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Advancement in Science and Technology for Promoting Agriculture Growth

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ABSTRACT: Interests in agricultural advancement also was reflected in the early provision for a state agricultural college and model farm to promote better farming techniques. The formal program of instruction began at Ames in 1869, and the college eventually developed into a nationally recognized leader in scientific agricultural advancement. The college developed extension services, education for people who are not enrolled as students, to provide up-to-date assistance for women and men on Iowa's farms. They learned about soil conservation, corn seed selection and cultivation, crop rotation and manure management.

KEYWORDS: science, technology, agriculture, growth, soil conservation

I.INTRODUCTION

Agricultural development practices over a while have been perceived to exploit natural resources faster than they could be renewed. Exponential growth in the human population has resulted in demand for food and shelter, which the “natural” carrying capacity of the land is under pressure to provide.

Natural imbalance is visible in pollution, soil degradation, wildlife population decline, and human-created alterations of flora and fauna. It is reasonable to assume that human population growth will continue and place greater demands on the agri-ecosystem. Thus, technology has and will continue to play a major role in agriculture and sustainable development going forward.

Technology has a major role in farming and agriculture practices; and with the advent of digital technology, the scope has widened. Innovation in agriculture is leading an evolution in agricultural practices, thereby reducing losses and increasing efficiency. This is positively impacting farmers. The use of digital and analytic tools is driving continuous improvement in agriculture, and the trend is here to stay, resulting in improving crop yields and helping to increase the income of the farming community.
The role of modern technology is significant in agricultural development; and with the advent of digital technology, the scope has widened. Innovation is leading to an evolution in agricultural practices, reducing losses and increasing efficiency.[1,2]

Technology in agriculture affects many areas of agriculture, such as fertilizers, pesticides, seed technology, etc. Biotechnology and genetic engineering have resulted in pest resistance and increased crop yields. Mechanization has led to efficient tilling, harvesting, and a reduction in manual labor. Irrigation methods and transportation systems have improved, processing machinery has reduced wastage, etc., and the effect is visible in all areas.
New-age technologies focus on robotics, precision agriculture, artificial intelligence, blockchain technology, and more.
In 1960, during the Green Revolution, India managed to achieve self-sufficiency in foodgrain production by leveraging modern methods of agriculture like chemical fertilizers and pesticides, higher quality seeds, and proper irrigation.

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Technological advances appeared eventually, in agricultural development in India. The introduction of tractors was followed by new tillage and harvesting equipment, irrigation methods, and air seeding technology, all leading to improved quality of the food and fiber.
Farmers can leverage scientific data and technology to enhance crop yields and keep themselves abreast with cutting-edge methods of farming.
Technology in agriculture affects many areas of agriculture. India managed to achieve self-sufficiency in food grain

production by leveraging modern methods of agriculture along with farm mechanization.
Improved productivity from the mechanization of agriculture – Manual labor and hand tools used in agriculture have limitations in terms of energy and output, especially in tropical environments. Resistance to agricultural mechanization, especially among smallholder farmers due to accessibility, cost, and maintenance issues, often acts as a detrimental factor. To reduce manual labor and make processes faster, combine harvesters are finding greater use. Indian farming is characterized by small landholdings, and the need is to partner with others to take advantage of modern machines.

Capacity building of farmers through hand-holding, making modern machines available especially to small farms, and tackling affordability issues through policy will lead to greater adoption of mechanization services going forward. Agricultural mechanization has the potential to, directly and indirectly, affect yields through a reduction in post-harvest losses and an increase in harvest gains.
Climate/ weather prediction through artificial intelligence – A major advance in agriculture is the use of artificial intelligence (AI). Modern equipment and tools based on AI enable data gathering and assist in precision farming and informed decision-making. Drones, remote sensors, and satellites gather 24/7 data on weather patterns in and around the fields, providing farmers with vital information on temperature, rainfall, soil, humidity, etc.

However, AI finds slow acceptance in a country like India where marginal farming, fragmented landholdings, and other reasons act as impediments. But there is no doubt that technologies based on AI can bring precision to large-scale farming and lead to an exponential rise in productivity.
Resilient crops developed via the use of biotechnology – Agriculture refers to a wide resource of methodologies that include traditional breeding methods, genetic engineering, and the development of microorganisms for agriculture. Generally speaking, genetic engineering uses the understanding of DNA to identify and work with genes to increase crop resistance to pests, and the development of high-yielding varieties also makes improvements to livestock.

The spinoff of biotechnology in agriculture has resulted in all-around benefits for farmers and end consumers. Though some controversial approaches have led to resistance to the adoption of biotechnology, there is no doubt that the future of agriculture is heavily dependent on SAFE biotechnology, given the changing climate and increase in population.
Agriculture Sensors – Communications technology has evolved rapidly in India and made smart farming a possibility. Sensors are now being used in agriculture to provide data to farmers to monitor and optimize crops given the environmental conditions and challenges. These sensors are based on wireless connectivity and find application in many areas such as determining soil composition and moisture content, nutrient detection, location for precision, airflow, etc. Sensors help farmers save on pesticides, and labor, and result in efficient fertilizer application. They allow farmers to maximize yields using minimal natural resources.
Improving farm yields and supply chain management use Big Data – The collection and compilation of data and its further processing to make it useful for decision-making/problem-solving are expanding the way big data functions. Big data is slated to play a major role in smart farming, and the benefits percolate across the entire supply chain and the markets. Agriculture is becoming larger, and it depends on a large number of variables.
This is resulting in greater collection and use of complex data, which has to be meaningfully interpreted and managed. Data can be from external sources such as social media, supplier networks, markets, or from sensor/machine data from the fields. Transformation of agriculture from using big data is taking place that affects crop yield, supply chain management, yield prediction, etc.

