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Pertinence of Internet of Things (IoT) in the Paddy Agriculture Sectors in Indian Context

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Abstract*: *In the modern era, technology has played an inevitable role Population of India is almost equivalent to 17.7% of the world population. On the basis of arable land area, India is placed second largest in the world. Even though India is the second largest producer of rice, biggest problems faced by farmers in our country is lack of knowledge in the technological development. The number of smart phone users will be more than 800 million by the end of 2022. Under this circumstance, Internet of Things (IoTs) has a major role in the agriculture field for productivity by monitoring day to day progress of the field. IoT aims to take internet connectivity to another level by connecting multiple devices at a time to the internet, thereby facilitating man to machine and machine to machine interactions. With the agricultural apps installed in the smart phone, farmers can realize the progress of the crop as well as the schemes and subsidies announced by the authorities. This paper reveals the importance of Internet of Things in the agriculture sector.

Keywords*: *Cloud, Greenhouse, Internet, IoTs, Kisan Yojana, Precision Farming, RFID, Sensors

I. INTRODUCTION

The current population of India is 1,406,939,847 as on 29th June ,2022, based on world meter elaboration of the latest United Nations data. India population is almost equivalent to 17.7% of the total world population. India ranks number 2 in the list of countries by population. 35% of the population is urban population (483,098,640 people in 2020). As per record, the total land area is 2,973,190 km2. India's arable land area is 159.7 million hectares, which is the second largest in the world after the United States. Its gross irrigated crop area of 82.6 million hectares is the largest in the world. On the basis of prediction, in the year 2030 Indian population will reach in the figure 1,503,642,322 and will be ranked as first in the world population. The Table I shows the historical Indian population data and figure 1 reveals the growth rate.
Even though India is the second largest producer of rice, biggest problems faced by farmers in our country are insufficient water supply, less use of modern farming equipment, over dependence on traditional crops, poor storage facilities, transportation problems in rural areas and Government schemes are yet to reach small farmers

Table 1 – India-Historical Indian Population Data

Year	Population	% of Growth
2010	1,234,281,170	
2011	1,250,287,943	1.297
2012	1,265,780,247	1.239
2013	1,280,842,125	1.19
2014	1,295,600,772	1.152
2015	1,310,152,403	1.123
2016	1,324,517,249	1.096
2017	1,338,676,785	1.069
2018	1,352,642,280	1.043
2019	1,366,417,754	1.018
2020	1,380,004,385	0.994
2021	1,393,409,038	0.971
2022	1,406,631,776	0.949

The table II shows the rice production from the year 1950 to 2022. To improve productivity and profitability of rice production of small holders need attention besides a focus on technological development [1].

Table II – Rice Production

Year	Production in Million tonnes	% of increase
1950-51	20.59	
1960-61	34.58	67.95
1970-71	42.22	20.10
1980-81	53.63	27.03
1990-91	74.29	38.52
2000-01	84.98	14.39
2010-11	95.98	12.94
2020-21	121.40	26.48

As per the ministry of Agriculture, rabi paddy acreage as on 29th January 2021 was increased by 16.62%, 35.23 lakh hectares (87.05 lakh acres) as compared to 30.21 lakh hectares (74.64 lakh acres) during the same period of last year. The higher covered acreage is as follows, Telangana 11.31 lakh ha (27.95 lakh acres), Tamil Nadu 10.51 lakh ha (25.97 lakh acres), Andhra Pradesh 6.82 lakh ha (16.85 lakh acres), West Bengal 2.52 lakh ha (6.23 lakh acres), Assam 1.43 lakh ha (3.53 lakh acres), Odisha 1.00 lakh ha (2.47 lakh acres) and Kerala 0.78 lakh ha (1.93 lakh acres).

