

Agricultural Data Science as a Potential Field and Promoting Agricultural Activities & Sustainable Agriculture

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ABSTRACT

Agriculture is important for everyone due to its importance in our daily lives. Cultivation is valuable for all of us and required in the building of healthy agricultural systems development and in this context different technologies and also emerging Agricultural Informatics plays a leading role. In respect of developing modern agricultural systems, various methods are useful and enhancing. Apart from the core technologies various supporting technologies, also beneficial in modernizing agricultural production and systems practice. Among the technologies few important are genetic engineering, computing technology, nanoscience, Management Science, and so on. Information Technology and Agricultural Sciences result in the development of Agricultural Informatics with its various components. Recently various other components have developed viz. Data Analytics, AI & Robotics, Cloud Computing & Virtualization, Internet of Things, etc. And within these technologies, Big Data and Analytics is emerging and enhancing more on Agricultural Informatics since it holds the solution for managing data effectively with a large amount and also the complex data. The applications of Data Science, Big Data, or Analytics in different subjects have resulted in various new nomenclature and among these Agricultural Data Science is an important one. This paper deals with the Agricultural Informatics including features, applications emphasizing Big Data and Analytics. The paper discussed about Agricultural Data Science, i.e. possibilities of Big Data

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and Analytics in Agricultural with educational programs available and future potentials. The paper also states the challenges, issues, etc. in this regard.

Keywords: Agricultural Information Technology, Emerging Technologies, Analytics, Data Science, Agricultural Data Science

Agricultural Science and Information Science combine and make a subject called Agricultural Informatics which is an interdisciplinary and additionally very broad field. Agricultural Informatics is developing and enhancing not only agricultural systems additionally in environmental systems. Agricultural Informatics is dedicated to productivity growth including ecological systems. It helps in pre-production activities and applicable in the post-production of the agriculture job as well [1], [5], [26]. In enhancing and developing agricultural practice towards advanced and productive agricultural systems Agricultural Informatics is worthy. Smart agriculture is many today lies in healthy Agricultural Informatics practice. Therefore, even many educational and research programs have been started on Agricultural Informatics in many universities, internationally. Regarding the Agricultural Informatics development various branches from the Computing/ Information related branches are considered as important viz. Information Technology, Information Science, Information Systems, Computer Science Computing / Computer Applications, Computer Science and Engineering, etc.

Agricultural practice was started in sedentary human civilization and around 105,000 years ago. Later around 11,500 years before the nascent farming had been developed; whereas the concept of animal cultivations has emerged viz. pigs, sheep, cattle, etc. got started cultivation about 10, 000 years ago [3], [15], [33]. There are total 11 regions internationally engaged with agriculture. Cultivation and agriculture deal with various types of plants, trees, seeds, crops, domestic animals, chemicals, etc.

The advancement of the technologies and systems in Agriculture led Agricultural Technology, Agricultural Informatics, etc. In addition to the core of IT in Agricultural Informatics other areas viz. engineering, technologies, sciences, management, and economics also play an important role. Agricultural Informatics uses various procedures, methods, tools, and principles for healthy agricultural systems for crops, plants, and animals, etc. The technologies of IT especially the emerging Data Science and Analytics led the Agricultural Data Science [10], [22], [27].

Objectives

The present work ‘Agricultural Data Science as a Potential Field and Promoting Agricultural Activities & Sustainable Agriculture’ is theoretical in nature and aimed with the following objective and agendas (but not limited to)—

- ❖ To know about the basics of the Agricultural Informatics viz. origin, feature and nature in brief.
- ❖ To get the details on Agricultural Informatics, and its applications in respect of Agricultural systems development.
- ❖ To know about the emerging Agricultural Informatics technologies including the availability of programs, nationally, and internationally.

