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An Overview of Technological Transformation in Agricultural Sector

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Abstract

Technological transformation in agriculture sector shows much positive impact in terms of productivity, security and supply chain. By using traditional method of farming, the farmers' encounters many difficulties while preparing the soil, harvesting of crops and during sow seeds and difficult to get information about deficiency of nutrients in the soil. In contrast, technological transformation in agricultural sector various benefits such as increased productivity, enhanced farmer livelihood, better market linkage, informed decision-making, efficiency policy-making and implementation. Major advanced technologies such as livestock, vertical farming, robotics and technology of automation, artificial intelligence has huge potential in agricultural sector for better growth. This paper aimed to discuss about technological transformation in agricultural sector, mainly discussed about different aspects of technology in agriculture and technological innovations in agriculture. Continuous adaptation of modern technology in agriculture sector will increase income of small farmers as well as help in economy of the country in future.

Keywords: Artificial intelligence, Agriculture, Farming, Technology, Technological transformation.

Introduction

The world population drastically increasing day by day and because of natural resources are lacking due to climate change, the food security will be the major issue in the future. For considering these issues, agricultural sector plays an important role for marinating food supply as well ensure food security. The agricultural sector is the world's single largest employer. More than 40% of the world's population depends on the industry, which provides income and employment opportunities to poor rural households[1]. However, 836 million people worldwide still live in severe poverty, with developing countries accounting for the vast majority of the world's population hunger or undernutrition. Without a question, the situation is posing major challenges to family self-sufficiency and rural growth[1]. As a result, ideas like agriculture production or improving the efficiency and durability of subsistence agricultural practices have become increasingly popular around the world.

Recent technological developments are being used in agricultural processing and value chains in artificial intelligence, the Internet of Things, Blockchain and in other developing fields. For example, precision agriculture, robotics and drones not only enhance production, optimize the use of resources but also reduce waste and ensure traceability and quality of food. In general, technology refers to a well-balanced mix of resources, materials, expertise, and skills, while technological transformation refers to the application of modern agricultural technology to increase productivity[2]. Agriculture production can be supported by the adoption of modern farming technologies such as agriculture equipment, better-quality seed varieties, and fertilizers based on the inorganic compounds. Once the farmer gain complete knowledge related to the latest technology as well as its potential, latest agricultural technology interventions convert long-term steadiness. Adaptation of modern technology in agriculture sector changes the way of farming in different ways such as a farmer can govern his irrigation systems as well equipment related to irrigation from his phone as well as from computer also instead of monitor each field by driving and Crop sensors utilizes its capability in order to maximize the productivity by applying the fertilizers in effective fashion. Crop sensors can sense various parameters such as water content, humidity and level of nutrients that are responsible for the growth of any type of crop or plants [3]. This review paper discussed about technological transformation in agricultural sector and how modern technology change the way of farming and makes agriculture sector more productive.

LIFE-CYCLE OF AGRICULTURE

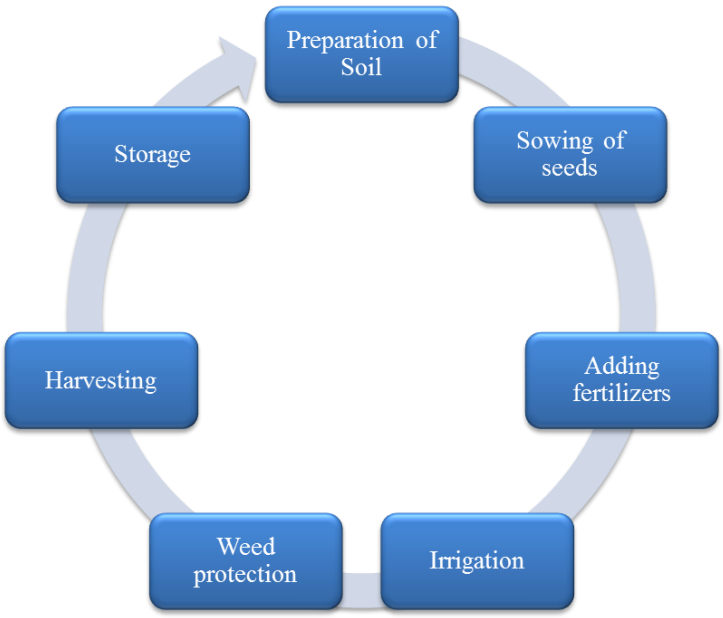

Figure 1: Schematic representation of Life cycle of Agriculture

The method of agriculture can be divided into different steps or parts as shown in the Figure 1.