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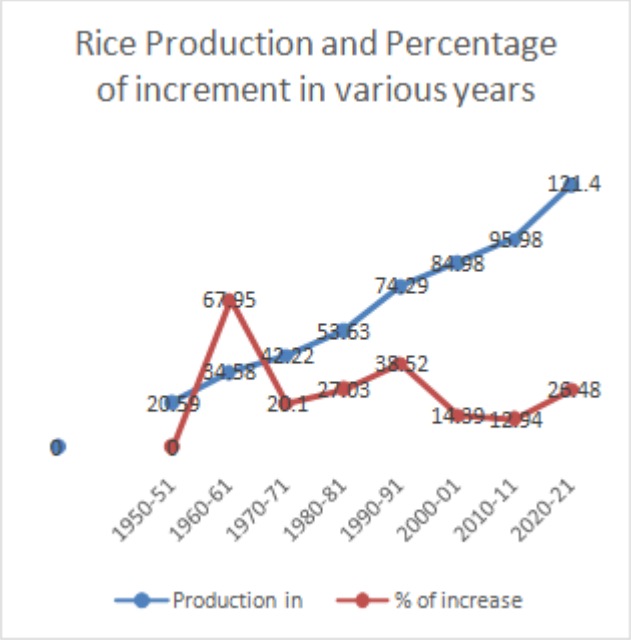

Fig. 1. Rice Production and Growth rate

State wise area under paddy in India is described in table III

Table III – State wise Area

State	2019-20 Lakh ha	% to total area	2020-21, Lakh ha	% to total area
Telangana	7.33	24.27	11.31	32.11
Tamil Nadu	10.42	34.50	10.51	29.83
Andhra Pradesh	6.74	22.31	6.82	19.36
West Bengal	2.10	6.95	2.52	7.15
Assam	1.33	4.40	1.43	4.06
Odisha	0.69	2.28	1.00	2.84
Chhattisgarh	0.54	1.77	0.84	2.39
Kerala	0.67	2.22	0.78	2.21
other	0.39	1.29	0.02	0.05
Total	30.21	100.00	35.23	100.00

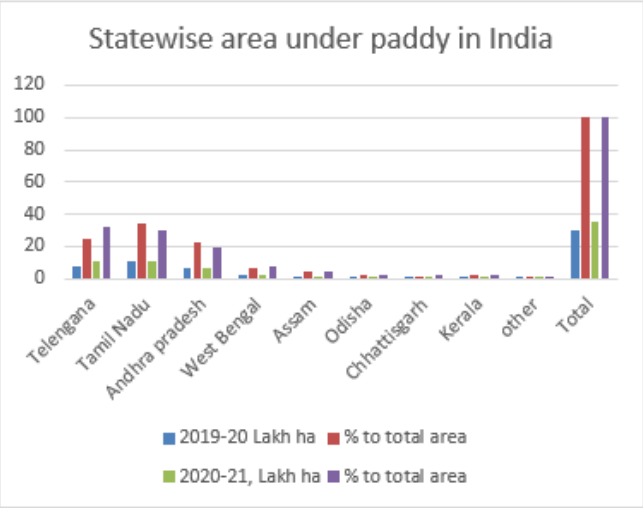

Fig. 2. State Wise Paddy Area in 2019-'20 & 2020-'21

The main solution to the above mentioned problems are better water management and modernization in agriculture. Since almost all the youth have smart phones, by using a modern agriculture app, youth can perform well in farms for better quality, highest productivity and enhance the efficiency. Due to technological intervention, the productivity has been recorded positively [2]. Technology affect on production has been always higher than by policy affect in all the periods [3].