- ❖ To get basics of Information Technologies products especially Big Data including features and characteristics in brief.
- ❖ Big Data and Analytics applications in Agricultural and similar areas which led the Agricultural Data Science.
- ❖ To know about the academic programs, components on Agricultural Data Science in brief.
- ❖ To know about the Agricultural Data Science or Big Data and Analytics issues, challenges, and potentialities in the contemporary context.

METHODS

The work entitled 'Agricultural Data Science as a Potential Field and Promoting Agricultural Activities & Sustainable Agriculture' is a theoretical paper and interdisciplinary in nature. To complete this work various secondary sources are used from different areas and subjects viz. IT, Agricultural Sciences, Environment, etc. Further primary sources have also been gathered, analyzed, reported here. The real scenario of Agricultural Data Science also has been mapped using websites analysis of various universities which offers the program. Additionally, websites of the companies have been analyzed also government project reports, etc. to incorporate in the subjects.

Big Data and Data Science: Role and Importance

Data is an important aspect in today's context and required in all the sectors and areas viz. Healthcare sector, Government sector, Business, horticulture, Management, Education, Agriculture, etc. The amount of data is increasing each and every day and therefore it is needed in various activities [11], [23], [34]. For proper management of the data, various techniques are being used. Big Data is dedicated to growing and Managing large amounts of data management especially Complex data management and thus it is also called as Big Data Management. Various kind of analytical tools are also used in a large amount of data management and therefore it is called as Data Analytics or simply Analytics. Analytics in various domains and fields results in other areas and concentration of Analytics viz.

- ❖ Business Analytics or Business Big Data
- ❖ Healthcare Analytics or Healthcare Big Data
- ❖ Medical Analytics or Medical Big Data
- ❖ Marketing Analytics or Marketing Big Data
- ❖ Government Analytics or Governmental Big Data
- ❖ Learning Analytics or Learning Big Data.

Big Data application in Agriculture can be called as Agricultural Analytics. Big data term emerged in 1990 but massive changes are noticeable in recent past in the commercial world in different organizations and institutes worldwide [7], [17], [30].

'Tera Data Corporation' begun with the concept in 1984 and thereafter 'Teradata' being used in several structured and unstructured data management purposes. Seisent IMC also contributed to big data

management. Google, apache, Oracle, IBM, EMC, DELL, etc., also made important contributions to Big Data and Analytics Management.

- ❖ Big Data is rising gradually in other sector and also increasing tremendously from the perspective of a dozen terabytes to many Exabytes. The nature of the Big Data is also changing rapidly—
- ❖ Big Data needs integration of data with the nature, complexity, and the context of massive scale.
- ❖ Big Data is close to the software as well as a high level of programming viz. Python or R programming, etc [4], [14], [32].
- ❖ Mathematical science and some of the other subjects viz. artificial intelligence including machine learning, deep learning, etc. are considered as important in Big Data.
- ❖ Big Data is concerned with a large number of data; hence here operation research is considered as important.
- ❖ Big Data lies in Discrete mathematics, fuzzy logic, etc with the support of inductive statistics for low information density.
- ❖ Database and Data Warehouse or similar systems within a time frame can be possible using Big Data management tools and techniques [8], [20], [23].

Big Data is important in different and thus various other areas have been created due to the applications of Big Data in the concerned field viz. Business Analytics (Big Data applications in Business and Corporate), Health Analytics (Analytics in Healthcare, medical and allied segment, etc.), Retail Analytics (Use of Big Data in retail and allied sectors), etc. Therefore, Big Data applications in diverse sectors such as Transportation, Governance, Education, Business, Manufacturing, etc lead different big data domains and fields. Primarily big giant MNCs are considered as Microsoft Corporation, Teradata Corporation, SAP, EMC, HP, Dell. Initially, only private bodies implemented Big Data, and later government sectors including also considered as an important part of Big data and analytics [9], [16], [24]. The applications of Big Data are rising in different are for its emergence and need. Big Data considered with volume as important features—

