Role of Innovative Smart Farming in India and its Impact on Agricultural Productivity

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Abstract – In this paper we explored the role of innovative smart farming in India and its impact on agricultural productivity. With remote sensing, we can argue that smart farming is all about minimizing waste, increasing production, and making maximum use of resources. Precision farming is also known as smart farming. It entails the use of a variety of technologies, including IoT devices, big data analytics, remote sensing, artificial intelligence, and robots. It has been scientifically proved that using these technologies improve profits, reduces waste, and preserves the quality of the environment. This paper examines the current state of advanced farm management systems by revisiting each critical step, from data collection in crop fields to variable rate applications, in order for growers to make informed decisions that save money while also protecting the environment and transforming how food is produced to meet future population growth sustainably. As data has become a crucial part in contemporary agriculture to assist farmers with important decision-making, current advancements in data management are causing Smart Farming to expand rapidly. With objective data obtained via sensors, valuable benefits emerge with the goal of increasing production and sustainability.

KEYWORD: Innovative, Smart, Farming, Advanced, Techniques, India, Agricultural, Productivity

I. INTRODUCTION

Farming has been practiced since ancient times, and farmers constitute the backbone of the industry. Farmers toiling away in the fields, providing food for the globe. Farming used to be a very labor-intensive method that required a great deal of time and effort. As time passes, labor-intensive methods give way to capital-intensive ones that allow for more output with less effort. In India, smart farming is required to assist farmers increase their output and revenue. Our farmers rely on the monsoon, which decides whether they can plant their grain or not [59], in the twenty-first century, when phones are wiser than people. This demonstrates the critical need to improve Indian agriculture. This week, we're focusing on smart agricultural methods and solutions in India [54].

Agriculture is experiencing a transition fueled by new technology, which seems to be extremely promising since it will allow this main sector to reach new levels of agricultural production and profitability [1]. Precision agriculture, which entails applying inputs (what's needed) when and where they're needed, is the third wave of the modern agriculture revolution (the first was mechanization, and the second was the green revolution with its genetic modification [2]), and it's now being enhanced by the availability of larger amounts of data. Precision Agriculture technology improved net returns and operational profitability, according to the United States Department of Agriculture (USDA) [3]. On addition, when it comes to the environment, new technologies are increasingly being used in farms to ensure the long-term viability of agricultural output.

The deployment of these technologies, however, is fraught with risk and trade-offs. According to a market study, improved farmer education and training, knowledge exchange, easier access to financial resources, and rising consumer demand for organic food are all variables that would promote the implementation of sustainable farming technology [4]. When using these new technologies to get data from crops [56], the difficulty is to produce something cohesive and meaningful, since data is nothing more than numbers or pictures. Farms that choose to be
technology-driven in some manner reap significant benefits, including cost savings and greater output with little effort, as well as higher quality food produced with more ecologically friendly methods [5]. However, bringing these benefits to the farm will be contingent not only on farmers' willingness to embrace new technology in their fields, but also on each farm's capacity for scale economies, since profit margins rise with farm size. Taking into account that the highest adoption rates for three technologies (computer mapping, guidance, and variable-rate equipment) were on farms over 1500 hectares, the USDA reported that Precision Agriculture adopters had an average corn farm operating profit of 163 dollars per hectare higher than non-adopters [3]. Depending on the crop, such margins may go as high as 272 dollars. Smart Farming services must be used more often not just to improve a farm financial performance, but also to fulfill the food requirements of a growing population [6].

