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An Overview of Technological Advancement in Agricultural

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ABSTRACT: ***In terms of production, security, and supply chain, technological revolution in agriculture has had a significant beneficial effect. Farmers that use the conventional way of farming have many challenges in terms of soil preparation, crop harvesting, and seed sowing, as well as difficulty in obtaining information regarding nutrient shortage in the soil. Technological transformation in the agricultural sector, on the other hand, has a number of advantages, including higher productivity, improved farmer livelihood, improved market linkage, informed decision-making, and efficient policy-making and implementation. Major sophisticated technologies, such as livestock, vertical farming, robotics and automation technology, and artificial intelligence, have enormous development potential in the agriculture industry. This article intended to examine technological change in the agricultural sector, with a focus on various elements of agriculture technology and technological advances. Continuous use of new technologies in the agricultural industry would boost small farmers' revenue and contribute to the country's economy in the future.***

KEYWORDS: ***Artificial intelligence, Agriculture, Farming, Technology, Technological transformation.***

1. INTRODUCTION

Food security will be a significant problem in the future as the global population grows at an exponential rate, and natural resources become scarce as a result of climate change. In light of these concerns, the agriculture industry plays a critical role in both increasing food supply and ensuring food security. Agriculture is the single biggest job in the planet. More than 40% of the world's population is dependent on the industry, which offers money and jobs to impoverished rural families. However, 836 million people live in extreme poverty throughout the globe, with developing nations accounting for the overwhelming bulk of individuals suffering from hunger or malnutrition. Without a doubt, the situation is presenting significant obstacles to family self-sufficiency and rural development. As a consequence, concepts such as agriculture production and enhancing the efficiency and long-term viability of subsistence farming methods have gained traction throughout the globe [1].

In agricultural processing and value chains, recent technology advancements such as artificial intelligence, the Internet of Things, Block chain, and other emerging areas are being utilized. Precision agriculture, robots, and drones, for example, improve output, optimize resource usage, minimize waste, and guarantee food traceability and quality. Technology, in general, refers to a well-balanced combination of resources, materials, knowledge, and skills, while technological transformation refers to the use of contemporary agricultural technology to boost production. Adoption of contemporary agricultural technology such as agriculture equipment, higher-quality seed types, and inorganic compound fertilizers may help boost agriculture output. Newest agricultural technology interventions convert long-term stability after the farmer has full understanding of the latest technology as well as its possibilities. The adoption of modern technology in the agriculture sector has changed farming in a variety of ways, such as a farmer being able to control his irrigation systems as well as irrigation-related equipment from his phone or computer instead of driving to each field to monitor it, and crop sensors utilizing their capability to maximize productivity by applying fertilizers in an effective manner. Crop sensors can detect a variety of factors, including water content,

humidity, and nutrient levels, all of which are important for the development of any crop or plant. This review article examined the agricultural industry's technological revolution and how contemporary technology has changed the way people farm and made the sector more productive [2]–[5].

1.1. 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:

- Agriculture is influenced by climatic factors such as precipitation, temperature, and humidity, and therefore plays a significant part in the life cycle of agriculture. Increased erosion and emissions are causing climatic shifts, making it harder for farmers to make decisions about soil planning, crop seed, and harvest.
- Each crop has its unique set of nutritional requirements in the soil. In the soil of the agricultural field, three major nutrients are needed for crop growth: nitrogen, potassium, and phosphorus. Any nutrient shortage may have an impact on crop production as well as quality.
- As can be seen, weed management plays an important part in the agricultural lifecycle. If not controlled, it may lead to increased production costs as well as decreased nutrient absorption from the soil, leading in nutritional insufficiency.

1.1.Life-Cycle Of Agriculture:

Agriculture may be broken down into various stages or components, such as soil preparation, seed planting, fertilizer application, irrigation, weed control, and so on.

- Soil Preparation:

During this stage of farming, farmers prepare the soil for planting the seeds. Large clumps of dirt are broken up, and debris such as twigs and pebbles, as well as some roots, are removed. Apply fertilizers and organic matter to create an ideal environment for crops, depending on the kind of crop.

- Seed Planting:

This step requires paying close attention to both the space between two seeds and the depth at which they should be placed. At this point, temperature, humidity, and rainfall are all significant considerations.

