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ROLE OF ARTIFICIAL INTELLIGENCE AND ITS APPLICATIONS IN BRIDGING THE GAP BETWEEN AGRICULTURAL DEMAND SUPPLY AND CONCERNS: A STUDY

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ABSTRACT

With global demand for food set to rise by at least 50 per cent by 2050, agriculture is poised for another revolution. This paper examines the major concerns and developments in the agriculture sector, food security and agribusiness. It also explores the top tech innovations in the agricultural industry and applications of artificial intelligence to provide the researchers and entrepreneur with an understanding and concerns of current and emerging trends that would help in full filling the gap existing between the agriculture demand and supply.

KEYWORDS:

Artificial Intelligence, Predictive Analytics, Machine Learning, Gross Domestic Product, FAO, ICRISAT.

INTRODUCTION

Agriculture is both a major industry and foundation of the economy. Advances in technology are key to the future of agriculture as farmers strive to feed the world with limited natural resources. There are an estimated 570 million farms in the world and in a neat twist of number synergy, according to Valoral Advisors, funding in technological innovations along the agriculture and food value chain has reached to around $570 million in 2014. As per a report published by Food and Agriculture Organization of the United Nations, the world's population is expected to grow to almost 10 billion by 2050 boosting agricultural demand. To meet the same there needs to be some 50 percent increase in the agriculture production compared to 2013.

Agriculture at the global level has become more efficient, in recent decades. With improved Modern agronomy, plant breeding, agrochemicals such as pesticides and fertilizers, technological developments and improved agribusiness understanding across the countries have lead to sharp increase in the yields from cultivation and filled the agricultural demand supply gap to certain extent, but at the same time they have caused widespread ecological damage and negative human health effects with increase in competition for natural resources. This is mainly due to intensified owing to consumption patterns driven mainly by population growth, changing dietary patterns, industrial development, urbanization and climate change across different parts of the world. Land degradation, deforestation and water scarcities are among the most visible manifestations of this unsustainable competition.

STATEMENT OF THE PROBLEM

Since the development of agriculture, industrialized agriculture has been supporting successfully in producing large quantities of food to feed the population. But increasing population has been the cause of concern for the future food production and it is leading to food security issues. Problems in agriculture like reduced land holding pattern, environmental problems, land degradation, lack of labor and marketing policies have put the agriculture industry is in jeopardy situation. The study intends to create a linkage between the agriculturists, researchers and entrepreneur and tries to overcome the structural constraints that limit the farmers in increasing the yield with available land holding and helps over all in reducing the environmental degradation. In connection with these agricultural activities, various forms and extent of problems could be identified and prioritized to decide upon them by the policymakers.

OBJECTIVES OF THE STUDY

The following main objectives have been set for the research study:

1. To examine the existing agriculture produce demand & supply gap and major developments in the sector.
2. To explore the use of existing technologies in increasing the agriculture production; role of upcoming technological innovations in the agricultural industry like artificial intelligence and its concerns.

REVIEW OF LITERATURE

The researcher has reviewed doctoral thesis, journal and literature relevant to agriculture production, demand supply gap, marketing activities and technologies used and same is presented here.

Legesse (2000), found that during eighties wheat area showed a declining growth rate *i.e.,* 3.94 per cent per annum but production and productivity showed a negative growth rate. During nineties the Karnataka state recorded a significant positive growth rate of 3.47 per cent in area while

in production the state recorded a mild growth, but productivity showed a negative growth rate.

Dalawai (2004), analyzed the relationship between the prices in major six domestic cotton markets and also at international market (New York) using the co- integration technique. The results clearly indicated that all the price series in major four DCH cotton markets and two Jayadhar cotton markets in the state were assumed to be stationary at order of integration one.

Srinivasa Murthy A. P. and Rameshwari Varma (1984), in their study highlight that "Agricultural prices and Economic Development" entitled the prices of agriculture commodities and their determination are influenced by a complex set of factors, including governmental policies especially in the context of planning relating to stabilization, fixation of support and procurement prices, the operation of controls, generation of incentives to producers etc, as well as by the formers response to these policy measures.

Acharya S. S. (1988), has focused on integrated analysis of production, marketing and price scene of Pulses sector. Detailed features of market structure, practices, channels, price spread in pulses have been given price fluctuations, seasonality in prices, effect of price and non-price factors, terms of trade for pulses vis-a-vis other crops and relative changes in inter-crops and input-output price parities have been analysed.

Ramamoorthy (1996) studied the major socio-economic constraints in cotton production and management. The study identified the major production constraints as poor quality input supply, inadequate credit supply and high production risk and the marketing constraints as price fluctuation, storage problems under weighment and poor market development.