II. GLOBAL AGRICULTURE TRANSFORMATION FROM 4.0 TO 5.0

Agriculture 4.0, Digital Farming, or Smart Farming [54] are all terms used to describe a new philosophy focused on agricultural data that was created when telematics and data management were coupled with the already well-known idea of Precision Agriculture to improve the precision of operations [7]. As a consequence, Agriculture 4.0 is built on Precision Agriculture principles, with farmers applying technologies that collect data about their farms, which will be evaluated in order to make the best strategic and operational choices possible. Farmers have always gone to the fields to check on their crops [56] and make choices based on their previous experience. This method is no longer viable, for a variety of reasons, including the fact that certain fields are too vast to be effectively managed using the three-fold criteria that will guide the future years: efficiency, sustainability, and availability (for people). In the framework of Smart Farming, advanced management systems are offering practical answers. Furthermore, although some farmers have extensive expertise accumulated over many years of field labour, technology may offer a systematic method to identify unexpected issues that are difficult to detect via eyes examination on periodic inspections. Young farmers have a more positive attitude in embracing contemporary agricultural equipment than older farmers, since the former can supplement their limited field expertise with new smart instruments that provide critical information. However, in recent decades, the average age of farmers has risen alarmingly: 58 in the United States and Europe, 60 in Sub-Saharan Africa, and 63 in Japan [8,9]. This tendency, fortunately, is likely to reverse. Several European policies, for example, are being developed to facilitate access to early investment, loans, business assistance, and training in order to promote generational renewal [9]. In a rural development setting, generational renewal entails more than just lowering the average age of farmers; it also entails enabling a new generation of highly qualified young farmers to bring the full advantages of technology to bear on sustainable agricultural methods [10]. This means that young farmers will need to convert existing land into more modern and competitive farms in order to maintain viable food production while improving the agri-food chain competitiveness, because young people can transform the agricultural sector with advanced technologies and new thinking [8].

- **Internet of Things: Collecting Information**

In the agricultural environment [53], the Internet of Things (IoT) refers to the use of sensors and other devices to convert every element and activity involved in farming into data. According to one estimate, 10% to 15% of US farmers are adopting IoT solutions on their farms, which spans 1200 million hectares and 250,000 farms [11]. Agriculture 4.0 is driven by IoT [12]; in fact, IoT technologies are one of the reasons why agricultural can produce such a large quantity of useful data, and advancements in these technologies are anticipated to have a significant impact on the agriculture industry [13]. According to Myklevy et al., the IoT has the potential to improve agricultural output by 70% by 2050 [14], which is encouraging since the world needs to raise global food production by 60% by 2050 owing to a population rise of over nine thousand million people [15]. The primary benefits of using IoT are increased agricultural yields and lower costs. According to OnFarm research, an average farm adopting IoT increases production by 1.75 percent, reduces energy expenditures by 17 to 32 dollars per hectare, and reduces irrigation water usage by 8% [12].
Big Data: Analysis of Massive Data

The idea of big data is prevalent in many economic sectors in today's technology-based age, but is it currently accessible in agriculture? The ever-increasing quantity of data accessible for field management necessitates the development of some kind of automated method for extracting operational data from bulk data. The amount of data presently collected from most commercial sectors, on the other hand, is perhaps not yet at the level deemed to be classed as big data. Big data has three dimensions, according to Manyica et al. [16]: volume, velocity, and diversity. For authenticity, Kunisch [17] inserted a fourth V. Finally, Chi et al. introduced a fifth V to account for the additional dimension valorization [18]. The five Vs (dimensions) of big data, in general, represent:

- **Volume**: It refers to datasets that are too large for traditional database software tools to collect, store, manage, and evaluate. This definition contains an estimate of how large a dataset must be to be deemed large, and it varies per research sector, based on widely accessible software tools and popular dataset sizes, which usually start in the terabyte range [16].
- **Velocity**: The capacity to acquire, comprehend, and interpret events as they happen is referred to as velocity. This term refers to real-time applications in agriculture, such as data processing in the field to apply varying rates of chemicals in equipment with variable rate application technology.
- **Variety** refers to the many data forms (videos, text, and voice) as well as the various levels of complexity. This is particularly uncommon in agriculture, where many data sources, such as pictures and soil [57] or weather sensors, are utilised to operate in complicated situations.
- **The term ‘veracity’ relates to the data's quality, dependability, and general confidence.**
- **Valorization**: The capacity to spread information, admiration, and invention is known as valorization [18].

