/ideas, business strategies, business/functional systems.	Porter's five forces framework is used to analyze industry's competitive forces and to shape organization's strategy using 4 steps : (1) Gather the information on each of the five forces. (2) Analyze the results and display them on a diagram. (3) Formulate strategies based on the conclusions.
6	Can be used for quantitative study through prioritization of factors and constituent critical elements.	Used as qualitative tool to analyze industry's structure and use the results to formulate firm's strategy, it has its limitations and requires further analysis to be done, such as SWOT, PEST or Value Chain analysis.

(f) ABCD and PESTLE Analysis :

PESTLE analysis, which is sometimes referred as **PEST analysis,** is a concept in marketing principles. This concept is used as a tool by companies to track the environment they're operating in or are planning to launch a new project/product/service etc. The comparison of ABCD analysing framework and PESTLE analysing framework is given in table 8.7.

Table 8.7 : Comparison of ABCD and PESTLE analysing frameworks.

S. No.	ABCD Analysis Framework	PESTLE Analysis Framework
1	ABCD is a mnemonic denoted A for Advantages, B for Benefits, C for Constraints, and D for disadvantages.	PESTLE is a mnemonic which in its expanded form denotes P for Political, E for Economic, S for Social, T for Technological, L for Legal and E for Environmental.
2	Used as a tool for analysing business models, operating concepts/ideas, business strategies, business/functional systems.	Used as a tool by companies to track the environment they're operating in or are planning to launch a new project/product/service etc.
3	The framework contains various factors affecting different determinant issues under four constructs advantages, benefits, constraints and disadvantages and then identifying constituent critical elements.	The framework gives a bird's eye view of the whole environment from many different angles that one wants to check and keep a track of while contemplating on a certain idea/plan.
4	Constituent critical elements (CCE) are those characteristics, conditions, or variables which when maintained and sustained, can have significant impact on the factor affecting that particular determinant issue.	There are certain questions that one needs to ask while conducting this **analysis**, which give them an idea of what things to keep in mind.

5	Each of the factors may be different to different kinds of Determinant issues for business models, operating concepts/ideas, business strategies, business/functional systems.	Each of the factors may be different to different kinds of industries, but it is imperative to any strategy a company wants to develop that they conduct the PESTLE analysis as it forms a much more comprehensive version of the SWOT analysis.
6	Can be used for quantitative study through prioritization of factors and constituent critical elements.	Used for qualitative study on external environmental analysis of a company.

8.9 Factor & Elemental Analysis of Nanotechnology as Green Technology using ABCD Analysis :

The ABCD analysis framework is developed based on two features which include (1) factor analysis and (2) elemental analysis. In factor analysis part, various affecting factors under each determinant issue of the technology are identified for each construct as per a chosen attribute. These affecting factors are identified using the Focus group method. The constructs used in factor analysis are (i) Advantages, (ii) Benefits, (iii) Constraints, (iv) Disadvantages. In the elemental analysis, the critical constitutional elements of the technology are also identified for same determinant issues under same four constructs (i) Advantages, (ii) Benefits, (iii) Constraints, (iv) Disadvantages (ABCD). The scores are given to each critical constituent element under all four constructs and based on calculating overall scores the importance of technology and its constructs in solving both basic and advanced problems in the organization/society are determined and rated [47-59]. In qualitative analysis model, only the affecting factors are determined under same four constructs which is also called ABCD listing [60-71].

8.9.1. NANOTECHNOLOGY AS UNIVERSAL TECHNOLOGY :

It is known that many emerged technologies found their importance in more than one industry and sector. Such technologies used to create products, process, or services in many areas and to solve many problems or used in many applications in different areas of the society and named as general-purpose technology (GPT) [9]. There are many technologies which have shown such characteristics including those listed in table 8.8. But recently it is also seen that some of GPT's are grown in such a way that they found applications in solving both basic and advanced problems of the society. The two technologies identified in the 21st century are emerging to such category and hence can be called as universal technologies. They are Nanotechnology (NT) and Information Communication and Computation technology (ICCT). Some of

identified General Purpose technologies are listed in table 8.8 and the essential features of such universal technologies are listed in table 8.9.

Table 8.8 : Some of identified General Purpose technologies [9]

S. No.	Killer Technology	Spill over Effect	Era
1	Wheel	Mechanization	4000-3000 BC
2	Bronze	Tools & Weapons	2800 BC
3	Printing	Knowledge Economy	16th Century
4	Steam Engine	Industrial Revolution	18th Century
5	Electricity	Power generation & Usage	19th Century
6	Automobile	Long distance commuting & Transportation	20th Century
7	Airplane	International Travel & Transportation	20th Century
8	Telephone	Distance communication	20th Century
9	Television	Video communication	20th Century
10	Computer	Data Processing	20th Century
11	Internet	Data & Information Communication, E-business	20th Century
12	Mobile Communication	Ubiquitous communication	20Th Century
13	Biotechnology	Bio-engineering, Gene Therapy,	20th Century
14	Information Communication & Computation Technology (ICCT)	Ubiquitous computing & Communication	21st Century
15	Nanotechnology (NT)	Solutions to nutritious food, drinking water, renewable energy, Nanomedicine & Therapy	21st Century
16	Artificial Intelligence (AI)	Total automation	21st Century

Table 8. 9 : The essential features of Universal technologies

S. No.	Universal Technologies	Major Branches
1	Information Communication and Computation Technology (ICCT)	Audio & Video Communication
		Digital & Optical computation
		Internet
		Artificial Intelligence
		Big data and business Analytics
		Internet of Things
		Cloud Technology
		Digital Marketing
		3D Printing
		Virtual Reality
2	Nanotechnology (NT)	Nanobiotechnology
		Nanotechnology for Agricultural Research
		Nanotechnology for Potable water research
		Nanotechnology for Renewable research
		Nanotechnology for Space technology research
		Nanotechnology for Medicine
		Nano-pharmacology
		Nanoelectronics
		Nanophotonics
		Nanomechanics

8.9.2. NANOTECHNOLOGY AS GREEN TECHNOLOGY :

Green Technology (GT) can be used for environmental healing that reduces environmental damages created by the conventional industries in the society. It is expected that green technologies reduce the environmental degradation and supports to conserve natural resources. Green technologies are sustainable technologies which will not create a footprint when used for creating various products or processes. Green technologies support the use of natural

organic materials and hence do not contribute to produce green gasses which are responsible for environmental degradation. Since green technologies do not support environmental degradation and creating the footprint, they are sustainable and contributes to improve the lifestyle and comfortability of the people.

The nanotechnology emerging as universal technology is expected to solve both basic needs and comfort wants of human beings. The basic needs include food, drinking water, energy, cloth, shelter, health and environment, and the comfort wants are space travel, expanded lifespan etc. Planned and controlled development in nanotechnology leads to environmental sustainability and hence can be used as green technology. Some of the applications of nanotechnology initially thought as green technology are [79] :

- Clean, secure, affordable, renewable energy;
- Stronger, lighter, more durable recyclable materials;
- Low-cost filters to provide clean drinking water from seawater and drainage;
- Medical devices and drugs to detect and treat diseases more effectively with fewer or no side effects;
- Lighting that uses a fraction of the energy associated with conventional systems;
- Sensors to detect and identify harmful chemical and biological agents;
- Techniques to clean up harmful chemicals in the environment.
- Green building and sustainable infrastructure.
- Modified production processes to minimize green gas emission.

The green Nanotechnology is evolved as a general-purpose technology due to its applications in all areas of society and now further growing as universal technology. Hence in the advanced form of universal technology, it will have a significant impact on almost all industries and all areas of society by offering better built, longer lasting, cleaner, safer, and smarter products for the home, for communications, for medicine, for transportation, for agriculture, and for the industry in general. Thus, by controlled utilization of nanotechnology for environmental sustainability, it can be developed as a green technology for sustainable society. Due to its capability of cleaning of the environmental footprint of other technologies, nanotechnology can be used to enhance the environmental-sustainability of processes currently producing negative externalities. Further nanotechnology can be used to produce various products which can have enhanced environmental sustainability.

Green nanotechnology has two objectives :

(1) The first objective is of producing nanomaterials and fabricating nanoproducts which do not harm the environment and human health and producing nano-products which contribute to solve the environmental problems. It uses many existing principles of green science and green technology to remove the toxic ingredients of nanomaterials and nano-products used in various industries of the society [73].

(2) The second objective of green nanotechnology involves developing nanoproducts that are used to clean the environment either directly or indirectly. In the direct method, nanomaterials or nanoproducts can be used to clean hazardous waste sites, desalinate water, treatment of pollutants, or even sense and monitor any kind of environmental pollutants. In the indirect method, lightweight nanocomposites are used for fabricate automobile and spacecraft parts to save fuel and reduce materials used. Nanotechnology-enabled fuel cells, solar cells, and light-emitting diodes can reduce environmental pollution. Thus, nanotechnology can be used to green the environment for a long-time sustainability [73].

8.9.3 ABCD ANALYSIS OF NANOTECHNOLOGY :

The widespread growth of nanotechnology as green technology for various business processes can be analysed using many frameworks like SWOC, ABCD, and PESTLE. Out of them, ABCD framework is considered as most appropriate because, it uses many stakeholders as determinant issues. ABCD analysis framework is initially used to analyse systems, ideas, concepts, materials, strategies, and can be also used to analyse technology. Here, we are using ABCD framework to analyse nanotechnology as green technology by considering various determining issues like Organizational issues, Business issues, Consumers issues, Technological issues, Environmental issues, and Societal issues. Here, green technology features are considered as key attribute to identify the affecting factors under four constructs advantages, benefits, constraints, and disadvantages.

8.9.4. FACTOR ANALYSIS OF NANOTECHNOLOGY

The affecting factors under each construct, for identified key attributes for a chosen issue are obtained using focus group method and listed in table 8.10. The analysis identified five determinant issues related to nanotechnology as green technology. These include organizational issues, business issues, customer issues, environmental issues, and societal issues. The key attributes identified under organizational issues includes employees of the organizations, infrastructure of the organizations, and the investment of the organizations which involved in nanotechnology based green business. Similarly, the business issues contain four key attributes including products, markets, expansion, and competitors. The customers

issues contain four key attributes including quality, features, cost, and support. The Environmental Issues contain two key attributes environmental degradation and Environmental Improvement. Finally, the societal issues contain three key attributes including basic problems, advanced problems, and immortality as given in table 8.10. Totally, in this analysis 64 affecting factors are identified and listed under the constructs advantages, benefits, constraints, and disadvantages.

Table 8.10: Affecting factors of Nanotechnology as green technology under four constructs

Determinant Issues	Key Attributes	Advantages	Benefits	Constraints	Disadvantages
Organizational Issues	Employees	Skilled employees	Standard Quality	Difficulty in getting skilled employees	Cost of employees
	Infrastructure	Less infrastructure	Better return	New technology	Risk of new technology-based infrastructure investment
	Investment	New technology	High return	Higher investment	Risk for higher investment
Business Issues	Products	Nanoproducts can be green products	Clean environment	High production cost	May have hidden long term
	Markets	Easy due to special characteristics	Better business	Creating awareness	Initial Cost of creating awareness
	Competitors	Difficult to copy by competitors	Monopoly	New technology	Huge investment for research & development
	Expansion	Opportunity for expansion	Increased market share	Educating the collaborators	Copying by others
Consumer Issues	Quality	Optimum	Durability & renewable	Cost	May have side effects
	Features	Many	Comfortable life	Confused due to general purpose technology	Fear on Side effects
	Cost	Low pollutant	Helpful for poor people	Affordability	Difficulty in large scale operation
	Support	Low failure rate	Low maintenance cost	Frequent service	Minimum service support
Environmental Issues	Environmental degradation	Less environmental degradation	Less pollution	Complexity in the system	Prolonged technology breakthrough than expected
	Environmental Improvement	Cleaning	Better environment	Scaling	Negative effects if any

Social Issues	Basic problems	Can be solves optimally	All basic problems will be solved	Commercialization	Delay in realization
	Advanced problems	Can be solved optimally	All advanced problems for human comfortability will be solved.	Still in experimental level	Unpredictable adverse effects
	Immortality	Life span expansion	Slow aging / No aging	Slow research in nanotechnology	Negative aspects of immortality /deathlessness

8.9.5. ELEMENTAL ANALYSIS OF NANOTECHNOLOGY :

Apart from affecting factors identified in previous section through factor analysis framework, one can also carry out the elemental analysis to identify critical constituent elements for each affecting factor for chosen determinant issues. These critical constituent elements for the four constructs advantages, benefits, constraints, and disadvantages are listed in tables 8.11 to 8.14 respectively.