Bonny (1996) surveyed the constraints on commercial production of vegetable in Pananchery and Duthur, Kerala and reported that increased cost of plant protection chemicals was perceived as the most important factor by the respondents followed by inadequate market facilities, poor storage and other post-harvest facilities, insufficient capital and high labour costs.

Patel *et al.* (1997) in their study on marketing efficiency of Anand vegetable market in Gujarat reported that lack of storage facilities, delay in payment of sale proceeds, high cold storage charges, monopoly of few middlemen and need of timely display of these perceptive products etc. were the major problems faced by the cabbage and cauliflower growers.

Wasim Ahmad , Sanjay Sehgal, (2015), this paper aims to examine the destabilization effect in the case of India's agricultural commodity market for the sample period of 01 January 2009 to 31 May 2013.

RESEARCH METHODOLOGY AND LIMITATION OF THE STUDY

Sources of data:

The study is mainly based on secondary data and primary data. The secondary data has been collected from various sources like various articles, white papers, newspapers, magazines, journals, books, websites of statistical abstracts, Reserve Bank of India, Ministry of Agriculture, Agricultural statistics at a glance, Directorate of Economics and Statistics, Government publications, professional and academic journals, prominent websites dealing with agriculture Artificial Intelligence, statistics and from various institutional libraries. The primary data in the form of respondents' opinion has been collected from the farmers'. The objectives of the study were kept in mind while framing the questionnaire using open ended and five point Likert's Scale. The limitation of the study is, it is based on sample responses only and covers only selected agriculture area.

DEVELOPMENTS AND CONCERNS IN THE AGRICULTURE SECTOR

Slowdown in Yield Increase:

Increased use of land, irrigation and agro-chemicals played a major role in the growth of agricultural production in earlier days. However, it is now recognized that increased production was often accompanied by negative effects on agriculture's natural resource base, including land degradation, salinization of irrigated areas, over-extraction of groundwater, the build-up of pest resistance and the erosion of biodiversity, etc. These have lead to slowdown in increase of yield. As per the recent studies there is a need of increase in the Cereal production by 43.4 percent by 2050 from 2.068 billion tonnes in 2005–07 to 3.009 (Alexandratos and Bruinsma, 2012) to meet the demand. The assumption is that 80 percent of this increase should come from yield increase by 2050. This indicates an annual growth rate of around 0.9 percent is required.

Increased Research and Development Spending:

After 2000, global expenditure on agricultural R&D has increased from 25 billion to 33.6 billion(in US $) constituting an increase of 3.1 percent a year during the period from 2000 to 2009 and continuous spending is done on R&D year by year. During this period half of the increase in expenditure was contributed by India and China. One-fifth of the total increase in spending worldwide was contributed by Russian Federation along with countries like Argentina, Brazil, Iran, and Nigeria. Below table gives percentage growth of public spending on agricultural R&D by world, India and China.

Table No -1:
Real growth of public spending on agricultural R&D (percent)

Country	1970-80	1980-90	1990-2000	2000-09
India	1.7	5.6	6.7	5.2
China	7.8	5.1	3.9	9.9
World	4.1	2.4	1.9	3.1

Source: *Compiled from: Pardey, Chan-Kang and Dehmer, 2014*

As per the research reports, by 2008 private investment in R&D has also increased to 18.2 billion from 12.9 billion in 1994 (in US$) (Beintema et al., 2012). The study also indicates the total private investment at global level in food processing and R&D in agriculture constituted for about 21 percent in 2008. Indian participation in spending for R&D accounted for 19 percent (Pray and Nagarajan, 2012) and 16 percent of china (Pal, Rahija and Beintema, 2012), (excluding

food processing) compared to more spending in developed and high income countries. Most of the developed and high income countries are investing in research and still there needs to be similar kind of spending in agricultural R&D in as for as country like India is concerned where there is huge opportunity for growth to boost the production and that would help to reduce the gap between the demand supplies to certain extent.

Role of Information and Communication Technologies:

Information and communication technologies are playing revolutionary role in third world countries in terms of enhancement agriculture production and improving farmers business towards agriculture. With the help of technologies and mobiles, farmers are being informed about agricultural innovations, weather conditions, input availability, financial services and market prices, and also connecting them with buyers. With improvement in the communication technology farmers are able maximize the yield and earn more profit for their crop due to optimization of the crops based on the soil type and growing the crop to an ideal size making it easier to harvest. But many of the farmers still face the problem of determining which seed would be best to increase the yield and generate more profit with the existing situation due to abnormal environmental condition. Mobile phones are the success story of bridging the rural digital gap, bringing tangible economic benefits and acting as agents of social mobilization through improved communication, but few studies also indicate that developers' fail to look at the context in which farmers use these services means. As per report by GSMA Mobile Economy 2016, it is estimated that by 2020, out of the incremental 1 billion new mobile users more than 90 percent of the subscribers would be from low- and middle-income countries. Increased usage communication technologies like mobile phones and internet day by day are leading to shortening of the distance between isolated small and medium farmers' and people involved in producing, processing, transporting, marketing, and regulating food As an affordable and accessible means of communication, rural communities are realizing the potential of mobile telephony to create economic opportunities and strengthen social networks, but like all technologies, this also has certain limitations and challenges.