Kunisch [17] found that big data is only useful in certain instances in agriculture, depending on each farm and its degree of technological adoption. Nonetheless, the Proagrica study [19] showed that big data is rapidly being used in agriculture. Wolfert et al. [20] presented a review of big data applications in Smart Farming, while Kamilaris et al. [18] identified 34 works where big data was applied in agricultural applications. In response to this trend, the Consortium of International Agricultural Research Centers (CGIAR, Montpellier, France) established a Platform for Big Data in Agriculture with the goal of using big data approaches to solve agricultural development problems faster, better, and at a larger scale than ever before [21].

Agriculture 5.0: Robotics and Artificial Intelligence (AI) to Aid People's Nutrition

Agriculture 5.0 is likely to be the one for the first half of the twenty-first century, since large engineering problems usually drive big answers via disruptive technologies. Agriculture 5.0 refers to farms that use Precision Agriculture concepts and equipment that includes unmanned operations and autonomous decision-making systems. As a result, Agriculture 5.0 entails the employment of robots and AI in some manner [22]. Farms have always required a large number of employees, mainly seasonal, to harvest crops [56] and maintain them productive. However, society has shifted away from being an agricultural culture with huge numbers of people living on farms to one where people live in cities, and farms are now suffering a labour crisis. Agricultural robots with AI characteristics [61] are one option to assist with the labour crisis. Farm robots, according to a Forbes research [23], supplement human labour by harvesting crops at a greater volume and quicker rate than human workers. Despite the fact that robots are still slower than humans in many situations, agriculture is presently developing robotic systems to operate in the field and assist farmers with repetitive chores [24–27], bringing agricultural systems closer to the new idea of Agriculture 5.0. According to Reddy et al. [28], the use of robots in agriculture improved production and decreased farm running expenses in many nations. As previously stated, agricultural robotic applications are growing at an exponential rate [27], which offers promising solutions for Smart Farming in dealing with labour shortages and long-term declining profitability; however, as with most innovations, there are significant limitations to overcome in the early stages. Because scale economics make tiny individual farms less lucrative [30], these technologies are still too costly for
most farmers, particularly those with small farms [29]. Agricultural robots[61], on the other hand, will undoubtedly be used in the future as an option to increase output [4,31]. In 2015, global agriculture output and crop yields slowed [56]. Agricultural robots[61] was developed to address these issues and to meet the growing need for high yields. Agricultural robots will be able to do field activities with better efficiency than farmers, according to the Verified Industry Intelligence study [32], providing a boost to the worldwide agriculture and crop production market.

In the past five years, agricultural tech companies have raised over 800 million dollars [31]. Startups that use robots and machine learning to address issues in agriculture began to gain traction in 2014, coinciding with a surge in interest in artificial intelligence [33]. In fact, in the past five years, venture capital investment for AI has grown by 450 percent [34]. This type of new agriculture pretends to do more with less because, according to the Food and Agriculture Organization of the United Nations (FAO), feeding people while increasing production sustainably and caring for the environment will be critical in the coming years, as the world population is expected to reach 9.6 billion by 2050 [35]. Agriculture’s advanced sensing technologies can help meet the challenge by providing detailed information on soil, crop status [56], and environmental conditions, allowing for precise application of phytosanitary products, resulting in reduced herbicide and pesticide use, improved water use efficiency, and increased crop yield and quality [2].

III. ADVANCED FARMING PRINCIPLES STAGES

Measurements of important crop characteristics must be effectively processed so that figures or pictures may be translated into useful information without ambiguity. Crop management based on field data had already developed by the time Precision Agriculture was introduced thirty years ago, but the current digital information era has undoubtedly changed it. Field management has always consisted on visually examining the growth of crops to arrive at a diagnosis with which farmers make choices and activate providing various treatments to their crops in areas where technology has not yet reached. This method is based on field experience and data seen through the perspective of farmers. Associated growers may also follow the advice of cooperative technicians or engineers employed by the society to which they belong. Field management changes according to the operational cycle illustrated in Figure 1 on farms where sophisticated technology has been deployed.

