Targeting second green revolution in India: Applying Big Data technology to precision Agriculture management systems for sustainable production

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ABSTRACT

Precision Agriculture (PA) has evolved from a concept some decades ago into an emerging technology today. The catalyst for the emergence of Precision agriculture has been satellite positioning and navigation. The combination of Global Positioning System (GPS) and mobile mapping provide the agriculturist with a new capability of gathering information for implementing decision-based Precision Agriculture. While adoption of precision farming in wide concept has been modest in India. In India, the current agricultural management and its practices are not prudentially viable neither environmentally supportable and the yields of many agricultural products in India are critically low. In the near future, it will become essential for the country to build a high yielding and varied agricultural. This paper identifies the corollaries of traditional farming practices and addresses how to increase the yield of the agricultural commodities by using present day computer technologies. Further, it also acknowledges the critical computing and diagnostic ability of Big Data analytics in processing huge volumes of transactional data in real time situations. It was identified that the small size of farms and fields in most of Indian agriculture limits economic gains from currently available precision farming technology. However, the public concerns for the environment and food security may mean that those potential benefits of precision agriculture in rural agriculture system are beginning to receive attention.

***Keywords*— Precision Farming, Agriculture Management, Big data, Farming Technology, Food Security**

I. INTRODUCTION

India is a country with more than billion plus people, and also one of the world's rapidly flourishing economies. Today, India ranks second worldwide in farm output. Agriculture is topographically the broadest economic sector and plays a symbolic role in the comprehensive socio-economic domicile of India[1] But, the existent report asserts that the agriculture sector continue to trail for India.[2] The economic augmentation of agriculture to India's GDP is indirectly declining with the country's economic growth.

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Precision agriculture (PA) or **Precision farming (PF)** is a farming management concept based on observing, measuring and responding to inter and intra-field variability in crops. Crop variability typically has both a spatial and temporal component which makes statistical/computational treatments quite involved. The rampant evolution of data over the past decade has initiated a unique realm in the domain of information technology and data science called Big Data. This ingenious technology is acquiring intensifying consideration as an idea to upgrade the performance of agricultural systems by combining different systems via a data and communications platform to diminish redundant crop failures, enhance and hasten agricultural governing, and permit passage to all stratum of agricultural services for a wide range of circumstances. The e-Agriculture service data can be considered as a Big Data because of its variety of data with huge volumes flowing with high velocity. Some of the solutions to the e-Agriculture service big data include the predominant current technologies like HDFS, MapReduce, Hadoop, STORM etc. Adoption of big data in agriculture significantly decreases the possibility of crop failure and farmer's primary concerns and recommends the soil sensing and crop yield information to be stored in data centres.

II. INTRODUCTION TO BIG-DATA

Big data is an evolving term that describes any voluminous amount of structured, semi-structured and unstructured data that has the potential to be mined for information. [3] Big data is a set of techniques and technologies that require new forms of integration to uncover large hidden values from large datasets that are diverse, complex, and of a massive scale. Big data is creating a new culture in which business and IT leaders must join forces to realize value from all data. But for the proper understanding of this continuously growing

data we need a new fundamental approach to architecture, tools as well as practices. The vast Indian agricultural system is ought to harness agriculture's "big data" by interpreting a complex set of data, including electronic farm records and sensor data. This enables agriculturists to access and analyse agriculture's big data to ascertain quality, determine best practice, assess treatment strategies and identify crops at risk.

A. Characteristics of Big Data

In addition to the exponential growth of data the changing user behaviour and globalization is also responsible for directing Big Data. Thus, many organizations are seeking for analysing such models to enhance their functioning. The typical characteristics of the big data are-

Variety: In Big data, the variety and heterogeneity of data sources and storage has increased, fuelled by the use of cloud, web & online computing. [3] This refers to the inconsistency which can be shown by the data at times.