Table 8.11 : Advantages of Nanotechnology as Green technology

Particulars	Key Attributes	Factors Affecting	Critical Constituent Elements
Organizational Issues	Employees	Skilled employees	(i) Increased productivity (ii) Sophisticated facility (iii) More Jobs
	Infrastructure	Less infrastructure	(i) Small facilities (ii) Easy to manufacture (iii) Decreased cost
	Investment	New technology	(i) More initial investment (ii) New products (iii) New business
Business Issues	Products	Nanoproducts can be green products	(i) Low pollution (ii) Possibility to clean the environment (iii) Less side effects

	Marketing	Easy due to special characteristics	(i) Products have ideal characteristics (ii) Easy to market (iii) Many positive features
	Competitors	Difficult to copy by competitors	(i) Research for development (ii) Patented protection (iii) Uniqueness
	Expansion	Opportunity for expansion	(i) Global expansion opportunity (ii) Opportunity for cost leader (iii) Opportunity for collaboration
Consumer Issues	Quality	Optimum	(i) Ideal products (ii) Expected quality (iii) Durability
	Features	Many	(i) Green products (ii) Small & light in weight products (iii) Strong products
	Cost	Low pollutant	(i) Moderate cost-pollution ratio (ii) Controlling the pollution (iii) Low cost high durability
	Support	Low failure rate	(i) Durability (ii) No frequent replacement (iii) More operation period
Environmental Issues	Environmental degradation	Less environmental degradation	(i) No contribution to pollution (ii) Improving environment (iii) Quality environment for future generations
	Environmental Improvement	Cleaning of environment	(i) Possibility to clean environment

			(ii) Possibility to green the environment (iii) Improved products usage
Social Issues	Basic problems	Can be solves optimally	(i) Optimum to ideal solutions (ii) Opportunity to solve basic problems
	Advanced problems	Can be solved optimally	(i) People can live comfortable life (ii) Life is going to be easy (iii) Equality for everyone
	Immortality	Life span expansion	(i) Disease control (ii) Health equality (iii) Enhanced time for achievements

Table 8. 12 : Benefits of Nanotechnology as Green technology

Particulars	Key Attributes	Factors Affecting	Critical Constituent Elements
Organizational Issues	Employees	Standard Quality	(i) Increased return (ii) Improved working conditions (iii) More salary
	Infrastructure	Better return	(i) Increased profit (ii) Sustainability (iii) Further investment opportunity
	Investment	High return	(i) More profit (ii) More return to stakeholders (iii) Expansion to other areas
Business Issues	Products	Clean environment	(i) Less pollution (ii) Good health (iii) Clean resources

	Marketing	Better business	(i) Business growth (ii) Attractive products (iii) More sales
	Competitors	Monopoly	(i) High tech products (ii) Patenting opportunity (iii) Enhanced earning
	Expansion	Increased market share	(i) More branches (ii) More subsidiaries (iii) More products for different problems
Consumer Issues	Quality	Durability & renewable	(i) No environmental pollution (ii) Clean products (iii) Trouble free operations
	Features	Comfortable life	(i) More essential features (ii) Need based support (iii) Availability of essential components
	Cost	Helpful for poor people	(i) Low cost (ii) Improved quality of life (iii) Abundantly available
	Support	Low maintenance cost	(i) Quality products (ii) Self-repairing technology (iii) Product replacement opportunity
Environmental Issues	Environmental degradation	Less pollution	(i) Clean environment (ii) Green environment (iii) Better living conditions
	Environmental Improvement	Better environment	(i) Comfortable life

			(ii) Health improvement (iii) Less diseases
Societal Issues	Basic problems	All basic problems will be solved	(i) Abundancy in food, water and energy (ii) Progressed civilization (iii) Improved living conditions
	Advanced problems	All advanced problems for human comfortability will be solved.	(i)Self-sufficiency in Resources usage (ii) Decreased social differences (iii) Opportunities for everybody
	Immortality	Slow aging / No aging	(i) No diseases (ii) Automatic curing of diseases (iii) Expanded lifespan

Table 8.13 : Constraints of Nanotechnology as Green technology

Particulars	Key Attributes	Factors Affecting	Critical Constituent Elements
Organizational Issues	Employees	Difficulty in getting skilled employees	(i) Essential Technology education (ii) Continuous Research & training (iii) Advanced skills
	Infrastructure	New technology	(i) Investment for new technology infrastructure (ii) Continuous upgradation (iii) Frequent upgradation
	Investment	Higher investment	(i) Investment for survival (ii) Investment for sustainability (iii) Investment for monopoly
Business Issues	Products	High production cost	(i) Due to spreading of commercialization cost on production

			(ii) Due to complex technology (iii) Due to advanced features
	Marketing	Creating awareness	(i) Training to create awareness (ii) Acceptability of people (iii) Education level of people
	Competitors	New technology	(i) Enhanced competition due to new entrants (ii) Flood of resources initially due to high expectation (iii) Completion by existing business organizations
	Expansion	Educating the collaborators	(i) Importance and easiness of technology (ii) Product features (iii) Investment by collaborators
Consumer Issues	Quality	Cost	(i) Return on price (ii) Procrastination in usage (iii) Doubt on expected benefits
	Features	Confused due to general purpose technology	(i) Expected solutions in all areas of society (ii) Sustainability is a question (iii) Questions on side effects
	Cost	Affordability	(i) New technology is costly (ii) New technology is challenging (iii) New technology is difficult accept.
	Support	Frequent service	(i) New and hence less penetration (ii) Less service centres initially (iii) Services may be costly due to shortage of skilled people

Environmental Issues	Environmental degradation	Complexity of the system	(i) Controlling the emission of green gases is difficult process (ii) Monitoring and controlling the pollution is difficult (iii) Industrial environmental pollution is difficult to control
	Environmental Improvement	Scaling	(i) Large scale cleaning is difficult throughout the globe. (ii) Maintenance of cleaned environment is a challenge in terms of energy requirement (iii) All countries should involve in the process.
Social Issues	Basic problems	Commercialization	(i) Commercialization of new technology is risky (ii) Commercialization of new technology is difficult (iii) Commercialization of new technology is costly.
	Advanced problems	Still in experimental level	(i) Acceptance of new technology by people. (ii) Technology penetration is slow. (iii) Side effects are yet to know.
	Immortality	Slow research in nanotechnology	(i) Uncertainty in anticipated results (ii) Research laboratory results are difficult to commercialize in expected time frame (iii) Anticipated negative implications on immortality.

Table 8.14 : Disadvantages of Nanotechnology as Green technology

Particulars	Key Attributes	Factors Affecting	Critical Constituent Elements
	Employees	Cost of employees	(i) Technically trained employees are costly.

Organizational Issues			(ii) Increase in employee turnover. (iii) Employees have high bargain power.
	Infrastructure	Risk of new technology-based infrastructure investment	(i) Infrastructure investment risk (ii) Infrastructure modification (iii) Uncertainty in infrastructure investment
	Investment	Risk for higher investment	(i) New technologies are slow penetrating (ii) People acceptance is difficult. (iii) Technologies which are initially promising may be prohibitively costly.
Business Issues	Products	May have hidden long term affects	(i) Side effects (ii) Fail to achieve goal (iii) Product features & promotions.
	Marketing	Initial Cost of creating awareness	(i) New brand building cost (ii) Challenge of creating awareness for new products. (iii) Challenge on product performance.
	Competitors	Huge investment for research & development	(i) Initial cost. (ii) Availing patent protection. (iii) Technology management
	Expansion	Copying by others	(i) Patent time (ii) Outsourcing (iii) Starting foreign subsidiaries
	Quality	May have side effects	(i) Minimizing side effects (ii) Precautioning during use

Consumer Issues			(iii) Quality control
	Features	Fear on side effects	(i) Check for branded products. (ii) Quality control through sufficient clinical trails (iii) Precaution during use.
	Cost	Difficulty in large scale operation	(i) Investment cost (ii) Maintenance cost (iii) Resource cost
	Support	Minimum service support	(i) After sales service (ii) Promised quality monitoring (iii) Feedback
Environmental Issues	Environmental degradation	Prolonged technology breakthrough time than expected	(i) Waiting for breakthrough (ii) Govt. involvement (iii) Stringent rules
	Environmental Improvement	Negative effects if any	(i) Environmental side effects (ii) Cost of environmental improvement (iii) Disputes in countries responsibilities
Social Issues	Basic problems	Delay in realization	(i) Long time problems are difficult to tackle. (ii) Delay in patent acceptance (iii) Delay in availing finance for investments
	Advanced problems	Unpredictable adverse effects	(i) Fear in adopting new technology (ii) Sometimes predictions may not work. (iii) Global regulations may hider firm's performance.

	Immortality	Negative aspects of immortality /deathlessness	(i) Aging (ii) Antiaging (iii) Stagnated growth & challenges.

8.10 Conclusion :

The paper contains discussions on how to use ABCD analysing framework on a given business model, or on a business strategy or on a Concept/idea or on a business system. This includes how various issues should be identified for models/strategy/concepts/systems based on a generalized framework and then how to derive a specific framework for either a business model or a concept or a system specifically. A general guideline is developed on how to identify various factors affecting based on the four constructs : advantages, benefits, constraints and disadvantages. Finally, ABCD analysing framework is compared with other known business model frameworks like SWOT, **Competitive Profile Matrix (**CPM**)** analysis, EFE & IFE Matrices, BCG analysing frameworks, Porter's Five Forces Model, and PESTLE Analysis.Based on "prioritization of factors" and calculating the scores, we can further improve the analysis method and named it as advanced ABCD analysing technique. An advanced ABCD goes a step further to make it quantitative. The possibility of using ABCD analysis framework for exploratory research and empirical research are also discussed.

In this paper, we have analysed the Nanotechnology as green technology using ABCD analysis framework. 64 affecting factors of nanotechnology as green technology and 192 critical constituent elements are identified in the analysis under the four constructs advantages, benefits, constraints, and disadvantages. Thus, nanotechnology as a technology for sustaining and improving green environment has many opportunities and challenges to solve organizational problems, business problems, customers problems, environmental problems, and societal problems in order to change the life style and health of the human beings and hence considered as boon of human species to grow, expand, and enjoy the life without may varies in future days. Such interpretation of nanotechnology as a green technology through its affecting factors and critical constituent elements are going to interpret the consequences of this new technology favourable continuation of human life in this universe [74-76].

REFERENCES :

[1] Timmers, P. (1998). Business models for e-commerce, *Electronic Markets*, 8(2), 3-7.

[2] Rappa, M. (2001). Managing the digital enterprise - business models on the Web, *North Carolina State University Working Paper.*

[3] Pateli, A. G., Giaglis, G.M. (2004). A research framework for analysing e-Business models, *European Journal of Infor*mation Systems, 13(4), 302-314.

