Application of Big Data in Agriculture Development in Meghalaya

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Abstract : This study highlights the drawbacks of traditional agriculture practices in Meghalaya and reviews various big data analytics to enhance agricultural framework with adequate information , an essential element of any activity in agricultural sector. The study also finally suggests a big data framework for agriculture practices in Meghalaya.

Keywords: Big Data, Agriculture, Framework, Meghalaya, Analytics.

1.0 Introduction:

Agriculture forms the basis for food security and hence it is important. In India, majority of the population i.e., above 55% is dependent on agriculture as per the recent information. Agriculture is the field that enables the farmers to grow ideal crops in accordance with the environmental balance. In India, wheat and rice are the major grown crops along with sugarcane, potatoes, oil seeds etc. Farmers also grow non-food items like rubber, cotton, jute etc. More than 70% of the household in the rural area depend on agriculture. This domain provides employment to more than 60% of the total population and has a contribution to GDP also.

The world witnessed the continuously increasing use of technology in agriculture since the 19th century, when the industry began to plough fields with tractors. It was during this period, the agricultural revolution made a remarkable impact on the productivity as a consequence of vast improve-ments in technology. The agricultural sector transformed into a much technologically intense and data rich industry with the advent of biotechnology, plant genetics, chemical inputs and guidance systems. Farmers, in developed countries generate and capture huge agricultural data using mobile technology, which are stored and later retrieved by application softwares with the help of the database management softwares. Information is a fundamental and an essential element of any activity in agricultural sector. The present study is an attempt to explore big data analytics with special reference to Meghalaya to enhance agricultural framework.

2.0 Review of Literature :

This section highlights various literature related to challenges and opportunities in Agriculture and thereafter gap in the literature which finally forms the basis of the paper.

2.1. Challenges and Opportunities in Agriculture :

The recent challenges and opportunities in in agricultural sector in India are outlined below:

Challenges :

- Low growth- Weather Dependent,45% irrigation
- Sustainability-
  - land & environmental degradation
  - unsustainable use of water, soils
- Profitability-
  - Size of farm- 1.33 to 1.16
  - Level of technology adoption
  - Profitability of Agriculture vis-a-vis other sectors
  - Raising small holder productivity
  - Disguised unemployment-pressure on land
- Sustaining investment-
  - Neglect in policy- Decline in Public Investment(4.9 to 3.5 %)
  - Low return- lack of Private interest
- Climate change
  - Droughts, floods, erratic rains - greatest impact in rain-fed areas
  - India's crop yields could fall by 30% by 2050(IPCC)
- Marketing- Price instability, Imperfect markets
- Rising wages and other input costs- MNREGA, migration, energy
- International Competitiveness-WTO
- Inadequate infrastructure-Physical
  - Supply chain constraints
- Inadequacy of intuitions- credit and market, extension, R&D, risk management
- Need for Large investments in Agro-processing

Opportunities:

- India is a global agricultural powerhouse world's largest producer of milk, pulses, and spices, largest area under wheat, rice and cotton world's largest cattle herd (buffaloes)
- Second largest producer of rice, wheat, cotton, sugarcane, farmed fish, sheep & goat meat, fruit, vegetables and tea.
- Diverse agro-climatic conditions/zones
- Fertile soils
- Large Domestic Market-
- Rising demand for food- high value fruits and proteins meat, dairy and fishery products.

- Rapid Urbanisation and increasing middle class
- Domestic R&D and Extension capacity
- Global Markets- expanding demand, bio-fuel competition
- Enterprising Farming Community
- Scope for Increasing cropping intensity
- Yeild Gap between world Average and across regions in India
- Best Farmers overall profitability is 77% higher than average farmers profitability
- Enhanced and balanced use of Fertilisers, HYV,irrigation can boost yields
- Better seeds can raise yields by 40%
- Irrigation- minor irrigation has better returns on investment
- Credit-larger credit availability for small farms can raise per capita output
- Farm size-technology adoption, diversification

2.2. Research Gap:

At present we are at the immense need of another Green revolution to supply the food demand of growing population. With the decrease of available cultivable land globally and the decreased cultivable water resources, it is almost impossible to report higher crop yield. Agricultural based big data analytics is one approach, believed to have a significant role and positive impact on the increase of crop yield by providing the optimum condition for the plant growth and decreasing the yield gaps and the crop damage and wastage. India is basically agriculture based country and approximately 70% our country economics is directly or indirectly related to the agricultural crops. The principle crop which occupies the highest (60-70%) percentage of cultivable land in the Indian soil is the paddy culture and it is the major crop especially in central and south parts of the India. Rice crop cultivation plays an imperative part in sustenance security of India, contributing over 40% to general yield generation. The enhanced yield of the rice crop depends largely on the water availability and climatic conditions. For example, low precipitation or temperature extremes can drastically diminish rice yield. Growing better strategies to foresee yield efficiency in a mixture of climatic conditions can help to understand the role of different principle factors that influence the rice crop yield. Big data analytic methods related to the rice crop yield prediction and estimation will certainly support the farmers to understand the optimum condition of the significant factors for the rice crop yield, hence can achieve higher crop yield.

