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Future and Scope of Big Data in Indian Agricultural Sector

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Abstract

The recent developments in terms of data analytics has been a threshold for Agricultural activities which has help the farming industry to maximise productivity and mitigate risks through predictive data analytics. Big Data is not only helping farmers around the world to gain valuable information on farming but also facilitating them to maximise their production efficiency by the various methods of precision farming.

This next generation Green Revolution has a huge bet on Big Data, and considering India, which as an agricultural nation has over 58% of rural population dependent on farming for livelihood, is in very urgent need of transforming this sector for the growth of the nation. Agricultural export also nearly one fifth of the total exports in India **[1].** As India move along with world it need to find out ways toward integrated data analytics which will empower Indian agricultural industry towards sustainable growth. This study thus will dwell more into the various methods adopted by developed and some of the developing nations to implement Big Data techniques in Agriculture and will try to analyse where, how and by what means the predictive data analytics can shape the future of Agriculture in India.

To formulate the basic premise of this study, various research papers, books, and online assets have been counselled, which constitute the primary information for the analysis. The information will be subjected to big data analytics framework introduced by various research organisations around the world for precision farming.

Keywords: Big Data analytics in Agriculture, Precision farming, Future of Indian Agriculture.

1.Introduction

As per IBM nearly 57.2 billion bytes of digital data is generated in the last two years which is almost 90% of the total data generated till date **[2]**.Big data as per experts does not have a real definition, but as said in today's context the huge amount of data being generated digitally in every part and region of the world gave forward the concept of Big Data. Per Gartner, ''Big data is defined as high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision making **[3].**

1.1 Big Data in Agriculture

Big Data in Agriculture is basically the use of predictive data analytics technology to process Agriculture Related Data, come up with intelligent information and integrate it with various stages of farming to mitigate inevitable risks and increase the efficiency of farm production and entire Agricultural supply chain. Per a research the world population is going to increase by 9.7 billion in 2050 compared to the present 7.3 billion **[4]**. This huge increase in the population can widen the hunger gap and will require new farming techniques which could increase the productivity in limited available land. Agriculturist therefore are looking towards Big data as a means to resolve the food insecurity through predictive data analytics.

1.2 Significance of Big Data in field of agriculture

According to a report of USDA on US agriculture, "Data science is another main thrust in the agribusiness **[5]**. The report goes ahead to note, "As per the USDA, U.S. farmers spent more than $367 billion on agricultural generation in 2013. Matt Darr with Iowa State University says in regards to 66% of each dollar spent on farming is based around choices of seed choice, fruitfulness, and land availability. A large amount of data available could have an impact on those choices." The objective is to let Big Data Analytics help agriculturists settle on better choices to build yields and make creation more effective. Getting food from farm to folks securely is another region in which huge information is assuming an undeniably noteworthy part. Mary Shacklett (@MaryShacklett), Chief Executive Officer of Transworld Data, talks about the significance of a safe food supply chain. "Because of growing attention to food safety and nourishment wellbeing," she explains, "the FDA's Food Safety Modernization Act (FSMA) was marked into law on January 4, 2011. In its first stages, the FSMA concentrated on controlling agricultural production sources and the respective supply chain; in 2014, it has focussed more on distribution and logistics of food from farm producer to end customer." **[5]**
The article further explains, "Getting more from less is what it's about." John Schlageck articulates, "Some believes 'Big Data' might be the next big methodology in agriculture. Others call it the best progress in agribusiness since the Green Revolution amid the 1940s, '50s and '60s when one of the greatest rushes of research and innovation impelled the development of agricultural production around the globe. Some often put it in the same league of technological solution as Biotech. **[6]**. Schlageck concedes there are concerns connected with social occasion and utilizing huge information; yet, its utilization appears to be inevitable. He noticed that information will be assembled in various new ways:

"Drones hovering above land and farms to record high resolution pictures, and field sensors giving prompt data concerning crop conditions including dampness, nutrients, bugs, and so forth, may be a common practice in agri-big data period. Agri-business organizations are putting money on its future. Prescriptive planting or relating soil, atmosphere and seed information is the potential realized in big data farming. The potential for an expansion in crop yields is another potential."

According to Isabelle M. Carbonell from University of California, ‘’The corporate histories of significant agribusinesses, including the American organizations Monsanto, DuPont and Dow, the German Bayer and BASF, the Swiss Syngenta and most recently Chinese ChemChina, are complex but all of them are repositioning them as a major agrochemical and agricultural input producers. Through a progression of acquisitions, mergers, deals and spinoffs, they rise today as major multinational organizations competing for worldwide food productions. Out of all these efforts, because of purchasing Climate Corp, Monsanto emerges as the most dedicated agribusiness to seek after the utilization of big data in agriculture’’ **[7]**.

The recent deal in which Monsanto purchased Climate Corp for USD 930 million shows how aggressively it is thinking of investing in Big data driven largest biotech agribusiness. As an entire integration process of collective data and information, modern tractors will be equipped with wireless sensors which will instruct farmers when to sow seeds and irrigate them, the right time to apply fertilizers and pesticides and when to harvest the same with detailed climatic conditions.This wireless technology will be legally regulated by Monsanto and farmer must sign the technology terms and conditions.

According to another study, ‘’Compared to larger farms, smaller farms using organic method of production such as intercropping, drip-irrigation etc. are producing more output per unit area’’. For example, there is an estimation "adopting organic farming would bring down the operating cost of farming generation in the United Kingdom by 75%, from £1,514 million a year to £385 million a year" (Pretty, Ball, Lang, and Morison, 2005).

Large agribusiness corporations including the American organizations Monsanto, DuPont and Dow, the German Bayer and BASF, the Swiss Syngenta corporations are aggressively doing mergers and acquisition or alliances and are competing to become the leader in global food production. These alliances basic aim is to synergize the information available at various industrial verticals and lead through agricultural production by utilizing the Big data available for precise farming.