Impact of Adverse Climatic Conditions:

IPCC - Intergovernmental Panel on Climate Change that reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change has mentioned in its recent reports that agronomic adaptation would be able to improve the yields to certain level but would depend on the adaptation measures used by small and medium farmers against environmental conditions like climate changes, rain etc. As mentioned in a research report, crop rotation techniques would benefit more when rainfall is better compared to lower rainfall, also use of mineral fertilizers would fetch more yield with average climatic conditions compared to varied climatic changes in terms of rain (Arslan etal., 2015). So to bridge the gap between the demand-supply of agricultural produce, certain measures needs to be adapted for climate changes to increase the yield including other stages of the food supply chain like food processing, packaging, transport, storage and trade.

In order to encourage such adoption, improvements are needed in infrastructure, extension, climate information, access to credit, and social insurance – conditions which are at the heart of rural development (FAO, 2016e).

Increased consumption due to increasing population and slower growth in yield is driving increased demand for agricultural produce. Farmers along with new researches around the globe are working continuously to reduce agricultural demand supply gaps, but in achieving this, planet's resources are being adversely impacted. On the contrary to balance the sometimes opposing goals of increasing production and conserving resources, researchers and entrepreneurs are working on ways to sustainably intensify agriculture on its existing footprint. In the current scenario many researchers and entrepreneurs have access to the tools and techniques like Data mining and Artificial Intelligence to make use of these to overcome the mentioned problems. Adapting of these techniques would improve the agriculture production and increase the yield along with improvement in the quality food, and it can be a powerful tool that would help in fighting against world hunger in the future.

Most Popular Applications Of AI In Agriculture Appear To Fall Into Three Major Categories:

Agricultural Robots:

Agricultural robot is a robot deployed for agricultural purposes. These are being extensively used in agriculture for the purpose Harvesting, Weed control, Pruning, Planting seeding, Spraying and Phenotyping, Sorting & Packing, Environmental monitoring and Soil analysis. Many companies are involved in developing robots to handle such essential agricultural tasks that help in increasing the yield at a higher volume and at a faster pace than humans. Below are the companies and purposes for which robots are being developed.

Amazone-Werke Gmbh: Has developed a robot called Multiple-purpose lightweight robot for weeding, applying fertilizer. ***Clearpath Robotics:*** This Company has developed a robot that is used for harvesting, mowing, hauling, research, etc. ***Wageningen UR:*** Has developed an intelligent machine that is used for harvesting and spraying. ***F Poulsen Engineering ApS:*** Company has developed a machine that autonomously garners row crop grains from combine machines and brings it out of the field to the transport area. ***Rowbot:*** Company has developed a Rowbot that travels between corn rows, often under the leaf canopy to apply nitrogen fertilizer and also to seed cover crops. This collects sensor data to inform both current and future work. GPS and several sensors keep the robot from trampling the crop. ***F Poulsen Engineering ApS:*** Develops intelligent machines for Weeding and thinning of lettuce, cabbage, fennel and onions.

Crop and Soil Monitoring:

Crop and Soil Monitoring techniques measure a variety of essential soil properties on the go. These generally use soil sensors and are considered to be the important tool that helps to identify accurately, what is going on below the surface and also gives instantaneous information on soil moisture content, salinity, temperature, and more. Due to increase in scarcity of water, knowing about when to irrigate and how much water needs to be irrigated for a crop would help in more crop per drop, so techniques like remote monitoring of crop gives information on minute crop water usage, so farmers can irrigate

at the optimal time for maximum plant growth and better crop quality. Many companies in the world are developing deep-learning algorithms to process data captured by drones and software-based technology to monitor crop and soil health. Below are the companies involved in developing such models.

Progressive Environmental and Agricultural Technologies (PEAT): This Company helps in Diagnosis Pests / Soil Defects – The Company has developed apps, this image recognition app identifies possible defects through images captured by the user's smart phone camera. Users are then provided with soil restoration techniques, tips and other possible solutions. ***Precision Hawk:*** This Company develops Drone and UAV remote sensing applications and data processing services that help in gathering and providing data for crop researchers, consultants and farmers and ranchers to make farm management decisions. ***Agribotix:*** This provides Drone services for precision agriculture for agronomists, crop consults, farm managers and big industrial farm corporations. These produce and process images of high resolution and maps using various sensors and provide prescription maps to match the application of fertilizer to the places wherever it is required. ***EcoRobotix:*** A robotic platform for weeding of spaced-row cultures. This includes wireless communication for gathering and transferring information which includes advanced weed recognition algorithms, fast robotic arms and advanced sensor technology.