To cater a sustainable economic development, the agriculture sector must be strengthened to play much more active and indispensable role in any overall strategy of economic progress (Todaro and Smith, 2004). But, due to little scope for horizontal growth, agriculturists concern trated their approaches towards vertical development of agriculture. But, again the issue of sustainability is the hindrance to the overexploitation of the natural resources. In this regard, the relatively less exploited hilly areas can be made a panacea to the problem and the north-eastern hilly regions of the country has the real potential to provide additional thrust to boost up the

agricultural production in India. Amongst the several states in north-eastern region, fairly good agricultural development was achieved in Meghalaya in last twenty five years. The State is primarily an agrarian economy and about 75 per cent of the population depends on agriculture. It achieved almost forty two per cent increases in total cropped area during last twenty five years; particularly, in cultivation of food grains, vegetables, fruits, commercial flowers, plantation crops, orchids and Anthurium. (Statistical Hand Book, Meghalaya, 2014).

But, like other hilly states, the development of agriculture is also not easy task due to several constraints, like tough terrains, traditional Jhum cultivation (Slash and Burn Shifting Cultivation), tradition bound farmers, poor infrastructural facilities, inadequate marketing facilities and lack of intensive extension activities (Lahiri and Das, 2010). So, a well directed and efficiently coordinated extension activity to disseminate the farm information is the key element to develop the agricultural scenario in Meghalaya. Thus study is an attempt to explore big data analytics for Meghalaya and to support the dialogs on how government can cultivate in enormous information examination to enhance agricultural framework.

3.0. Objectives of the Study:

The study has been formulated in an exploratory type of research design with the following objectives

1. To examine agricultural practices in Meghalaya
2. To explore and suggest a framework using Big Data Analytics for agriculture practices in Meghalaya

4.0. Traditional agricultural practices in Meghalaya, North East India

Traditional agriculture is often considered a step between the local hunt- and-gather practice, which provides communities with subsistence levels of food, and the practices of modern agriculture, used for mass-production of food for global distribution. This traditional agriculture practice develops a balance between meeting our present needs, conserving natural resources, and protecting the environment for the benefit of future generations. Traditional agricultural approaches are not practical for mass food production, but accounts for a substantial amount of local food production in the developing world.

In recent years, documenting the traditional wisdom has gained significant attention world over, because of its importance in developing a high potential environment and sustainable management. Identification and utilization of such indigenous knowledge from the elderly people of rural and tribals will surely bridge the gap between the current science and age-old practices. Indigenous knowledge linked with the manipulation and use of natural resources in various ways, forms the basis for their link with nature, and the varied levels refinement depend on the level at which the society finds itself in the social evolutionary basis.

Meghalaya (25.47–26.10N latitude and 89.45–92.47 E longitude) is one of the most picturesque states of India (Fig.1), offering a spectrum of sylvan surroundings, rich cultural heritage and luxurious vegetation comprising of a large variety of flora and fauna. Meghalaya is one of the seven sister states of the North-eastern region, bounded by Assam on the North and East, and on the west partly by Assam and Bangladesh. Bangladesh forms the southern boundary of this state. Meghalaya is divided into seven districts, Jaintia hills, East Khasi hills, West Khasi hills, Ri-bhoi, East Garo hills, West Garo hills and South Garo hills. It is among the wettest places on earth and is the home of an extraordinary diversity of people that includes the Khasi, Jaintia and Garo tribes.

Mghalaya experiences two distinct seasons, i.e. winter and monsoon, and is characterized by a cool climate throughout the year. The village of Mawsynram (about 16 km West of Cherrapunji) in the southern slopes of Khasi hills district receives the heaviest rainfall (11690 mm) in the world. Numerous rivers flow through Meghalaya although none of them are navigable, due to steep slope, rocky beds followed by strong water currents.

Predominant tribal populations, the original inhabitants of this state are Khasis, Jaintias and Garos. Khasis and Jaintias trace their ancestry to the Mongolian race, while the Garos belong to the Tibeto-Burman race. Their cultural traits and ethnic origins remain distinctive, mainly due to their geographical isolation. The Khas ilanguage spoken here is believed to be one of the few surviving dialects of the Mon-Khmer family of languages in India.