2.Agricultural sector in India, some facts and figures

According to a report by KPMG, ‘’’In India majority of population lives in rural areas and one of their main occupation is agriculture. Despite supporting nearly 60 percent of India's total population, the contribution of agribusiness to the GDP has been declining rapidly. It as of now stands at around 17.4 percent. A sector that offers work to the greater part of the nation's population contributing under 1/5 to its GDP shows a high reason for introspection. While India grew by more than 7 percent for during the financial year 2015-16, farming stayed pretty much stagnant’’ **[8].**
Also, the population of our country is increasing exponentially and according to one of the reports the agricultural dependent population grew by 50 percent, which is an astonishing

figure when compared to US, where it has dropped by 37 percent. It states that "The agricultural dependent population of the United States, declined by 37% because of large scale of mechanisation, enhanced product assortments, manures, pesticides, and government sponsorships — all of which added to economies of scale and solidification in US farming". It further states that, Asia's agricultural population grew by 20 percent, and its non-agricultural population has grown by 130 percent and India constitutes a large share in this statistical data **[9].**

2.1 Challenges faced by Indian Agricultural Sector

According to a world bank report, "India has approximately 195 m ha under cultivation of which nearly 63 percent are rain fed (about 125m ha) while 37 percent are irrigated (70m ha). Also, forests cover about 65m ha of India's territory" **[10]**. As per this report, there are mainly three key challenges that needs to be addressed to improve health of agricultural sector which directly influences most of the population in the country.

1. **Increasing agricultural productivity per unit of land:** Raising productivity per unit of land should be the growth factor for agricultural growth as basically all cultivable land is farmed.

2. **Reducing rural poverty through a socially comprehensive methodology that involves both agriculture and no-farming sector:** Rural improvement should likewise profit poor people, landless, females, scheduled casts and tribes. In addition, there are difficult territorial terrains: the dominant part of India's poor agricultural farms depends on rains or are in the in the Eastern Indo-Gangetic fields. Reaching out such terrains is a very difficult task.

3. **Ascertaining that agricultural development fulfils the food needs:** The sharp ascent in sustenance crop generation amid India's Green Revolution of the 1970s empowered the nation to accomplish independence in sustenance grains and fight off the danger of starvation. But this production scenario gradually declined in mid-90's and 2000s and has been a cause of concerns with rapidly increasing population and force a challenge to fulfill basic nutrition demand of poor people both in rural and urban areas.

Government failure is another important concern in agriculture because the high dangers included make help and assistance fundamental. Like some other business undertaking, farming is subjected to high dangers due to the involvement of the various factors involved. For example, climate is frequently an issue - you have dry spells in one year and overwhelming rains in the following. Both the factors are a heavy loss to the farmers; thus, they need to search for a normal period to earn profit. Government, in this manner, needs to play a vital part in offering help to farmers.

3. Feasibility of Precision farming in Indian Agricultural sector

Precision Agriculture (PA) is a management concept of farming idea which is based on monitoring, measuring and responding to identify, analyse and manage spatial and temporal variability within inter and intra-field for optimum production and profitability, sustainability and preservation of agricultural land resource optimizing production costs**[11]**.

Analysing research report by IHDS (Indian Human development survey) following factors can be a vital factor in determining the future of Precision farming using big data analytics in the field of Indian agricultural sector **[12]**.

1. **Percentage of agriculture depended population in India**: A majority (nearly 63%) of household is dependent on income from agriculture, 39 percent of the household cultivate land, 43 % own the livestock, 29% have some family member employed in agricultural labour and about 7% have rented out their agricultural land and receive income. Also 97% household in cultivation is rural **[12]**.

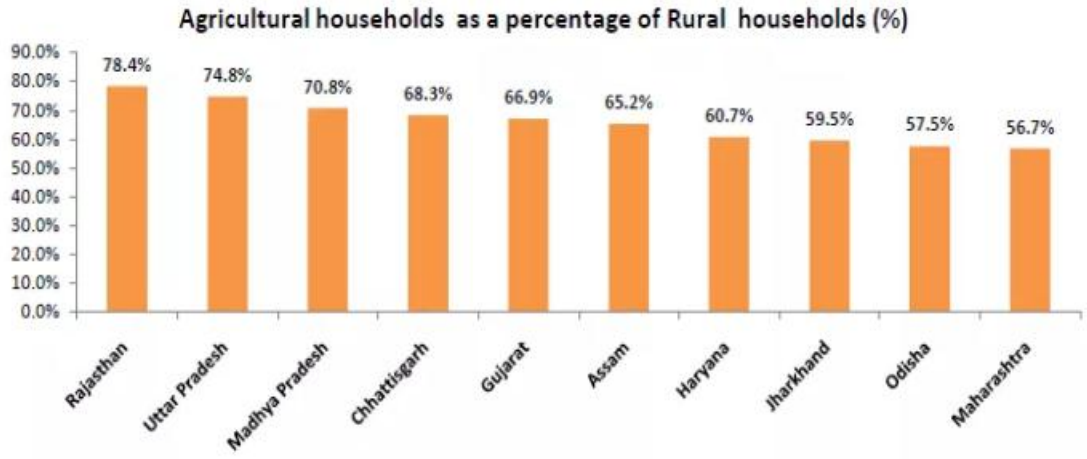

Figure 2.Agricultural Households as a percentage of Rural Households (Source: NSSO,2015)

2. **Valuable Land and Water resources:** One of the major developments of the post-independence in 20th century the twentieth century is a decrease in normal farm size and an increase in number of small farms. Thee NSSO records between 1961 to 2002–3, the number of marginal farms that were classified as marginal (less than one hectare) expanded from 39% of all farms to almost 70% farms; medium and large farms (less than four hectares) diminished from around 19% of all farms to 5%. Also, in the recent years much of the change has occurred due to land fragmentation because of huge population growth. Most of the farmers cultivate less than 1 hectare and only 14 % work on more than 2 hectares **[12]**, Figure2.Also, farming income relies upon land and water. Big agricultural lands have large income. Proper irrigation just doubles the farm income as most of the irrigated farms are multiple cropped compared to un-irrigated farms