- *Preparation of Soil:* Farmers formulate the soil for sowing the seeds during this stage of farming. Wide soil clumps are broken up and debris including sticks as well as rocks, and some roots are removed. Also, depending on the type of crop, apply fertilizers and organic matter to generate an optimal environment for crops.

- *Sowing of Seeds:* In this stage necessitates attention to the distance between two seeds as well as the depth at which the seeds should be planted. Temperature, humidity, and rainfall are all important factors at this stage.

- *Adding Fertilizers:* Soil fertility must be maintained for the production of stable as well nutritious crops. Fertilizers plays an important role in crop growth, the most common nutrients that are required for the healthy crops are potassium, phosphorous and the nitrogen. Fertilizers remove the unwanted elements from the soil and enhance the fertility of the land; the nutrients present in the soil will decide the crop's quality.

- *Irrigation:* This stage or step plays an important role in order to maintain humidity as well as moisture present in the soil. Under watering as well as overwatering in the crop can have adverse effect on the crop growth and if watering in the crops is not done in the proper fashion then crops can be damage also.

- *Weed Protection:* Sometimes there are various unwanted plants are growing near the actual crop as well as sometimes at the boundary of the land. These types of plants have huge adverse effect on crop growth, crop quality and crop yield that is why is very important to protect crop from weeds.

- *Harvesting:* In this stage, the matured or ripe crop grabs and cut from the land. Harvesting has been utilized large number of labors and sometime utilizes the heavy machines in order to harvest the crops from the fields. Machines are usually used in the commercial or industrial farming.

- *Storage:* In this stage, the harvested crop need to store in order to maintain the food security. Storage of crop maintains the food supply during off-season of the crops.

CHALLENGES ENCOUNTERED BY FARMERS BY USING TRADITIONAL METHOD OF FARMING

There many challenges are facing by the traditional farming sector; some of the challenges are listed down:

1) Agriculture plays an important role in the life cycle of agriculture through climatic influences including precipitation, temperature and humidity. Climatological changes are caused by increasing erosion and emissions, so it is difficult for farmers to decide on soil planning, crop seed and harvest.

2) Every crop has its own requirement of nutrients in the soil. For the crop growth, there are three main nutrients are required such as nitrogen, potassium and the phosphorous in the soil of the crop land [4]. The deficiency of any of the nutrients can affect the productivity as well quality of the crops.

3) Weed control plays a significant role in the lifecycle of agricultural, as can be seen. If not regulated, it may result in production improvement costs as well as the absorption of nutrients from the soil, resulting in nutrient deficiency.

AGRICULTURE TECHNOLOGIES

Industry 4.0 has major agriculture operations, which have combined cyber physical networks, web apps for subjects, artificial and machine learning, big information and research and agricultural machinery cloud technologies. Creating design solutions for surveillance and process management in farmers is crucial to the creation of innovative elements, including sensors and cloud storage, for tracking soil parameters and weather conditions, in order to allow intelligent irrigation solutions and to handle attacks on pesticides or the use of cyber-physical systems. Big data and machine learning are critical for data mining, livestock crop management and water management systems[5]. Real-time tracking systems reduce pesticide use for fleets of drones and land vehicles, and smarter farming technologies play a part in accurate handling in real-time. Drones and intelligent glasses can be used together to map and sample cultivated soils in an artificial reality so that the future vulnerable area can be defined and regulated. In the event of unexpected events and circumstances that could affect future harm, such as the destructiveness of food goods passing through the supply chain, sensors and intelligent systems are crucial.