Predictive Analytics:

Predictive analytics in the agriculture industry is supported by data mining and machine learning techniques due to the huge availability of data over the years. Now with availability of real-time data on weather, soil & air quality and crop maturity etc, predictive analytics can be used to make smarter decisions on agriculture production and marketing. Below are the companies involved in developing such models.

Where – This Company with the help of satellites and its own developed machine learning algorithms, predicts weather for analyzing crop sustainability and evaluate farms for the presence of diseases and pests. It delivers agricultural intelligence into the hands of farmers, commercial growers, commodity traders and policy makers. It also helps in identifying the risks and opportunities in the commodities market by providing weather and agronomic models and tools to proactively identify relationships between weather events and its commercial impacts.

Sustainability – A company that helps in predicting weather, analyzing crop sustainability and evaluate farms for the presence of diseases and pests using its machine learning algorithms with help of satellites. ***FarmShots*** analyzes satellite & drone imagery of farms for Monitoring Crop Health and Sustainability. Specifically the company aims to "detect diseases, pests, and poor plant nutrition on farms. ***CropX*** offers an integrated hardware and software system for measuring soil moisture, temperature and electrical conductivity and sending that data to the cloud where it can be accessed from any mobile or fixed device.

INDIAN SCENARIO

Agriculture is the most important sector of Indian Economy and it contributes to the 18 percent of India's gross domestic product (GDP). As majority of the population in India belongs to the farmers leading to dependency on timely rainfall for cropping, harvesting to realize the subsequent profits. Uncertainty surrounding this phenomenon has always haunted the farmers over the years. With advent of newer technologies in farming along with previous experiences has reduced uncertainty, but increased Small and fragmented land-holdings, increase in depletion and exhaustion of soils due to non-replenishing of the soil over the years, lack of irrigation facilities, soil erosion, lack of mechanization has resulted into lower yields and has become the major concern for the growers. Due these old age problems Indian farmers are now turning in to new technologies like AI for sowing the crops by predicting the environmental factors with the help of predictive analytics. Karnataka and Andra-Pradesh governments have joined hands with Microsoft to support their farmers with new applications being developed by the Microsoft that uses powerful cloud based predictive analytics to forecast the weather and also helps in arriving at a precise date for sowing.

Microsoft along with ICRISAT ran a program for across 7 villages involving 175 farmers in the Andra-Pradesh. This program helped the farmers to get the text messages on their mobile related sowing advisories, such as the sowing date, land preparation, soil test based fertilizer application, and so on. Despite of less faith in the technology by the farmers a record yield was achieved with an increase of yield between 30 to 40 percent. Other intelligence techniques and apps are being developed in terms of Pest attack prediction that enables farmers to plan in advance and reduce the crop loss due to pests and thereby helping them to increase the farm income. Price forecasting model for policy makers is being developed in conjunction with Karnataka government to predict future commodity arrival and the corresponding prices based on remote sensing data from geo-stationary satellite images to predict crop yields through every stage of farming and historical prices. Generally growers get affected due to drastic variations in weather conditions such as changes in rain, increase in temperature and ground water variations; these can affect farmers, specifically those who are dependent on monsoons. To overcome these concerns the cloud and AI to predict proper timings for sowing, pest control and commodity pricing is a major initiative towards increasing the yield that would reduce the scarcity of the food, creating increased income and providing stability for the agricultural community.

CONCERNS

In current scenario, the technology comes at higher price which farmers cannot afford easily, so government should intervene between the technology provider and farmers and find a way to deploy them in a cost effective way. Due to illiteracy and lack of proper knowledge and lack of faith in technology farmers tend to reject in adapting the newer technologies. Due to huge opportunity in this field venture capitalists are funding huge money into the sector, by forcing many agricultural technology startups to complete development as quickly as possible and trying to flood the market with their products. This would result in a failure of a product, leading to skepticism from the market and deliver a blow to the integrity of Artificial Intelligence and Machine Learning.

The technology is all about making judgments with complex scenarios, the farmers should be given with final and easy decisions, because it would certainly create confusion and increase frustration among the growers if all the variables and conditions are put together in a complex manner, it is always better to make some basic rules of thumb that would be fairly

effective and understood by the farmers. So in most cases, the problem is not that the technology is not being used but the enough time needs to be given to the sector and the people to get adapted to the new technologies. For technology to truly make an impact in the field, more effort, skills, and funding is needed to test these technologies in farmers' fields. There is huge potential for artificial intelligence and machine learning to revolutionize agriculture by integrating these technologies into critical markets on a global scale. Only then can it make a difference to the Farmers and reduce the world hunger.

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