- Fertilizer Addition:

For the development of stable and nutritious crops, soil fertility must be maintained. Fertilizers are essential for agricultural development, and the most common nutrients needed for healthy crops are potassium, phosphorus, and nitrogen. Fertilizers remove undesirable materials from the soil and improve its fertility; the nutrients in the soil determine the quality of the produce.

- Irrigation:

This stage or phase is critical for maintaining humidity and moisture in the soil. Crops that are under watered or overwatered may have negative effects on their growth, while crops that are not watered properly can be damaged.

- Weed Control:

Various undesirable plants may occasionally be seen growing near the real crop, as well as at the land's border. These plants have a significant negative impact on crop development, quality, and production, which is why it is critical to protect crops against weeds.

- Harvesting:

The developed or ripe crop grabs and cuts the land at this time. Harvesting has traditionally relied on a large number of laborers and, on occasion, heavy machinery to harvest crops from the fields. Typically, machines are employed in commercial or industrial farming.

- Storage:

The harvested crop must be stored at this point in order to ensure food security. Crop storage ensures that food is available throughout the crop's off-season.

1.2. Agriculture Technologies:

Major agriculture operations have integrated cyber physical networks, online applications for subjects, artificial and machine learning, big data and research, and cloud technology for agricultural equipment as part of Industry 4.0. The creation of innovative elements, such as sensors and cloud storage, for tracking soil parameters and weather conditions, in order to allow intelligent irrigation solutions and to handle pesticide attacks or the use of cyber-physical systems, requires design solutions for surveillance and process management in farmers. Data mining, livestock crop management, and water management systems all benefit from big data and machine learning. Real-time tracking systems let fleets of drones and ground vehicles use less pesticide, while smarter agricultural technology help with precise real-time handling. Drones and intelligent glasses may be used combined in an artificial reality to map and sample farmed soils, allowing the future susceptible region to be identified and controlled. Sensors and intelligent systems are critical in the case of unforeseen occurrences and situations that may influence future damage, such as the destructiveness of food products moving through the supply chain.

The adoption of contemporary business models has an effect on the possibility of new methods to improve the functioning of various agricultural businesses. Farmers may increase productive activity by optimizing the use of resources (including labor), pricing, and quantitative and qualitative production possibilities by utilizing a variety of accepted models tailored to production characteristics. Object description, geographical comparisons, physical and chemical parameter estimates, satellite navigation, networking, information collection and analysis, process automation, and driving are among the most essential. Sensory greenhouse management, electrical efficiency, phenology monitoring, insect or seed disease identification, supply chain traceability, irrigation planning, plant growth optimization, land tracking, and agricultural land management are some of the other scenarios covered by digital technology in the field of farming.

Block chain technologies on improved transparency and food protection, advanced genetics, controlled environmental and vertical agriculture, biotechnology, including microbiome and biological soil agent, farmed beef, and substitute meat/milk protein will all contribute to agricultural sustainability in the coming years. 3D printing would allow for the development of food-related technology as well as delectable plant substitutes. This is critical for environmental preservation as well as the development and growth of new businesses and services [6], [7].

1.2.1. Technological Transformation in Agriculture:

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The key determinants of digital maturity include strategic views, customer centricity, and ICTs, as well as process infrastructure, talent, skills and capacity development, creativity, and culture. Digital technology is transforming the global economy and society, and all efforts are being made to alter business structures. As a response to the spread of the latest digital technology and the emergence of new technological challenges, 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. Increased sales, efficiency, and a customer-centric focus are just a few of the potential advantages, which may lead to better value creation or new methods of engaging customers. Any business that wants to develop, expand, be more efficient, and be more sustainable must embrace digital transformation.

Farmers and politicians' decision-making is hampered by climate change, decreasing resource availability, and cost and price unpredictability. These changes have resulted in an age in which new gadgets outnumber humans in previously un-automated activities such as networking and pattern recognition in uncertain or changing environments. Too far, the employment of agricultural technology has been restricted, with an emphasis on the company's long-term sustainability. Future research will concentrate on smart digital services that will assist farmers in meeting long-term problems.