Volume: The quantity of data generated as Big Data ranges from Terabytes to Exabytes and Zettabytes of data. The volume has been increasing exponentially.

Velocity: It refers to the speed of generation of data or how fast the data is generated and processed to meet the demands and the challenges which lie ahead in the path of growth and development.

Veracity: Accuracy of analysis depends on the veracity of the source data. It refers to the biases, noise and abnormality in data.

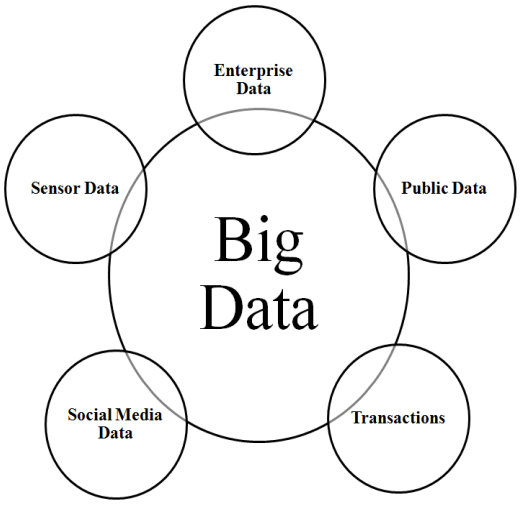


Fig. 1 Big Data conceptualization

B. Big data technology and analysis technology

To process large data for getting the data value is becoming very import because more and more types of data are produced and the current technology is increasingly unable to handle it, so a complete set of techniques and tools to analyse and understand big data is necessary for data owner to discover the value in data[4].In the entire data processing, the basic processing of big data with traditional data processing is not different because big data In each steps the related tools are being developed with *MapReduce* parallel processing technology for data processing[5] The key technologies include the following aspects-

Large data gathering: The different of data collection methods is to acquire data generated from the source including inter action between people and people, people and machine, the machine and the machine such as Web, networking, mobile phones, sensors and so on.

Large data storage and management; NoSQL are used for large data storage and management. The data processing mode is completely distributed in various low-cost servers and storage disk so that it helps the web page and a variety of interactive applications quickly process massive amounts of data. It uses a series of distributed technology for real-time analysis of massive data to meet the business needs under big data environment.

Big data analysis/mining: Big data technology is about how to analyse and dig out the value for data source. Traditional relational database for large data analysis tasks cannot be qualified, because the systems are parallel relational database systems to pursue high degree of data consistency and fault tolerance. *MapReduce* and *Hadoop* are as the representative of non-relational data analysis techniques and suitable for large-scale parallel processing. It has achieved significant progress in internet information search and other big data analytics and has become mainstream technology.

Large data visualization: It is big data analysis / mining results representation [6]. Generally it refers only to reporting tools & business intelligence analysis product. It is coming a modern branch of descriptive statistics. It involves the creation and study of the visual representation of data, which means that information that has been abstracted in some schematic form,

including attributes or variables for the units of information.

III. CONCEPT OF PRECISION AGRICULTURE

Precision agriculture (PA) is a strategy of managing small areas within fields instead of managing whole fields as a single unit. Typically, precision farming is associated with sophisticated computer and satellite technologies, which some farmers have neither the physical nor the financial resources to implement. However, even without expensive technologies, precision farming may be used to enhance a wide variety of crop management decisions. [7] Precision Agriculture (PA) is directly linked with Site-specific management (SSM). SSM is the idea of doing the right thing, at the right place, at the right time. This idea is as old as agriculture, but during the mechanization of agriculture in the 20th century there was strong economic pressure to treat large fields with uniform agronomic practices. Precision farming provides a way to automate SSM using information technology, thereby making SSM practical in commercial agriculture. PA includes all those agricultural production practices that use information technology either to tailor input use to achieve desired outcomes, or to monitor those outcomes e.g. variable rate application (VRA), yield monitors, remote sensing [8]