5.0 Present status of agriculture in Meghalaya:

Agriculture is the main occupation of the people of Meghalaya. About 83 % of the total population of state depends on agriculture for their livelihood. However, agricultural land is accounted as only 48 % of the total geographical area of the state. The state offers scope for cultivation of a wide variety of agricultural crops because of highly diversified topography, altitude and climatic conditions. Rice (Oryza sativa Linn.) and maize (Zea mays Linn.) are the major food crops. Important fruits grown are orange (Citrus reticulata Blanco), pineapple (Ananas comosus Merrill), lemon (Citrus limon Burm. f.), guava (Psidium guajava Linn.), jack fruit (Artocarpus heterophyllus Lam.) and bananas (Musa sp.). Potato (Solanum tuberosum Linn.), jute (Hibiscus cannabinus Linn.), cotton (Gossypium sp.), arecanut (Areca catechu Linn.), ginger (Zingiber officinale Rosc.), turmeric (Curcuma domestica Valeton), betel leaf (Piper betle Linn.) and black pepper (Piper nigrum Linn.) are the chief commercial crops. Jhum or the shifting cultivation and Terrace cultivation are predominant in the state, bringing land under permanent cultivation in later case.

6. 0. Draw backs of Traditional Agriculture:

Information and communication technology (ICT) is extensively utilized in farming to provide indispensible information at right time and at a least expense. In traditional agriculture, a schedule is predetermined considering factors such as rainfall, suitable weather, etc, and all tasks are performed in order accordingly. Despite their efforts, farmers face difficulty in making proper decisions due to lack of essential information at appropriate time.

7.0. **Precision Agriculture and Big Data :**

Thus, it is required to collect real time data on weather, air quality, and soil fertility and even on availability of labour and essentially the capital investment in total and analytical predictions, to make ingenious decisions. This way of farming is known as Precision agriculture.

Big Data has emerged big in integrating various industries across the world among which agriculture too is a part. Agriculture and other agri-businesses require innumerable decisions to be taken based on various influencing factors that are stranded with intricate problems. Big Data is now a driving factor for progress in precision agriculture upon which farm-ers are relying, with the expectation of maximum yields.

Big data in agriculture involves digital records of farm data. Big data in agriculture involves digital records of farm data. This includes soil moisture content, temperature, weather variability pattern, irrigation facility, financial assistance like insurance and loans schemes, humidity level data, nutrient content data, historical cultivation data of the field and also knowledgeable articles on agriculture writ-ten by researchers and innovative agriculture practitioners. Global Positioning System (GPS) and Geographic Information System (GIS) have enabled to quantify the spatial variability within fields. GPS allows collection of geo referenced data and GIS makes spatial analysis and visualization of interpolated maps . Data is collected via various sensors such as soil moisture sensors, microphone sensor to detect pest using sound detecting technology and detection algorithms, chemical/gaseous sensors to measure gaseous emission from fields (like during ripening of fruits, flower pollination, etc.) and ultrasonic sensors to detect underground water availability for irrigation.

8.0. Data Management and Analytics:

The primary aim of data management is to make sure that end users get high quality data with easy access. Here are few tools to manage and analyses big data generated from agricultural sector:

1. Hadoop: It serves as a core platform to structure big data. It is a Java platform programming framework and hence supports processing of large data sets in distributed computing environment

2. MapReduce: MapReduce is programming paradigm sup-ported by Hadoop to handle parallel processing of big data distributed across a large number of computers.

3. HDFS: Hadoop Distributed File System, a high performance data access tool used across Hadoop clusters is the primary storage system used by Hadoop applications.

4. HBase: It is a column oriented data base management sys-tem which runs on top of Hadoop. It is well suited for sparse datasets.

9.0 Big Data Analytics in US agriculture :

Annually, farmers in US generate about $375 billion from crops .

Almost all new farm equipments are equipped with sensors using which terabytes of data is collected in each stage from ploughing to harvesting and marketing their pro-duce. Agriculturists say that 80% of their farm data reside on tractors and it is reported that they have witnessed 15% reduction of cost on inputs . Adoption of precision agriculture has increased yields by 13% .

The extent of using modern technology in US has reached a significant level that farmers choose whether to use data themselves, share it locally or up-load it to the cloud. John Deere, a leading manufacturer of agricultural products and tools in US, has always been a pioneering industry to introduce advanced technology in farming machinery. The eponymous founder of the esteemed company, John Deere, in the early 19th century personally designed steel ploughs and hence transmuted the lives of the itinerant people to settle in a place by earning their livelihood through agriculture. It has initiated several service oriented programs to avail farmers the best use of crowd sourced data and real time monitoring of huge data pooled over cloud platforms by thousands of farmer across the continent or globe .