- ❖ **Volume:** This is simply the amount of data, content, and form.
- ❖ **Variety:** Different kinds of forms can hold Big Data systems viz. text, image, audio, video, etc; therefore, Big Data is nothing but the complex data management.
- ❖ **Variable:** Variable is an important aspect of data which is changeable. Inconsistency is also fallen under Bigdata and data analytics.
- ❖ **Veracity:** Quality is important in any data systems and information systems therefore perfect accuracy with the applications is important and this is known as veracity [2], [12], [18].
- ❖ **Velocity:** Velocity is the speed of the data, this is considered as important and valuable in this regard. For details regarding Big Data characteristics refer Fig. 1.

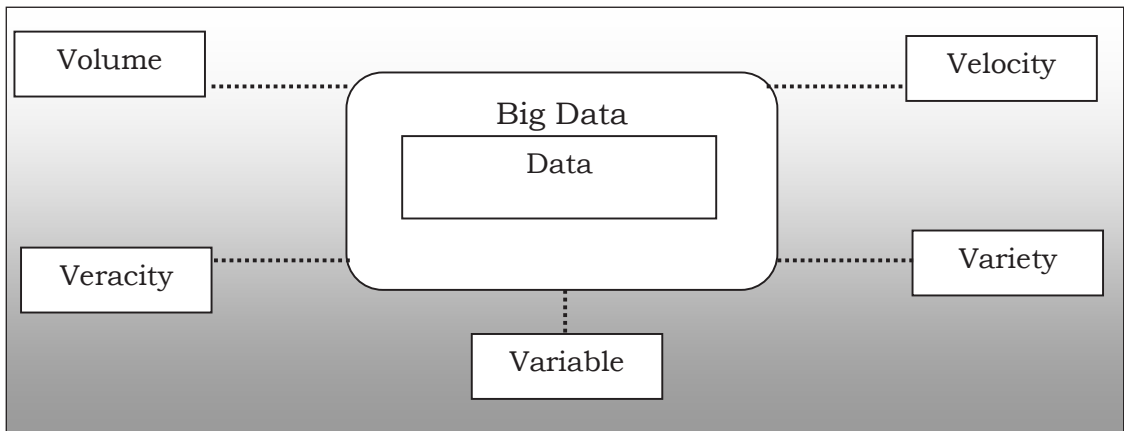


Fig. 1: The Core Characteristics of Big Data

Agricultural IT and Data Science: An Overview

Information Technology is an important Applied Science dedicated in information activities ranging from collection, selection, organization, processing, management, dissemination. Here for the complete information solutions, various sub-technologies play an important role viz.—

- ❖ Software Technology.
- ❖ Network Technology.
- ❖ Web Technology.
- ❖ Database Technology.
- ❖ Multimedia Technology, etc. [10], [13], [26].

The applications of various parts of these technologies led various other domain specific Information Technologies viz. Health Information Technology, Geo Information Technology, Medical Information Technology and so on. The growing Information Technology lead various emerging technologies in each subsystem and technologies such as in Network Technology emerging are Wireless Network, Cyber Security, Converged Network whereas in Multimedia Technology it is maybe Animations, VFX, 3D Printing, etc. Therefore, in respect of Database and Data related technologies Big Data, Analytics, Data Sciences, etc.

Even in an important move Data Science or Big Data in concentration with other domain and fields are noticeable viz. Health Data Science, Educational Data Science or Educational Analytics, Agricultural Data Science, and so on. Some of the universities and institutes internationally started Agricultural Data Science and allied programs at different level viz. Masters, PG Diploma, PG Certificate, or simply certificate as depicted in Table 1.