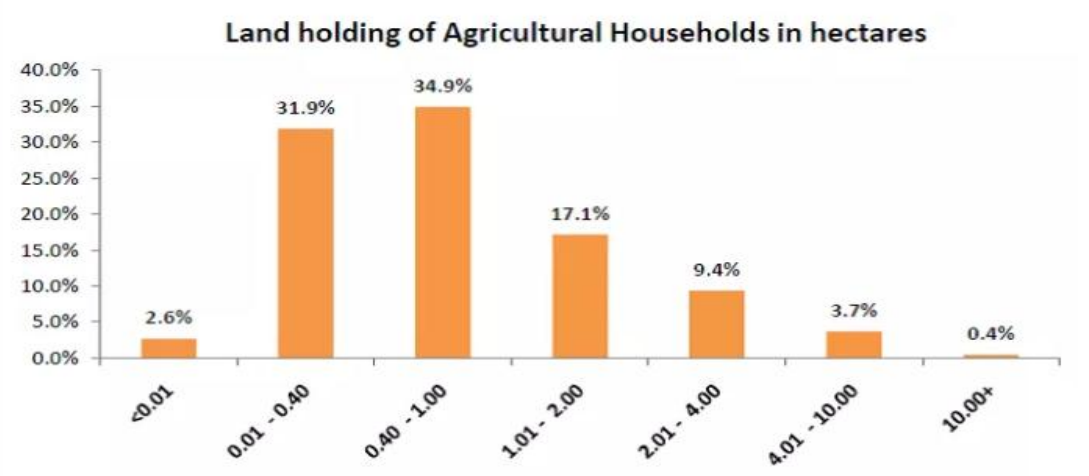

Figure 3. Land holding of Agricultural Households in hectares (Source: NSSO, 2015)

3. **Agricultural Income:** According to the IHDS research,50% of rural farming households earns Rs8,475 or less from the crops and animals they raise. But a few families earned significantly more. So, the normal (mean) rural income was Rs21,609. Analysis also shows that 11% of farmers incurred higher expense than gross cultivation income, thus, suffered overall loss in the production over a year **[12]**. Also, 53% of agricultural households are indebted and levels are as high as 93% in states like Andhra Pradesh.

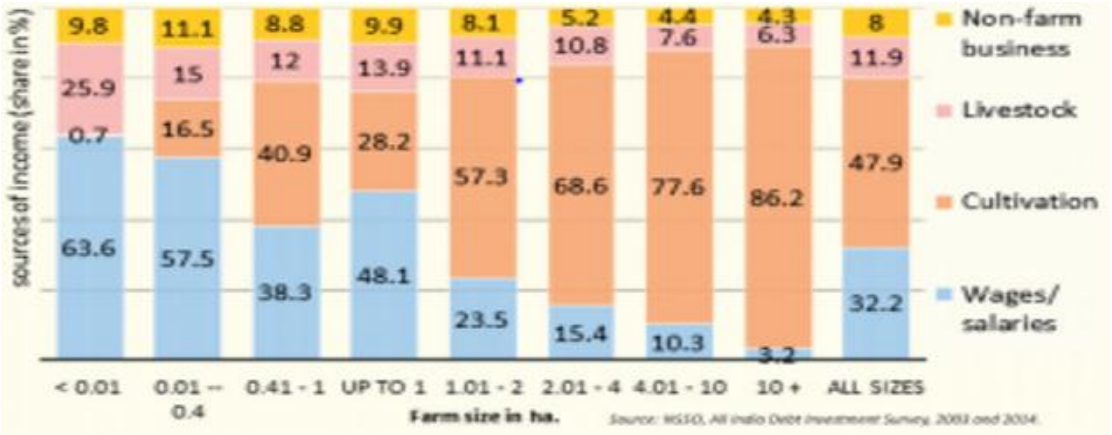

Figure 4.Distribution of income of farmers as per the farm sizes and classes (Source: NSSO, 2014)

4. **Farm Inputs:** More Indian farmers are utilizing latest day farm inputs than before. Nearly 50% use chemical herbicides and a quarter have water system pumps. Tractors are still exceptional (4 % for all the farms) however in some states like Punjab nearly 50% of population uses tractors. One of the main reasons for the states like Punjab to have larger farm inputs is because these states have more than 50% of continuous field sizes that are bigger than 15 ha. However, the spread of the latest farm inputs is quite

uneven in as large farms use more farm inputs than small farms and as said earlier marginal farms (less than one hectare) expanded from 39% of all farms to almost 70% of total farms**[12]**. This has resulted in restrain for farmers operating in such fields to increase the number of farm inputs for better cultivation as it would increase the operation cost without realising the necessary benefits.

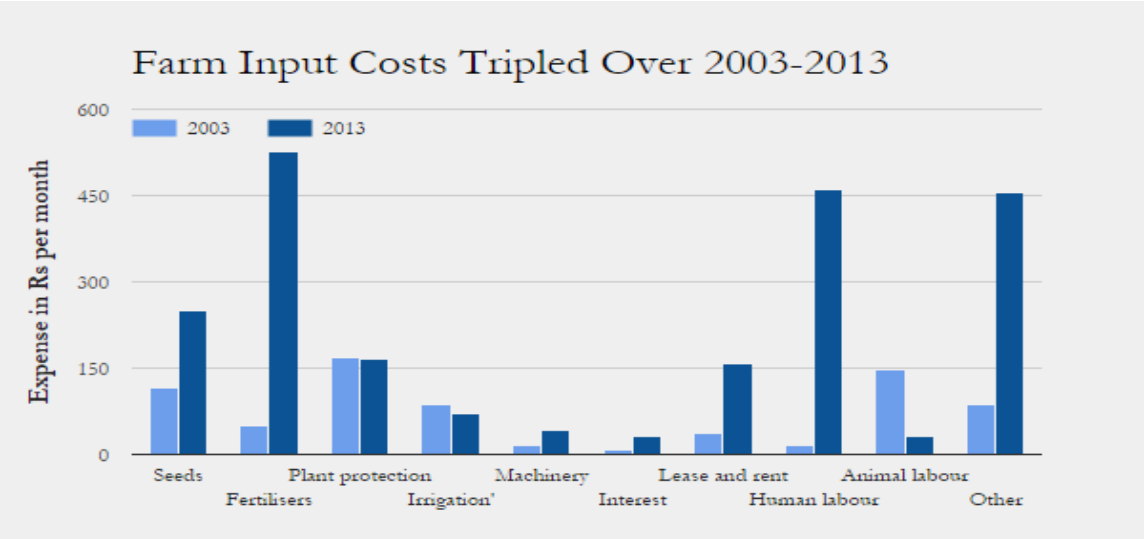

Figure 5. Farm Input Cost, 2003-2013 (Source: Commission on Agricultural Costs and Prices, Department of Agriculture)

4.CGIAR proposal for Big Data Analytics coordination platform

CGIAR (Consortium of International Agricultural Research Centres) which is a group of more than 15 research centres around the world dedicated for increasing food security and human health and nutrition has uniquely positioned itself as thought leadership in using Big data to transform agricultural production. As per its study, a whole lot of factors contribute to farmer's profit in agribusiness. Some of them are water availability, soil moisture, fertilizer, weather, pesticides, market scenario, government policies etc.