The mobile Internet, data automation, and the Internet of Things will create a global economic potential of up to $33 trillion by 2025, resulting in an exponential rise in computer capacity. The mix of income and expenditures will shift dramatically as a result of green energy technologies and creative resource research. By 2025, the agricultural precision market is expected to increase by 15%, with revenues surpassing $12 billion. As the sector evolves, intelligent agricultural techniques will become more prevalent, as will advancements in management algorithms, broad details, developing technology, and renewable energy systems. Furthermore, regulated precision agricultural services are projected to increase by more than 27% from 2019 to 2025 [5], [8]–[10]. The agriculture sector's major contemporary technological breakthroughs are described here:

1.2.2. Indoor Farming:

Vertical farming inside may be utilized, land constraints can be addressed, and even the environmental effect of farming can be reduced by decreasing the distance traveled by the agricultural sector's supply chain and the crop production rate. Vertical indoor farming is a technique of growing goods in a controlled and monitored environment by stacking them one by one. In contrast to conventional agricultural techniques, the usage of vertically placed farmed railways decreases the amount of land accessible for plant development. Because of its capacity to flourish in tiny areas, this farming technique is frequently associated with metropolitan and urban agriculture. Because no plant development needs soil, vertical farms are uncommon. Hydroponic or aeroponic systems are used for the bulks. Artificial wax lamps are used in place of natural illumination.

The benefits of indoor vertical farming are obvious, from sustainable urban development to increased agricultural production while reducing labor expenses. As food production rises with regular harvests, vertical agriculture can precisely monitor year-round light, moisture, and water variables. Vertical farms use 70% less water than horizontal farms, resulting in greater resource conservation. The use of automated robots to manage harvesting, planting, and transportation significantly reduces labor costs, alleviating the agricultural industry's present manpower crisis.

1.2.3. Farm Automation:

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Agricultural automation, often known as "intelligent agriculture," is a kind of technology that boosts farm output by automating crop and livestock production cycles. Drones, sophisticated equipment tractors, robotic harvesters, automated irrigation, and seeding contemporary robotics are among the technologies being developed by an increasing number of businesses. Agricultural automation is being adopted by an increasing number of conventional farming businesses, despite the fact that these technologies are still in their infancy.

Robotics and drones, as well as computer vision technologies, have completely changed modern agriculture. The primary goal of automation-based land farm technology is to handle the more regular tasks. Harvest automation, automated tractors, planting and weeding, and Ariel Drones are just a few of the innovations used by today's big farms. Population expansion, labor difficulties on plantations, and changing customer preferences are among problems that agricultural automation technology solves. The benefits of automating traditional agricultural operations are significant, since they address issues such as customer preferences, labor shortages, and the environmental impact of farming.

1.2.4. Livestock Farming Technology:

The traditional cattle sector is frequently overlooked and neglected, despite the fact that it is the most essential. We rely on livestock as a major source of natural renewable energy on a daily basis. Cattle management has historically been a problem for poultry farms, dairy farms, livestock ranches, and other livestock-related agricultural businesses. Livestock management is responsible for maintaining a consistent financial report, supervising employees, and ensuring that animals are properly cared for and fed. On the other hand, recent advances indicate that contemporary technology is changing the area of cattle management. New technology have significantly enhanced the business in the past 8 to 10 years, making livestock monitoring and handling more easier and data-driven. This objective may be achieved via nutritional improvements, genetics, healthcare, digital technology, and other kinds of technology.

Animal and livestock productivity, welfare, and management may all be improved with the use of livestock technology. The concept of the "connected cow" has arisen as dairy herds are fitted with sensors to monitor health and enhance production. Wearable sensors put on the cattle may monitor daily behavior and health problems, as well as provide data-driven views for the whole herd. All of this information is converted into expressive, actionable data that producers can look at quickly and easily to make quick management decisions. Sensor and data technology will be very beneficial to the present cattle sector. It has the potential to improve livestock productivity and health by detecting animals in poor health and identifying development areas. Computer vision allows us to gather a large amount of unbiased data that can be combined into meaningful, actionable views. Data-driven decision-making produces safer, more reliable, and timely outcomes for livestock and herd production.