Table 1: List of Universities and Institutes with Agricultural Data Science & Allied Programs

Universities, Institutions& Programs	Focus of the Program/ Contents
Harper Adams University, Newport, England M.Sc. (Data Science for Global Agriculture, Food and Environment)	<ul style="list-style-type: none"> ⊗ Statistical Analysis for Data Science ⊗ Techniques in Machine Learning and Artificial Intelligence ⊗ Data Visualisation and Analytics ⊗ Elective module ⊗ Big Data and Decision Making- Case Studies ⊗ Research Project <p>Optional modules</p> <ul style="list-style-type: none"> ⊗ Advanced Research Methods - Applied Econometrics ⊗ Geographical Information Systems ⊗ Fundamentals of Agroecology ⊗ Ecological Entomology ⊗ Biodiversity and Ecosystem Services ⊗ Food Security and Sustainability ⊗ Agri-food Supply Chain Strategy, Operations and Management ⊗ Agricultural Economics, Policy and Trade ⊗ Elective module
Harper Adams University, Newport, England PG Diploma (Data Science for Global Agriculture, Food and Environment)	<ul style="list-style-type: none"> ⊗ Statistical Analysis for Data Science ⊗ Techniques in Machine Learning and Artificial Intelligence ⊗ Data Visualisation and Analytics ⊗ Elective module ⊗ Big Data and Decision Making- Case Studies <p>Optional modules</p> <ul style="list-style-type: none"> ⊗ Advanced Research Methods - Applied Econometrics ⊗ Geographical Information Systems ⊗ Fundamentals of Agroecology ⊗ Ecological Entomology ⊗ Biodiversity and Ecosystem Services ⊗ Food Security and Sustainability ⊗ Agri-food Supply Chain Strategy, Operations and Management ⊗ Agricultural Economics, Policy and Trade ⊗ Elective module
Harper Adams University, Newport, England PG Certificate (Data Science for Global Agriculture, Food and Environment)	<ul style="list-style-type: none"> ⊗ Statistical Analysis for Data Science ⊗ Techniques in Machine Learning and Artificial Intelligence ⊗ Data Visualisation and Analytics ⊗ Elective module

UniLaSalle France MSc Agricultural & Food Data Management	⊗ Agriculture and Event of Big Data
	⊗ Data Quality Management in Agriculture
	⊗ Data Analysis Applied to Agriculture
	⊗ Survey Methods
	⊗ Software Engineering
	⊗ IT Big Data Management I
	⊗ Cross Fields
	⊗ Agriculture and Event of Big Data
	⊗ Data Quality Management in Agriculture
	⊗ Data Analysis Applied to Agriculture
	⊗ Survey Methods
	⊗ Software Engineering
	⊗ IT Big Data Management I
	⊗ Cross Fields
NC State University, US Certificate in Agricultural Data Science	Focused on the basics of Computing, Data Science and Agricultural Science

There are different reasons in the starting of Agricultural Data Science and allied programs in different universities and academic institutions viz. the need for skilled manpower in the agricultural sector with data analytics knowledge, to improve and develop data analytics uses in agriculture and allied sciences [18], [31]. Furthermore, and other degree programs on other streams also Agricultural Data Science and allied programs can be started due to wider job potentiality viz.

- ❖ Agricultural Data Scientist
- ❖ Agricultural Data Miner
- ❖ Chief Data Officer (Agriculture & Environment)
- ❖ Epidemiologist (Animals and Plants)
- ❖ Manager and Director (animal health observatories)
- ❖ Designer / Developer
- ❖ Agriculture & Environment Data Designer
- ❖ Agricultural Machinery Designer
- ❖ Consultant (Agriculture & Environment)
- ❖ Data / Business analyst
- ❖ Researchers (Agriculture & Environment)

Therefore, Agricultural Data Science programs can be offered with different streams and subjects, and as far as Engineering and Technology it can be offered in the subjects as under (refer table 2).