![Figure 1: Advanced agriculture information-based management cycle](image)

This management method, which is based on objective field data and intelligent decision-making, begins with the crop to be managed, taking use of its internal variability, both spatially and temporally. The sensors are the particular components via which objective data are collected, while the platform refers to the physical method by which information is received. The information immediately obtained from the crop, soil, or ambient factors is referred to as data [57]. Data from the sensors may be retrieved in a variety of methods, ranging from putting a pen drive into a USB port to obtaining data via software programs synced with the Internet [36]. Filtering procedures and AI algorithms are used at the nexus between the data and decision stages to ensure that only the proper data is obtained and that the farmer makes the best choices possible. Finally, actuation refers to the actual execution of a decision system-commanded action, which is usually carried out by sophisticated equipment that may accept instructions from an electronic control unit. The cycle begins and ends at the crop level when each activity takes place.
over the crop; the crop's reaction is then recorded by specialised sensors, and the loop continues methodically until harvesting time, which marks the conclusion of the crop life cycle.

- **Stage I Crop**

The number of management zones is a function of natural variability within the field, field size, and specific management variables, according to Zhang et al. [37]. If the variability is significant, the minimum size of a zone is restricted by each farmer's capacity to manage areas within a field differently in terms of economics and logistics. In addition to deciding on the size of the working zones, the metrics to be monitored inside those zones must be carefully chosen early in the process. Crop biometric characteristics were classified in a tri-level classification of crop features by Rovira-Más and Saiz-Rubio [38], depending on whether the focus of attention was at the soil level, plant level, or product level [58, 59, 60]. This divide allowed for the superimposition of different layers on a standardised map with the goal of producing a data-based wine quality index for each subfield area in a vineyard, known as the Quality Potential Index (QPI). However, as Klassen et al. [39] found when assessing soil variability in rice fields, there may be certain instances where the spatial variability of a field is so minimal that a single mapping session is adequate.

- **Stage II: Platforms Supporting Sensors**

Sensors are the ubiquitous gadgets that are used to monitor crops and extract objective data from them. They're typically built into a platform, which is the generic word for the structures where sensors are installed and transported in Figure 1. These platforms may be mounted on off-road vehicles or installed on the ground in fields, such as at local weather stations. Getting a broader variety of non-invasive sensors that can measure on-the-go will be one of the most pressing problems to overcome in the next years. Because these sensors may be connected to autonomous platforms and robots, this method would be closer to Agriculture 5.0[61]. Although not all characteristics of interest can currently be assessed non-invasively and at a distance from the object, certain technologies, such as multispectral or hyper spectral imaging, are making considerable advances.

- **Remote Sensing Platforms: Satellites**

When field data became widely available via artificial satellites, remote sensing played a critical part in the development of Smart Farming. The American Landsat satellites (eight satellites take spectral data from the Earth every 16 to 18 days), the European Sentinel 2 satellite system (it provides multispectral data at 10 m pixel resolution for NDVI—Normalized Difference Vegetation Index—imagery, soil [57], and water cover every ten days), and the RapidEye constellation (five satellites) are all important satellites that provide agricultural data (collects multispectral data from the RGB bands including the red-edge, two NIR bands, and 8 SWIR bands with a resolution of 1.24 m at nadir). IKONOS and QuickBird have already been shut down. Several reviews on satellite sensing applications exist, with current research focusing on the possible uses of thermal technology applying remote sensing [40] and the nutritional condition of commodity crops [41].

- **Aircraft Systems**

Crops and satellites are separated by a significant distance, usually about 700 kilometers, and better insights are gained when sensors are kept closer to the objectives. The distance to land for aviation systems may be as little as 100 meters. In Spain, for example, unmanned flying aircraft are restricted to a height of 120 meters above the earth. Fixed-wing aircrafts and multirotor aircrafts are the two types of unmanned aerial vehicles (UAVs) and remotely piloted aircrafts (RPAs). Because they can take off and land vertically, rotary-wing UAVs are more stable flyers; but, they are slower and can't cover as much ground throughout their battery life. Fixed-wing platforms, on the other
hand, can cover more ground and carry bigger payloads each flight, but they are more costly and more likely to fail after repeated landings. [41]

- **The Great Push for Agriculture 5.0: Proximal Sensing: Ground Autonomous Systems**