The potential of new strategies to enhance the functioning of different agricultural operations has an impact with the adoption of modern business models. By using a range of adopted models customized to production specifics, farmers may boost productive activity, maximizing the usage of resources (including labor), prices and quantitative as well as qualitative production opportunities. The most important ones are the description of objects, spatial comparisons, physical and chemical parameter estimation, satellite navigation, networking, information gathering and analysis, process automation and driving. Other scenarios covered by digital technology in the fields of farming include sensory management of greenhouse, electrical efficiency, phenology monitoring, insect or seed disease identification, supply chain traceability, planning for irrigation, plant growth optimization, land tracking and agricultural land management.

The next few years will all be contributing to agricultural sustainability through the block chain technologies on improved transparency as well as food protection, advanced genetics, controlled environmental and vertical agriculture, biotechnology, including microbiome as well as biological soil agent, farmed beef, and substitute meat/milk protein. 3D printing would enable the development of technologies for food and delicious plant replacements. This is vital to environmental protection, as well as providing opportunities to launch and grow new companies and services. [6].

TECHNOLOGICAL TRANSFORMATION IN AGRICULTURE

Strategic perspectives, consumer centralism and ICTs, as well as process infrastructure, talent, skills and capability building, creativity and culture are the core determinants by which digital maturity can be assessed. The global economy and culture are being transformed by digital technology, and all attempts are being made to change business models. This includes the creation and application of innovative solutions as well as the

introduction of a revolutionary corporate culture and programs that use modern innovations to achieve a strategic edge as a reaction to the spread of the latest digital technology and the advent of new technological challenges. Increased sales, efficiency, and a customer-centric orientation are only a few of the possible benefits, which may lead to value development improvements or new ways of customer engagement. Any company that strives for growth, expansion, efficiency, and sustainability must embrace digital transformation[7].

Climate change, a dwindling availability of resources and cost and price uncertainty all limit farmers and policymakers' decision-making. These shifting developments lead to an era where emerging devices are outweighing people in behaviors that do not comply with existing laws that were previously un-automated, like networking or the identification of patterns in uncertain or developing settings. To date, the use of technologies from agriculture was limited, with focus on the long-term survival of the company. Future studies will focus on smart digital services that will help farmers meet sustainable challenges.

The world economic potential of up to $33 trillion in 2025 will be generated by the mobile Internet, data automation and the Internet of Things, leading to the exponential increase in computing power. Influenced by green energy technology and innovative resource research, the composition of income & expenditures that will change greatly[8]. The agricultural precision market is projected to grow by 15% by 2025 with sales above the approximate $12 billion. An changing industry will result in an improved use of intelligent farm practices and advancement in management algorithms, broad details, emerging technologies and renewable energy systems. Moreover, from 2019 to 2025, there is expected a more than 27 percent growth in controlled precision farming services[9]. Major modern technology innovations (as shown in Figure 2) in agricultural sector are discussed below:

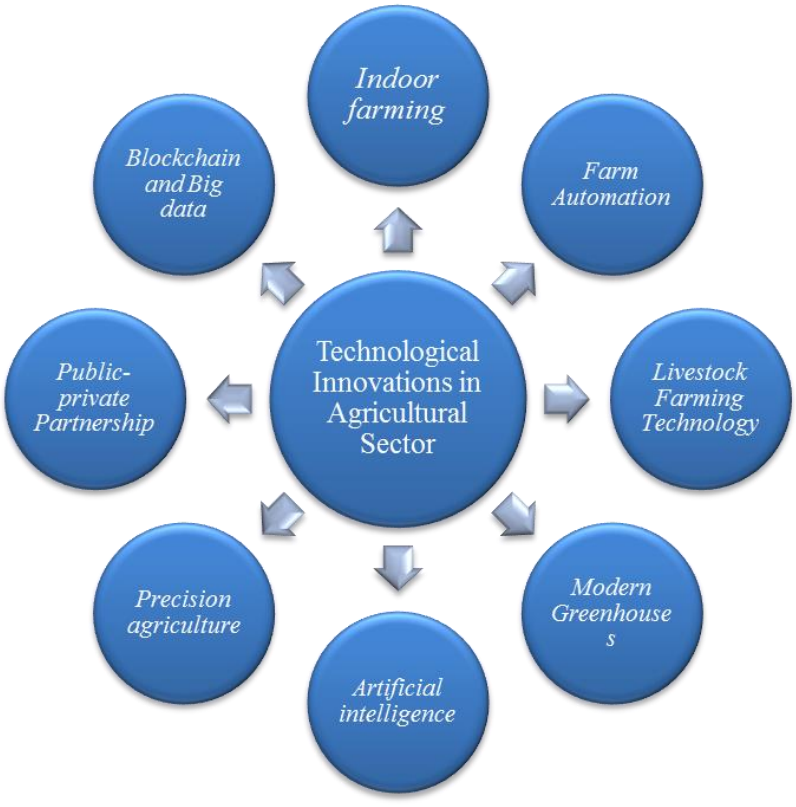

Figure 2: Schematic Representation of the Technological innovations in Agricultural Sector

1. *Indoor Farming:*

By reducing the distance traveled by the supply chain of the agriculture sector and the crop yield rate, vertical farming indoors can be used, land restrictions can be resolved and even the environmental impact of farming minimized. Vertical indoor farming is the method of cultivating products, stacked one at a time in a closed and

supervised setting. The use of vertically installed cultivated rails significantly reduces the land area available for plant growth in comparison to traditional agricultural methods. This method of farming is often linked to metropolitan and urban agriculture due to its ability to thrive in smaller spaces. Any vertical farms are rare because no plant growth requires soil. The bulks are hydroponic or aeroponic. Instead of natural lighting, artificial wax lamps are used.

From sustainable urban growth to an improved crop yield while lowering labor costs, the advantages of indoor vertical farming are clear. Vertical agriculture can accurately measure year-round light, moisture and water factors as food production increases with predictable harvests. 70% less water is used by vertical farms than horizontal farms, which means that they save more resources. The use of automated robotics to control harvesting and planting and transport greatly lowers the cost of labor, solving the current labor shortage in the agriculture industry.

2. *Farm Automation:*

Farm automation - also known as 'intelligent agriculture' - is a technological form which improves farm productivity by automating crop production and cattle production cycles. A increasing number of companies are developing Drones, advanced machinery tractors, robotic harvesters, automatic irrigation and seeding modern robotics. While these technologies are still relatively recent, a growing number of traditional farming companies implement agricultural automation.

Modern agriculture has been fully transformed by technological advances extending from robots and drones to applications related to computer vision. The main aim of land farm technology based on automation is to take care of the more routine activities. Harvest automation, automated tractors as well as seeding and weeding, and Drones from Ariel are just some of today's large farms' inventions. Technology of agricultural automation addresses important issues including population growth, labor shortages on plantations, and changing consumer tastes. The advantages of automating conventional farming processes are enormous, as they address concerns such as consumer desires, labor shortages, and farming's environmental footprint.

3. *Livestock Farming Technology:*

While it is probably the most important, the traditional livestock industry is often ignored and underserved. Livestock is a key source of natural renewable energy that we depend on every day. The management of poultry farms, dairy farms, livestock ranches and other livestock-related agricultural enterprises has traditionally been concerned with livestock management. Livestock management must maintain a consistent accounting report, supervise staff and ensure that cattle are well cared for and fed. Recent developments, on the other hand, show that modern technology is transforming the field of management of livestock. In the last 8 to10 years, new technologies have greatly improved the industry, making monitoring and handling livestock much simpler and data-driven. Nutritional innovations, genetics, healthcare, digital technology, and other forms of technology can all be used to achieve this goal.