Considering all these factors an analytics algorithm must be developed which can help farmers to arrive at the following decisions:

- Right farming techniques and the improvements needed in respective areas to maximize productivity
- Weather forecast analysis to utilize weather conditions optimally and mitigate any risk due to bad weather
- Water resources availability and counter scarcity based on statistical data analysis
- Optimum farming decisions by following best practices of farming based on the respective analysed data.
- Analyse Government policies and utilize them to maximise farming profits.
- Market analysis with current and past trends in agribusiness.
- Right fertilizer based on the nutrition levels of soil and how they are going to change over the years
- Select the right hybrids for genetically modified crops.

According to a report of CGIAR, a group of scientists at International Centre for Tropical Agriculture (CIAT) says, "With the accessibility of advanced data innovation and information technology, we have an opportunity in farming to settle on more informed decisions based on the data". They are also using Big Data tools to have precise strategies that can help small scale farmers to mitigate risk during climate change**[13]**.

One such research lead by a team of scientist from CIAT is studying the cultivation of rice in Colombia by partnering with Colombian government, CGIAR Research Institute on Climate Change, Agriculture and Food Security.

Some interesting facts about this research based on Bid Data analytics can be highlighted below:

- Big data analytics have been used to analyse changing patterns of climate and future forecast based on past statistics and how this impacts the rice yields in Colombia.

- This analyses helps to find the most productive rice breeds, planting timings in different region of the country and seasonal forecast. This methodology of Big Data Analytics in crop farming has resulted in boost of rice yield by 1 to 3 tons per hectare.

- The tool used for the data analytics works wherever data is available and has helped the farmers greatly to analyse their production estimates for rice. As a result, this technique is now being scaled out through Peru, Argentina, Uruguay, and Nicaragua.

Big Data Analytics framework used by CIAT team for Agricultural research

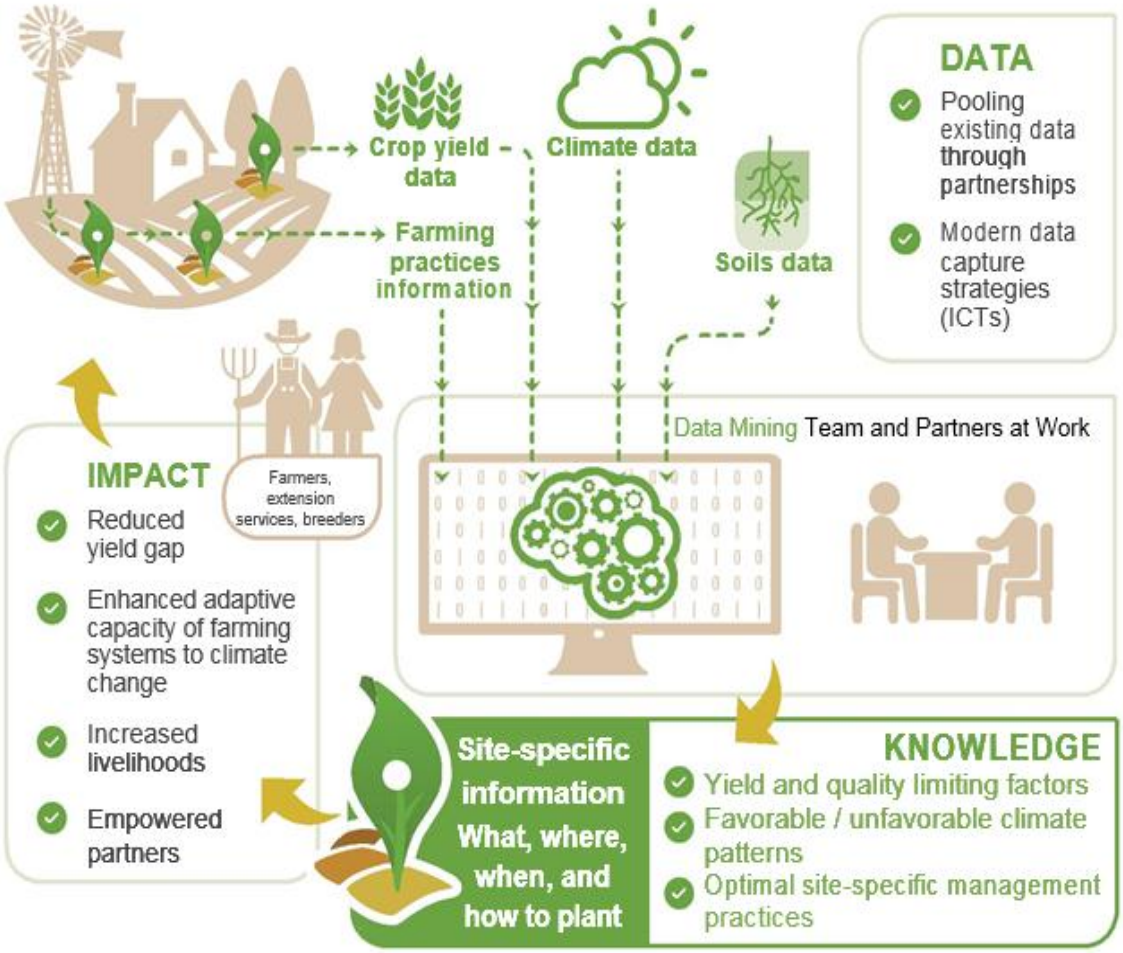

Figure 6. Big Data Analytics framework used by CIAT team for Agricultural research,

Source(CGIAR)

CIAT's research team leading Big Data analytics predominantly showed confidence in data through historical statistics of climate, farming methods and yields gathered and documented by Colombia's National Federation of Rice Growers (FEDEARROWZ).

CIAT followed a completely new approach for Big Data analysis in which they gathered a large uncontrolled real world data combination, rather than a traditional method of agronomics in which optimal technology for an environment conducts experiments for stringently controlled soil and climate conditions.
This helped in producing the finer details for production improvement of rice and also gives feedback to farmers about how they can adapt to climate changes to mitigate any risk and optimize production.