The table IV shows that more Internet Connected Devices than People in the world, **Source: Cisco IBSG, April**

Table IV – Internet Connected Device with Population

Year	World Population	Connected Devices	Connected devices per person
2003	6.3 Billion	500 Million	0.08
2010	6.8 Billion	12.5 Billion	1.84
2015	7.2 Billion	25 Billion	3.47
2020	7.6 Billion	50 Billion	6.58

Internet Revolution can be described in the table V

The number of Smartphone users in India was estimated to reach over 748 million in 2020 and have over 800 million Smartphone users by 2022. India will have 1 billion smart phone users by 2026. Smart phone have become the most used medium for transferring voice, image, information, and delivering different types of services worldwide. The table 4 reveals the brief idea about the internet users in India. Smart phones may provide an opportunity to develop farmer's capacities with specific applications offering fast access to continually updated and reliable information [4]. The technology can always address the barriers faced by farmers in poorer countries [5].

Table V – Revolution of Internet

Year	Category	Description
1969-1995	Internet of Boffins	ARPANET in 1969, Telenet in 1974, Ethernet in 1980, full text web search engine in 1994.
1995-2000	Internet of Geeks	Amazon stated its first online retail service in 1995, eBay in 1995, Hotmail started its free web based email service in 1996, Google search in 1998, PayPal in 1998.
2000-2007	Internet of masses	Social networking sites came into existence Wikipedia in 2001, Face book in 2004, You Tube in 2005, Twitter in 2006.
2007-2011	Mobile Internet	Access to Internet via cellular phone service provider (introduction of smartphones)
2012 onwards	Internet of things	Things can be connected to each other using internet. The basic requirements are unique identity (RFID, Bar codes, QR Codes, Digital watermarking), communication ability and sensors.

Table VI – Smart Phone users in India

Year	Smartphone users (in Crore)	Growth rate %
2010	3.40	0
2012	9.06	166.47
2014	18.99	109.60
2016	30.45	60.35
2018	47.93	57.41
2020	74.83	56.12
2022	93.13	24.46

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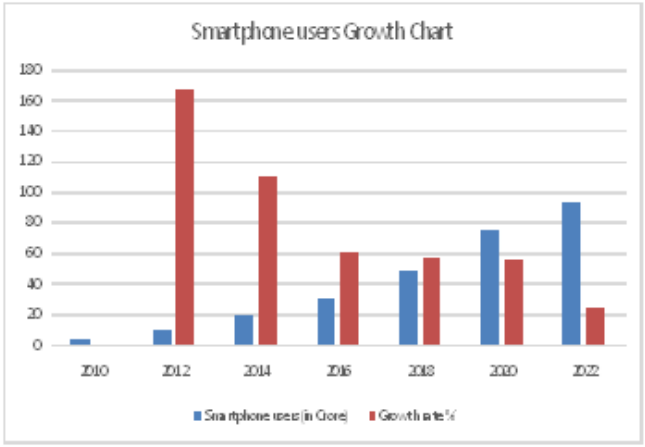

Fig. 3.Growth chart of smart phone

II. CHALLENGES IN AGRICULTURE FIELD

A. Following are the main challenges faced in agriculture field.

- Lack of knowledge in Information communication technologies (ICT)
- Lack of interest in agriculture profession among youth and educated professionals
- Ignorance of subsidiaries given by the Government.
- High cost of agricultural machineries
- Lack of mechanization
- Drastic changes in the climate conditions
- Less knowledge about the weather forecast
- Lack of awareness about sales distribution information
- Over influence of middle men in the product sales.
- Uncooperative nature of Public, NGOs and the Government undertakings during natural calamities.

Delay to identify the weed in the agriculture field, especially in paddy field . Also rhinoceros beetle menace in coconut

Fig. 4.Normal rice paddy with weed

Let us consider the case of 'Pokkali', the oldest and tallest rice variety of the world. Pokkali faming is practiced in kerala and is climate adaptive, oldest organic technique in agriculture, mo use of fertilizers, gasping for survival due to uncontrolled climate condition. Being a double crop, pokkali is losing out to aquaculture. Experts have called for its nutrious value but also for it role against saline water intrusion. Though many recommendations have been put forward for its conservation, they mostly remain unimplemented. In such a environment, we, the people are need of implementation of Internet of Things. Even though we are living in digital era, the technological development is not highly introduced in agriculture field of the country. As per records mentioned above, India is ranked the second position in world populations, rice production and wheat production. As per list of countries by smartphone penetration in 2021, India has 1.39 billion population and 492.78 million smartphone users, so that India is ranked in the second position. Under this situation, we have to motivate farmers to equip with technology in the field, especially Internet of Things (IoT).