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Livestock monitoring – The use of chips and body sensors can help prevent disease outbreaks and are crucial in large-scale livestock management. Chips and body sensors measure vital parameters and indicators that could detect illness early and prevent herd infection. Similarly, ultrasounds are a useful tool to judge the quality of meat. This helps control and improve the quality of the meat.

Monitor and Control Crop Irrigation Systems through Smartphones – Mobile technology has also been playing a significant role in monitoring and controlling crop irrigation systems.
With this modern technology, farmers can control their irrigation systems via smartphones and computers instead of driving to each field.
Moisture sensors planted underground can provide information regarding the moisture levels present at certain depths in the soil.

Here are a few uses of modern technology in agriculture.
Technologies can enable the transition of modern agriculture in the field. While some technologies have transformed the way we operate, there is a need for spreading technological advancements in agriculture,
like artificial intelligence and machine vision.[2,3]
The use of modern technology in agriculture can enable millions of farmers to benefit from the acquisition of real-time farm information.
Farmers can have ready availability of weather information and disaster warnings, and also have instant access to farm data.
Having a range of technologies enables the transition of modern agriculture in the field. There are many promising trends and pilot projects in modern technology in agriculture.
The Agriculture Development program at S M Sehgal Foundation promotes sustainable livelihoods by building the capacities of farmers, including women producers, with improved agricultural practices and new technologies that increase crop yields, conserve water, and improve soil fertility. The team works with small-holder farmers in rain-fed and irrigated areas to facilitate the adoption of improved and advanced agricultural practices that include soil health management, crop production management, input-use efficiency, small farm mechanization, water-efficient irrigation techniques, horticultural development, livestock management, use of information and communication technology (ICT) in agriculture.

Helping farmers to achieve food security in India requires uplifting and enhancing a lot of the farming community by increasing their income. Intervention in agriculture through modern technology and mechanization has the potential to address hunger and malnutrition as well as challenges such as poverty, water and energy use, climate change, and others.

Farm Mechanization: S M Sehgal Foundation in partnership with GE has implemented the Gram Utkarsh project in Prayagraj, Uttar Pradesh, to help farmers make agriculture more rewarding. Some of the areas this scheme has been able to help with:

- Paddy thresher. Through the Gram Utkarsh Project, Brijesh Pal, a farmer of village Chakanur, acquired an electric paddy thresher machine that helps separate the grain from the crop. The paddy thresher has saved time and labor costs needed for crop threshing and has also enabled Brijesh to earn extra income from renting out the machine to fellow farmers.

- Drill. A seed drill is another farm mechanization tool that helps farmers at the time of sowing. Farmer Inderjeet Singh, from village Chakpura Miyan Khurd, used the seed drill he received under the project. He shares multiple benefits, such as penetration of the seed at the right depth in the soil, along with manure, even distribution of seeds, water-saving, use of less seed, good sprouting, and of course financial savings.

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- Solar sprayer. Kamlesh Pandey, from village Rahikala, put a solar sprayer to use in his field with the help of this project. He shares that he can now do the spraying himself, and one bigha can be covered in thirty minutes, which earlier was more time-consuming and required manual labor.

Yet another example of pioneering work in the area of mechanization has been the Gram Utthan of PTC Foundation, which is implemented by the S M Sehgal Foundation.

Chalitar Bhagat is a progressive farmer of Nariar village of Motipur block, Muzaffarpur, Bihar. He has been associated with this project since 2017. Chalitar says, "Getting timely agricultural labor is a major problem in agriculture. It increases the cost of production and so the profits decrease. Hence mechanization in agriculture is beneficial for farmers."

In 2018, the project team provided a subsidized zero tillage machine to Chalitar and trained him on its operation. Now he uses the machine in his field and is an entrepreneur by renting his service to neighboring villages such as Pakhnaha Shivram, Akuraha, Prasad, Puraina, Bhilaipur, Birpur, and others. After using the machine for more than three years, Chalitar says that it has revolutionized his farming and life.

The Agriculture Development program at S M Sehgal Foundation promotes new modern technology in agricultural development in India.

The use of modern technology in land leveling has helped Ayyaz in reducing the time and cost of irrigation. A CSR-supported project implemented by S M Sehgal Foundation educated him about the multiple benefits of laser land leveling, and he decided to try this practice on one acre of his two-acre land. Out of the total cost of renting, which is INR 2,250 for laser leveling one acre of his farm, he received the support of INR 800 from the project, as he was a first-time implementer, and it would be a demonstration for other farmers

After implementing laser land leveling, Ayyaz shares that this practice reduced the cost and time of irrigation by about half. Earlier it used to take him 10–11 hours to irrigate his one-acre wheat field once, which cost him INR 90 per hour, and he had to undertake five such irrigations, which cost him a total of INR 4,500. After laser leveling, it took him only six hours to irrigate the field, which resulted in saving INR 1,800. This technique also improved crop productivity due to the even distribution of water and fertilizers in the field.

A CSR-supported project implemented by S M Sehgal Foundation educates rural communities regarding the multiple benefits of laser land leveling, resulting in increased savings.