5. Scope of Big Data Analytics for Indian Agricultural Sector

Some of the important factors highlighted below addresses the question as to 'How Big Data Analytics can resolve various challenges faced by Indian Agricultural sector?'**[14]**

Food Inflation:

Food Inflation can be handled much better with timely availability of data. Food inflation has been a consistent issue in Indian economy. Though demand pattern can be determined with the recent trends but supply is a difficult bid to predict. Figure 7shows how Minimum Support Price (MSP) and Whole Sale Price Index (WPI) have increased sharply since 2007.

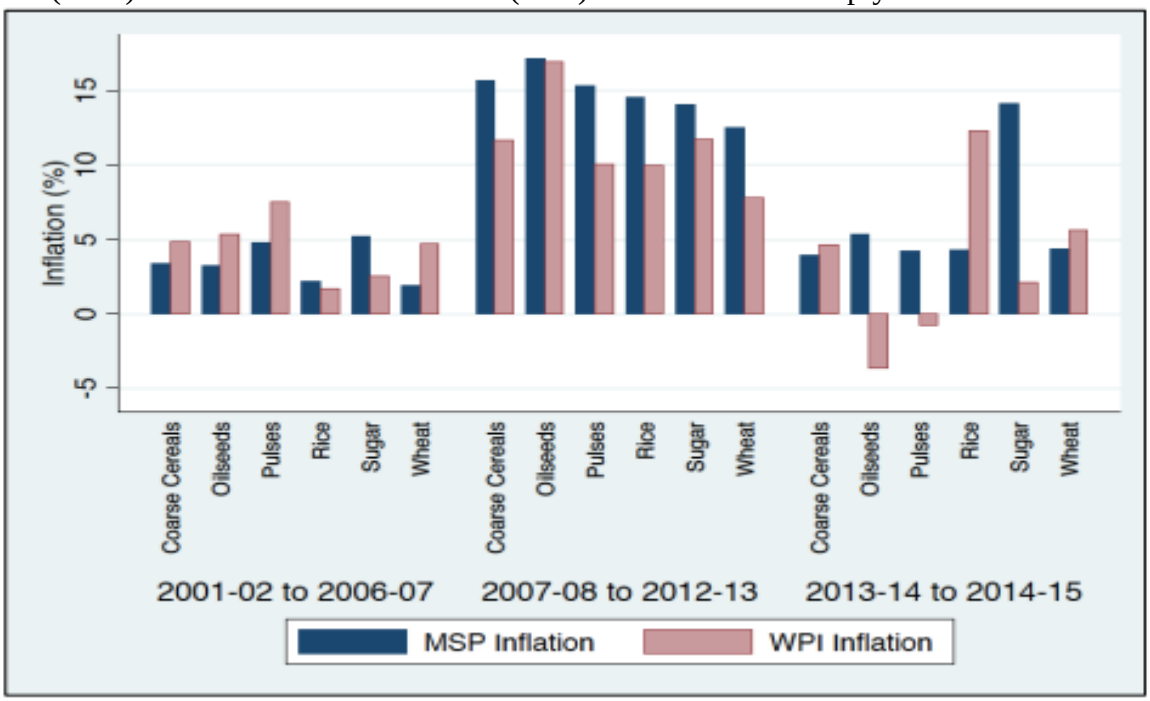

Figure 7. MSPs and Wholesale Prices, Source: Ministry of Agriculture, Government of India & Authors' Estimates

We normally observe more price variations in products like rice, sugar, wheat and onion. During recent times, even staples like oilseeds and pulses have likewise indicated sharp pricing turns both in upside and downwards. The answer for this problem is timely availability of data and accessibility to information for

a) sowing, b) reap and c) generation.

Production advisory can be issued if sowing is considerably more than what market can assimilate. Similarly, stocks can be discharged and import requests can be put in time if farming/production data demonstrates lower throughput than market demand.

A real-time evaluation of likely throughput for any harvest can diminish existing information asymmetry which brings about unpredictability in costs. In this manner, the issues of inflationary pressure (on the off chance of lower than anticipated yield) and panic among farmers (if there is more than expected yield) can be addressed with timely and precise data.

To get the constant information for a million of hectares of cultivation land satellite imagery should be used. It can possibly catch pictures of agriculturist fields to 1 m x 1m resolution (20

– 25 pixels), which is enhancing further with technological innovation. Since the dispatch of NASA's satellite Landsat-8 in 2013, many organizations including Geosys, Planetlabs, Skybox have propelled satellites who are giving satellite pictures to many farmers in developed countries. The information can be purchased at approx. taken a toll $ 0.01 to $ 0.02 for each hectare **[14]**.

Considering the significance of agriculture to Indian economy and India's capacity in launching satellites (as showed consistently by ISRO's researchers), there is a need for government to invest more and launch satellite with dedicated to farming applications.

Post Productions waste reduction:

After Harvest wastage of agricultural produce can be reduced with availability of data. The heavy wastage of food in the supply chain from farms to folks cost into billions of dollars. Multiple transfer points from farm to industry or end customer with lack of quality is the main driver of wastage. For instance, apples going in trucks from Himachal and Kashmir bear more pressure (considering over-burdening/poor case plans) than they can retain and similarly Alphonso mangoes transported in extraordinary summer from Konkan to Mumbai experience heat stress even in temperature controlled trucks.

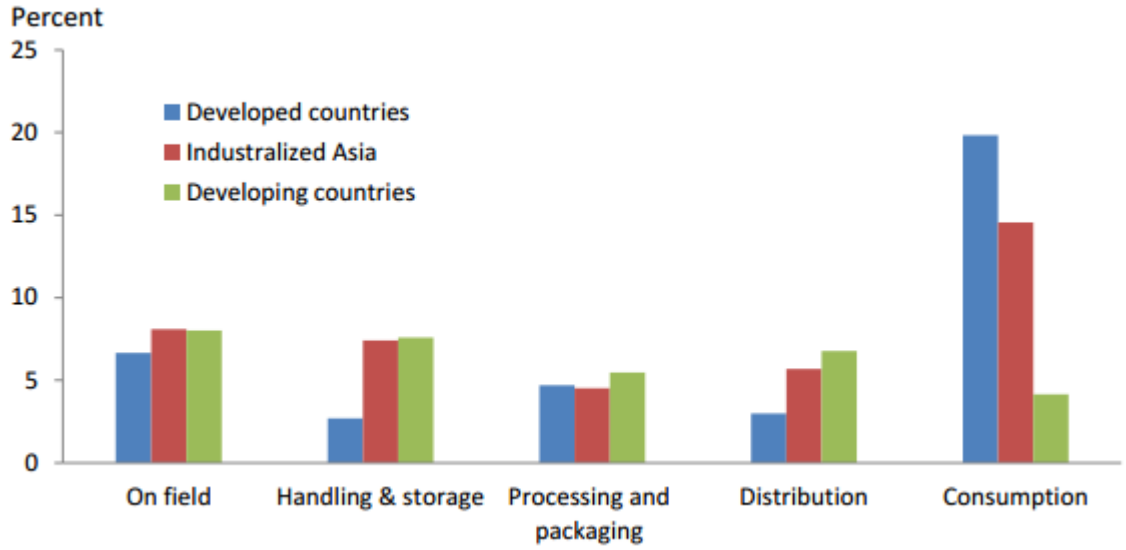

Figure 8. Food losses at different stages of supply chain across countries around the world,