Livestock technology can help increase or boost animal and livestock production, welfare, and management. As much dairy herds are suited with sensors to track health as well as improved productivity, the idea of the "connected cow" has emerged. Distinct wearable sensors placed on the cattle can monitor everyday behavior and issues related to health while also offering data-driven perspectives for the whole herd. All of this data is being transformed into expressive, actionable information for producers to look at speedily and easily in order to make fast management conclusions. The current livestock industry will greatly benefit from sensor and data technologies. It may increase livestock production and health by identifying animals with poor health and recognizing areas for development. Computer vision enables us to collect a wide range of impartial data that can be synthesized into useful, actionable perceptions. Data-driven decision-creating leads to safer, more reliable and timely decisions, which improve livestock, herd productivity.

4. *Modern Greenhouses:*

In recent years, the greenhouse industry has grown from low level testing and esthetic installations to large-scale installations that explicitly engage in conventional land-based food production. Thanks to the latest phenomenal developments in growing technology, the industry is booming like never before today. Wide-ranging, capital-intensive, and urban greenhouses are now becoming increasingly common.

The sector has seen intense developments in recent years as they have grown. In modern greenhouses, lights and automated control systems based on light emitting diode (LED) are increasingly used to perfectly customize the growing environment. Competitive greenhouse companies are raising their growth facilities near metropolitan centers to draw on the ever-increasing market for local produce. To meet these targets, the greenhouse industry is expanding to develop the resources required to succeed on today's market by focusing on venture capital and other outlets.

5. *Precision Agriculture:*

Agriculture sector is changing, and modern technology is charming an increasingly important measure of any commercial or industrial farm. Firms of precision agriculture are emerging technologies that will enable farmers to optimize growth rate by monitoring every aspect of crop production, including level of moisture, pests' condition, condition of soil, and microclimates. Precision agriculture allows farmers to improve productivity and provide knowledge about management of cost in order to gain knowledge about upgraded techniques for crops planting as well as growing. This utilizes real-time data from Global positioning System (GPS) satellites in order to make well-versed decisions about when to fertilize and irrigation, as well as what crops to plant when[10].

6. *Blockchain and Big Data:*

The factors related to the agriculture are very complex and diverse such as there are wide spectrum of type of crops, conditions based on geography and climate. Since creating sense of all of these data is such a difficult task, agricultural sector has always rich in data but the knowledge associated with this field is poor, but the situations and conditions are changing now because of advanced data management system. Industries are now collaborating with different farmers to help in order to understand about plans for better seeding. Since these companies plan to use this data for their own purposes, that is why data privacy is the major issues confronting the agriculture industry in the near future. The General Data Protection Regulation (GDPR) is already a working template in the EU, so it is likely to be ahead of the US as these progresses.

The consumer involvement on the Block chain-based network by suppliers from the USA and the consumer in China, through banks delivering and verifying the credit letter, has already utilized to start exporting the soybeans to the USA. The appropriate certificates were issued by the shipping companies as part of the procedure. The agriculture department of USA (called as USDA) then discussed about how certificates of phytosanitary can be included in the whole process. This agreement showed how technology of blockchain can simplify most of the complex processes involved in trade that is done on the international level, which is especially valuable for commodity traders who deal in greater volumes but very low margins. We believe that the utilization of Blockchain in agricultural sector will become increasingly popular as a way to improve transparency in supply chain, minimize the risk of shortage of foods, and encourage more productive transactions.

7. *Artificial Intelligence:*

AI is being used by the agriculture industry to aid produce improved crops, manage pests, track soil and rising weather conditions, coordinate data with farmers, reduce amount of work, and enhance the handling of multitasks related to supply chain of agriculture sector. Artificial intelligence can be used for different purposes:

- *Weather Forecasting:*

Weather conditions are plays an important role in crop production. Weather forecasting helps to the farmers in order to analyze the condition of weather so they can take decisions about crops in easiest way. They can easily

schedule about the type of crop that can best suited in that weather conditions based on artificial intelligence. Since the weather conditions are changing frequently due to climate change, farmers facing lots of problem for taking the decision about correct time for seed sowing.

- *Health Monitoring System for crop as well as soil:*

The form of soil as well as the nutrients in the soil affects the grown crop type and crop quality. Soil quality is deteriorating as a result of increased deforestation, making it difficult to ascertain the quality of the soil.