The world population is slated to grow to about 9 billion by 2050. The challenge is to find ways and means to produce enough to feed it. The challenge of reducing acreage under agriculture and food wastage in production and distribution is having a major impact on the world. The increasing role of technology in agriculture to address these issues is the only way forward to a food-secure future. Technology can help save foreign exchange for countries, increase productivity, and lead to an improvement in the overall standard of farmer communities. India has a long way to go in the adoption of modern farming practices through technology. The pace is slow and path-breaking efforts need to be made to educate farmers about the benefits to be had with technology. Transcending the barriers of archaic farming practices and medieval mindsets is a challenge that needs to be overcome for a better tomorrow. Technology in agriculture has the potential to truly lead India to be "Atmanirbhar Bharat" in all respects, and be less dependent on extraneous factors.[3,4]

II.DISCUSSION

By 2050 it is estimated that the global population will surpass nine billion, with urban populations growing and rural populations declining. Although absolute food production might be sufficient to feed such a growing population, there are substantial gaps among countries in the use of science, technology and innovation in agriculture and food production. With productive arable land and freshwater resources severely constrained in many parts of world and poor agricultural practices or the consequences of climate change leading to land and marine degradation, it is imperative that we transform our agrifood systems. This will only be possible through widespread application of science, technology and innovation.

Here are just five of the many ways science, technology and innovation can make agrifood systems more resilient and sustainable.

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1. Using digital applications in agrifood systems

In the agrifood sector, there have been recent advances, such as mobile technologies, remote-sensing and distributed computing, in the areas of Information and Communication Technologies (ICTs). Narrowing of the 'digital divide' has allowed small-scale producers to harness mobile phone networks and internet availability to access information, inputs, markets and finance. Although these technologies are spreading rapidly, they are also evolving rapidly, and poorer communities are struggling to keep up with developments in infrastructure, costs, e-literacy, regulatory frameworks and access to services.

Mobile phone apps have widespread functions in terms of management, monitoring, marketing, finance and decision-support and are increasingly relied on by small-scale producers. In Fiji, for example, a smart phone app is being used to help grow nutritious food and promote healthy eating.

Digital technology, such as Artificial Intelligence and blockchain, can play an important part in enhancing the sustainability of agrifood systems. By providing training and ensuring access to the newest technology, FAO is helping to ensure that small-scale producers do not miss out on any advances in this fast-evolving domain.

2. Using innovation to reclaim underutilized space for urban agriculture

In 2050, it is estimated that two thirds of the world's population will live in urban settings. The urban and peri-urban environments represent largely untapped resources in terms of land and water for plant production, agroforestry, livestock keeping and aquaculture. Underutilized space in and around towns can be used to green the environment and produce food, reducing reliance on transported and traded goods, which are becoming increasingly expensive.

An extension of urban production is 'vertical agriculture', which can utilize idle structures, such as old buildings or discarded shipping containers. This type of agriculture makes use of vertical space to produce crops in a controlled environment. It is automated indoor farming using hydroponics, an artificial atmosphere and LED lighting. Production is possible year-round and is independent of the weather, but the set-up is costly and requires a great deal of electricity. Although this relatively sophisticated technology is only currently suited to regions where there is easy access to specialized equipment and the start-up finance, advances in technologies might enable broader uptake soon.

FAO is providing resources to decision-makers to advance urban agriculture and ensure that appropriate technologies are available to all, promoting the conversion of urban areas into Green Cities.

3. Reducing distances and enhancing access through the internet

Traditionally, for small-scale rural producers, the further away one was from towns and cities, the more difficult it was to access services.

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With the development and spread of digital technologies, such as the internet and mobile phones, some of the problems of distance and limited or costly access can be mitigated. Planning and management are vastly improved by being able to coordinate digitally between producers and buyers, for example, and having access to data sources that can help with decision-making. Mobile technologies cannot completely substitute for physical infrastructure, but they can facilitate access to many services to a far greater extent than was previously possible.

4. Developing irradiated vaccines for animals

Vaccines are vital to control and prevent numerous animal diseases, some of which also threaten human health. Vaccines stimulate an immunological response that helps fight impending disease. Radiation can be used to inactivate pathogenic microorganisms so a vaccinated animal does not develop a disease and is not put at risk through vaccination with a live microorganism, which could inadvertently initiate a disease.[4,5]

Irradiation technology allows development of safe vaccines for animals because it obviates the need for chemical compounds that are usually used to deactivate microorganisms such as viruses.

A programme of the Joint FAO/International Atomic Energy Agency (IAEA) Centre of Nuclear Techniques in Food and Agriculture is supporting staff training and providing supplies and equipment for the Ethiopian National Veterinary Institute (NVI). All technical staff in the NVI's Research and Development Department have received training by FAO and IAEA. "Whether through short courses or longer fellowships, they have all been exposed to cutting edge science," said Martha Yami, Director General of the NVI.

Livestock exports, which number over one million cattle per year, are vital to the Ethiopian economy. Such exports would not be possible without nuclear techniques. Irradiated animal vaccines bolster the livestock industry in countries where disease represents a barrier to sustainable production.

5. Upgrading value chains with better technology

Value chains are complex. They provide salaries, profits, tax revenues and consumer supplies. They also involve a broad range of individuals – from producers all the way to consumers.

Their sustainability rests on economic, social and environmental components and any underperforming aspect can impact sustainability at any or all of these levels.

FAO supports sustainable food chain value development, which looks at value chains holistically and connects producers to consumers. FAO also helps key players in value chains identify areas of underperformance and intervene accordingly.

Science, technology and innovation can supply new solutions to the problems facing agrifood systems. Harnessing these, we will be better placed to produce food securely for our future.

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III.RESULTS

The global demand for food continues to rise and is projected to increase up to 102% to satisfy the requirements of 9 billion people by 2050. Consequently, agricultural production needs to also increase by 60%–70% to ensure the supply of raw materials for food, feed, and fiber. Ensuring a sustainable future, despite today's sustained and intensified pressure on global resources, means that each actor in the food system needs to commit themselves to develop and enforcing practices that will reduce the use of natural resources where possible, and reuse, recycle, and repurpose them otherwise. Government entities can aid these efforts by implementing policies and strategies for efficient resource management on both national and local levels.