[4] Linder, J., Cantrell, S. (2000). Changing business models: Surveying the landscape, *Accenture Institute for Strategic Change Report.*

[5] Hamel, G. (2000). *Leading the revolution*, Harvard Business School Press, Boston.

[6] Gordijn, J., Akkermans, J. M., van Vliet, J.C. (2001). Designing and evaluating e-business models, *IEEE Intelligent Systems,* 16(4), 11-17.

[7] Afuah, A., Tucci, C. (2003). *Internet business models and strategies: Text and Cases*. McGraw-Hill, 2nd edition, Boston.

[8] Aithal, P. S., (2015). Concept of Ideal Business & Its Realization Using E-Business Model. *International Journal of Science and Research (IJSR)*, 4(3), 1267 – 1274. ISSN 2319-7064, DOI: http://doi.org/10.5281/zenodo.61648.

[9] Aithal, P. S. and Shubhrajyotsna Aithal (2018). Study of various General-Purpose Technologies and Their Comparison towards developing Sustainable Society. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, 3(2), 16-33.

[10] Aithal, P. S. (2016). Study on ABCD Analysis Technique for Business Models, Business strategies, Operating Concepts & Business Systems, *International Journal in Management and Social Science*, 4(1), 98-115. DOI :http://doi.org/10.5281/zenodo.161137.

[11] Aithal, P. S. and Suresh Kumar, P. M. (2015). Applying SWOC Analysis to an Institution of Higher Education. *International Journal of Management, IT and Engineering (IJMIE)*, 5(7), 231-247. DOI: http://doi.org/10.5281/zenodo.163425.

[12] Madhushree, L. M., Revathi, R., Anil Kumar, Aithal, P. S. (2018). Business Strategies of Top Indian IT Company: Mindtree. *International Journal of Case Studies in Business IT and Education (IJCSBE),* 2(1), 22-36. DOI: http://dx.doi.org/10.5281/zenedo.1249871.

[13] Aithal, P. S., Shailashree, V. T., Suresh Kumar, P. M. (2015). A New ABCD Technique to Analyze Business Models & Concepts, *International Journal of Management, IT and Engineering (IJMIE)*, 5(4), 409-423. DOI : http://doi.org/10.5281/zenodo.61652.

[14] Gupta, A. (2013). Environment & PEST analysis: an approach to external business environment. *International Journal of Modern Social Sciences*, *2*(1), 34-43.

[15] Aithal P. S. (2017). Impact of Domestic, Foreign, and Global Environments on International Business Decisions of Multinational Firms: A Systematic Study. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, 2(2), 57-73. DOI: http://dx.doi.org/10.5281/zenodo.1067103.

[16] Aithal, P. S., Shailashree, V. T., & Suresh Kumar, P. M. (2015). Application of ABCD Analysis Model for Black Ocean Strategy. *International Journal of Applied Research (IJAR)*, 1(10), 331-337. DOI: http://doi.org/ 10.5281/zenodo.163424.

[17] Aithal, P. S., Shailashree, V. T., & Suresh Kumar P. M., (2016). ABCD analysis of Stage Model in Higher Education. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 11-24. DOI: http://doi.org/10.5 281/zenodo.154233.

[18] Aithal, P. S., Shailashree, V. T., & Suresh Kumar, P. M. (2016). Analysis of NAAC Accreditation System using ABCD framework. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 30-44. DOI: http://doi.org/10. 5281/zenodo.154272.

[19] Aithal, P. S., Shailashree, V. T., & Suresh Kumar, P. M. (2016). Application of ABCD Analysis Framework on Private University System in India. *International Journal of Management Sciences and Business Research (IJMSBR)*, 5(4), 159-170. DOI : http://doi.org/10.5281/zenodo.161111.

[20] Ballantyne, J., and Brignall S., (1994), *A Taxonomy of Performance Measurement Frameworks,* Research Paper 135, Warwick Business School.

[21] Wu, B. (1992). *Manufacturing Systems Design and Analysis,* Chapman and Hall, London.

[22] Lee S. F., and Ko, A. S. O., (2000). Building Balanced Scorecard with SWOT Analysis, and Implementing 'Sun Tzu's The Art of Business Management Strategies' on QFD Methodology. *Managerial Auditing Journal,* 15(1–2), 68–76.

[23] Kaplan, R., Norton, D., (1992). The Balanced Scorecard - Measures That Drive Performance. *Harvard Business Review*, Jan-Feb, pp 71-79.

[24] de Wit, B., and Meyer R., (1998), *Strategy, Process, Content and Context,* 2nd ed. Thomson Learning, London.

[25] Porter, M. E. (1985)., *Competitive Advantage: Creating and Sustaining Superior Performance.* New York: The Free Press.

[26] Magretta, J. (2003). What management is - How it works and why it's everyone's business. Profile Books, pp 44.

[27] Magretta, J. (2002). Why business models matter. Harvard Business Review 2002, pp 33-36.

[28] Kagermann, H. and Österle H. (2006). Geschäftsmodelle 2010 - Wie CEOs Unternehmen transformieren. Frankfurter Allgemeine Buch, pp 276.

[29] Müller-Stewens, G. and C. Lechner (2005). Strategisches Management – Wiestrategische Initiativenzum Wandelführen, Schä_er-Pöschel, pp 410.

[30] Hedman, J. and Kalling T., (2003), The business model concept: theoretical underpinnings and empirical illustrations. EJIS 12, pp. 49 - 52.

[31] Sterman, J. (2000). Business Dynamics. Wiley, pp 22.

[32] Warren, K. (2002). Competitive Strategy Dynamics. Wiley, pp 20.

[33] Aithal P. S, Shailashree V. T., Suresh Kumar P. M. (2015). A New ABCD Technique to Analyze Business Models & Concepts. *International Journal of Management, IT and Engineering (IJMIE)*, 5(4), 409 - 423.

[34] Reshma, Sridhar Acharya P., Aithal P. S. (2015). Information Technology Innovations in Office Management - A Case Study. *International Journal of Research & Development in Technology and Management Sciences*, 21(6), 35 - 53. DOI: http://doi.org/10.5281/zenodo.61636.

[35] Reshma, Aithal P. S., and Sridhar Acharya P. (2015). Relevance of On-line Office Administration through Working from Home in Future Education System. *International Journal of Application or Innovation in Engineering & Management (IJAIEM)*, 4(4), 345 - 355. DOI : http://doi.org/10.5281/zenodo.163882.

[36] Aithal P. S., Suresh Kumar P. M. (2015). Black Ocean Strategy - A Probe into a New type of Strategy used for Organizational Success. *GE International Journal of Management Research*, *3*(8), 45 - 65. DOI : http://doi.org/10.5281/zenodo.163423.

[37] Aithal, P. S., Shailashree V. T., & P.M. Suresh Kumar, (2015). Application of ABCD Analysis Model for Black Ocean Strategy. *International Journal of Applied Research (IJAR)*, 1(10), 331 - 337, DOI : http://doi.org/10.5281/zenodo.163424.

[38] Aithal, P. S., Shailashree, V. T. & Suresh Kumar, P. M. (2016). Analysis of NAAC Accreditation System using ABCD framework. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 30 - 44, DOI : http://doi.org/10.5281/zenodo.154272.

[39] Aithal P. S. & Suresh Kumar P. M., (2015). Enhancement of Graduate attributes in Higher Education Institutions through Stage Models. *IMPACT: International Journal of Research in Business Management*, 3, Issue 3, pp. 121 - 130, March 2015.

[40] Aithal, P. S., Shailashree, V. T. & Suresh Kumar, P. M. (2016). ABCD analysis of Stage Model in Higher Education. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 11-24, DOI : http://doi.org/10.5281/zenodo.154233.

[41] Rogers E.M. (1995). 'Diffusion of Innovation', The Free Press, NY.

[42] Morgan R. M., and Hunt S. D. (1994). The commitment-trust theory of relationship marketing. *Journal of Marketing*, 58, 20–38.

[43] Shields, Patricia and Rangarjan, N. (2013). A Playbook for Research Methods: Integrating Conceptual Frameworks and Project Management. Stillwater, OK: New Forums Press. See chapter Five for an extensive discussion of exploratory research.

[44] Sue Greener, Joe Martelli, An introduction to Business Research Methods, 2nd Ed. 2015, Bookboon.com.

[45] David, F. R. (2009). Strategic Management: Concepts and Cases. 12th ed. FT Prentice Hall.

[46] Porter, M.E. (2008). The Five Competitive Forces That Shape Strategy. Harvard Business Review. Available at: http://hbr.org/2008/01/the-five-competitive-forces-that-shape-strategy/

[47] Aithal, P. S., Shailashree, V. T., & Suresh Kumar, P. M. (2016). The Study of New National Institutional Ranking System using ABCD Framework. *International Journal of Current Research and Modern Education (IJCRME)*, *1*(1), 389–402. DOI : http://doi.org/10.5281/zenodo.161077.

[48] Aithal, S., & Aithal, P. S. (2016). ABCD analysis of Dye doped Polymers for Photonic Applications, IRA-International Journal of Applied Sciences, 4 (3), 358-378. DOI: http://dx.doi.org/10. 21013/j as.v4.n3.p1.

[49] Aithal, P. S., Shailashree, V. T. & Suresh Kumar, P. M., (2016). Analysis of ABC Model of Annual Research Productivity using ABCD Framework. *International Journal of Current Research and Modern Education (IJCRME)*, 1(1), 846-858. DOI :http://doi.org/10.5281/ zenodo.62022.

[50] Varun Shenoy, & Aithal P. S., (2016). ABCD Analysis of On-line Campus Placement Model, IRA-International Journal of Management & Social Sciences, 5(2), 227-244. DOI: http://dx.doi.org/10.21013/jmss .v5.n2.p3.

[51] Aithal, P. S., Shailashree V. T. & Suresh Kumar P.M. (2016). Factors & Elemental Analysis of Six Thinking Hats Technique using ABCD Framework. *International Journal of Advanced Trends in Engineering and Technology (IJATET),* 1(1), 85-95. DOI :http://doi.org/10.5281/zenodo.240259.

[52] Aithal, P. S. & Suresh Kumar, P. M. (2016). CCE Approach through ABCD Analysis of 'Theory A' on Organizational Performance. *International Journal of Current Research and Modern Education (IJCRME)* 1(1), 169-185. DOI: http://dx.doi.org/10. 5281/zenodo.164704**.**

[53] Aithal, P. S. (2017). ABCD Analysis of Recently Announced New Research Indices. *International Journal of Management, Technology, and Social Sciences (IJMTS),* 2(1), 65-76. DOI: http://doi.org/10.5281/ zenodo. 583644.

[54] Aithal, P. S. (2017). Factor Analysis based on ABCD Framework on Recently Announced New Research Indices, *International Journal of Management, Technology, and Social Sciences (IJMTS),* 1(1), 82-94. DOI: http://dx.doi.org/1 0.5281/zenodo.584105.

[55] Aithal, P. S., (2017). ABCD Analysis as Research Methodology in Company Case Studies. *International Journal of Management, Technology, and Social Sciences (IJMTS),* 2(2), 40-54. DOI: http://dx.doi.org/10.5 281/zenodo.891621.

[56] Aithal, Architha., Aithal, P. S. (2017). ABCD Analysis of Task Shifting-An optimum Alternative Solution to Professional Healthcare Personnel Shortage. *International Journal of Health Sciences and Pharmacy (IJHSP)*, 1(2), 36-51. DOI: http://dx.doi.org/10.5281/zenodo.1038975.