- *Analyzing Crop Health By Drones:*

The health monitoring of crop by drone-based imaging have been introduced by SkySqurrel Technologies. This method, the drones collects data from lands or fields, which is then transmitted to a computer via Universal Serial Bus (USB) drive and the data analyzed by specialists. SkySqurrel Technologies Company analyzes the images that are captures by drones with algorithms and provides a comprehensive report on the farm's current health. It assists farmers in identifying pests as well as microorganisms such as bacteria, allowing them to utilize pest control or can be use other techniques in a timely manner.

- *Agricultural Robots:*

Robots are capable to perform multiple pieces of work on the land farms are being developed by AI companies. When compared to humans, this form of robot equipped to manage weeds as well as harvest crops at high rate with higher volumes. These kinds of robots are programmed to inspect crop quality as well as detect weeds while harvesting and packing the crops simultaneously. These kinds of robots can also deal with the difficulties that farm labor faces.

- *AI-Enabled Pests:*

Pests are biggest destructive factor of farmers' crops. Artificial intelligence (AI) systems analyze images captures by satellite and compare them to past data to determine if any insects have landed and, if so, which insect is landed. And the send warnings send to the smartphones of farmers so that they can proceed with the necessary precautions and utilize the necessary pest control, allowing Artificial intelligence (AI) to assist farmers in their pest control efforts.

8. Public-Private Partnership:

Consistent Research and developments, pursued by both the public and private sectors, are poised to propel technology implementation in Indian agriculture to new heights. Precision farming, satellite soil mapping and water conditions, hydroponics, and energy-efficient and adaptable machineries have all proven their worth in the Indian farming field. To ensure greater technology adoption, the emphasis is shifting to bettering synergies between various stakeholders. Both the public and private sectors have made substantial investments in Research & Development and the development of new technologies to resolve the issue of sustainable agriculture. Given the structural shift in agriculture and the growing demand for technology, it is important to ensure that innovations are accessible to farmers and agribusiness players, are viable on the field, and are scalable. Strengthening the public-private connection in this sector, while exploiting the respective competitive advantage, has a lot of merit. Naturally, problems associated with commercialization must be tackled. Agriculture must be the backbone of the Indian economy, as it employs greater than half of the population of the country. Changes in the agricultural sector, as well as the overall economy, will be unavoidable as a result of technological advancements.

DISCUSSION

Farming is civilization's oldest sector, but farming to be changed by digitization and emerging technologies. Blockchain as well as sensor technology, and handling of Big Data present a huge opportunity in the agricultural

sector. One of the most significant historical developments was the shift of human communities from hunting and gathering to farming. This new industry brought with it latest technology, including plough, which reduces the risk of diseases, shifting weather as well as pestilence. Now, there are new challenges in front of the world to feed growing world population that is influenced as much by evolving consumer preferences as by need. The traditional farming sector is finally being disrupted by digitization. In the near future, modern technologies such as technologies related to sensors, precision farming, blockchain as well as big data will play an important in the growth of agricultural sector. There will be numerous opportunities for famers as innovators, technology providing firms and others who play an important part in the supply chain of food in order to adopt the latest technology for greater efficiency drive.

CONCLUSION

Modern farming is more important to progress than ever before. The sector as a whole faces critical challenges, including increased supply costs, shortage of labors and shifting consumer responsibilities and sustainability aspirations. The need for solutions to these challenges is rapidly being recognized by farming firms. In the last ten years, agriculture technology has seen a large rise in investment. Indoor vertical farming, technology related to livestock, automation as well as robotics, advanced greenhouse practices, AI as well as precision agriculture, and blockchain have all seen significant technological advancements in the space. By providing farmers with more knowledge about the crop and soil structure, modern technology in agriculture reduces the risk of diseases and pests while also increasing efficiency and growth in agriculture. In order to utilize the technology in agriculture sector completely, it is recommended that government must make proper policies to spread the knowledge of technology in agriculture among the small farmers.

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