The distance between the sensors and the target crop is less than 2 meters when monitoring platforms are operated from the ground. When data is collected from ground-based platforms, it is referred to as proximal sensing since the sensor is close to the plant [59]. In terms of sensor payload, ground vehicles are multivalent. As these vehicles go closer to the crop, the data they collect becomes more accurate, and resolutions of one or more samples per meter are possible, limited only by the specifications of the sensors used. Weather circumstances such as intense sunshine or low lighting are no longer an issue when active sensors are employed, and real-time applications such as weed spraying with prior identification of the pest are feasible when on-the-fly processing is used [42]. In the past five years, there has been a strong push for the scenario where data is collected from an autonomous platform (unmanned ground vehicle or UGV) [43].

- **Stage III: Data**

Apart from the degree of automation, one of the most significant distinctions between traditional and contemporary farming is the data gathered straight from the crops. Decisions are relative and subjective on traditional farms, where farmers evaluate by visual evaluation. Modern farming allows for objective decision-making based on quantitative data. Sensors enable data gathering in the field, but the unique mix of non-invasive technology and on-the-fly sensing from moving platforms has opened the door to enormous data collection, a precursor to big data in agriculture. However, dealing with an abundance of data is a significant problem, since important information may be obscured by noise.

A map-based approach, which takes into account the critical role of positioning systems, is a method in which a Global Positioning System (GPS) receiver and a data logger (e.g., an onboard computer) are used to record the position of a specific measurement (georeferenced data) so that several maps can be generated and processed alongside other layers of data. GNSS receivers are the universal position devices used to build maps in general; however, in some cases, such as greenhouses or dense fields of tall trees, GNSS is not the best option due to the difficulty of getting signals with reliable accuracy; thus, alternative solutions such as machine vision must be implemented [44].

- **Data Management Software to Make Decision Making Easier**

The usage of Geographic Information Systems (GIS) is a common method to handle field data shown on maps and culminating in a practical solution (GIS). Any kind of georeferenced information may be stored, evaluated, manipulated, and mapped using this collection of computer-based tools (or data platforms). For Precision Agriculture applications, a specialised GIS system called the Field-level Geographic Information System (FIS) was created [45], although it was designed for outdated computer operating systems like Windows 3.1, 95, 98, or NT [46]. The farm management information system (FMIS) is an updated version of FIS, according to Burlacu et al. [47], which is a management information system designed to assist farmers with a variety of tasks, including operational planning, implementation, and documentation, as well as the evaluation of completed field work.

- **Stage IV: Decision-Making**

People struggle to manage complicated information in circumstances when numerous field factors must be evaluated in order to make successful choices. Artificial intelligence (AI) methods such as deep learning or neural networks, fuzzy logic, evolutionary algorithms, or expert systems may assist in these situations. With its modelling and
reasoning skills, AI can play a critical role in agriculture, assisting in the interpretation of all available data. Fuzzy logic, for example, is a type of AI that mimics human reasoning by simulating the process of making decisions that involve multiple options rather than a single ‘true’ or ‘false’ option; this technique employs linguistic variables that are well suited to the complexity of the challenges posed by the diversity of agricultural decision-making. Agriculture, according to Dengel [20], provides a wide range of applications for AI core technologies as agents working in uncontrolled settings. For kiwi, maize, and potato, Giusti and Marsili-Libellia [48] developed a fuzzy-based decision support system (DSS) using soil moisture and rain prediction as input variables. Similarly, Navarro-Helln et al. [49] created a DSS that predicted weekly irrigation for citrus trees based on climatic and soil factors; in that study, real-time soil data were used [57]. Because the DSS was permitted to adjust to local disturbances, settings in a closed-loop control system were crucial in avoiding the accumulative impact caused by mistakes in successive weekly estimates. Lindsay Corporation (Omaha, Nebraska, USA) was also identified for its product FieldNETAdvisorTM [50], which helps farmers make irrigation management choices. When various factors are taken into account, DSS may become more robust and dependable, but certain processes remain contentious since goals may lead to different solutions at different periods depending on the priority set by decision makers or other individuals participating in the operation. [51].