III. INTERNET OF THINGS

Kevin Ashton's quoting "The Internet of Things has the potential to change the world, just as the internet did. Maybe even more so" is very much important point in the modern era. Mr. Kenvin proposed the term IoT in 1999 by connecting each and every thing to the internet with the relationship of people to people, people to things and things to things. IoT is an environment where objects, animals or people are equipped with unique identifiers capable of data transmission over Internet network without the need for human - human or human- things interaction (Gluhak et al.,2011). It is a network of physical objects known as "things" embedded with electronics, network connectivity, software, sensors which enables these objects to collect and exchange data. IoT aims to take internet connectivity to another level by connecting multiple devices at a time to the internet , thereby facilitating man to machine and machine to machine interactions. IoT ecosystem is not limited to a particular field but has business applications in the area of medical, factory line automation, retail, home automation, healthcare, vehicle automation and more. Internet of Tings (IoT), being a new era of computing in the digital world, aims for the development of larger number of smart devices that would support a variety of applications and services [7]. Radio Frequency Identification (RFID) and Wireless Sensor Networks (WSN) are enabling factors in the development of IoT [7]. The main components of IoT are the integration of four distinct components: Sensors, connectivity, data processing and a user interface.

- Sensors& Actuators:- Sensor devices help in collecting up to date data from the surrounding environment which have various degrees of complexities ranging from a simple temperature monitoring to complex full video feed. Actuators work opposite to that of sensors. While sensors, sense; actuators act. The sensors can detect a change in the environment and actuator can make something happen based on the trigger. For example flow of water in the drip irrigation system. Using the data collected by sensors, farmers will be able to control the operations on the agricultural field wirelessly and remotely anytime [12]

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- Connectivity:-Collected data with sensors are sent to cloud infrastructure through various mediums of communication channel between sensors and cloud such as cellular networks, WAN, satellite networks, Wi-Fi, Bluetooth ,ZigBee , LoRa WAN , DDS, MOTT and many more. IoT protocols are responsible for transferring data in the online world. IoT gateways are responsible for easy management of data traffic by protecting system from unauthorized access and malicious attacks. Gateways also preprocess data from the sensors before sending it to the cloud. The world is moving toward system-to-system connection, with smart network reaching its peak [8].
- IoT Cloud:- Collected data is travelled to the cloud and needs to be processed. They form the brain of IoT ecosystem as they are typically responsible for processing, commanding or taking analytics into account for the collected data. Clouds make Information effectively available for consumers with the immense computing power, storage capabilities, networking options, analytics and other service components. Edge Computing on the other hand is preferred when large amounts of data processing and storage are required on-premises.
- IoT analytics and Data Processing:- The software developed for data processing can collect the data from cloud and process the data to make appropriate decision accordingly. IoT analytics is used to make sense of vast amount of analog data. Analytics involves converting raw data into useful insights that later are analyzed to drive decision making. Analytics requires storage power and intelligent computation to be able to make sense of any data.
- End user devices and User Interface:- A user may interact with the system via the device like smart phones, tablets, and laptops. User Interface can achieved by triggering alarms on phones and/or notifying through emails or SMS. This can be done either by automatically or interactively through actively check in on their IoT system. For example a user has many cameras installed in his paddy fields and can monitor the requirement of fresh water through the mobile system.