Source FAO Production data 2011

Figure 8. depicts the food wastage at different levels of supply chain across the world. It can be clearly seen that developing countries like India suffers a lot of waste before the end stage of consumption.Considering a way out, one can track the quality nature of farm products during transportation and warehousing. It is possible to catch live data through web-empowered gadgets which can take care of the issue. There are gadgets/remote sensors which can screen components bringing on wastage amid capacity (pest, rodents, dampness), transportation (high temperature, pressure, humidity).

Improving soil fertility and productivity with data application:

Figure 9. shows the projected study by Food and Agriculture Organization of the United Nations which shows a wide gap between nutrient consumption and production in India.

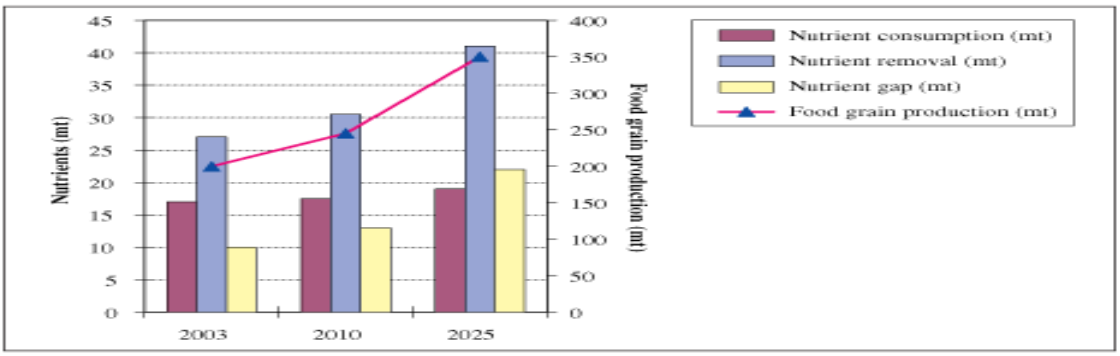

Figure9. Projected food grain production in relation to nutrient consumption, removal and gap. Source FAO

Soil productivity and fertility can be enhanced with information application. Poor efficiency in India in many harvests can be generally ascribed to absence of soil fertility. Soil richness in India is further going down because of mistaken use of inorganic fertilizers (more Nitrogen (N) and less of Phosphorus (P) and Potash (K) than the prescribed blend). NPK mapping at every field is fundamental for the correct remedy including sort of seed, seed rate, water system, plant development controllers, composts and so on.
Again, data on crop imagery can likewise be caught through agriculturist's cell phones and imparted to agronomist to discover solutions for pest attacks and poor productivity. Temperature and humidity information from climate stations can be also included to see effect of temperature/mugginess on product development.

Providing necessary financial help to the farmers:

Financing to poor Indian farmers is another test which data analytics can resolve. The present need as estimated for providing loans to the farmers remains at approx. USD 135 bn. Majority of financial institutions and banks still face difficulty to determine the credit worthiness of farmers because of absence of KYC records. Loaning to farmers can turn out to be exceptionally productive, legitimate and information driven, if the investors have access to data on the likely yield from agriculturist's field. In like manner, insurance agencies can find out risk premium if they have access to climate, soil, pest and yield information.

6. Present scenario of Precision farmingin India

Precision Agriculture (PA) is a management concept of farming idea which is based monitoring, measuring and responding to identify, analyse and manage spatial and temporal variability within inter and intra-field for optimum production and profitability, sustainability and preservation of agricultural land resource optimizing production costs. **[11]**. Though a proven concept, it is mostly restricted to some of the developed countries such as Europe and America and except for a few, very less literature is available in Indian context.
The research for precision farming has already started in India, in many research institutes. Indian Space Application Centre (ISRO), Ahmedabad has begun research in the Central

Potato Research Station farm at Jalandhar, Punjab to analyse the role of remote sensing in mapping the variations of output with respect to space and time. M S Swaminathan research Foundation, Chennai, in a joint effort with NABARD, has adopted a small village in Dindigul region of Tamil Nadu for variable rate input application. Indian Agricultural Research Organization has attracted made up a long term plan to do precision farming research in the institute's farm. Project Directorate for Cropping Systems Research (PDCSR), Modipuram and Meerut (UP) in alliance with Central Institute of Agricultural Engineering (CIAE), Bhopal likewise initiated variable rate input application in various cropping systems. **[15]**
Considering all these efforts and research in precision farming in India, next couple of years may help the Indian farmers to leverage the data analytics in field of agriculture without compromising the quality of land.

6.1. Technology required for Precision farming

Some of the methods used for precision farming that are being used in some of the countries are discussed below:**[16]**

Mapping

The generation of maps for plant and soil properties is the most critical and initial phase in precision agriculture. These maps will quantify spatial variations and give the premise to controlling spatial variations. Collection of data happens both before and after crop production and is upgraded by gathering exact area arranges utilizing the GPS.

Global Positioning receivers

GPS communicate signals that permit GPS recipients to register their location. This data is given progressively, implying that nonstop position data is given while in movement. With exact area location at any time allows soil and product estimations to be mapped. GPS recipients, either conveyed to the field or mounted on locations allows clients to come back to specified location and test or treat those areas.

Production yield monitoring and mapping

In highly automated frameworks, grain yield sis measure and record continuously in clean green elevator of grain of a join. At the point when connected with a GPS beneficiary, yield screens can give information important to yield maps.

Variable Rate Fertilizer(VRT) application and Grid soil sampling

Soil essence is taken from random areas in the sampling range are consolidated and sent to a research facility to be tested. Crop advisors make fertilizer application suggestions from the soil test data. Grid soil examining utilizes similar standards of soil testing yet expands the intensity of sampling. After all the testing done, the fertilizer application map is plotted utilizing the whole set of soil samples.