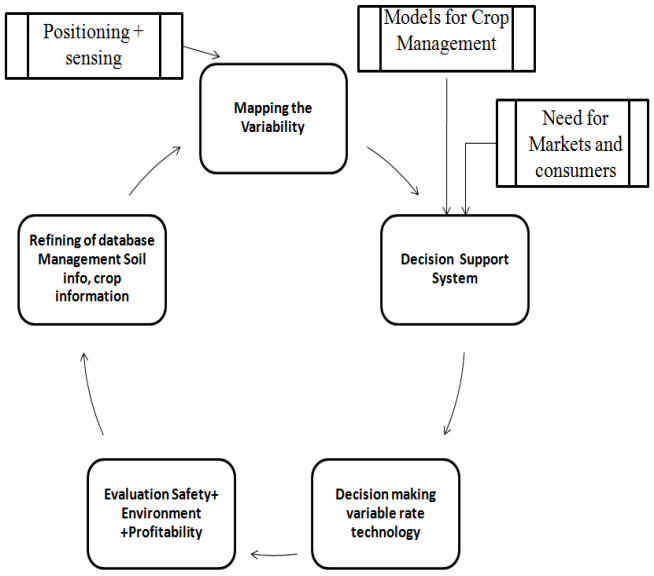


Fig.2 Process of Precision Agriculture (PA)

Precision Agriculture (PA) is the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production for improving production and environmental quality. The success in precision agriculture depends on the accurate assessment of the variability, its management and evaluation in space-time continuum in crop production. The agronomic feasibility of precision agriculture has been intuitive, depending largely on the application of traditional arrangement recommendations at finer scale. The potential for economic, environmental and social benefits of precision agriculture is largely unrealized because the space-time continuum of crop production has not been adequately addressed. [9] Though widely adopted in developed countries, the adoption of precision farming in India is yet to take affirm ground primarily due to its unique pattern of land holdings, poor infrastructure, lack of farmers'
Inclination to take risk, socio-economic and demographic conditions.

A. Elements of precision Agriculture

Precision agriculture (PA) basically depends on measurement and understanding of variability, the main components of precision farming system must address the variability. Precision agriculture technology is information based and decision focused the components include, Remote Sensing (RS), GIS, GPS, Soil Testing, Yield Monitors and Variable Rate Technology. Precision farming requires the requisition, management, analysis and output of large amount of spatial and temporal data. Precision farming is concerned with spatial and temporal variability and it is information based and decision focused, it is the spatial analysis capabilities of GIS that enable precision agriculture. GPS has greatly enabled precision farming and is of great importance to precision farming, particularly for guidance and digital evaluation. Modelling position accuracies at the centimetre level are possible in DGPS receivers' accurate guidance and navigation systems will allow for farming operations at height and under unfavourable weather conditions.

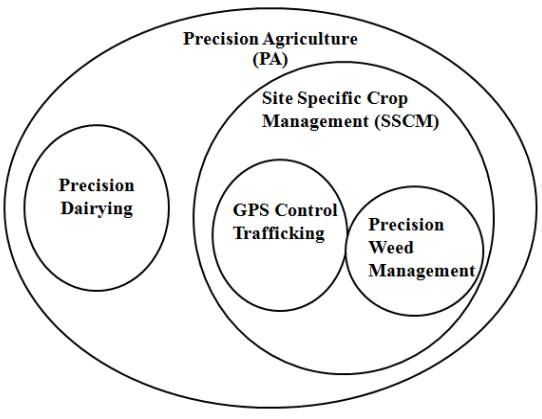


Fig.3. Precision Agriculture (PA) and its applications areas

B. Big data Tools, Methods & technologies used in Precision Farming

Following tools & methods are being used in PA systems-

Global Positioning System (GPS): GPS is a navigation system based on a network of satellites that helps users to record positional information like latitude, longitude and elevation with an accuracy of between 100 and 0.01 m. GPS allows farmers to locate the exact position of field features, such as soil type, pest occurrence, weed invasion, water holes, boundaries and obstructions. [10]