IV. HOW IS INTERNET OF THINGS USED IN AGRICULTURE?

Smart agriculture is already making a big difference in the sector with its ability to optimize resources, reduce wastage and increase farm productivity. It can also reduce costs, increase revenue , and innovate in ways never thought possible before. It also empowers the farmers by giving real-time data on product conditions and speeding up decision-making. IoT applications help to elimination of space, reduction of cost ,energy saving and intensive monitoring [6]. Inclusion of IoT, along with cloud computing, big data analytics , and wireless sensor networks can provide sufficient scope to predict, process and analyse the situations and improve the activities in the real-time scenario[9]. IoT and related technologies will be the potential solution to solve the problem of human resources for agriculture development is becoming less due to migration of youth to cities and land use for agriculture cultivation is being used for rapid development[10].

- Precision Agriculture:- It is a farming management approach that uses digital technologies to motivate farmers to make better decisions about where, when, and how much to fertilize, irrigate and spray pesticides. By using sensors to collect data on soil moisture, weather, crop health, and real-time location asset tracking (RTLAT), farmers can make more technological decisions about how to care for their crops.
- Crop Monitoring:- Crop monitoring involves the use of sensors, drones and satellites to monitor crop health and identify locations requiring attention . Ccrop health, humidity, rainfall, temperature and more can be monitored continuously.
- Livestock Monitoring:-It uses sensors and RFID tags to track location and health of livestock which aids in ranchers determining the condition of livestock to avoid spreading disease to the rest.
- Irrigation management:-Irrigation management uses sensors to detect when and how much water is needed by individual plants or paddy field to save water and also reduces weeds and runoff. Purity of water can be identified user sensors.
- Smart Pest Control:- Sensors detect the presence of pets and then dispense pesticides as required to protect crops which helps to reduce pesticide usage and can use smart irrigation management to spray where is needed.
- Fertilizer Management:- Sensors notify farmers to determine which area need more fertilizer and can track how much fertilizer has been used in the season. It reduces the environmental damage.
- Weather Forecasting:- Famers can dependent on satellite weather forecasts to decide when is the appropriate time to plant or harvest for better yield of the item.

V. BENEFITS OF INTERNET OF THINGS IN AGRICULTURE

In the digital era, famers are motivated by the use of smart technology to increase productivity and efficiency. Smart farming based on IoT technologies enables farmers for efficient utilization of fertilizer, water and electricity. Some of the benefits of IoT are described as follows.

- Data:-The ability to collect data is the main benefit of IoT in agriculture. Farmers can track everything from soil moisture levels with help of sensors in the farm for the health of crop. With help of data mining algorithm, farmers can take decisions about irrigation, pesticides and fertilization.
- Enhanced quality:- With the data collected at their fingertips, farmers can monitor their corps each moment ,which allows them to detect any problems early on and take corrective measures to rectify it.