[57] Varun Shenoy & Aithal, P. S., (2017). Quantitative ABCD Analysis of IEDRA Model of Placement Determination. *International Journal of Case Studies in Business, IT and Education (IJCSBE),* 1(2), 103-113. DOI: http://dx.doi.org/10.5281/zenodo.1133691.

[58] Keerthan Raj, & Aithal, P. S. (2018). Generating Wealth at the Base of the Pyramid – A Study using ABCD Analysis Technique. *International Journal of Computational Research and Development (IJCRD)*, 3(1), 68-76. DOI : http://doi.org/10.5281/zenodo.1205586.

[59] Shubhrajyotsna Aithal and Aithal P. S. (2016). ABCD analysis of Dye doped Polymers for Photonic Applications, IRA-International Journal of Applied Sciences, 4(3), 358-378. DOI : http://doi.org/10.5281/zenodo.155103. DOI :http://dx.doi.org/10.21013/jas.v4.n3.p1.

[60] Krishna Prasad & Aithal P. S. (2018). ABCD Analysis of Fingerprint Hash Code, Password and OTP based Multifactor Authentication Model. *Saudi Journal of Business and Management Studies*, 3(1), 65-80. DOI: http://doi.org/10.21276/sjbms.2018.3.1.10.

[61] Keerthan Raj, & Aithal, P. S. (2018). Generating Wealth at the Base of the Pyramid – A Study using ABCD Analysis Technique. *International Journal of Computational Research and Development (IJCRD)*, 3(1), 68-76. DOI :http://doi.org/10.5281/zenodo.1205586.

[62] Architha Aithal & A. R. Shabaraya (2018). Users Perspectives on Online Pharmacy Model. *International Journal of Health Sciences and Pharmacy (IJHSP)*, 2(1), 29-36. DOI: http://dx.doi.org/10.5281/zenodo.1292790.

[63] Narula, A.V., & Aithal, P. S. (2018). Employability Skill traits Management Quotient [ESMQ] – A Conceptual Model Proposal. *International Journal of Applied Engineering and Management Letters (IJAEML)*, 2(1), 1-30. DOI: http://dx.doi.org/10.5281/zenodo.1156138.

[64] Aithal, P. S. & Suresh Kumar, P. M. (2016). Opportunities and Challenges for Private Universities in India. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 88-113. DOI :http://doi.org/10.5281/zenodo. 161157.

[65] Padmanabha Shenoy, & Aithal, P. S. (2016). A Study on History of Paper and possible Paper Free World. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 337-355. DOI : http://doi.org/10.5281/zenodo. 161141.

[66] Aithal, P.S., (2015). Comparative Study on MBA Programmes in Private & Public Universities - A case study of MBA programme plan of Srinivas University. *International Journal of Management Sciences and Business Research (IJMSBR)***,** 4(12), 106-122. DOI :http://doi.org/10.5281/z enodo.163884.

[67] Aithal P. S., & Shubhrajyotsna Aithal (2016). Impact of On-line Education on Higher Education System. *International Journal of Engineering Research and Modern Education (IJERME),* 1(1), 225-235. DOI :http://doi.org/ 10.5281/zenodo.161113.

[68] Aithal P. S., and Suresh Kumar P. M., (2016). Analysis of Choice Based Credit System in Higher Education. *International Journal of Engineering Research and Modern Education (IJERME)*, 1(1), 278-284. DOI **:**http://doi.org/ 10.5281/zenodo.161046.

[69] Varun Shenoy and Aithal, P. S., (2016). Changing Approaches in Campus Placements - A new futuristic Model. *International Journal of Scientific Research and Modern Education (IJSRME)*, 1(1), 766 – 776. DOI :http://doi.org /10.5281/zenodo.160966.

[70] Prithi Rao, and Aithal, P.S. (2016). Green Education Concepts & Strategies in Higher Education Model. *International Journal of Scientific Research and Modern Education (IJSRME)*, 1(1), 793-802. DOI :http://doi.org/ 10.5281/zenodo.160877.

[71] Aithal, P. S. & Shubhrajyotsna Aithal (2016). Ekalavya Model of Higher Education – an Innovation of IBM's Big Data University. *International Journal of Current Research and Modern Education (IJCRME)*, 1(2), 190-205. DOI: http://dx.doi.org/10.5281/ZENODO.198704**.**

[72] Aithal, P. S. and Aithal, Shubhrajyotsna (2016). Opportunities & Challenges for Green Technology in 21st Century. *International Journal of Current Research and Modern Education (IJCRME)*, 1(1), 818-828. DOI : http://doi.org/10.5281/zenodo.62020.

[73] Nanotechnology and Life Cycle Assessment, Washington DC, 2-3 October 2006. http://www.nanotechproject.org/file_download/files/NanoLCA_3.07.pdf referred on 03/09/2018.

[74] Aithal, P. S., Shailashree, V. T., Suresh Kumar, P. M. (April 2015). A New ABCD Technique to Analyze Business Models & Concepts. *International Journal of Management, IT and Engineering (IJMIE)*, 5(4), 409 – 423. DOI : http://doi.org/10.5281/zenodo.61652.

[75] Aithal, P. S. (January 2016). Study on ABCD Analysis Technique for Business Models, business strategies, Operating Concepts & Business Systems. *International Journal in Management and Social Science*, 4(1), 98-115. www.ijmr.net.in DOI : http://doi.org/10.5281/zenodo.161137.

[76] Aithal P. S. & Shubhrajyotsna Aithal (2018). Factor & Elemental Analysis of Nanotechnology as Green Technology using ABCD Framework. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, 3(2), 57-72. DOI : https://doi.org/10.5281/zenodo.1451490.

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CHAPTER 9

MARCHING TOWARDS TECHNOLOGICAL IMMORTALITY

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ABSTRACT :
The chapter is a comprehensive summary of the work on ideal systems, ideal technology, and Nanotechnology based innovations for human life comfortability are discussed with a question to analyse –Are we marching toward technological immortality ?

9.1 INTRODUCTION :

Technology is an applied science used to develop materials, products, processes, and systems which can be used to improve the quality of life of human beings. Technology can be utilized both for solving basic problems of mankind and advanced requirements for their comfortability. Technology provides an opportunity to improve the quality of facilities like communication, transportation, entertainment, and any other problem which need a comfortable and innovative solution [1]. Basically, technology is used to solve problems related to the matter, energy, space or time and manipulate them as per individual and society requirements. Technology is used to simplify, to make easy and effortless systems at comparatively less cost and time saving purpose. Technology is dynamic and based on human requirement is changing and growing. The saga of growth of technology provided many gifts to the society in terms of providing the comfortable lifestyle to the human beings in the society. The developmental stages like industrial age, information age, e-business age, and present artificial intelligence age. Changes in technology due to the many contributions and efforts of scientist and engineers resulted in ubiquitous communication and business opportunities and making human life optimally comfortable reaching to ideal comfortability level [2-11]. Table 9.1 highlights the basic and advanced expectations of a human being and the level of achievements using presently available technologies.

Table 9.1 : Basic and advanced expectations of human beings and their present status

S. No.	Problem	Category	Present status of technology support	Anticipated technology to solve and take to desired level

1	Food	Basic	Medium	ICCT & Nanotechnology
2	Drinking water	Basic	Medium	Nanotechnology
3	Energy	Basic	Medium	Nanotechnology
4	Travel	Advanced	Medium	ICCT & NT
5	Shelter	Basic	Medium	NT
6	Ubiquitous Communication	Advanced	Final stage	ICCT & NT
6	Entertainment	Advanced	Final stage	ICCT
7	Health	Basic	Medium stage	ICCT & NT
8	Space travel	Advanced	Lower stage	NT & GT
9	Aging	Advanced	Lower stage	NT & BT
10	Immortality	Advanced	Lower stage	NT & BT

While examining table 9.1, it is observed that many of the basic requirements and comfortable life requirements based on the desire of human beings are yet to reach their expected/desired level. The two universal technologies ICCT and NT are expected to solve these basic and advanced problems along with other supportive technologies like Bio-technology (BT) and Gravitation technology (GT).

9.2 Nanotechnology based Innovations and Human Life Comfortability :

9.2.1 Objectives of the Study

This study is intended to discuss the perspectives and the progress of nanotechnology as an ideal technology to solve some of the major medical issues like drug delivery, treating cancer, surgery, organ regeneration, and even anti-aging. The study also discusses the concepts to know the possibility of using it through various concepts and techniques to be developed during this century to provide various medical related nanotechnology issues like nanorobots, human resurrection & artificial body with the original brain, connecting brains to cloud & internet, and overtaking of human intelligence by machines. Further, the paper discusses the possibility and challenges of achieving the human immortality and its implications.

9.3. Nanotechnology as New Hope to Realize Ideal Technology :

Nanotechnology focuses on building and manipulating materials (1-100 nm) that are a millionth the size of the length of an ant (typically 6-12 mm in length). Not only do nanotechnologists focus on building these materials but they want them to be functional and useful in an array of

applications including therapeutics. Nanotechnologists alongside clinicians and biologists are making strides towards defeating mortality, or death, in a quickly growing area of study known as nanomedicine. Future research advances in nanomedicine are expected to support life extension through the possible repair of many processes in the human body thought to be responsible for aging of the human being. One of the founders of nanotechnology, K. Eric Drexler [12], proposed cell repair machines in his book 'Engines of Creation' 1986, by using hypothetical molecular computers called nanobots, which are used to operate within the body cells. Raymond Kurzweil, a futurist and transhumanist writer, proposed in his book on '*The Singularity Is Near*' that nanorobots can completely provide a remedy for the process of aging by 2030 [13]. A well-known and highly respected innovator and visionary Peter Diamandis M.D., MIT graduate and Founder/Chairman of XPrize and Singularity University, addressed the future of nanomedicine saying "*We're going to look at your genome and all of your body's systems and identify what's likely to kill you and find it before it does. So, stopping you from dying is the first bit.*"

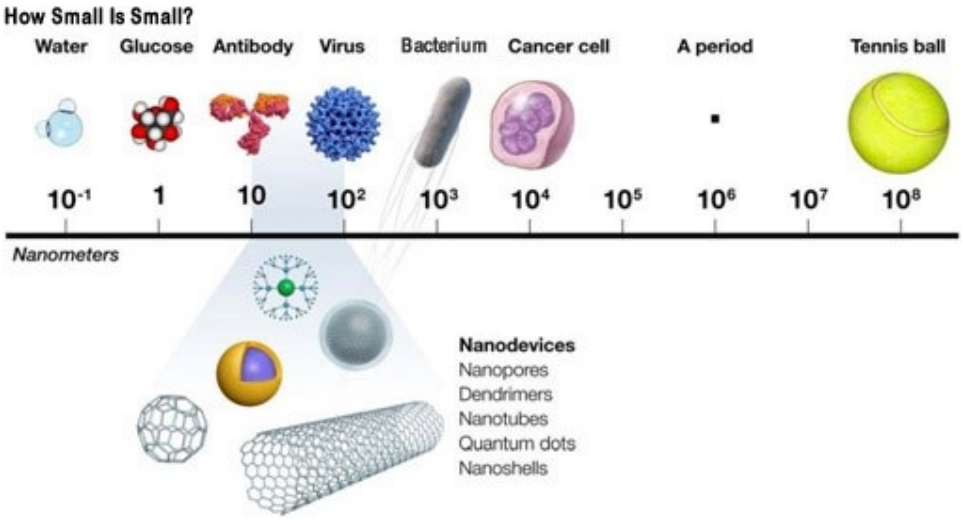

Fig 9.1 : Nanoscale : Adopted from http://bit.ly/howsmallissmallscale [14]

Table 9.2 : An idea on various breakthroughs expected in nanotechnology advents

S. No	Breakthrough Issues	Technology	Universal Technology
1	Nanorobots	Nano-biotechnology	NT
2	Human Resurrection & Artificial body with original brain	Artificial Intelligence	ICCT & NT
3	Connecting brains to cloud & Internet	Artificial Intelligence	ICCT

4	Singularity	Nanotechnology, Artificial Intelligence	NT & ICCT

9.3.1 Nanobots :

Nanobots are robots that are microscopic in nature, measured largely on the scale of nanometers. They are currently in the research and development phase, but on realization, they are expected to do specific tasks at the atomic, molecular and cellular level and help in bringing about many breakthroughs, especially in medical science. Nanobots are also known as nanomachines, nanorobots, nanomites, nanites or nanoids. The circulatory system of living beings is a natural highway for nanobots which will cruise through the bloodstream to the area of distress. They may be used to attach themselves to specific cells, such as cancer cells, and report the position and structure of these tissues. Nanobots can be considered to be a machine version of a bacteria or virus. They can be biological or synthetic but are adapted to perform preprogrammed tasks at the atomic level. They are expected to be autonomous in nature and powered by a small cell or battery, or even solar cells. The whole idea behind nanobots is in having a device which can interact at the nanoscale and help in understanding or manipulating structures at the nanoscale level. In the development of nanobots, nanoassembly and nanomanipulation have important roles.