Myjohndeere.com is a web portal for authenticated farmers to collect and analyse the data collected from their own machinery from anywhere. It also allows sharing and using the aggregated data from other users around the world .

Emerging companies such as Farmers Business Network count Google Ventures as an investor and have made collecting, gathering, and analyzing data from farms across nations as their primary business . Though, agriculture is a low margin business, effective big data management has made

10.0 Precision Agriculture in India

Agriculture sector is the backbone of Indian economy. In spite of it, its contribution to the country's total GDP is only about 17.9% as declared by the Planning Commission of India, in 2014. Around 70% of the rural households rely on agriculture for their living. India stands second in the world as a producer of agricultural products and has marked 7.68% of the total global agricultural output.

Big data and its applications could become a single solution to 3/4th of the existing problems.

Agriculture sector is struggling to increase the productivity of crop in India. Monsoon rainfall is the main source of water for more than 60 percent of the crops. Smart agriculture driven by Information Technology is the emerging trend in the research in this area in recent days. One of the areas being explored is the problem of yield prediction which is a major concern. Data mining techniques are being widely used as a part of solution for crop yield prediction. Various data mining techniques are under evaluation for estimation of crop production of the future years . Data mining is the process in which the hidden patterns are discovered using analysis of large data sets. The data mining and data analytics techniques use artificial intelligence, statistics, machine learning and database system. In data mining, unsupervised and supervised methods are being used. In unsupervised learning, clusters are formed using large data sets and in supervised learning classification are done based on the data sets. In clustering technique, 'data points' are examined to group them into 'clusters' according to specific parameter. The data points in same cluster have less distance compared to data points of different clusters. The analysis of the cluster divides data into well organized groups. The natural structure of the data is captured by these well-formed groups .

Water is very much essential in agriculture. Though India is the most irrigated country after China, only one-third of the cropped area is under irrigation. India is in the tropical region, hence has a very uncertain and unreliable monsoons with which we cannot expect sustained progress in agriculture. Agricultural lands have been used for cultivation for more than thousand years that has led to the depletion of soil nutrients and hence the fertility. Manures and fertilizers play an important role in nourishing soil but farmers lack the knowledge on how to use chemical fertilisers and in what amount it is required to replenish the soil fertility. Another problem in most of the developing countries, including India is the lack of use of newer tools and mechanism. Even today, a significant number of farmers use traditional and simple hand held tools like wooden ploughs driven by ox, sickles, etc,. The major concern in India is the inadequate help provided by the government to face challenges and risks.

Some of the studies in Crop yield prediction with Data Analytics highlighted below:

Title	Author	Highlights
Rice Crop Yield Prediction using Data Mining Techniques: An Overview	Dakshayini Patil, Dr. M .S, Shirdhonkar/ 2017	Discussed various data mining techniques utilized for prediction of rice crop yield for the state of Maharashtra, India. WEKA tool was applied in dataset processing
A Survey on Crop Yield Prediction based on	Dhivya B H, Manjula R, Siva Bharathi S,	Presented a survey on the different algorithms applied in

Agricultural Data	Madhumathi R/ 2017	the assessment and prediction of crop yield Discussed about the mechanism of knowledge the discovery in Agricultural data mining
A Study on Various Data Mining Techniques for Crop Yield Prediction	Yogesh Gandge, Sandhya/ 2017	Discussed various data mining techniques employed for predicting the crop yield and signifies the importance of accurate data extraction methods of big data analytics.
Big Data for weed control and crop protection	F K Van Evert, S Fountas, D Jakovetic, V Crnojevic, I Travlos & C Kempenaar/ 2017	Critically discussed about the challenges faced and the profound opportunities lies in the Big Data analytics in agriculture: Outlined Big Data analytics models with numerical algorithms applied Represent the importance of reforming the mined data in the form of understandable information to the farmers. Discussed about various advances, tools and algorithms applied in transforming the data in to easily understandable information to the framers and thrown a light on success story of Netherlands in achieving the maximum crop yield and their smart forming practices. Also discussed about the control of invasive, parasitic and herbicide-resistant weeds to improve the overall crop yield applying Big Data analytics.
The Impact of Data Analytics in Crop	Swarupa Rani A/ 2017	Discussed the application of mathematical model like fuzzy logic designs in optimization of the crop