- Risk Reduction:- By tracking weather conditions, ioT helps farmer to reduce risks about when to plant and harvest their crops. It helps reduce the risk of losing a crop to bad weather.
- Remote monitoring:-With helps of digital devices like computer or mobile, farmers can track the progress of their crop. Many types of trouble with soil or seeds can be alerted to famers with smart fart systems.
- Business Automation:- Automatic irrigation systems can adjust water flow rate based on soil moisture levels. This ensures that crops get the right amount of water without or under watering system. Thus saves farmer time and money.
- Improved ROI:- With the help of sensors and data analytics , farmers can reduce water usage , energy consumption and inputs like fertilizers.
- Drought monitoring:- One of the main challenge faced by many farmers is dealing with drought conditions. IoT system can predict water shortage that will occur in coming days. On the basis of this information, farmers can take decision when and where to irrigate in order to maximize crop watering.
- Harvest Automation:- In order to reduce labour costs and for more consistent product quality, robotics are increasingly being used in agricultural harvesting.
- Climate condition:-The whole Internet of things ecosystem is made up of sensors that can detect real-time weather conditions like humidity , rainfall, temperature and more accurately. The sensors monitor the condition of the crops and the weather surrounding them.
- Precision Farming:- It helps farmers to generate data with the help of sensors and analyze that information to take intelligent and quick decisions. The precision farming techniques like irrigation management , vehicle tracking help to analyze soil conditions and other related parameters to increase the operational efficiency.
- Smart Greenhouse & Carbon Neutral approach:- With solar-powered IoT sensors builds modern and inexpensive greenhouses. The water consumption and greenhouse state can be monitored via emails or SMS alerts. Sensors help to provide information on the pressure, humidity, temperate and light levels. Carbon neutral agriculture means equalizing the amount of greenhouse gases emitted into the atmosphere with the amount of greenhouse gases absorbed from the atmosphere.
- Data analytics: In the smart agriculture system, cloud based data storage and an end-on-end IoT platform plays an important role. The data is analyzed and transformed to meaningful information using analytics tools, which helps in analysis of weather conditions, crop conditions and livestock conditions for better decisions. Using predictive analytics, we can get an insight to make better decisions related to harvesting.
- Agricultural Drones: The introduction of agricultural drone is a trending distribution in the field. The ground and aerial drones are used for assessment of crop health, crop monitoring, field analysis planting & crop spring. Drones with thermal or multispectral sensors identify the areas that require changes in irrigation. Eventually smart drones have reduced the environmental impact like massive reduction and much lower chemical reaching the groundwater.
- Farmers can monitor and control remotely the ecosystem with Ubidots, an IoT platform, monitor in real-time the status of all their devices and equipment, get alerts for any abnormal situation, analysis data to detect patters and trends , and spot inefficiencies in their production process and take corrective actions.

Fig. 5.Solar based sensors

The IoT technology has realized the smart wearable's, connected devices, automated machines, and driverless cars. But, in agriculture, the IoT has brought the greatest impact in the digital world. Recent statics reveals that the global population is about to reach 9.6 billion by 2050. And, to feed this massive population, the agriculture industry is bounded to adopt the Internet of Things. Among the challenges like extreme weather conditions, climate changes, environmental impact, IoT is eradicating these things. The industrial IoT has been a driving force behind increased agricultural production and number of connected devices related to agricultural will grow from 13 million in the year 2014 to 225 million by 2024. With the implementation of 5G, it is expected that faster and broader IoT technologies will be applied to various agricultural processes, and automatically increase crop quality and production, and can reduce labor [11].

Fig. 6. Pesticides spared by drones

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VI. AGRICULTURAL APPS

The agricultural app- Apni Kheti, which is available in Hindi, Punjabi and English, can be customized based on the user's profile. Apni Kheti is a reliable platform that always provides farmers with authentic information, the first choice to gain knowledge on farming. Kisan Yojana is another popular Android agriculture app available for free, which provides information about all Government schemes to kisan to reduce gap between the rural people and the Government. Another one is FarmBee –RML Farmer, which provides fertile agriculture content and information at every stage of the crop life cycle. The next is Agri Media Video App, a video category app provides chat service for farmers to solve their query related to agriculture with the option of uploaded images of infected crops. The Iffco Kisan App provides information about the latest agriculture advice, latest mandi prices and farming tips. The most likely apps by farmers is Agri App, which provides chat option and diversified videos of agriculture work. The block diagram of Internet of Things is described as follows.