Nanobots is an emerging field of nanotechnology creating machines or robots whose parts are in nanometre scale. Considering their potential, nanobots find their first and most prominent applications in medical science. Applications such as closing open wounds, rebuilding ruptured arteries and veins and traversing through the body for diagnoses are some important possible realizations. They are expected to aid in research related to cancer, AIDS and other major diseases as well as in helping brain, heart and diabetes research. Other applications where nanobots can potentially be of use are in aerospace, security, defense, electronics and environmental protection [15].

Nanobots/robots can be programmable and updatable to find and destroy any irregularities in the human body much like a virus or malware program on a computer. Exosome sensing capabilities and intercellular communication analysis will allow nanomachines to real time information about our total body health. This information will most likely include the current inflammation levels of human beings especially according to specific body locations which could be particularly useful after surgeries or even by athletes after intense training or sporting events. Nanomachines will be able to detect diet changes and how human bodies respond to differences in nutrients intake. Nanomachines will be able to act as biosensors for temperature,

heart rate, LDL/HDL levels as well as neurotransmitter indication of mental states such as sadness, happiness, depression, and anxiety. Nanomachines will be completely wifi/Bluetooth /or some future variant for direct and seamless communication to handheld technology. The implications of such monitoring are practically endless. Sensors in babies will give information about their health and mental health that can't be communicated to us through language to their parents. Emergency rooms will be revolutionized as doctors will no longer need to take physicals or blood tests.

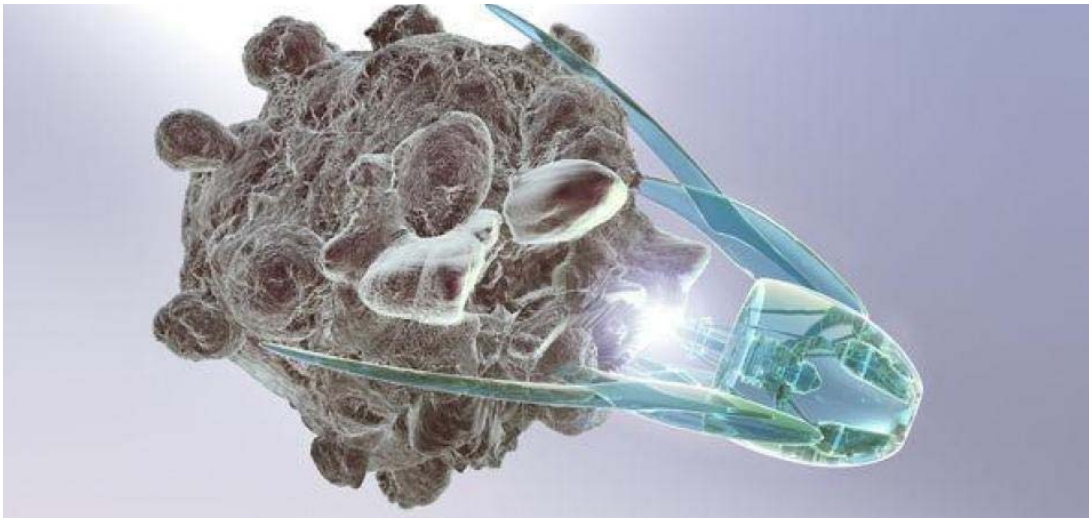

Fig. 9.2 : Nanobot as a killer of cancerous cells. Adapted from Chris' Blog at http://dbdblog.com [16]

9.3.2 Cell Replacement :

It is predicted that by the year 2040, nanotech machines called nanobots are developed in such a way that they can move throughout our bodies, repairing damaged cells and organs, effectively curing and wiping out any diseases and also be able to back up our memories and personalities. Thus, anyone lives from 2040 to 2050 could be close to immortal. The process collaboration between man and machines through nanotechnology as nanobots moves through human bloodstreams and eventually even replace or modify biological blood. It is also estimated that the combined research and discoveries of nanotechnology and biotechnology will vanish all dangerous diseases like cancer, alzheimer's diseases, diabetes, and obesity by eliminating biological diseases and aging leading to lifespan expansion. This helps to extend the health and longevity of human beings. Nanotechnology based boats are expected to heal wounds almost instantaneously and able to regenerate human and animal body parts so that the person injured in accidents can also be cured instantaneously. Many types of cancers are already

cured successfully at laboratory level using nano-bio technology. Nanobots are micro-machines and will be self-replicating to the required level within the living body to function as per they are programmed [17].

It is also expected that nanotechnology along with ICCT and BT is able to freeze human brain, create artificial new body, repair any damage happened even to the human brain, and transfer it into a new body. This process could then be repeated in perpetuity to reach perfect immorality. As per various reports, the three diseases which are major contributors to all deaths all over the world are heart disease, cancer, and chronic lower respiratory diseases. Table 9.3 lists the estimated world over a percentage of the people dies annually [18].

Table 9.3 : Percentage of mortality worldwide due to major diseases.

S. No	Name of Disease	Number of deaths annually	Percentage
1	Heart	20 million	30 %
2	Cancer	10 million	15 %
3	Lower respiratory diseases	3 million	05 %

(1) Nanotechnology supported heart disease Research :

Heart Disease research using nanotechnology is not as well supported by government and industrial funds but there have been some remarkable innovations to improve patients' lives. Nano-biomaterials are beginning to be used for blood vessel replacement, bioresorbable stents, cardiac patches, and local drug delivery. To overcome conventional limitations of drug delivery, nano delivery methods are used for more precise and long-lasting diseases especially in combination with stem cell therapy, gene delivery, tissue factor (TF) inhibitors, miRNAs, leukotriene modifiers and thrombolytic agents. Researchers are using nanoparticles to overcome common, current issues in cardiovascular care such as systemic toxicity and stent thrombosis. Finally, cardiologists and researchers are successful in using nanomedicine in the treatment of atherosclerosis which results in heart attacks and strokes among many people around the world each year [18].

(2) Nanotechnology and Cancer Research :

Cancer research using nanomedicine is a very effective and fast-growing field with many important innovations and discoveries announced recently. Many research groups are using gold nanorods to be injected and stored in tumours which improves diagnostic capabilities by means of using photothermal technology to heat the rods which can specifically kill cancer

cells. In another case, a team of researchers works with nanoparticles carrying TNF-related apoptosis-inducing ligand (TRAIL) to specifically to the tumour cells to kill cancer cells and cancer stem cells which are particularly susceptible to this methodology. Using nanoparticles it is possible to overcome many previous restrictions for delivery of drugs to tumours and overcoming certain barriers such as blood-retinal and blood-brain blocks. Using another technique called nano delivery of viral or non-viral gene induction which supports programmed cell death (apoptosis), researchers and doctors are working to handle and control the killing of fast growing and metastatic cancer cells. Using Boron Neutron Capture Therapy (BNCT) along with the delivery properties of nanoparticles is a more recent therapeutic technique to kill tumour cells effectively. These are many examples and techniques for using nanotechnology to control cancer by cancer researchers and oncologists [18].

In the year 2018, researchers for the first time successfully used tiny, nanometre-sized robots to treat cancerous tumours in mice. Researchers from Arizona State University and the National Center for Nanoscience and Technology of the Chinese Academy of Sciences injected nanobots made from a folded sheet of DNA into the bloodstream of mice. These targeted the blood vessels around cancerous tumours, injecting them with blood-clotting drugs to cut off their blood supply. According to the study, published in Nature Biotechnology, in February, the treatment was successful in shrinking the tumours and inhibiting their spread. The idea of armies of minuscule robots patrolling our bodies, cleaning and maintaining them has been a theme in science fiction for decades. Scientists are exploring the use of nanobots for a number of healthcare uses, not only for fighting cancer but also to unblock blood vessels in hard to reach areas, taking biopsies or measuring the level of certain chemicals in otherwise inaccessible areas of the body. Bioengineered bots made from DNA, such as those used in the mouse tumour tests, have been shown to be capable of delivering small doses of drugs with great precision.

(3) Nanotechnology and Respiratory Research :

Though the amount of funding is limited form Govt. and industrial sources for research in nanomedicine, researchers are addressing the problems of lower respiratory Infections. They found that nanoparticle encapsulation of antimicrobial chemo drugs decreases the toxicity to patients, increases antibiotic resistance activity of drug resistant bacteria. TB is the second deadly disease due to infection worldwide mainly due to limitations in drug delivery, patient compliance, and multiple drug resistant strains. Medicines using nanoparticles will support the delivery of drugs intracellularly by focussing on infected macrophage parts and stimulate them

simultaneously to cure TB. It is also shown that nanomedicine has the ability to overcome antibiotic resistance. Nanomedicine used for treating azithromycin microspheres also shown improvements in curing macrolide-resistant streptococcus pneumonia strains in many patients. Thus, nanomedicine research for curing respiratory diseases have shown tremendous opportunities in future days [18].