Sensor Technologies: Various technologies like electromagnetic, conductivity, photo-electricity, and ultrasound – are used to measure humidity, vegetation, temperature, vapor, air etc. Remote-sensing data are used to: distinguish crop species; locate stress conditions; discover pests and weeds; and monitor drought, soil and plant conditions. Sensors enable the collection of immense quantities of data without laboratory analysis.[11]

Geographic Information Services (GIS): This system comprises hardware, software and procedures designed to support the compilation, storage, retrieval and analysis of feature attributes and location data to produce maps. Computerized GIS maps are different from conventional maps and contain various layers of information e.g. yield, soil survey maps, rainfall, crops, soil nutrient levels and pests etc. GIS helps convert digital information to a form that can be recognized and used but its real role is using statistics and spatial methods to analyze characters and geography.

Variable Rate Technology (VRT): It is automatic and may
be applied to numerous farming operations. VRT systems set the rate of delivery of farm inputs depending on the soil type noted in a soil map. Information extrapolated from the GIS can control processes, such as seeding, fertilizer and pesticide application, and herbicide selection and application, at a variable (appropriate) rate in the right place at the right time.[12]

IV. PROBLEMS WITH CURRENT AGRICULTURE SYSTEM IN INDIA

Though around 70% of India's total population dependent on agriculture for their livelihood, currently, the issues that afflict the Indian agriculture are the deficiency of proper knowledge and infrastructure in the rural areas. Problems related to irrigation, market infrastructure and transport infrastructure add significant cost to farmers' operations. Another issue is lack of delivery mechanisms. There are a number of schemes aimed towards developing agriculture. We don't have effective delivery mechanisms that can translate those into effective facilitation at the ground level, in terms of increasing productivity or decreasing cost or increasing price realization. Inadequate government support exacerbates these issues. Government failure is a major concern in agriculture because the high risks involved make help and facilitation necessary. Like any other business enterprise, agriculture is subjected to high risks because of the volatile nature of the factors involved.

A. What is the need of Precision Agriculture in India?

Even with the spectacular growth in the agriculture, the productivity levels of many major crops are far below than expectation. India have not achieved even the lowest level of potential productivity of Indian high yielding varieties (HYVs) Also India has very high rate of natural resource degradation including soil and water. Indian Agriculture is characterized by small and marginal operational holdings and is subject to fragmentation due to land ceiling acts, and in some cases, family disputes. Such small holdings are often over-manned, resulting in disguised unemployment and low productivity of labor. [13]

V. IMPLEMENTATION OF BIG-DATA TECHNOLOGY IN AGRICULTURE SYSTEM

Big data provides a ground for collecting, storing and analyzing data to unveil the information not previously known. By wisely using the ever-increasing amount of data available, we could develop new vision by reconsideration of the data or merging it with other available information. In agriculture this means not just mining crop records, precipitation maps, diagnostic reports etc., for insights, diagnoses and decision support device, but also continuous analysis of the data streams produced for and by the specified area at every time instant. The proposed concept enables agriculturists, big-data analysts and staff to have role-based access to information on electronic farm records. The Big data in agriculture refers to the Electronic Farm Records (EFR) which includes soil temperatures maps and data, precipitation maps and data, electrical conductivity maps and data, moisture content data, air permeability maps and data, nutrient contents and pH level data, past cultivation records, insurance and yield related information and social media posts including tweets,

blogs, new feeds and articles in agriculture journal. The job of the big data scientist is to mine the big data and discover the associations, understand patterns and trends to improve the agricultural systems, increase crop productivity and lower costs involved by proper diagnosing the various factors. Most of the analytics of the agricultural data are executed by yearly data recreation in relational databases that produce pre-processed reports. The analysis of the data is ought to be done on the spot. Also, data vivification needs to be done in real-time not once in a month or in a year.