Crop Scouting

Crop scouting, is the extremely fundamental activity of going through a crop field while making continuous stops for different observations which include weed patches, insect or fungal infestation etc. For precision farming, there are different mobile applications that are compatible with all sorts of cell phones. Additionally, with the progression of (GPS) and unmanned aerial vehicles(UAVs), farmers don't have to stroll through their fields.

Remote Sensing

It is basically collection of data from a remote or distant place. Data sensors can essentially be hand-held gadgets, mounted on air ship or satellite-based. Remotely-detected data give a tool to determine crop health. Crop stress related with moisture, nutrients, compaction, trim maladies and other plant health concerns are frequently effortlessly distinguished in overhead pictures.

Global Information Centres (GIS)

Geographic Information systems (GIS) are Computer equipment loaded with software that utilizes attributes and area information to deliver maps. A vital capacity of a rural GIS is to store layers of data, for example, yields, soil study maps, remotely detected information, crop scouting reports and soil supplement levels.

Information Management System

The implementation of precision agriculture requires management skills and maintenance of database information systems to process and store the data. To effectively use this information farmer, require clear business objectives and the relevant information as per the objective in order realise tangible benefits.

7. Future of Big Data and Precision farming in Indian agriculture

Future farming will be extremely aggressive, research concentrated and market driven. WTO agreement and advancement of trade in agriculture have made new opportunities but also new dangers to the agriculture of developing nations. Removal of quantitative limitations on import from 1 April, 2001 in India made quality and cost optimization the two most critical elements to maintain in the globalized era. The high cost of production and low efficiency, even though India produces a huge number of crops and grains, will toss Indian farmers out of the cost competitive free market **[17]**.

Precision farming using Big Data Analytics, however a proven technology innovation is still for the mostly limited to developed (American and European) nations. In developing countries like India, it has picked up a momentum but still has a very long way to go. One of the significant issues for this is the small farm size. As discussed previously, 74% of total farms are less than a hectare. However major agricultural states like Punjab, Rajasthan, Haryana and Gujarat there are more than 20% agricultural land with operational holding size of more than 4 hectares for a single field **[15]**.

Regarding India's agricultural practices, small size of lands and fields in the clear majority of Indian agribusiness limits economic gains from precision farming technology, however, when

we consider continuous field with same crop (for the most part under same farming management practices) the field sizes are vast. Utilizing aeronautical information, it has been found that in Patiala area of Punjab, more than 50% of continuous field sizes are bigger than 15 ha. **[15]** These continuous fields can be considered as the target for implementing precision farming with the end goal of usage of maximising cultivation.

Precision agriculture consolidates the new technologies borne of the data analytics age with a mature farming industry. The below highlighted figure defines some of the important factors to be considered in precision farming. The issue pertaining to precision farming includes perceived benefits and the challenges faced during widespread adoption of precision farming **[18]**. See **Error! Reference source not found.**.

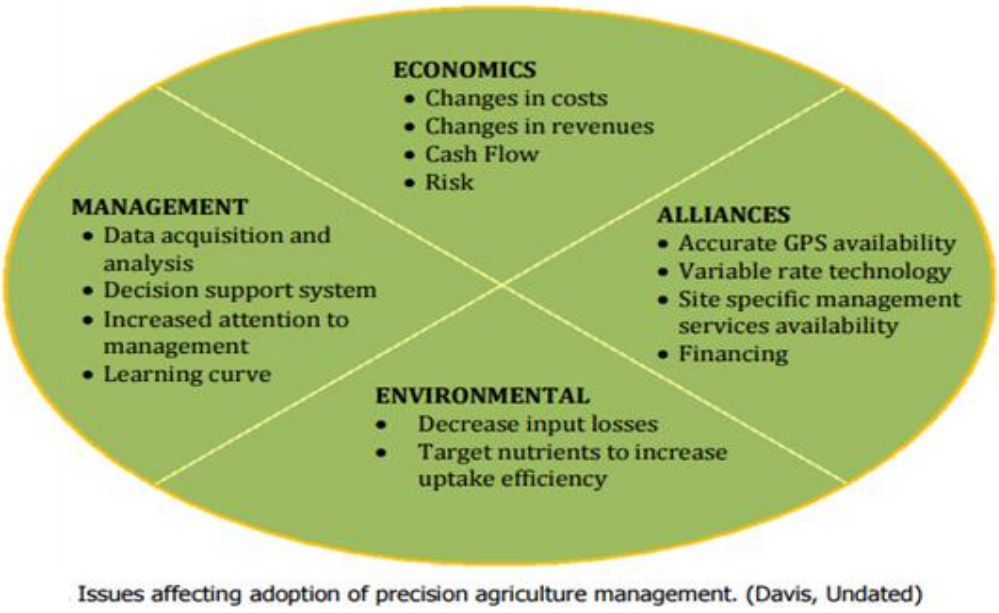

Figure 10. Source: ***[20]***

This figure describes the four important factors:

1. **Management:** Management encompasses the frame work for data acquisition and analysis, decision support system, increased attention by monitoring and the possible learning curve for the persons involved in agricultural activities through precision farming.
2. **Economics:** The economics involves the cost benefit analysis by optimizing cost, increasing revenue and cash flows and mitigating risks associated in conventional farming.
3. **Alliances:** It determines the possible partnership to get access to precision farming tools and technologies specific to site management and the possible financing required to leverage the technology
4. **Environment:** Last but not the least sustained agricultural production with decrease in input losses and waste reduction, and increasing the nutrients efficiency of the soil for more production.

8. Conclusion

Precision farming is an up and coming idea in agribusiness that consolidations the new innovations borne of the data age to take care of the existing issues in agriculture. If effectively used, it can help to issue of tackle the issue related to food security, while maintaining the sustainability of farming. Precision farming with the help of Big data analytics can address both economic and nourishment issues that encompasses production agribusiness today.
As per the analysis and discussion on different aspects, scope and future of Big data analytics and precision farming we can conclude determine following factors which are necessary for its implementation in India.