1.2.5. Modern Greenhouses:

The greenhouse business has evolved in recent years, from low-level testing and cosmetic installations to large-scale installations that openly participate in traditional land-based food production. The business is expanding like never before, thanks to the most recent amazing breakthroughs in growing technologies. Greenhouses that are large-scale, capital-intensive, and located in metropolitan areas are becoming more prevalent.

As they have expanded in recent years, the industry has witnessed a lot of changes. Lights and automated control systems based on light emitting diode (LED) are widely utilized in contemporary greenhouses to precisely tailor the growth environment. Competitive

greenhouse businesses are expanding their production facilities near urban areas in order to tap on the growing demand for local food. To achieve these goals, the greenhouse sector is growing to create the resources needed to compete in today's market, with an emphasis on venture capital and other funding sources.

1.2.6. Precision Agriculture:

Modern technology is becoming an increasingly essential aspect of any commercial or industrial farm as the agriculture industry evolves. Precision agriculture firms are new technologies that will allow farmers to maximize crop growth rates by monitoring every element of agricultural production, including moisture levels, insect conditions, soil conditions, and microclimates. Precision agriculture enables farmers to increase production and acquire knowledge of cost management in order to learn about improved crop planting and growing methods. This makes use of real-time data from GPS satellites to make informed choices about when to fertilize and irrigate, as well as what crops to grow at when times.

1.2.7. Block chain and Big Data:

Agriculture involves many complicated and varied variables, such as a broad range of crop types, geographical and climatic circumstances, and so on. Because making sense of all of this data is such a tough job, the agricultural sector has always been rich in data, but the knowledge connected with this area is weak. However, thanks to improved data management systems, circumstances and conditions are changing today. Industries are increasingly working with a variety of farmers in order to better understand planting plans. Because these businesses want to exploit this information for their own reasons, data privacy is one of the most pressing problems facing the agricultural sector in the near future. The EU's General Data Protection Regulation (GDPR) is already in effect, so it will likely be ahead of the US as these issues develop.

Consumer participation on a Block chain-based network by suppliers from the United States and consumers in China, through banks sending and validating credit letters, has already been used to begin exporting soybeans to the United States. As part of the process, the shipping firms provided the necessary certifications. The United States Department of Agriculture (USDA) then explored how phytosanitary certifications might be included into the process. This agreement demonstrated how block chain technology may simplify many of the complicated procedures involved in international trading, which is particularly useful for commodity merchants who deal in large quantities but low margins. We think that the use of Block chain in the agriculture industry will grow in popularity as a means to enhance supply chain transparency, reduce the danger of food shortages, and promote more productive transactions.

1.2.8. 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.

2. DISCUSSION

Agriculture is the oldest sector of civilization, yet it is being transformed by digitalization and new technology. In the agriculture industry, block chain, sensor technologies, and Big Data management offer enormous opportunities. The transition of human societies from hunting and gathering to farming was one of the most important historical events. This new sector introduced cutting-edge technology, such as the plough, which lowers the danger of illness, changing weather, and plague. Now, the globe faces new difficulties in feeding a rising

global population, which is affected as much by changing consumer tastes as it is by necessity. Digitization is finally disrupting the conventional agricultural industry. Modern technology such as sensors, precision farming, block chain, and big data will play a significant role in the agriculture sector's development in the near future. There will be many possibilities for entrepreneurs, technology providers, and others who play a key role in the food supply chain to embrace the newest technologies in order to increase efficiency.

3. CONCLUSION

Agriculture in the modern era is more essential than it has ever been in the history of humanity. Increased supplier prices, workforce shortages, changing customer duties, and environmental ambitions are just a few of the problems facing the industry as a whole. Farming companies are quickly recognizing the need for answers to these problems. Agriculture technology has experienced significant investment growth in the past 10 years. Indoor vertical farming, livestock technology, automation and robotics, improved greenhouse techniques, artificial intelligence and precision agriculture, and block chain are all examples of major technical advances in the sector. Modern agricultural technology lowers the danger of illnesses and pests while also improving efficiency and development in agriculture by giving farmers with greater information about the crop and soil structure. In order to fully use technology in the agricultural industry, it is suggested that the government implement laws that encourage small farmers to learn about technology.

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