Table 2: Possible Agricultural Data Science & Allied Programs in Engineering Context

Agricultural Data Science in Engineering Context
BE/BTech/ME/MTech- Agricultural Data Science
BE/BTech/ME/MTech- Data Science (Agricultural)
BE/BTech/ME/MTech-IT (Agricultural Data Science)
BE/BTech/ME/MTech-CSE (Agricultural Data Science)
BE/BTech/ME/MTech-ICT (Agricultural Data Science)
BE/BTech/ME/MTech-Software Engineering (Agricultural Data Science)

Here proposed programs are listed with both Engineering and Technology nomenclature, and degrees not only as full-fledged Agricultural Data Science but also in other concentration as a specialization viz. Computer Science and Engineering, Information Technology, and few other less offered streams also i.e. Information and Communication Technology, Software Engineering. All these subjects are proposed in taught programs only; however, these can be offered with research degree context and additionally with MPhil/PhDs.

Table 3: Possible Agricultural Data Science & Allied Programs in Science taught Context

Agricultural Data Science in Science Context
BSc/MSc- Agricultural Data Science
BSc/MSc- Data Science (Agricultural)
BSc/MSc-IT (Agricultural Data Science)
BSc/MSc-CS (Agricultural Data Science)
BSc/MSc-ICT (Agricultural Data Science)
BSc/MSc-Software Engineering (Agricultural Data Science)

Similarly, Agricultural Data Science can also offer with the Science degree as depicted in table 4.

Table 4: Possible Agricultural Data Science & Allied Programs in by research context (Science)

Agricultural Data Science by Research Context
BSc/MSc (By Research)- Agricultural Data Science
BSc/MSc (By Research)- Data Science (Agricultural)
BSc/MSc (By Research)-IT (Agricultural Data Science)
BSc/MSc (By Research)-CS (Agricultural Data Science)
BSc/MSc (By Research)-ICT (Agricultural Data Science)
BSc/MSc (By Research)-Software Engineering (Agricultural Data Science)

It is important to note that Management as an interdisciplinary study also close with the Agriculture. Therefore, Agricultural Data Science can come with the specialization of Agricultural Management or even full-fledged Agricultural Data Science specialization in BBA/MBA/DBA Degree.

Table 5: Possible Agricultural Data Science & Allied Programs in Management

Agricultural Data Science in Management Context
BBA/MBA- Agricultural Management (Agricultural Analytics)
BBA/MBA- Agricultural Data Science
B.Mgmt/ M.Mgmt.- Data Science (Agricultural)
DBA- Agricultural Data Science

These management degrees also been offered with the context of research degrees. Further all these programs can be offered with the MPhil/PhD Degree.

Ground of Agricultural Data Science as a domain

Agricultural Data Science is one of the important and emerging nomenclatures and can grow rapidly due to the wider requirement and potentiality of Big Data and Analytics in developing smarter agricultural systems. The populations are increasing day by day and as a result the demand for the food also and in this respect the uses of Big Data and other emerging technologies into agriculture can provide the result directly and indirectly. Here IoT devices, Cloud Computing based systems, Virtualization, Robotics and AI etc. can help partially to the Big Data and Analytics systems by gathering and processing data from the fields, soil, and plants aid, crops etc. Since Agricultural fields are dedicated in generating variety of data and complex data in different models therefore Big Data and Analytics can be considered as important in this respect. The Compound Annual Growth Rate regarding Big Data in the field of Agriculture is 16.2% therefore it is an important sign. The market size of Big Data and Analytics in agriculture during 2018 was 585 USD million and it may be reach up to 1236 million by the end of 2023.

In respect of growing populations

Populations are rising around the world and it is bringing an important challenge regarding the food productions and therefore agricultural farms, industries etc. are in the search of better and productive agricultural products and in this respect Big data could be consider worthy. In this context additionally, farmers and others are able in collecting real time data on rainfall patterns, water cycles, soil condition. Even the crop related aspects viz. crop condition, fertilizer requirements etc. are possible to gather with the help of Agricultural Data Science practice towards productive agricultural foods [6], [12].

Therefore, in developing smart decisions and better profitability, in right decisions Agricultural Data Science can be considered as worthy. Mathematical modeling is important regarding agro development in different context. Various sensors are important in collection of the data management and proper decision making and towards the necessity of Agricultural Data Science.