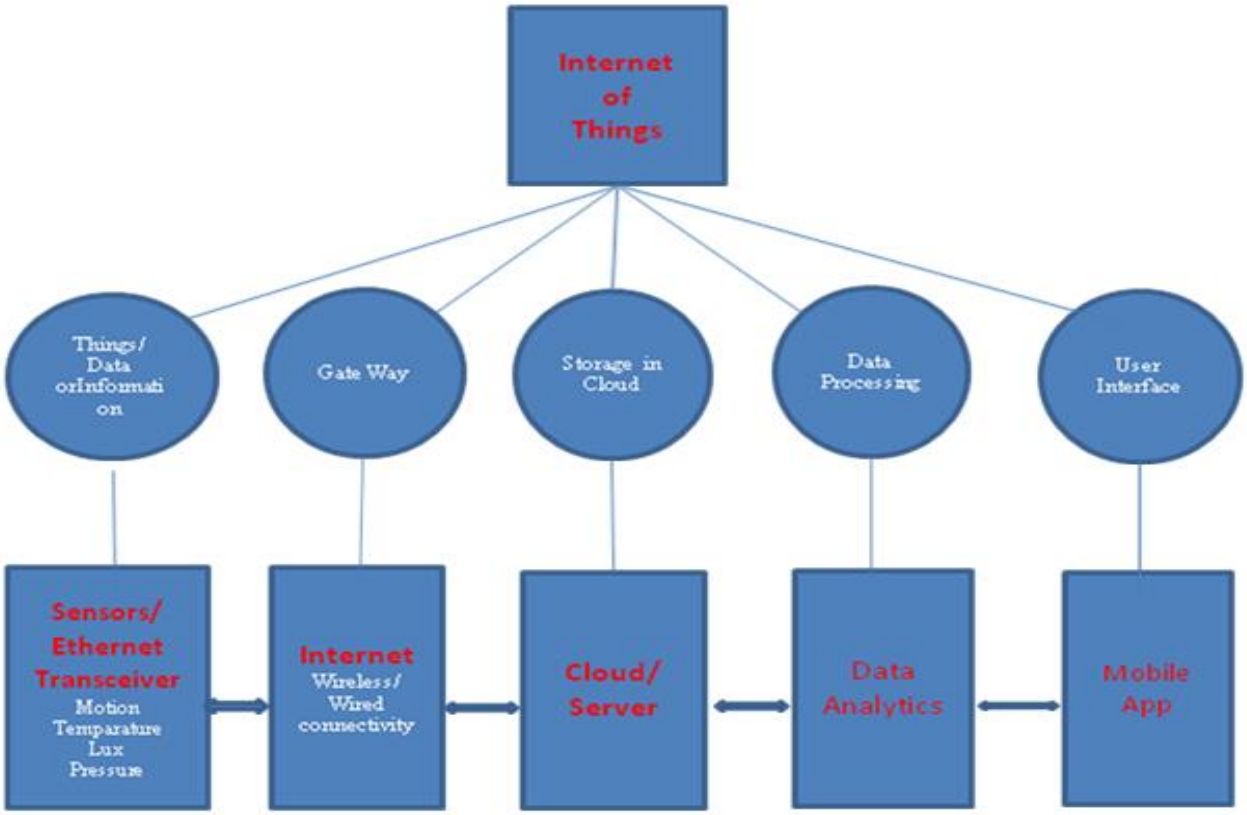

Fig. 7. Block Diagram of Internet of Things (IoTs)

VII. RESULT AND DISCUSSION

India is likely to have **887.4 million** smart phone users by 2030.Modern India has had a strong focus on science and technology, realizing that it is a key element for economic growth. India ranks third among the most attractive investment destinations for technology transactions in the world. The government has introduced multiple policies aimed at projecting India as a science and technology powerhouse and promoting both public and private sector involvement in the R&D practice. As a result, India's gross expenditure on R&D (GERD) has been consistently increasing over the years. Many IoT startups in griculture sector like Aarav unmanned systems, Croppln, Agdhi, Intello Labs, Gramwork X are under progress, which makes a massive shift from conventional system to technological based system results more production with less efforts.

VIII. CONCLUSION

With a vision to transform a country into a digitally empowered society and knowledge economy, Internet of Things (IoTs) can help farmers in the agriculture field for better productivity by monitoring day to day affairs in the field through various apps installed in the smart phones and educate them the real utilization.

DECLARATION

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Authors Contributions	All authors have equal participation in this article.

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