Adopting sustainable farming practices worldwide is contributing to the agroecosystem's efforts to meet the world's current food needs while also ensuring that future generations will be able to meet theirs with the limited resources that they will have. These practices also focus on holistic development that incorporates environmental, social, and economic sustainability which are the three fundamental pillars of sustainable development.[5,6]

New Technologies in Agriculture- How do they help ensure Economic Sustainability?
Technological advancements are today integral to attaining sustainability goals in agriculture. Satellite and GPS technologies, sensors, smart irrigation, drones, and automation, to list a few, provide the means for precision agriculture, which further aids in effective resource utilization. On the one hand, they reduce the use of harmful agrochemicals and, on the other, they help conserve non-renewable resources. They also help agriculturists to prepare days in advance for unseasonal or extreme weather events, thereby reducing crop losses during such events.

Other technologies that hold the promise of promoting sustainability are blockchain technologies for food safety through greater transparency, controlled environmental agriculture (CEA), and biotechnology, along with 3D printing technology that allows the production of food products while saving both time and energy. Scientific research and advancements in agriculture enable farmers to utilize the best of traditional and technology-led crop production for nutritious, high-output yield while causing as little damage to the environment as possible and ensuring cost-effectiveness. With adequate and timely information at hand, even remotely-located rural farmers can adopt practices for sustainable and climate-smart agriculture that result in economic gains. Watch how Cropin made this possible.

One of the ways for a stakeholder to realize economic sustainability is by achieving optimal production quantities at lower production costs. Data from satellite images, sensors, and IoT devices facilitate smarter decisions to optimize farm operations by using as minimal resources as possible and mitigating risks to realize optimal crop yields. Traceability in agriculture makes agri-supply chains more transparent and provides stakeholders with increased control over operations and quality compliance. It enables them to identify and address issues, such as food loss or wastage, and recognize opportunities to make processes cost-effective. They also help reduce the stakeholders' response time to food crises, thus saving up to millions of dollars in losses. Traceability to source, along with accurate certification and product labeling, provides agri-enterprises with a competitive edge that helps improve their access to local and international markets and leads to better price realization for smallholder farmers.

Promoting Economically Sustainable Farming by enhancing access to Finance for Smallholder Farmers
Smallholder farmers cultivate crops on 12% of the world's farmlands and constitute a majority of producers in developing economies. To encourage them to produce high-quality yield, it is crucial to improve their access to financial assistance, which can aid them in investing further in farm productivity by procuring high-quality inputs, upgrading their post-harvest processes, staying informed about sustainable farming practices like vertical farming, and adopting better risk management practices; all of which will support their transition from subsistence farming to one that is economically and commercially viable.

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Farmer aggregation models play a crucial role in bringing together individual farmers under a structured system of their own. They enable them to adopt sustainable livelihood activities that ensure increased income and an enhanced livelihood for themselves on account of economies of scale. However, a significant number of farmer producer organizations/companies (FPOs/FPCs) face several systemic issues that impede their progress, including the inability to raise external capital owing to a lack of collateral to offer to lenders; insufficient market access; and inefficient constitutional governance and management of human resources, to name a few.

One of the solutions that seek to improve an FPO's access to capital is Rabo Foundation's Credit Guarantee Product, which is India's first credit enhancement product and is also estimated to be the largest-used product tailor-made for the farmer institutions' segment in the country. The guarantee that this development finance product provides is available to any local financial institution (FI) interested in extending finance to the target group. FIs that are concerned about the risks associated with lending to this often-unexplored space can leverage the Credit Guarantee Product and benefit from Rabobank's deep F&A sectoral knowledge and network. The product encourages FIs to initiate the flow of money and goods between farmers and FPOs and between the FPO and the market. It also helps the FIs to invest in SMEs that implement modern technologies and innovations at the initial stages, where the interest of mainstream lenders is lacking.

Another effective instrument that improves the incomes of smallholders is the Warehouse Receipt Finance (WRF), where stored produce is used as collateral to finance post-harvest credit needs. When implemented through effective FPOs/FPCs, it has the possibility of generating a sustainable increase in small farmers' incomes. However, despite its effectiveness and high potential, the reach of WRF is highly restricted to smallholder farmers. To encourage WRF to the smallholder farmer groups and their institutions, Rabo Foundation has designed a 2-stage guarantee product that addresses the price risk and default risk of the FIs. Known as the Commodity Finance Guarantee, it ensures a relatively higher loan-to-value (LTV) and a guarantee to mitigate price risk in case of adverse price movement. Additionally, the product includes a provision to share 50% of the principal and interest loss with the lender. The Rabo Foundation has signed MoUs with three of the largest Indian FIs for the product's implementation.[6,7]

While, on the one hand, the Rabo Foundation is encouraging FIs to invest confidently in smallholder agriculture, it is also facilitating debt funding in the AgTech sector. The Foundation has introduced a USD 2-million debt-finance product, in collaboration with Caspian Impact Investments, that provides credit to start-ups with the potential to use advanced digitization technologies to address the issues that smallholder farmers face. The product aims to enable liquidity beyond conventional angel/venture capital as a source of high-risk capital.