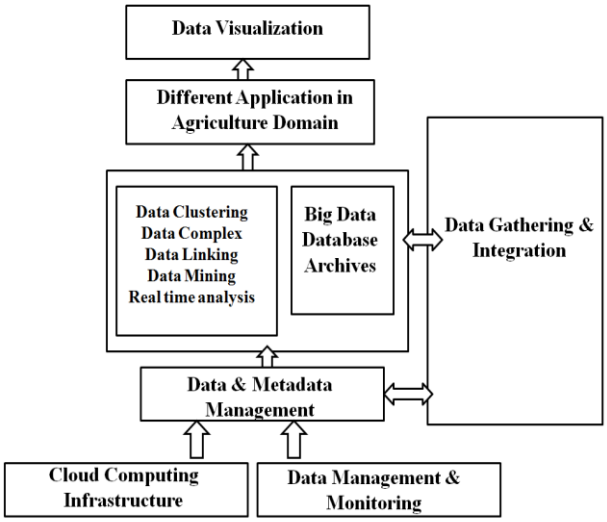
A variety of sensors can be used to control variable rate application equipment in real-time or in conjunction with a Global Positioning System (GPS) to generate field maps of particular soil properties. To offer better services to the people, the agricultural system needs to evolve and innovate continuously. The information acquired by the big data analysis can be comprehensively used for precision agriculture. These applications of big data can be tested, polished and enhanced rapidly and economically and will entirely change delivery and research in the agricultural sector. Though, the big data analytics in agriculture plays a crucial role to provide better agricultural services, it provide analysis on the historical data to uncover hidden information. The big data analytics has challenges like heterogeneity and incompleteness of data, scale, timeliness, privacy and human collaboration [14].The future research is all about to get through the obstacles and use big data analytics in agriculture for unveiling the proficiency from the raw unstructured data.

A. Agriculture information system design based on Big Data technology

The current agricultural information system infrastructure must meet big data processing demand. This requires not only the gradual standardization and upgrading of the business system, and its basic platform facilities should be able to expand and integrate resources for avoiding the construction of a simple computing power and storage capacity requirements, as showed on Figure below-

The construction and improvement of infrastructure is considered for sustainable development and the proposed expansion of a comprehensive solution which will enhance the overall efficiency of the existing system to ensure that it will not affect the reliability, availability, and security improvements in the application system. The researchers generally believe that cloud computing technologies are used to build infrastructure and platform including core technologies and services such as cloud computing, virtualization, cloud storage, cloud security, and other key technologies, which will be designed to meet the requirements of better data storage, data protection and more secure, better grading process data. Therefore, the construction of infrastructure and improvement of agricultural information platform should take advantage of cloud computing technology model to make sure that supports the efficiency of data storage, data analysis, data management, and data. In order to build an agricultural big data analysis application platform, we rely on related data analysis and processing technology based on agricultural big data. The framework of agricultural big data systems uses the technologies of the internet of things to gather data, and use cloud computing technologies for data processing so that the big data system should be built on *MapReduce* technologies, which will have good expansibility and applicability. Based on the big data technology frame, intelligent decision support system should be developed.

Fig.4 Information System hierarchy based on Big Data technology



VI. PRECISION AGRICULTURE IN INDIAN SCENARIO

A. What precision agriculture will achieve overall?

In general, a farming system involves five factors; which are: plant variety, field features, technology, regional infrastructure, and the motivation/ intentions of the farmer. Better integration of these five factors can create a competitive farming system which suits local conditions. [15] Precision farming uses field maps, variable-rate technologies and a decision support system. Variable-rate technology not only increases productivity by re-organizing the three factors of technology, plants and fields, but also creates a better

linkage with the regional infrastructure, e.g. by following environmental regulations. A decision support system provides the best technology, taking into account the aims and motivation of farmers as well as environmental factors. In other words, precision farming brings about an innovation in the whole system of agriculture.