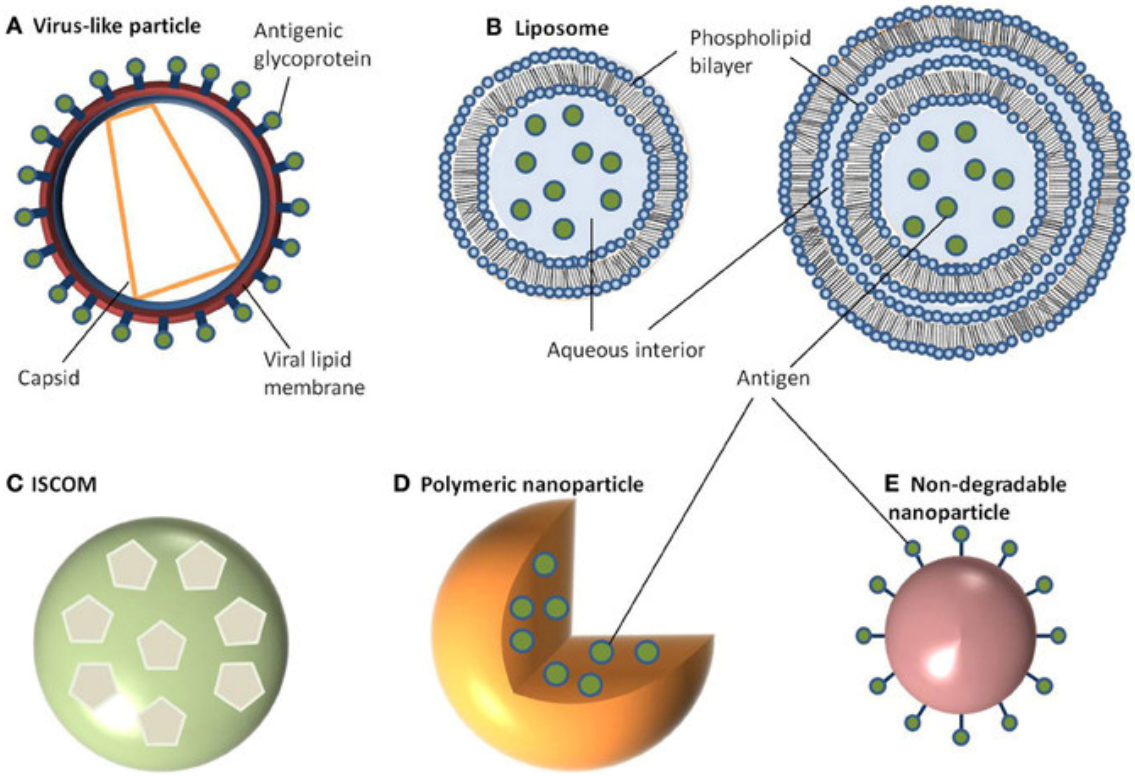

Fig. 9.3 : Nanoparticle with Virus-like Particles (VLPs) Photo source http://bit.ly/vaccinenanoparticledelivery. [19]

9.3.3 Regeneration of Body Parts :

Regeneration means the regrowth of a damaged or missing organ part from the remaining tissue. As adults, humans can regenerate some organs, such as the liver. If part of the liver is lost by disease or injury, the liver grows back to its original size, though not its original shape. Every cell in our body contains DNA which has the genetic footprint with the required information to build or regenerate the body. But the automatic regeneration is difficult due to the possible reason that the regeneration of human organs may take a huge amount of energy. Further the complex and highly developed human immune system opposes the process of regeneration of body parts. It is hoped that the techniques like gene activation or gene editing to start the regeneration process may help such possibilities. In one technique, nanoscaffolds prepared polymer fibres are used as a substitute for missing limb or damaged organ. The

nanoscsffold monitor adhesion of cells on to it so that the missing bones and tissues can be reconstructed [20-21].

Table 9.4 : Nanotechnology based body parts regeneration research

S. No	Body Parts	Nanotechnology Solution	Reference
1	Organ Regeneration	3D Printing	[22] Biazar, E. et al, (2018)
2	Tissue Regeneration	Integration of nanocomposites and biomimetic scaffolds.	[23] Cassidy, J. W. (2014).
3	Bone Regeneration	Calcium Silicate Nano-Composites	[24] Mollaqasem, V. K., (2014)
4	Blood (Artificial)	Bio-inspired nanocomposites	[25] Sen Gupta, A. (2017)
5	Cells Regeneration	Stem cell tracking with nanoparticles	[26] Accomasso, L., (2016)
6	Limb Regeneration	Nanostructured polymeric scaffolds	[27] Laurencin, C. T., (2016)
7	Skin Regeneration	Bioinspired Nanotechnology	[28] Tavakol, S., (2016)
8	Bone Joints Regeneration	bio-nanomaterials the emerging prospect for therapy	[29] Gangadoo, S., (2015)
9	Nerve Reconstruction	bio-functionalized nanomaterials	[30] Sedaghati, T., (2015) [31] Biazar, E., (2010)
10	Blood vessels Repair	Modeling Nanorobot Control Using Swarm Intelligence	[32] Kaewkamnerdpong, B., (2015)
11	Musculoskeletal Soft Tissues	Advanced biomaterials and biomimetic scaffold designs	[33] James, R., (2016)

9.3.4 Environmental Purification :

Experts all over the world are in consensus that one of the major factors that will determine the future of human health is the health of our environment and the planet. In the environmental sciences, nanotechnology is a very hot topic, especially when addressing environmental sustainability and reversal of environmental damage caused by the actions of mankind. Nanotechnologists alongside environmental experts have been able to utilize nanomotor degradation and removal of contaminants from water sources. Environmentalists are excited about the use of this technology for water quality monitoring and eventually would like to see “sense and destroy” applications. Future directions in this field even entail immunology influenced chemotactic abilities capable of allowing nanomachines to track contamination back to its source for clearance and reporting to the

appropriate authorities. In environmental applications of nanotechnology, a kind of nanorobots called nanomachines can self-replicate under pre-determined, set conditions, can potentially help people to control the changes in the environment. Nanorobots can be programmed to act like a buffer to prevent environmental changes, and help to maintain predetermined temperatures and pressure conditions. Nanomachines also have the ability to act like a chemical factory to process excessive levels of CO_2 from the air or produce nontoxic endothermic or exothermic reactions to heat or cool the environment. Thus, nanomachines can be used to cool the oceans to prevent further melting of artic ice. The light reflective properties of nanomaterials added to the oceans can be altered and hence by decreasing or increasing the oceans ability to absorb sunlight could have considerable effects on global warming. Such possibilities for solving various environmental problems and pollutions are truly endless and exciting to for further research. Nanotechnology not only has tremendous implications for the monitoring of human health but also in real time monitoring of the environment and its purification in ways before never thought possible.

9.3.5 Connecting Brains to Cloud &Internet :

While forecasting futuristic technology, it is predicted that a time will come for connecting our brains to computers in the cloud through the internet. Computers and mobile phones are already billions of times the speed and powerful than their predecessors and now one can connect them to the internet where millions of computers living in the cloud. According to Ray Kurzweil, director of engineering at Google [34], humans will have hybrid brains able to connect to the cloud, just as with computers. The brains and computers will all be connected using DNA strands called *Nanobots or nanorobots and* synthetic neocortex. In this cloud, thousands of computers can be connected to update human intelligence. The larger the cloud, the thinking becomes more complicated due to the *combination of biological and non-biological thinking processes*. Ray Kurzweil also foresee that by the end of 2030, human thinking should be almost entirely non-biological and able to work like an external hard drive with the ability to backup information using technology. This also will increase the ability of the human mind. Continuation to this concept, we predict that such networks further leads to connecting many brains and computers together and if happens a **Universal Super Intelligence (USI) System** may evolve. Such USI System is expected to connect many brains and computers in the universe to automatically store and exchange information and intelligence anywhere in the network ubiquitously. The technology of USI system will give rise to access to a wider field of consciousness by connecting and using the aggregate thinking powers of

millions of humans at a time which increases the thinking power exponentially and supports the new world of innovation, design, and an abundance of wealth. This concept of Universal Super Intelligence (USI) along with universal artificial intelligence (UAI) [35-39] also leads to the evolution of **Super Human Beings (SHB)** as shown in the diagrammatic idea (fig 9.4).

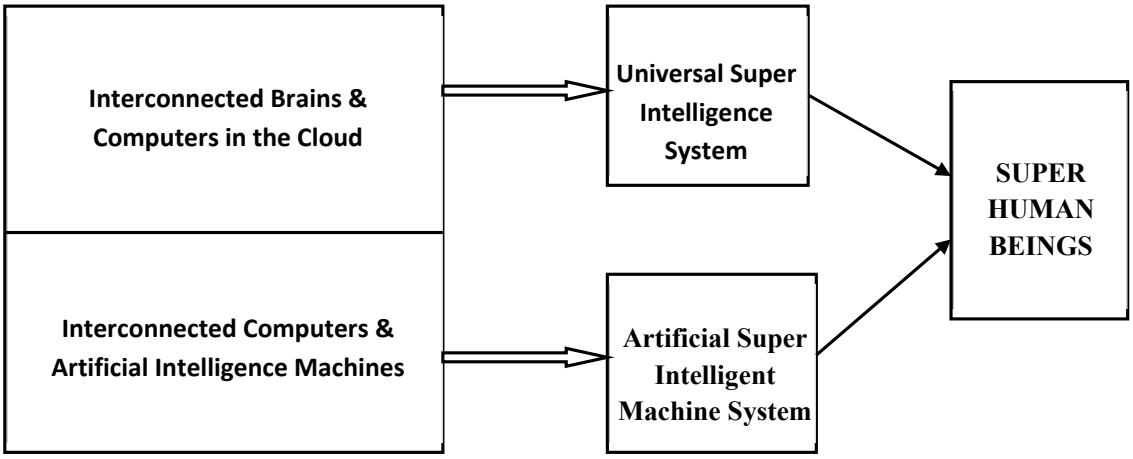

Fig. 9.4. Hypothetical Concept of Universal super intelligence, Artificial super intelligence, and Superhuman beings.

9.3.6 Singularity :

The Singularity is a hypothetical concept to be created in the future due to the invention of super-intelligent machines which are network connected intelligent computers & machines. Superintelligence is a cognitive capacity created technologically which is far above the general thinking capacity of humans. The technological singularity is predicted and the name is coined by Vernor Vinge [40] which is a hypothesis that the discovery of artificial super intelligent machine systems will abruptly trigger runaway technological growth to an infinite amount, resulting in unfathomable changes in the society and to human civilization [13]. Artificial superintelligence is a term referring to the time when the capability of computers and artificial intelligence machines will surpass humans. At the time when the technical singularity is created, the artificially developed nonbiological intelligent machines are expected to be several billion times powerful compared to all human intelligence available today.

The question is whether the Singularity occurs and when? The answer is yes. The technology will advance continuously and grow beyond our ability to foresee or control its outcomes and the society and the world will be transformed beyond our recognition by using superintelligence created through the singularity to solve human problems, including poverty, energy, disease, and even mortality. Advents in nanotechnology, biotechnology, artificial intelligence, and robotics during the next 30 years are expected to play an important role in the realization

of Singularity. The singularity theory predicts that the super-intelligency will be created by self-directed networked computers and will increase further exponentially rather than incrementally. There are many proposed mechanisms for adding superintelligence to humans which include concepts like brain-computer interfaces, artificial intelligence (AI) brain implants, biological alteration of the brain, and genetic engineering. The humanity and the world scenario would be quite different after the singularity status is reached in such a way that a human being could potentially scan his consciousness into an external computer and live eternally in the form of virtual reality or as a sentient robot leading the status of Super-human being. Thus, the combination of two technologies, ICCT along with AI, and Nanotechnology have the ability to either push the human species into a new and beautiful future which can be called as a golden era or if the technology is not properly managed and controlled will also may bring our downfall with unprecedented disaster. At least, it's comforting and happiest to know that our best and brightest future will be at the helm of this journey as it moves closer towards immortality [41-44].

9.4. CONCEPT IDEAL HUMAN BEING :

When we model human being as a perfect person, we assume some characteristics of a human being which makes him ideal. These characteristics can be divided into his physical capabilities, mental capabilities, and ethical behaviour. Ideal human being concept will help to identify a 'God-like' person in the society with 3 primary characteristics as omnipotence with supreme power, omniscience with all knowing (past, present, and future), and omnipresence with ubiquitous. The above three characteristics of God can be developed by human beings either by using scientific technology or by means of spiritual philosophy. Thus, there are two parallel paths (may be interconnected) for human beings to earn the characteristics of human Model of God. They are (1) Achieving super-human-being status through the technological singularity and universal super-intelligent system. (2) Achieving super-human-being status through spiritual philosophy. In both paths, they may reach super-human status [45].