Speaking of advanced technologies, satellite technology has been making a breakthrough in the finance sector over the last several years. An in-depth analysis of geodata from satellite images provides FIs with information on the crop under cultivation, its health and growth stage, and up-to-date weather data that has a direct impact on the yield. AI-enabled solutions like Cropin Intelligence also provide FIs with details on a farmer's creditworthiness based on the farm plot's historical, current, and predictive performance. FI's can leverage this intelligence as an alternate source of data, along with field data on the farm's location, type of crops being grown, and inputs used, to assess risks before providing credit. Digital technologies show immense potential to increase the time- and cost-efficiency of processing loans and also reduce NPAs.

With several new technologies being developed, tested, and implemented each day, the Rabo Foundation is conducting various pilot schemes in East Africa with partners including the Netherlands Space Office and the Geodata for Agriculture and Water (G4AW) program. In one of the projects, the Foundation combined their farm input loan to farmers' cooperatives with insurance and advice. In 2018, the Foundation tied up with NpM (Netherlands Platform for Inclusive Finance), Bill and Melinda Gates Foundation, FMO (Dutch Entrepreneurial Development Bank), the Netherlands Space Office, and ICCO (Interchurch Coordination Committee Development Aid) to establish the Geodata for Inclusive Finance and Food (G4IFF) workstream. Its goal continues to be the

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improvement of risk management and the lowering of transaction costs for FIs, as well as to increase smallholder farmers' access to financial services with the help of geodata-based information.

New Technologies in Agriculture and beyond
Satellite Data Fuels Advances in Agritech
Satellite farming has become more widespread, efficient, and cost-effective. The use of hyperspectral satellites allows for higher-resolution images of farms, providing detailed information about each pixel and reducing the need for expensive sensors. Sensors can be useful in certain situations but are costly to maintain and need to be more easily scalable. With satellite data, farmers can access a range of information, including atmospheric and soil temperature, soil nutrients, carbon emissions, moisture levels, and local weather conditions, making crop cultivation more reliable and efficient.

Satellites are also helping enterprises track and achieve their environmental, social, and governance (ESG) goals, such as becoming carbon neutral and purchasing carbon credits. Enhanced satellite data can help monitor deforestation and reforestation levels, the presence and quality of water bodies, and more. The advancements in satellite technology will drive the adoption of technology in agriculture, particularly in developing markets where smallholder farmers may need assistance to afford sensor deployments on a large scale. Meanwhile, farmers in developed markets can optimize their technology spending by saving on sensor deployment costs.

The growing impact of cloud computing
The future of farming is closely tied to cloud computing, and it has become so essential to agriculture that it is hard to imagine how the industry would function without it. Cloud computing allows agribusinesses to manage multiple technology solutions efficiently, vast amounts of data, predictive intelligence models, and other proprietary business intelligence tools under a single platform, helping to make important farming and business decisions. A specialized agriculture cloud platform can significantly reduce the time it takes for technology investments to pay off, lower barriers to innovation within the agriculture ecosystem, and bring together the capabilities needed to address major challenges. Many companies in the agriculture sector spend a lot of time and resources building fundamental technology infrastructure rather than focusing on innovation and intellectual property development in their specific areas of business. Just as railways were once a symbol of growth and prosperity, the agriculture cloud will become the central focus for new applications and developments by agtech companies, particularly as concerns about data security and privacy continue to dissipate.

High-speed 5G networks connecting the global agriculture ecosystem
The rollout of 5G technology is revolutionizing numerous industries by improving decision-making, production processes, and factory operations. Agriculture is also seeing significant benefits from this advanced technology due to its low latency, increased network capacity, and reliable high-speed data transfer. With 5G, transferring large amounts of data such as images, videos, 3D models, weather, and topographical information from connected farms can be quick and easy, saving time and improving AI/ML modeling accuracy. For example, data from the numerous cameras in a connected farm can be transferred with just one click, a task that previously took days using traditional networks. Overall, 5G will help accelerate agriculture's digitization for farmers and businesses.

Integration of the agri-ecosystem
The agriculture ecosystem is complex and includes a range of stakeholders, such as seed manufacturers, farming and food processing companies, technology providers, and governments. These stakeholders often operate independently of one another, which can limit innovation and collaboration. However, there is a trend towards agri-digitization to address issues like food insecurity, climate risk, and supply chain disruptions. As a result, there will be increased collaboration between stakeholders in the value chain . Agritech companies will facilitate partnerships and information sharing and will be critical enablers within the agri-ecosystem. For example, virtual agronomists can be made available to millions of farmers around the world, allowing a single expert to monitor multiple farms. Additionally, purpose-built industry cloud platforms for agriculture may provide access to satellite imagery, data, and agri intelligence, enabling experts to identify and address issues throughout the value chain quickly.

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Today's technology paving the way for tomorrow's harvest. [7,8]
The agroecosystem is fast in embracing technology, and its fullest potential is yet to be discovered. Over the past five decades, digitization has resulted in the radical transformation of agriculture by improving its speed, scale, and productivity globally. Agriculture 4.0, the fourth agricultural revolution, has provided the agri-stakeholders with a broad range of technological options to choose from to help them achieve their goals — be it remote sensing and GPS technologies, artificial intelligence and machine learning, connected sensors, IoTs, or any of the other emerging technologies. Mounting pressures on the environment are also redirecting scientists' approach to the way we farm today. The road to sustainable farming requires significant investments in infrastructure and technology infusion, but its success can ensure that the current and future generations can live comfortably with the resources available.