Management based on Weather Conditions		yield, artificial neural networks in validation studies, genetic algorithms designs in accessing the fitness of the model applied, decision trees, and support vector machines to study soil, climate conditions and water regimes related to crop growth and pest management in agriculture.
A Study on Crop Yield Forecasting Using Classification Techniques	R.Sujatha, Dr.P.Isakki Devi/ 2016	Discuss the importance of comparing previous agricultural data with present to identify optimum condition favor enhanced crop yield. Envisaged the importance of best crop selection depending onthe season and the climatic factors which supports enhanced crop yield.
Prediction of Crop Yield using Regression Analysis	V. Sellamand E. Poovammal/ 2016	Regression analysis was carried out to find the relationship among the parameters i.e Area under Cultivation (AUC), Annual Rainfall (AR) and Food Price Index (FPI) which influences the final crop yield and reported that the crop yield principally depends on the Annual Rainfall (AR).
How good is good enough? Data requirements for reliable crop yieldsimulations and yield-gap analysis	Patricio Grassinia, Lenny G.J. van Bussel, Justin Van Warta, Joost Wolf,Lieven Claessens, d, Haishun Yanga, Hendrik	Presented a case study (Nebraska - USA and at a national scale for 7Argentina and Kenya) on the application of an explicit rationale design approach in identifying the data sources which simulates Crop (maize) yield and also helps in quantifying the maize yield gaps.

	Boogaarde, Hugo de Groote,Martin K. van Ittersumb, Kenneth G. Cassman/ 2015	Suggested the robust guidelines for analyzing the crop yield gaps, accessing the climate and land use changes at global level to address the issues of crop yield.
Prediction of crop yield using big data	Wu Fan, Chen Chong, Guo Xiaoling, Yu Hua Wang Juyun/ 2015	Developed a novel model i.e Nearest neighbors modeling tocalculate and predict the yield of crop depends on the available Big data sets.
The use of satellite data for crop yield gap analysis	David B. Lobell/ 2013	Discussed the use of remote sensing technology to identify and measure the causes of yield gaps and the assess the impact on the overall crop yield. Reported very simple methodologies to measure the yield difference with respect to season, environment and the land use.
Yield gap analysis with local to global relevance-A review	Martin K. van Ittersuma, Kenneth G. Cassmanb, Patricio Grassinib, Joost Wolfa, Pablo Tittonell, Zvi Hochmand	Discussed about the various methodsused on quantifying the yield gaps at local-to-global ratio. Reported few standard operation methods, employed inquantifythe crop yield potential on the data collected from the farmers ofwestern Kenya, Nebraska (USA) and Victoria (Australia). Study recommended for the use of accurate and current yield data, with calibrated and validated crop models and up scaling methods in the prediction of crop yield.

From the above literature It can be concluded that the research in the field of agriculture with reference to using IT trends like data analytics is in its infancy. As the food is the basic need of humans, the requirement of getting

the maximum yields using optimal resource will become the necessity in near future as a result of growing population. These studies indicate the need for improved techniques in crop yield analytics. There exists a lot of research scope in this research area.

11.0 Data Collection:

The agricultural data can be classified as private data and public data.

Private Big Data: This data set contains data obtained at the production level and generated by an individual farmer. It mainly includes information regarding ones farmer's field, soil type, irrigation level, yield, livestock, etc.

Public Big Data: At public level, there are funded agencies which collect, maintain and analyse data records. The records may contain data about weather conditions, soil survey, farm program participant records, marketing, etc.

Stages in Big Data process are collection of data, managing aggregated data, and effective usage of processed data

12.0 Data Analytics in R :

Once the data in the concerned area collected analysis can be done with data analytics in R, a statistical software . R is open source software environment user interface design for statistical computing and data visualization. It has vast range packages and built in feature support linear modeling, non –linear m0deling, classification, clustering and more ;therefore it is implemented in huge area of financial sector and health care etc. There are built in packages for popular open source big data platform as well as Hadoop and Spark ,Using R crop yield analytics can be designed and tested with cross validation method .

13.0 Conclusion :

The research study review various research of data analytics in precision agriculture .It also acknowledges the critical computing and diagnostic ability of data in processing massive volumes of transactional data in real time situations. The study presents the discussions on how data nalytics can be used as tool to provide timely information to the farmers in getting better returns from agriculture.

Data analytics is one of the best platforms for agriculture to improve productivity. The proposed study may be a significant work to increase agricultural production and provide benefits fo ICT and other advances technologies . The study may help in 1) creating jobs in agricultural sectors 2) investing new technologies 3) building and spreading international standards. Further, proposed study would an attempt to highlight some guidelines regarding policies related to big data application in Agriculture.

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