According to Indian sage Swami Vivekananda, man is usually enlightened by nature divine. All humans are 'heirs of immortal bliss'. Due to wrong education and theories, they forget their divinity and essential goodness. As a consequence, he starts believing that he is a sinner. This makes him to starts worshipping and pursuing the external matter and hence forgets spirituality within. He believes that every human being has a God within him and he says that right kind of education creates awareness on their divinity. Such a right education could result in making matured and enabling them to respect others including their neighbours, fellow citizens,

immediate surroundings and their environment to get enlightened with ten noble characteristics including contentment, forbearance, gentleness, respect for others' property, purity, self-control, knowledge, philosophic wisdom, veracity, and patience. An enlightened person, according to Vivekananda, by virtue of his training and education, is able to see the same Atman in every being and therefore treats them at par, even identical with himself [46-49].

9.5. HOW TO ACHIEVE IMMORTALITY :

Immortality is a state of human beings where they are immune to death for any reason like injury, disease, and age. Every human being has a desire to achieve immortality provided they are able to overcome aging old. It is believed that like two paths to achieve superhuman status, there are two paths to achieve immortality. Accordingly, they are named as (1) Immortality based on Philosophy, and (2) Immortality based on Technology. Technology based immortality promotes physical deathlessness and Philosophy based immortality promotes mental based eternal enlightenment.

9.5.1 Philosophy Based Immortality :

Immortality is discussed intensively in many Epics & Religious text. From the beginning of human life on the earth, there was continuous search, efforts, and struggle to achieve immortality. Some of the instances and references on immortality in different epics and religious text are mentioned below:

9.5.1.1 Hindu Philosophy :

Hindu scripture contains a mantra about the seven immortals, in which their names are recited for luck and longevity: Ashwathaama Balir Vyasaha Hanumanthra Vibeeshanaha Kriba Parasuramas cha Saptaitey Chiranjeevinaha Om Namah Shivay. It is also specified that other persons named Markandeya, had a boon that he will never die and is blessed with immortality [50].

Table 9.5 : List of some of the immortal characters in Hindu Epics/ Mythology

S. No.	Name of Immortal Characters (Chiranjivis)	Specification	Epics
1	Ashwathhama	Son of Dronacharya	Mahabharata
2	Vibhishana	Youngest brother of Ravana	Ramayana
3	Kripacharya	Son of Shardwan and Janpadi and used to teach the royal children, Kauravas, and Pandavas	Mahabharata

4	Hanuman	Pavan Putra	Ramayana
5	Parshuram	He is one of the amshawatar of Lord Vishnu (sixth avatar), and known as guardian angel, savior of mankind.	Mahabharata
6	Bali Chakrawarthi	Powerful ruler in Hinduism ever. Lord Vishnu granted immortality	Hindu Puranas
7	Rishi Vyas	Creator of many Puranas & storyteller of Mahabharata	Mahabharata

There are several other personages known as chiranjeevins, like Jambavantha (Jambavan). However, in Hinduism, "immortal" does not mean eternal. Even immortal things are dissolved at the end of the universe, including its secondary creator Brahma. The only eternal are **Vishnu** and **Shiva** of the Trimurti, i.e. manifestations of Brahman (the Supreme Reality), Sheshanaga (the Eternal Serpent), and the four Vedas.

9.5.1.2 : Cristian Philosophy :

According to the Christian tradition immortality in humans are endowed with non-physical souls. It is an attribute of the soul, and the body is its prison. The soul will be freed after the death of a person. The resurrection of humans on account of Christ who was first raised from the dead. The immortality in Christianity is a gift and only God is immortal. Immortality means the resurrection of the body. Christ's bodily resurrection, although as a body endowed with properties not limited to spatial restriction was the object of Christian hope that body and soul in their unity would be raised after death [51]. Thus, Christianity believes in the immortality of the soul. Dr. Temple, archbishop of Canterbury wrote that Man is not by nature immortal, but capable of immortality. He said, the God alone is immortal and he offers immortality to man not universally but conditionally [52-53].

9.6. TECHNOLOGY BASED IMMORTALITY :

There are three ways of achieving human life immortality.

(1) ***Renewing the body by rejuvenating it by means of Nano-bio Technology :*** This is supported by regaining the biological young body by preventing the aging of body cells or by replacing vital body organs with new parts.

(2) ***Living in artificially created Android bodies :*** This includes the ability to link human minds with the robotic machine effectively be living in the cloud. This means that even

when the original bodies die, the minds can still be able to live in the world using highly realistic robot bodies.

(3) ***Living in a virtual world :*** This is virtual immortality developed using artificial intelligence and virtual reality techniques.

9.7. CHALLENGES TO ACHIEVE HUMAN IMMORTALITY

(1) Technical Challenges : Developing nanobots, feeding them into the human body without risk, and controlling to work in human body in-search of its destination either for repair cells and body parts, or regeneration of various body parts using nanobots are challenging and highly sophisticated laboratories are essential throughout the world. Technical challenges can be handled effectively by means of creating awareness and developing more experts in the field.

(2) Biological Challenges : Identifying the causes of aging at the cellular level and solving them to stop aging of human beings and the basic biological challenge. We can also prolong the natural lifespan by preventing cell death and aging, preserving it through cryogenic methods or donors. scientists believe to be able to achieve immortality:

- **Discovering the Gene Power:** Scientists have the challenge to find the suitable gene which can support immortality and to implant it in the human body.
- **Successful Cloning :** Bio-technologists have a challenge to regenerate or replacement parts of the body or even cloning of a whole human being. Cloning is considered as a part of immortality research and presently it is evolved to the most desired level.
- **Cryogenics Technology for Body Preservation :** This technology helps to preserve the organism, and may help to keep the patient into cryogenic sleep until the medicine to their disease is found.

(3) Social Challenges : The immortality research may not receive full support from the people of the society over the world with the belief that it may have unimaginable social cultural problems. The mortal society makes the people to be more generous and honest due to the effect of aging and assured end of the life. If people think that they are going to be immortal the basic beliefs and culture of the society will be affected. The anticipated challenges include the justification on investment on immortality research, its effect on the economy, belief, culture and tradition of the people of the society.

9.8. IMPLICATIONS OF ACHIEVING PHYSICAL IMMORTALITY :

The following are the implications of achieving physical immortality for human beings :

(1) Deathlessness : Human mortality leads to tumbled motivation and time target for any activity. This may also kill innovation ability of human beings due to the fact that there is no

further threat for human life. The natural desires, interests, and goals that the human beings have now—then eventually decreases and as time progress, everybody will get bored and feels eternal life unbearably tedious.

Deathlessness life may be like being in heaven without any challenges but only with enjoyment. This leads to boar to many people who may search for change through further innovations through technology like high speed space travel etc.

(2) Static Time : Time is not going to be an important and non-repeatable resource. This may lead to non-active society. The people may become tension free and the life style may change entirely. The static time from the human beings' point of view may create opportunities for new research leading to new scientific laws & principles.

(3) Space : The immortality leads to increase in population so that the density of population increases continuously with time. Unless major part of the population finds relocation to other planets in the universe, the space constraints create various kind of problems which may end up with wars and fighting and hence people may find peace less life. On the other hand, using sophisticated technologies the space travel may common for everybody and in the process of finding the change in lifestyle, the majority of people may travel different space stations and new planets of different stars in the universe which may create new colonies in distant planets and galaxies.

(4) Population : Immortality of human beings leads to overpopulation on this earth. Already many countries are facing overpopulation problems and end of aging and immortality would lead to an accelerated population growth and eventually aggravate overpopulation problems in some regions of the world. The optimum solution to this problem is the relocation of additional population to other planets which is also possible through universal technologies.

(5) Beliefs & Culture : Curing aging leads to continuation of older people along with their culture. This will probably force to continue their ideas, beliefs, and culture and would block the way to the younger generations and their fresh ideologies and beliefs. Culturally, or mimetically, humankind has been evolving at an astonishing pace. The continuous improvements and extraordinary evolution in culture and tradition with time due to changes in generations in the society have changes the ethics and behaviour of the people may stop and we may end up with a generation of people without cultural progress which could be a catastrophe for humankind.

(6) Social Problems : Achieving immortality leads an infinite lifespan for human beings. This will create a social problem of wealth divide as the richer will become further richer and the

poorer will become further poorer. But there is another argument that people produce more due to experience effect. Hence poverty will quickly be eradicated. Poverty is almost entirely a problem of lack of human productivity. If people produce more than they consume they aren't in a state of poverty but of surplus.

Apart from many negative implications, immortality may promote many new opportunities and new solutions to anticipated problems and issues, provide a happy and prosperous day for everybody. Achieving immortality against aging is always better than the ravages and sufferings of aging and age-related chronic diseases in general.

9.9. CONCLUSIONS :

The search for lifespan extension and non-aging leading to human immortality is the objective of every technology. The frontier technologies like ICCT and Nanotechnology are expected to contribute to this long-time desire of human beings due to their abilities of grown as complementary and universal technologies with the capability to elevate towards ideal technologies. It is expected that with continuous contributions on ICCT and NT technologies by many researchers from different parts of the world, human life is certainly going to be more comfortable and the definition of technology is finding its real meaning by its contribution of supporting to solve people's real problems both at its basic and advanced level and marching towards achieving immortality. Managing such technological innovations systematically in order to lead the expected outcome is the real opportunity and challenge for technology management experts. In this process of managing progress in technology innovations fail while marching towards mortality to immortality, it is sure that at least it will try and contribute for solving humankind's problems like hunger, thirst, war, and suffering from health-related issues to wipe every tear from every eye as said by Abraham Lincoln. Finally, the ultimate goal of the science and technology should be the search for peace and harmony by and for human beings to continue their existence forever and the discovering the secrets of the universe.

REFERENCES :

[1] Aithal, P. S., & Shubhrajyotsna Aithal (2015). Ideal Technology Concept & its Realization Opportunity using Nanotechnology, *International Journal of Application or Innovation in Engineering & Management (IJAIEM)*, 4(2), 153 – 164. ISSN 2319-4847. DOI: http://doi.org/10.5281/zenodo.61591.

[2] Aithal, P. S. & Shubhrajyotsna Aithal (2018). Study of various General-Purpose Technologies and their contribution towards developing Sustainable Society, *International Journal of Management, Technology, and Social Sciences (IJMTS)*, 3(2), 16-33. ISSN : 2581-6012, DOI : http://dx.doi.org/10.5281/Zenodo.1409476.

[3] Aithal, P. S., & Shubhrajyotsna Aithal (2015). A review on Anticipated Breakthrough Technologies of 21st Century. *International Journal of Research & Development in Technology and Management Sciences*, 21(6), 112 – 133. ISBN - 1-63102-450-7, DOI : http://doi.org/10.5281/zenodo.61617.

[4] Aithal, P. S. (2016). Nanotechnology Innovations & Business Opportunities : A Review. *International Journal of Management, IT and Engineering (IJMIE)*, 6(1), 182-204. ISSN: 2249-0558, DOI : http://doi.org/10.5281/zenodo.161153.

[5] Aithal, P. S. & Shubhrajyotsna Aithal (2016). Opportunities & Challenges for Green Technology in 21st Century. *International Journal of Current Research and Modern Education (IJCRME)*, 1(1), 818-828. ISSN : 2455 – 5428. DOI : http://doi.org/10.5281/zenodo.62020.

[6] Aithal, Shubrajyotsna & Aithal, P. S. (2018). Concept of Ideal Water Purifier System to Produce Potable Water and its Realization Opportunities using Nanotechnology. *International Journal of Applied Engineering and Management Letters (IJAEML)*, 2(2), 8-26. DOI: http://dx.doi.org/10.5281/zenodo.1323714.

[7] Aithal, P. S. & Shubrajyotsna Aithal (2016). Nanotechnological Innovations & Business Environment for Indian Automobile Sector : A Futuristic Approach. *International Journal of Scientific Research and Modern Education (IJSRME)*, 1(1), 296-307. ISSN: 2455 – 5630. DOI : http://doi.org/10.5281/zenodo.161090.