IV.CONCLUSION

The implementation of smart agricultural technology is advantageous for all players in the agri-food chain. With its use in optimizing and automating agricultural operations and field activities, growers and landowners can now save significant amounts of time and effort. These are just a few examples of how farming has benefited from advances in agriculture technology:

- using less water, fertilizer, pesticides, and other inputs allows agricultural producers to cut costs and keep more of their profits;
- by preventing or drastically reducing the amount of chemical runoff into waterways, businesses lessen agriculture's impact on the environment and take steps toward greater sustainability;
- increasing crop yields while decreasing labor inputs;
- making it easier for farmers, agronomists, or other agricultural workers to communicate and coordinate activities using mobile devices, apps, or web-based resources;
- lowering barriers to accessing agricultural insurance and financial services as well as market and technological data;
- mitigation of the damage that could be caused by pests, natural calamities, and bad weather in agriculture with the help of affordable, always-on agricultural monitoring systems;
- increase in farm income through improved product quality and increased quality controls;
- timely recognizing nutrient deficiency in plants and notifying agricultural producers of the type and amount of fertilizer and other amendments needed;
- ability to foresee potential problems on the farm through the visualization of production patterns and trends gleaned from an analysis of current and historical agricultural data. By estimating their overall crop yield, agricultural producers can precisely budget for the next growing season and better prepare for emergencies.

Evolution Of Agriculture Technology
Technological progress in agriculture is intrinsically linked to the rise of urban centers and commercial exchange. New technological developments have always been prevalent in this field.
Nonetheless, the technological model of agricultural production remained largely subsistence-based and characterized by poor productivity until the early 20th century. This era, known as "Agriculture 1.0," is marked by the invention of the plow and the widespread use of animal drafts. Agriculture 2.0 started towards the tail end of the 19th century with the introduction of mechanical machinery such as tractors. And later on, agricultural technology underwent a number of active development cycles as the pace of technological progress increased tremendously.
Agriculture 3.0, Or Precision Farming

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Precision or smart farming, also called Agriculture 3.0, evolved out of the need to track and more efficiently manage all inputs into crop production. The pursuit of precision agriculture and its associated agricultural technology has led to the development of new farming methods and tools.

The Global Positioning Satellite System (GPS) was the breakthrough technology that made this age of farming possible. GPS helps find deviations within a given agricultural production space, allowing for more effective use of available resources. This was the main reason why the idea of sustainable agriculture and a number of automation options came about.

Agriculture 4.0, Or Connected Farming

The leap from smart farming to connected farming is a good example of how fast production technology used in agriculture moved forward at the turn of the century. Technology like autonomous machines, sensor-equipped robots, augmented reality, the Internet of Things (IoT), drones, and satellites is all part of the new agricultural environment, named Agriculture 4.0 .

Decision-making in the agricultural sector is now based on data that is stored in the cloud and accessible via digital tools. With the help of this analyzed data, farmers and other major players in the agricultural industry can make better decisions.

Agriculture 4.0 is being born in an era of ubiquitous automation and digital connectivity. All developments in agricultural technology are becoming more integrated and networked, with the goal of optimizing all stages of the production process and enhancing monitoring, management, and control of the business.

Agriculture 5.0, Or Digital Farming

Agriculture technology 5.0, or simply put, “digital agriculture,” refers to the next generation of farming methods and tools for maximizing crop yields and other agricultural outcomes. One such technology is 5G, which is currently undergoing rapid development and will improve the reach and accessibility of the latest agritech achievements around the world.

Compared to prior farming methods, digital agriculture technology excels in the following aspects:

- data collection efficiency: how much data can be collected in a given amount of time or space;
- data accuracy: how close a measurement is to the truth;
- timeliness: how quickly the data can be processed into practical information and reported to end users.

When it comes to weather, pests, and diseases, agricultural producers have little to no control. Yet, with the advent of digital technologies in agriculture, they may lessen the negative influence of these elements. Meanwhile, digital agricultural technologies give farmers the opportunity to greatly increase the efficiency of decision-making and the return on factors that they directly control. Some examples are:

- what types of crops to grow;
- how to rotate crops for the best results;
- when and how much water to use for precision irrigation;
- when, how much, and what kind of nutrients and plant protection products to apply;
- what kind of tillage works best with a given type of soil.

Agricultural experts agree that the most valuable tools and technologies of digital agriculture regarding competitive advantages are cutting-edge farm management software, space-based solutions (especially those that provide high-resolution satellite images), proximal sensors, connectivity instruments, and data-driven algorithms for threat prediction.

EOSDA Crop Monitoring

Advancements And Innovations In Agriculture Technology

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Agricultural technology has come a long way beyond the basics of planting, maintaining, and harvesting crops. From more resistant seeds to improved agricultural production planning and processing, many crucial improvements have been made in recent years. Improvements in agriculture technology can even enhance field-to-table distribution and logistics.

Rapid progress is also being made in the realm of agricultural software and technology, which facilitate both in-field labor and the management of different components of the food supply chain. Previously, monitoring the fields used to require going there in person, but now this may be done from afar. As a novel method for field observation, agricultural satellite technology is ideal for this purpose.

From assessing meteorological and historical field data to planning agricultural activities, EOSDA Crop Monitoring incorporates the relevant data at each stage of the decision-making process. This precision agricultural platform helps even when you need a human presence in the field. It can be used to assign in-field scouts to check out a questionable area and report back with what they find. Photos can be instantly attached to the task report from the smartphone.

Negative Impacts Of Agricultural Technology: Are There Any?

While it's true that modern farming has reaped many benefits from technological developments in terms of higher efficiency, lower costs, and larger yields, there is another side to the coin, which is specifically related to large-scale extensive agriculture. The most significant are its harmful effects on nature. The primary agricultural technology issues having a negative impact on the ecosystem are:

- soil and water pollution from the extensive pesticide use;
- loss of biodiversity due to the elimination of indigenous species in favor of agricultural crops;
- release of greenhouse gases, which result from clearing forests to make way for agricultural land and the further overuse of machinery.