1. **Considering the small size of the farms:** The formal meaning of precision farming is reasonable when the land possessions are extensive and enough variations exists between the fields. In India, the normal land area is very small even with rich and progressive farmers. It is thus important to review the revised meaning of Precision Farming with regards to Indian agricultural practices while holding the fundamental idea of Precision farming. The more appropriate definition for Precision Farming with regards to Indian cultivating situation could be: Precise use of farming data sources considering soil, climate and crop yield to optimize sustainable productivity, quality and benefit.

2. **Implementation of latest data analytics tools:**Agriculture is a location dependent spatial phenomenon which requires GIS tool and technology for handling spatial databases. The spatial IT will allow to examine a large set of agricultural related resources, for e.g. irrigation, soil, weather, geography and social factors simultaneously and precisely. Government in partnership with private companies should partner with some of the niche technology service providers to improve analytics in agriculture. Besides this farmer should be educated and equipped with easy process of data registration which could help in providing an early support system and warnings.

3. **Web of smart food grid:** Theneed for smart food grid arises due to manywastes that occur at various stages of supply chain. So, smart food grid will connect the entire supply chain right from production to consumption in a dynamic manner using digital technologies and data analytics. By introducing right set of algorithms this grid capability can be extended for different processeslike irrigation system or enhancing the soil fertility on one hand to circulating additional nutritive products and supplements needed consumer.

4. **Research and Innovations:**The future for Precision Agriculture holds optimism and can turn into an innovation with wide implications in the field of agriculture. The future direction of agriculture will depend upon the research community's ability to conduct extensive studies in this area, with confidence from the environmental and producer communities that changes will benefit the environment and increase the efficiency of agricultural production.

5. **Coordination between public and private sectors:**Though this technology is in its infancy in India, there are numerous opportunities of adoption. Progressive farmers with guidance from the public and private sectors, and agricultural associations, can adopt it in a limited scale. Without doubt, this is a technology that can help feed the growing population, keeping the environmental degradation to the minimum.

8.1 Conceptual Framework

Based on the complete analysis we can propose the below mentioned framework, which will broadly try to define the Precision farming methodology to be followed in India:

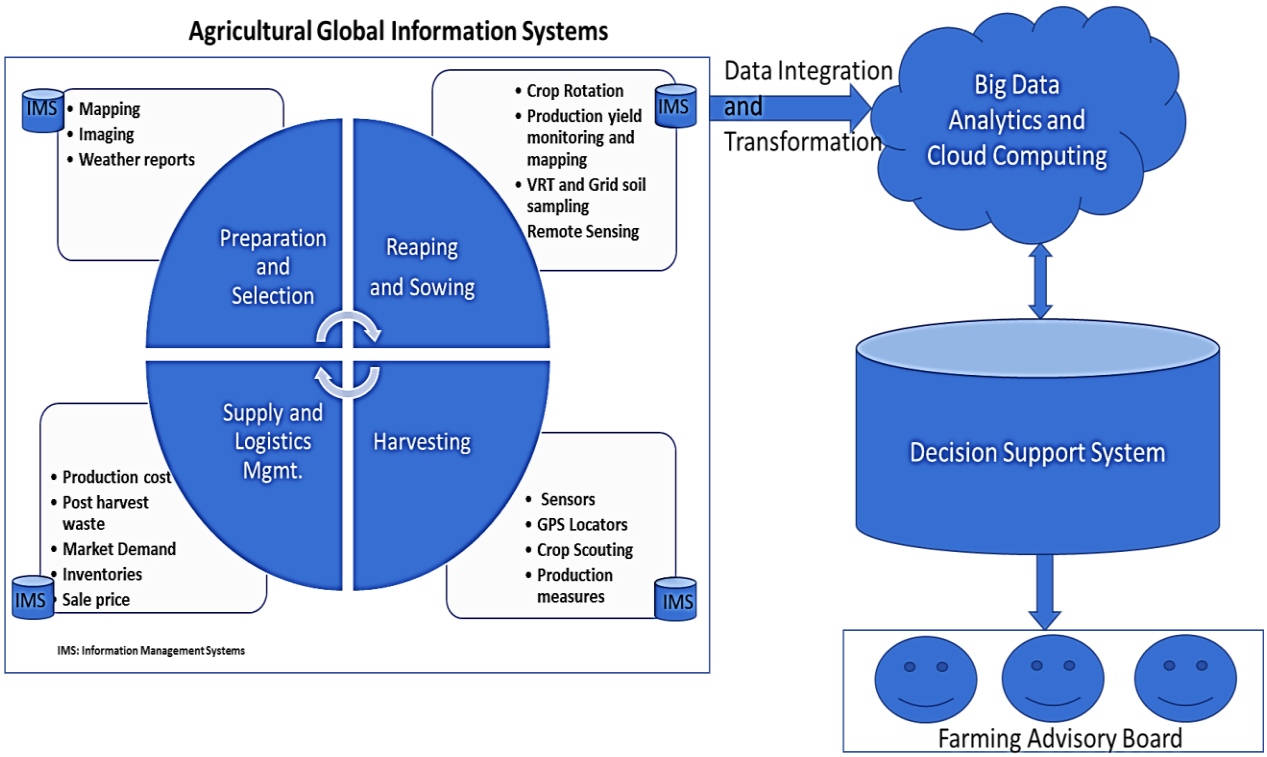

Figure 11. Conceptual framework for Precision farming in India using Big Data Analytics

The proposed framework in Fig.11 depicts how data pertaining to various stages of farming can be stored and managed through Information management systems at various levels. In brief, it can be discussed in few points below:

- It comprises of for stages in farming, Preparation and selection, Reaping and sowing, Harvesting and Supply and Logistics management.
- At each of these stages data is recorded using various technological equipment and methodologies such as mapping, imaging, GPS sensors etc.
- The data levels together at all these stages forms a Global Information systems for agriculture for various regions and geographies.

- The global information systems can then be integrated to Cloud based big data analytics engine which is equipped with software programs and algorithms for processing the huge volume of data and providing analytical information which can be stored in a decision support system which in turn can be accessed by farming advisory board.
- This board can then pass on the valuable information for various factors which can affect agricultural production and optimize it by mitigating the inevitable risks.
- The platform can be viewed as an intelligent management system which will enable farmers to collectively procure, sell, and perform various transactions right from farm to folks.

Finally, this model seems to be a great leap forward in implementation of big data analytics in Indian agricultural sector but also must overcome many challenges such as mobile compatibility issues, network connectivity issues, necessary capital investments and will require many efforts from technology enthusiasts in persuading farmers to accept, adapt and avail new technological solutions.

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