- **Stage V: Variable Rate Technology for Actuation**

The physical actuation of the crop is the last stage in the entire crop management cycle shown in Figure 1 for completing the loop. Actuation is defined as taking some action on or connected to the crop, and it may be done immediately after receiving information (real-time applications) or later in time (delayed applications) (off-line). Farmers need sophisticated equipment that can accept instructions from a digital control unit in order to carry out their choices. A smart system can direct variable rate machines to do a variety of agricultural activities [52]. VRT used to site-specific crop management (SSCM) offers the potential to enhance profit while reducing environmental impact since just what is required is administered.

**IV. ADOPTION OF INNOVATIVE SMART FARMING TECHNIQUES IN INDIAN AGRICULTURE SECTORS AND ITS BENIFITS**

Indians are a somewhat orthodox people. They think that the techniques or old practices that have been applied in agriculture from ancient times are the finest. However, as the population grows and technology advances, techniques must evolve as well. Farmers in India must embrace new technology to improve smart farming in order to achieve this. The following are some technologies that should be improved[53].

- **Product innovations:** There is a need for product innovation. Those goods that have been around for a long time and need to be updated. As a result, new technologies are being brought into the market that are creating whole new types of meals. Those items that are difficult to grow are put to the test in a lab.

- **Digital marketplaces:** The Indian government has launched an eNAM service for the country’s farmers. The eNAM (National Agriculture Market) is an electronic trading platform that connects farmers throughout India via existing APMC mandis. Its primary goal is to achieve agricultural market equality. Smoothness between buyers and sellers is produced as a result of this strategy, and it also encourages real-time pricing. Farmers may also use the digital marketplace to lease equipment, interact with local consumers, or pool resources for better insurance.

- **Operations software:** It will assist farmers in making better business choices, saving money, and tracking resources and production.

- **Skills-building tools:** There is a need for skill development in Indian agriculture. Farmers produce what their parents or forefathers taught them. They have no idea how to apply the new technology that have been presented to them. For this reason, farmers should have access to skill-building equipment on the market.
It comprises voice-over-internet-protocol services, movies, and mobile applications, among other things. Farmers may use these tools to share their experiences and learn new and creative techniques. AgriFind is a social networking site in France where farmers may ask questions and get assistance.

Resources: There is a need to completely use resources. In India, new irrigation methods provide highly targeted fertilizer and water. It's ideal for urban and vertical agriculture. There was less usage of water and soil in these techniques [57]. Pesticides are also reduced as a result of this.

**Smart farming Ideas**

- Smart farming and innovation go hand in hand. Agriculture in India is now experiencing significant difficulties. Smart agricultural innovations are urgently needed to speed up agriculture. Agriculture technology investment has seen a significant increase in the past ten years. Investment totaled $6.7 billion during the past five years, including $1.9 billion in the last year alone. These investments are being made to help Indian agriculture.

- **Indoor Vertical Farming**: Growing plants [60] in enclosed and regulated settings is known as indoor vertical farming. Plants are grown vertically using this technique [59], which requires less land area than conventional farming. Plants in vertical farms don't need soil to flourish [58], and the labour requirement is decreased as well. It is India's finest and first smart farming method.

- **Farm Automation**: Farm automation refers to the advancement of agricultural machinery and equipment. Companies are trying to achieve this goal. They're working on self-driving tractors, automated irrigation, drone development, robotics innovation, and sowing robots, among other things. The businesses not only offer high-quality, innovative equipment, but also make it accessible to farmers[61].

- **Livestock Farming Technology**: Livestock produces much-needed goods, yet livestock is the most misunderstood aspect of farming in our nation. Over the last eight to ten years, new technologies have resulted in significant changes and advancements in the sector. It makes it simple and comfortable to manage and monitor cattle. These technologies include genetics, nutrition, digital technology, and others.

- **Modern Greenhouses**: The usage of greenhouses in Indian agriculture has increased dramatically. It is revolving around the city and injected with capital. The greenhouse trend has been growing in recent years as market demand has risen significantly. A contemporary greenhouse currently has automated control systems, is technologically advanced, and uses LED lighting for growth.