Not all the disadvantages of technology in agriculture are tied to the environmental impact. Some concerns are associated with the various aspects of agricultural technology adoption by growers and their staff, namely:

- farmers lacking the education and hands-on experience needed can't operate machinery and software effectively, rendering them unable to take advantage of today's advanced agricultural technology;
- the machinery upkeep cost is really high;
- the use of chemical fertilizers and pesticides can harm the health of farmers and other agricultural employees who work on the land.

As agricultural technologies allow us to meet the food needs of the world's expanding population, it's clear that we can't turn our backs on them. But we can make their negative effects less severe by using and improving precision agricultural techniques that go hand in hand with eco-friendly practices. Because these technologies have the potential to reduce or even eliminate the adverse impacts of conventional farming methods, they help solve a wide range of environmental problems. In this way, industrial agricultural producers may get two birds with one stone: increase their competitive edge and benefit global long-term welfare at the same time.

What Types Of Precision Agricultural Technology Are Now In Use?

Maximizing yields and keeping up with the times both require farmers to be well-versed in the latest technological advancements and their applications in the agricultural sector.

GPS Technology In Agriculture

By using GPS data, precision agricultural technologies improve productivity while decreasing wasteful spending on inputs like seeds, fertilizer, pesticides, and fuel. In addition to providing location-based agricultural information, GPS can be used to facilitate communication between vehicles and streamline record-keeping when combined with farm management software . Among the many uses this technology enables in the agricultural sector are the following:

- monitoring and managing field operations;

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- collecting and analyzing data from the fields;
- accurate soil sampling;
- yield mapping;
- navigating and controlling of agricultural machinery;
- the ability to operate in low-visibility field conditions like heavy rain or fog.

Robotic Technology In Agriculture

Robotic farm labor technology appears to be a viable choice for precision agricultural needs because it can do monotonous tasks without sacrificing accuracy. The autonomous performance of such robots would allow for continuous field management and improved agricultural productivity and efficiency as a result of the robot's ability to gather information about its environment on its own . Autonomous devices operated remotely via telemetry are currently the most well-known and successful agricultural robotic technology.

Data Collection And Storage

The incorporation of big data into agriculture technology has enhanced the flow of information, facilitated more fast and precise analysis, and ultimately resulted in improved decision-making and strategic planning. Analyzing historical agricultural data, we may foresee potential outcomes, evaluate risks, and choose the best course of action to take. Thanks to improvements in agricultural technology, more and more information about farms can be collected and stored. Soil pH, relative humidity, nutrient levels, soil moisture, and past weather data are just some of the ag-tech indices that can be derived from field data with the use of agricultural technology.

An abundance of information about root and surface soil moisture values, vegetation productivity, crop types, field height, weather conditions, such as past precipitation and temperature readings, agricultural activities (irrigation, sowing, harvesting), and much more is available through EOSDA Crop Monitoring. You can analyze the field's volume and prior harvests, as well as make future harvest predictions, with the help of this agricultural data, which is presented on the platform in an accessible and simple format. In addition, this information has practical use in cooperative management, crop planning, and the identification of agricultural risks.

Smart Agriculture Sensors

Weather conditions, plant moisture, soil temperature and fertility, pest infestations, and weed locations can all be determined with the help of agriculture sensor technology. The use of this data assists growers, agri-consultants, insurers, and others involved in the agricultural sector in making more informed decisions, leading to more output from farms at lower costs.

Geographic Information Systems (GIS)

Geographical information systems (GIS) are essential for the storage, analysis, and visualization of spatial data for precision agriculture needs. One of the most important ways that GIS-based agriculture technology is used in farming is to gather information about a region's crops, soil, climate, and topography by using satellites and drones. Furthermore, GIS in agriculture enables the use of GPS apps in conjunction with smart tools to optimize the spreading of fertilizer and pesticides.

With the help of EOSDA Crop Monitoring's GIS capabilities, you may generate field productivity maps utilizing the basic NDVI index over a few years. By using these yield maps, it's easy to pinpoint the most productive parts of your field, as well as low-yielding places that would benefit from additional fertilizer or other methods to boost field productivity. Applying the correct quantity of fertilizer to the soil might be a challenge, but yield mapping can help; farmers will not only save money on fertilizer but also ensure that they don't pollute the soil and groundwater with the excess chemicals.

Agricultural Drone Technology

Drones, also known as unmanned aerial vehicles (UAVs), are becoming more and more common in the agricultural industry. Drones may scan a field from above and report on problems like pests, infections, and a lack of essential nutrients. This agricultural data gives farmers command over the state of their fields.

Satellite Remote Sensing Technology In Agriculture

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The use of satellites has revolutionized field monitoring by greatly increasing both the sheer volume of agricultural data and the frequency with which it is collected. Satellite sensors monitor, measure, and record the electromagnetic radiation reflected or emitted by Earth and its environs for further analysis and data extraction. With agriculture satellite technology, such as current and historical satellite images, you can track crop growth throughout the season even in vast, inaccessible areas. This information is beneficial for various purposes, including assessing the effectiveness of agricultural practices.

In order to help agricultural producers and landowners make educated decisions, the EOSDA Crop Monitoring one-stop platform processes satellite imaging data and makes it readily available along with vegetation indices and other essential field indications.

Mobile Technology In Agriculture

Agriculture-related mobile applications are currently expanding their market share and feature sets. By marking a field on a map and monitoring its NDVI vegetation index over time, the EOSDA Crop Monitoring mobile app allows you to keep tabs on a field's vegetation from anywhere without having to pull out a bulky laptop. You can track the weather in the field, plan and manage scouting tasks, and get updates on your current situation all from the convenience of your mobile device. One of the many benefits of mobile technology in agriculture is that the application can function even when not connected to the internet.