B. Precision Farming for Smaller farms in India

It should be noted that precision farming is characterized by variable management. A key point in precision farming is understanding variability in the field. There are at least two types of variability. One is within-field variability, the other is between-field or regional variability. Within-field variability focuses on a single field, and the one plant variety being cultivated. Between-field variability considers each field as a unit on a map. On a single small farm, the farmer can understand fairly well what is going on in each field. This makes possible variable-rate applications to meet site-specific requirements, using the farmer's knowledge and skills.

When it comes to an area of a few dozen hectares, containing many small fields, precision farming has to coordinate diverse types of land use and many farmers with different motivations, Regional precision farming must manage a hierarchy of variability: within-field, between-field and between-farmers. High-tech approaches, such as a yield meter with GPS,are available for regional precision farming covering many small farms. Moreover, measures to conserve or improve the environment should be undertaken on a similar scale. From the point of view of development in a rural area which includes small farms and local companies, precision farming offers the possibility of developing a new kind of industry, by fusing agriculture to various kinds of industrial activity If the multi-functions of agriculture are re-evaluated using information-added fields, value-added space of this kind can be seen as providing new resources, such as new biological materials, open-air classrooms and agro tourism.

C. Is precision farming good for Indian society?: An Ethical view

Precision farming will be widely adopted because it is profitable on individual farms. However, in this era of skeptics questioning all manner of technology, scientists also must examine the broader economic, social and environmental consequences.

National Economic Impact: The nationwide economic impact of precision farming will depend on whether the technology mainly saves inputs and costs or mainly increases output. In reality, economic benefits of precision farming are likely to come from more efficient use of inputs and from additional farm output. As a result, producers achieve greater crop output per pound of fertilizer, seed and pesticide. If the enlarged output-input ratio comes from using less fertilizer and other inputs, it will cut farmers' costs and save natural resources hence more of the long-term economic benefits of precision farming are likely to accrue to consumers than to land owners.

Social Economic Impact: The social impact of precision farming on family farms and rural farm com-Precision farming will be widely adopted because it is profitable on individual farms. However, in this era of skeptics questioning all manner of technology, scientists also must examine the broader economic, social and environmental consequences. On that basis, precision farming receives mostly high marks munities depends heavily on what it does to (1) economies of size. costs of production on large versus small farms and (2) labor requirements in farming. Hence rural community impact of PA will not be great.

Environmental Impact: Principal environmental problems of agriculture include water, air and food quality, and natural resource depletion. Precision farming is likely to raise productivity of land, decreasing land requirements to meet food and fiber demand. Site-specific control offered by precision farming could tailor chemical application to ameliorate environmental hot spots. Precision agriculture may provide a means to reduce application on sites contributing to such water quality problems.

VII. CONCLUSIONS

Data has become strategic resources as important as natural resources, human resources, implied great value, and has caused the scientific community and the business community's attention. With the recent rapid data growth, the existing data processing technology is difficult to meet the large demand and data value is very difficult to mine. Therefore, we must find and apply a new data processing technology to mine a data value from agricultural big data. This paper describes how to deal with the flood of agricultural data from the view of the big data technologies: (1) Deciding that which method is the most suitable for solving a particular data analysis is often critical because each data domain has

own data analysis model. So data analysis efficiently is necessary for agricultural data value mining [16]. (2) The big data technologies are the significant role in the development of agriculture modernization, but agricultural research and applications are required orderly by their importance and the government encourages the research institutes and enterprises whose have extensive data resources and technological advantages to carry out the research on agricultural data collection, storage, transport, mining, research and analysis, application.(3) In the recent years, information system integration or business integration are concerned too much. Now we must pay attention agricultural data integration in the big data area because the data can bring out its value once the data is gathered and stored in an integrated database.

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