[8] Aithal, P. S. & Shubhrajyotsna Aithal (2016). Nanotechnology Innovations & Business Opportunities in Renewable Energy Sector. *International Journal of Engineering Research and Modern Education (IJERME)*, 1(1), 674- 692. ISSN : 2455 – 4200. DOI : http://doi.org/10.5281/zenodo.160905.

[9] Aithal P. S. & Shubhrajyotsna Aithal (2016). Business Strategy for Nanotechnology based Products & Services. *International Journal of Management Sciences and Business Research (IJMSBR)*, 5(4), 139-149, ISSN 2226-8235. DOI : http://doi.org/10.5281/zenodo.161127.

[10] Aithal, P. S. & Shubhrajyotsna Aithal (2016). A New Model for Commercialization of Nanotechnology Products and Services. *International Journal of Computational Research and Development,* Vol. 1, Issue 1, pp. 84-93. *ISSN (Online): 2456 – 3137.*DOI :http://doi.org/10.5281/zenodo.163536.

[11] Aithal P. S. & Shubhrajyotsna Aithal (2018). Factor & Elemental Analysis of Nanotechnology as Green Technology using ABCD Framework. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, 3(2), 57-72.

[12] Drexler, K. E. (2004). Nanotechnology: from Feynman to funding. *Bulletin of Science, Technology & Society*, *24*(1), 21-27.

[13] Kurzweil, R. (2016). The singularity is near. Ethics and Emerging Technologies, 393--406 DOI: https://doi.org/10.1057/9781137349088.

[14] http://bit.ly/howsmallissmallscale

[15] Aithal, P. S. and Shubrajyotsna Aithal (2016). Nanotechnology Innovations and Commercialization – Opportunities, Challenges & Reasons for Delay. International Journal of Engineering and Manufacturing (IJEM), 6(6), pp. 15-25, ISSN: 2305-3631. DOI : http://doi.org/10.5281/zenodo.161161, DOI: http://doi.org/10.5815/ijem.2016.06.02.

[16] Adapted from Chris' Blog at http://dbdblog.com

[17] Yi, H., Rehman, F. U., Zhao, C., Liu, B., & He, N. (2016). Recent advances in nano scaffolds for bone repair. *Bone research*, *4*, 16050.

[18] Christopher Fleming, (2016). Adapted from Chris' Blog at http://dbdblog.com

[19] http://bit.ly/vaccinenanoparticledelivery.

[20] Chaudhury, K., Kumar, V., Kandasamy, J., & Roy Choudhury, S. (2014). Regenerative nanomedicine: current perspectives and future directions. *International journal of nanomedicine*, *9*, 4153.

[21] Sampogna, G., Guraya, S. Y., &Forgione, A. (2015). Regenerative medicine: Historical roots and potential strategies in modern medicine. *Journal of Microscopy and Ultrastructure*, *3*(3), 101-107.

[22] Biazar, E., Najafi S, M., Heidari K, S., Yazdankhah, M., Rafiei, A., &Biazar, D. (2018). 3D bio-printing technology for body tissues and organs regeneration. *Journal of medical engineering & technology*, 1-16.

[23] Cassidy, J. W. (2014). Nanotechnology in the regeneration of complex tissues. *Bone and tissue regeneration insights*, *5*, BTRI-S12331.

[24] Mollaqasem, V. K., Ardakani, M. H., & Hesaraki, S. (2014). Bone Regeneration Using Nanotechnology–Calcium Silicate Nano-Composites. *Advances in Environmental Biology*, *8*(12), 166-169.

[25] Sen Gupta, A. (2017). Bio-inspired nanomedicine strategies for artificial blood components. *Wiley Interdisciplinary Reviews: Nanomedicine and Nanobiotechnology*, *9*(6), e1464.

[26] Accomasso, L., Gallina, C., Turinetto, V., & Giachino, C. (2016). Stem cell tracking with nanoparticles for regenerative medicine purposes: an overview. *Stem cells international*, *2016*.

[27] Laurencin, C. T., & Nair, L. S. (2016). The Quest toward limb regeneration: a regenerative engineering approach. *Regenerative biomaterials*, *3*(2), 123-125.

[28] Tavakol, S., Jalili-Firoozinezhad, S., Mashinchian, O., & Mahmoudi, M. (2016). Bioinspired Nanotechnologies for Skin Regeneration. In *Nanoscience in Dermatology* (pp. 337-352).

[29] Gangadoo, S., Taylor-Robinson, A. W., & Chapman, J. (2015). From replacement to regeneration: are bio-nanomaterials the emerging prospect for therapy of defective joints and bones. *J. Biotechnol. Biomater.*, *5*, 2.

[30] Sedaghati, T., & Seifalian, A. M. (2015). Nanotechnology and bio-functionalisation for peripheral nerve regeneration. *Neural regeneration research*, *10*(8), 1191.

[31] Biazar, E., Khorasani, M. T., Montazeri, N., Pourshamsian, K., Daliri, M., Rezaei, M., & Roviemiab, Z. (2010). Types of neural guides and using nanotechnology for peripheral nerve reconstruction. *International journal of nanomedicine*, *5*, 839.

[32] Kaewkamnerdpong, B., Boonrong, P., Trihirun, S., & Achalakul, T. (2015). Modeling Nanorobot Control Using Swarm Intelligence for Blood Vessel Repair: A Rigid-Tube Model. In *Adaptation and Hybridization in Computational Intelligence* (pp. 205-236). Springer, Cham.

[33] James, R., Mengsteab, P., & Laurencin, C. T. (2016). Regenerative Engineering: Studies of the Rotator Cuff and other Musculoskeletal Soft Tissues. *MRS Advances*, *1*(18), 1255-1263.

[34] Kurzweil, R. (2004). The law of accelerating returns. In *Alan Turing: Life and legacy of a great thinker* (pp. 381-416). Springer, Berlin, Heidelberg.

[35] Everitt, T., & Hutter, M. (2018). Universal Artificial Intelligence. In *Foundations of Trusted Autonomy* (pp. 15-46). Springer, Cham.

[36] Mathe, E., & Spyrou, E. (2016, June). Connecting a Consumer Brain-Computer Interface to an Internet-of-Things Ecosystem. In *Proceedings of the 9th ACM International Conference on Pervasive Technologies Related to Assistive Environments* (p. 90). ACM.

[37] Maksimović, M. (2017). The roles of Nanotechnology and Internet of Nano things in healthcare transformation. *TecnoLógicas*, *20*(40), 139-153.

[38] Akyildiz, I. F., Pierobon, M., Balasubramaniam, S., & Koucheryavy, Y. (2015). The internet of bio-nano things. *IEEE Communications Magazine*, *53*(3), 32-40.

[39] Miailhe, N., & Hodes, C. (2017). The Third Age of Artificial Intelligence. *Field Actions Science Reports. The journal of field actions*, (Special Issue 17), 6-11.

[40] Vinge, V. (1993, March). Technological singularity. In *VISION-21 Symposium sponsored by NASA Lewis Research Center and the Ohio Aerospace Institute* (pp. 30-31).

[41] Tchon, K. (2017). Technological Singularity: A Path towards Artificial Intellects and Unpredictable Futures. In *A Treatise on Good Robots* (pp. 155-172). Routledge.

[42] Shanahan, M. (2015). *The technological singularity*. MIT Press.

[43] Wallach, W. (2016). The Singularity: Will We Survive Our Technology. *Jurimetrics*, *56*, 297.

[44] De Coninck, T. (2015). The Singularity: Fact or Fiction?.

[45] https://www.speakingtree.in/article/the-making-of-an-ideal-human-being

[46] Roncone, K. (2004). Nanotechnology: What next-generation warriors will wear. *JOM Journal of the Minerals, Metals and Materials Society*, *56*(1), 31-33.

[47] Sethe, S. (2007). Nanotechnology and life extension. *Nanoethics—the ethical and social implications of nanotechnology. New Jersey*, 353-365.

[48] Oderberg, D. S. (2014). Could there be a superhuman species?. *The Southern Journal of Philosophy*, *52*(2), 206-226.

[49] Kaushal, N., & Mishra, S. (2017). INFERENCE OF SWAMI VIVEKANANDA'S TEACHINGS AND SKILLS IN MODERN MANAGEMENT STUDIES. *International Journal of Information, Business and Management*, *9*(4), 150.

[50] https://www.sanskritimagazine.com/indian-religions/hinduism/chiranjivis-eight-immortals-hinduism/

[51] Encyclopedia of the Bible and Its Reception 12 (© Walter de Gruyter, Berlin/Boston 2015)

[52] Ball, B. W. (2011). The immortality of the soul: Could Christianity survive without it? Ministry: International Journal for Pastors, 83(5), 14-17.

[53] Twardowski, K. (2015). Contemporary philosophy on immortality of the soul. *Studia Neoaristotelica*, *12*(2), 72-83.

[54] Aithal P. S. & Shubhrajyotsna Aithal (2018). Nanotechnology based Innovations and Human Life Comfortability –Are we Marching towards Immortality ?. *International Journal of Applied Engineering and Management Letters (IJAEML)*, 2(2), 71-86. DOI : https://doi.org/10.5281/zenodo.1451498.

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Prof. Dr. P. Sreeramana Aithal has 29 years experience in Teaching & Research and 18 years experience in Administration. Dr. P. S. Aithal has secured the FIRST RANK in TOP 12,000 Business Management Authors in the Global Ranking of Elsevier's SSRN (USA) for maximum number of Research papers publications during 2017 & 2018. He has worked as Principal at Srinivas Institute of Management Studies, Mangalore from 2001-2017. Dr. P. S. Aithal studied his B.Sc. (Physics, Chemistry, & Mathematics) from Poornaprajna College, Udupi during 1985-88. Having four Master degrees in Physics with Electronics, Computer Science, Information Technology, and E-Business, he got his first Ph.D. degree in Physics from Mangalore University in the area of nonlinear optical materials and second Ph.D. degree in Business Management from Manipal University, Manipal, in the area of mobile banking. He worked as Post Doctoral Research Fellow at "Lasers & Quantum Optics Division, Physical Research Laboratory, Ahmedabad for two years from 1999-2000. In the year 2002, he has been selected for the prestigious Oversee Fellowship of Dept. of Science & Technology, Govt. of India – Better Opportunity for Young Scientists in Chosen Area of Science & Technology (BOYSCAST) Fellowship and did Post Doctoral Research at Centre for Research & Education in Optics & Lasers (CREOL), at University of Central Florida, Orlando, U.S.A. During his Post Doctoral Research at Ahmedabad & USA, he has worked in the area of Nonlinear Optics, Photonics, Optical Limiters and Optical Solitons. Dr. Aithal has got SERC Young Scientist Project on Nonlinear Optics funded by Dept. of Science & Technology, India. Dr. Aithal also had a visiting Associateship at Physical Research Laboratory, Ahmedabad, and Visiting Professorship of Grimsby Institute of Further & Higher Studies, Grimsby, U.K. He has 50 research publications in refereed International Journals in the area of Nonlinear Optics and Photonics, and 400 in refereed International Journals publications in Business Management, Higher Education, and Information Technology. He has presented more than 300 research papers in National & International Conferences/Seminars. Presently he is guiding research scholars for their M.Phil. and Ph.D. degrees in Electronics, Information

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Google Scholar : 650 Articles, Citations - 5,007; H-Index – 35, i-10-Index – 174.
SSRN : Full Papers – 498, Citations – 4,180, Top Business Author Ranking – 02.
ResearchGate : Papers - 520, My Readers – 7,10,314, Citations – 5,400. Score – 98.5% as on 10/03/2021.

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