Temperature and precipitation information and vegetation tracking in the EOSDA Crop Monitoring application.

How Does Technology Impact Agriculture?

As a result of the information age, there are more ways to use technology in farming than ever before. Agricultural businesses rely on technology to improve field management, which is only one of the many ways that innovations have changed farming.

The use of inputs like fertilizer and pesticides can be reduced with the help of advanced agricultural software. One more plus is that agricultural technology helps cut down on harmful pollutants like carbon dioxide. This became possible by streamlining the agricultural production process and eliminating unnecessary steps.

With gene editing technology in agriculture, producers in different parts of the world can create seeds better suited to the specific conditions of their climate and native soil. Climate smart agriculture helps to solve many challenges in food production offering specific strategies for growing crops. New crops can be cultivated with the help of fertilizers precisely applied to the soil. Also, the mechanization of processes improves agribusiness's productivity and efficiency across the board, including planting, harvesting, and distributing.

These days, when even drones are employed to keep an eye on agricultural fields, biotechnologies, nanotechnologies, and information and communication technologies (ICT) allow for the possibility of increasing crop yields in the most sustainable way possible.

Sustainable Prospects For Agriculture Technology

Accelerating technological advancements in farming are having a profound impact on the industry. Agricultural satellite technology is rising to the forefront to better manage inputs, streamline operations, and increase farm productivity. Higher yields and lower maintenance costs translate into greater agricultural earnings. Thus, leveraging satellites in the agricultural sector is a big step toward a more productive and sustainable farming technology that can keep up with the growing need for food around the world.[8,9]

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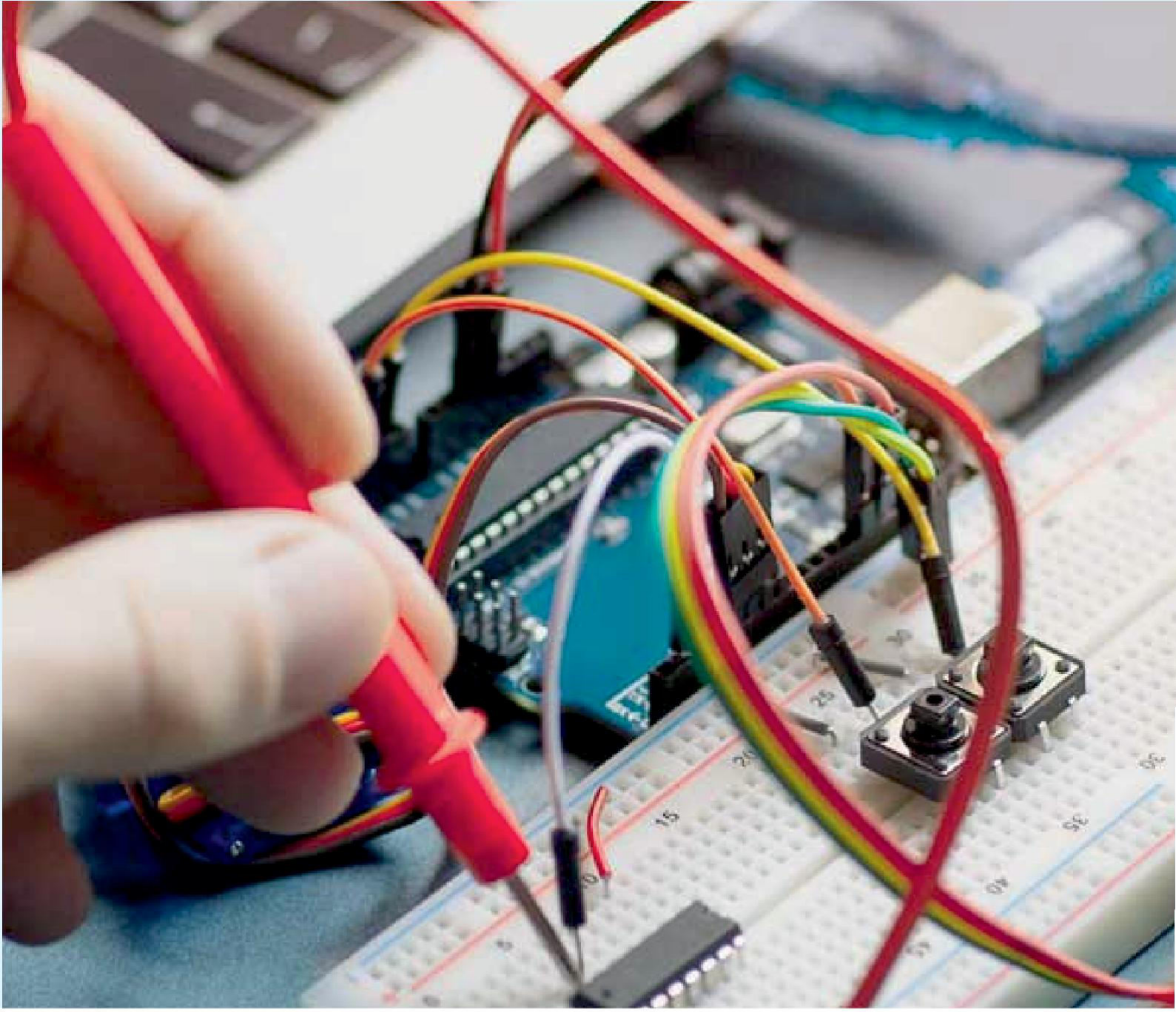

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