In Ethical Pesticides & Optimizing farm equipment

Agricultural Data Science can be treated as important in overall administration of the agricultural systems; further here whole Big Data, AI based can be associated for the predicting agricultural systems. Pesticide is harmful for the soil and agricultural products and here Analytics can be useful in identification of actual need of the pesticides and therefore can be important in managing and also in ethically supports

the human being and society as well. Data Analytics is also worthy in optimizing farm and related equipment. Therefore, Agricultural Data Science can be considered as valuable in big farms in different context. And further can be important in different areas (refers: Fig. 2).

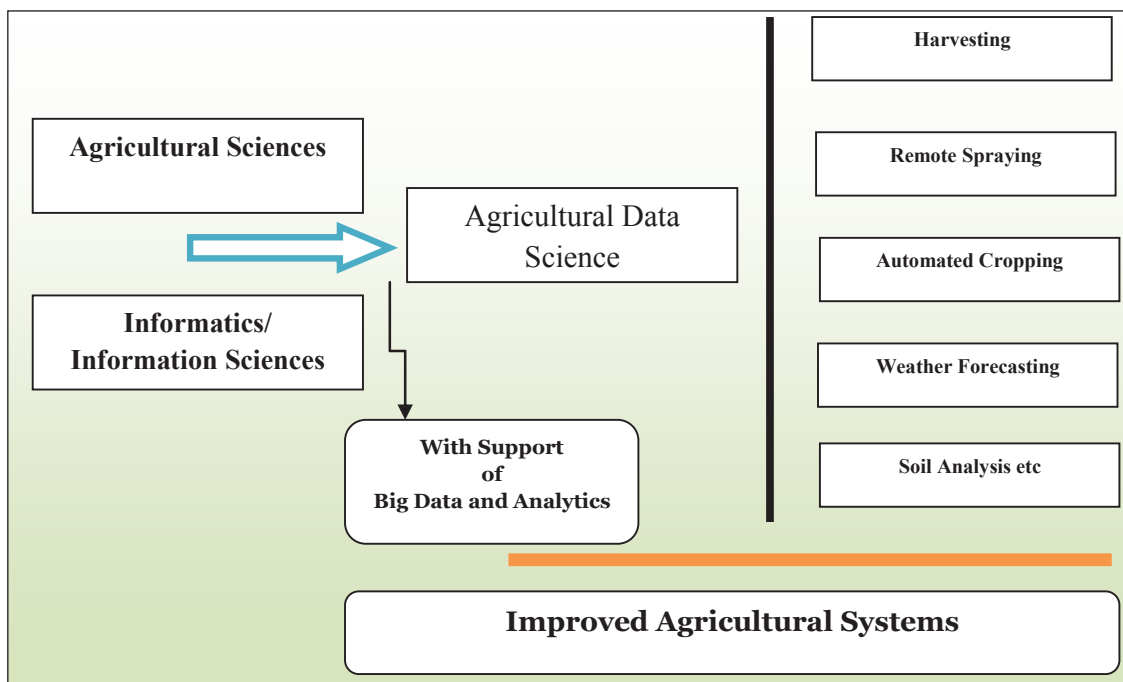


Fig. 2: Agricultural Data Science in smarter Agro Systems

In Risk Management

Risk Management can be worthy with the Big Data and Analytics applications risk in agriculture including pre producing and post producing agricultural system and this is also important in identification of crop failure, efficiency enhancement. As far as healthy risk management is concerned therefore supply chain management, marketing management etc. can be consider as important [19], [27].

Regarding Food Safety

Agricultural Data Science is worthy in Big Data and Analytics in Agricultural Systems and it also help in Food Safety Management. By the use of Humidity, temperature and chemicals agricultural systems can be smarter and can help in brining of Food Safety.