- **Precision Agriculture**: Precision agriculture firms have recently introduced technology that allow Indian farmers to increase their output. Pest stress, microclimates, moisture levels, and soil conditions are all controlled [58]. Precision agriculture provides farmers with suitable crop-growing and planting methods that increase efficiency and revenue [60].

- **Blockchain**: Food traceability, supply chain inefficiencies, safety recalls, and food fraud are all problems that blockchain is being applied to address in the food industry. It establishes a market for high-end goods that is verified and transparent. This checks whether or not transactions are safely shared with each seller. It aids in the creation of market and food supply transparency.

- **Artificial Intelligence**: Farmers' possibilities have grown as digital agriculture and technology have advanced. UAVs, satellites, and remote sensors can collect data for farmers for up to 24 hours. All of these devices can monitor plant health, temperature, soil condition, humidity, and other factors [58]. Farmers can now better comprehend the foundations of new technology. These may assist them in increasing production.

**Benefits of Smart farming**

- ** Increase in Efficiency**: Farmers may improve their efficiency by using smart farming techniques. Farmers can now produce more goods in a shorter amount of time thanks to improved technology. They are quickly examined, foresee problems before they occur, and make critical choices to put them at bay.
• **Expansion**: Agriculture expands because of the application of smart agricultural technology. All agricultural operations are completed on schedule and to a high standard. For these technologies, the short food chain is completed on time, and everyone in the nation receives adequate food at a reasonable price.

• **Proper Use of Resources**: Smart agricultural technologies make full and appropriate use of resources. Energy, water, and land are examples of resources. Data from sensors gathered by IoT farming helps to distribute an optimal quantity of resources to the plants [59, 60].

• **Cleaner process**: It's a more efficient method that saves electricity and water while also making frames more environmentally friendly. These devices assess fertilizer and pesticide use. In contrast to conventional agricultural techniques, these procedures provide organic and cleaner goods.

• **Agility**: Smart agricultural systems monitor unpredictably changing weather, air quality, humidity, soil in the fields, and crop health [58]. This allows for real-time monitoring and prediction of crop health. This offers expert guidance in the event of severe weather changes, which may preserve crops.

• **Improved product quality**: Crop sensors, farm mapping, and aerial drones are all used to assist enhance product quality. The optimum circumstances for increasing the value of nutritious goods are created by smart agricultural technology.

V. **CONCLUSION**

India's federal government is actively involved in the development of the agri-tech industry. They are always introducing new legislation to empower Indian farmers. Smart farming is supported by the Indian government since it aims to decrease effort while increasing output. They are now aiming to quadruple the income of farmers by 2022. They aim to improve farmers' revenue with the least amount of work possible via smart farming. For this, the NITI Aayog is working with a number of companies, including IBM, to develop technology-driven solutions. These farmers get real-time guidance and are financially supported in order to improve crop production.

In addition, with a grant of up to INR 2000 crore, the Indian government intends to digitise the PACS (Primary Agricultural Credit Society), MANAGE (Management of Agricultural Extension in Hyderabad), mentoring agri-tech start-ups, PMKSY (Pradhan Mantri Krishi Sinchayee Yojana), and One Nation One Market are some of the government's other smart farming initiatives.

Hi-tech and technologically sophisticated goods do really offer a pleasant working environment with a high level of productivity. Even if farmers want to embrace smart farming, if it is not cheap to them, they will not. The majority of Indian farmers have little money, which hinders them from taking advantage of the digital revolution in agriculture. As a result, start-up agri-tech companies must tailor their goods and services to the farmer's budget in order to reap the maximum advantages.

However, in order to get the most benefits from Agriculture 5.0, users must receive extensive training, preferably from young farmers willing to learn and implement contemporary agricultural technology, ensuring future generational renewal. It seems that the moment has come to go ahead toward a contemporary and sustainable agriculture capable of demonstrating the full potential of data-driven management in the face of the difficulties that confront food production in the twenty-first century. Most major farm equipment manufacturers have Agriculture 5.0 on their agendas for the next decade, and off-road equipment manufacturers will play a significant part in this transition if agricultural robots are regarded the next—smarter—generation of farm machinery.

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