Regarding Supply Chain management

Equipment management, supply chain management can be worthy with the Big Data Analytics. Big data is helpful in supply chain efficiencies by tracking and optimizing delivery truck routes with the associated technologies viz. Cloud Computing, Internet of Things, Robotics and AI, etc. Ultimately in complex data management and solving agriculture related issues Agricultural Data Science can be an important tool.

Data mining is helpful in healthy Agricultural Data Science practice by finding discovery patterns in large data sets using other tools and systems viz. artificial intelligence, machine learning statistics and it can help and led Precision agriculture towards profitability, efficiency and can be consider as important in future decision-making. As far as fertilizers, chemical, crops, seeds management are concerned Big Data Analytics is important and thus Agricultural Data Science can be a timely and worthy in nature. In agriculture capturing relevant data from a huge number of sources is fruitful in pre agriculture and post agricultural with Real-time insights. Therefore, in better decision making also Big data Analytics and allied technologies could be consider as important. Robot is also important in controlling, analysis and planning regarding agri-tech companies. In marketing division autonomous vehicle can be supported by the Big Data to soil moisture including prediction of the weather, image-capturing by the satellites and thus worthy in crop health identification and management [7], [29].

Therefore, in irrigation of a field of the agriculture, crop health identification, weather and pest infestations and drought conditions identification since Big Data is worthy therefore important to introduce Agricultural Data Science. Labor shortage is an important issue with the Big Data manpower aspects can be solved with; hence Agricultural Data Science can give the advantage for agriculture. Emerging technologies are rising in the developed countries and vast majority of farmers are interested in developing sustainable farming and here Big Data and is worthy and urgent. Hence Agricultural Data Science can be started as an academic programs and degrees. The satellite image of a plot of land and other geospatial approach can be further possible with the suitable for their decisions. Agricultural industry is rising and here Big Data can be considered as important in proper decision making including in precision farming. Big Data Analytics is required in food and agro product tracking with the effective using sensors, and analytics [21], [28].

Information Technology is dedicated in collection, selection, organization, processing, managing, dissemination of the information and here Big Data is applicable in managing large amount of complex data management that is also important in agricultural management powered by other technologies. Therefore, Big Data and Analytics and especially Agricultural Data Science is important to provide us following—

- ❖ Efficient Agriculture Systems
- ❖ Expansion of the Agro Systems
- ❖ Speedy Agricultural Systems
- ❖ Quality Production
- ❖ Quantity Enhancement of Agro Products
- ❖ Livestock Management.

There are certain issues in developing and starting of the Agricultural Data Science practice or deeply Agricultural Data Science as an academic program viz. Bachelors, Masters, Doctoral etc. Some of the potential challenges in this regard are include fund; which is important to run the process and big data practice in the agriculture. Further technological implementation is an important issue for a developing country like India. Opportunities are another important issue, which is need to offer in respect of educational program in the field including academic, training and doctoral program. Initiative is also very

important to grow the system properly and effectively. And further for the solid practice of Agricultural Data Science joint and collaborative initiative is very important and timely also [8], [28].

CONCLUSION

The population is growing rapidly and according to The Food and Agriculture Organization (FAO), United States it is may reach to 9.3 billion from current 7.3 billion by the year 2050. But as per the study it is noted that there may be chance of growing up to 70%. With the limited land, water, and fertilizers and increasing population it is difficult to core with the traditional tools, techniques and methods. Therefore, proper and healthy Agricultural System is the need of hour by the modern thinkers, scientist, technologist, policy makers etc. Technologies are play an important role for the healthy IT infrastructure and data-driven decisions is worthy and to be supported by the Big Data in many ways which can led agriculture systems towards higher productivity, sustainability, transparency to consumers wanting to know more about their food. Data Systems and Technologies making agricultural professionals in many ways by making decisions and Modern technology support. Data on soil, water, farms, marketing can be possible from the, Big Data and allied technologies viz. Internet of Things (IoT), Cloud, Robotics, etc.

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