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Digitalization: A Tool for Modern Extension Activity

Diptarka Ghosal, Ashok Kumar* and Akkamahadevi Naik

Department of Agricultural Extension Education, M.S. Swaminathan School of Agriculture (MSSSOA), CUTM, Paralakhemundi, Odisha, India

*Corresponding author: ashokbrr8@gmail.com

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ABSTRACT

By the year 2050, the world population is projected to exceed 9 billion, leading to increased agricultural consumption. Agriculture, as the most promising industry, faces several challenges, including a shortage of labour for farming. However, the integration of advanced technologies such as drones and remote sensing in agriculture offers potential solutions to address these issues. Digital agriculture now takes a comprehensive approach, drawing on knowledge from various fields like information science, environmental science, computer and software engineering, GIS, GPS, remote sensing technology, and virtual satellite imaging to better align soil, climate, and environment with agricultural practices. The decisions of farmers to adopt new technology are influenced by a variety of social and economic factors. The complexity of digital agriculture lies in the implementation of sophisticated innovations like smart devices, network infrastructure, technical expertise, and statistical knowledge, distinguishing it from traditional agriculture. The outlook for digital agriculture in India appears promising. The success of digital agriculture in the country will depend on several key factors, including the affordability of technology, ease of access and operation, simple system maintenance, timely grievance resolution, and appropriate policy support. Additionally, robust research and development that addresses ground-level challenges and ensures efficient last-mile delivery are necessary to empower Indian farmers through digital agriculture in a meaningful manner.

Keywords: Digital Agriculture, Remote Sensing, Information Technology, Development, Empower Farmers

Digital agriculture is a modern approach that utilizes advanced technology to promote sustainable development in crop, fisheries, and livestock sectors. It involves the adoption of digital technology to replace traditional agricultural practices, encompassing virtual agriculture, information-driven agriculture, and lean agriculture. To facilitate this transformation, a substantial amount of data is required from various stages of crop production, fisheries, and livestock management. Digital agriculture now encompasses a holistic approach that integrates knowledge from information science, environmental science, computer and software engineering, system science, GIS, GPS, remote sensing technology, and virtual satellite imaging. This integration enhances the alignment of soil, climate, and environment with agricultural activities (Schuster, 2017). Now the world population is more than 7 billion which will be around 9.6 billion by 2050 (Wang, 2011). By 2030, around 5 billion middle-income individuals will have sufficient income to afford enough food, but an estimated 4.5 billion people may still experience food insecurity. To meet the food demands of this

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large population, there is a pressing need to double agricultural production within a short period, posing a major challenge for humanity. The key solution lies in leveraging modern and sophisticated technologies, including the integration of big data in agriculture, at every step of the agricultural production process (Van and Woodard, 2017). In the future, digital agriculture will play a vital role in fulfilling farmers' increasing food requirements. Big data technologies serve as valuable tools for gathering extensive agricultural data at a minimal cost, promoting insight-driven, productive, and efficient agricultural practices. By integrating digital agriculture with big data technologies, farmers can experience a substantial increase in productivity, with crop agriculture potentially seeing improvements of about 10 to 15 percent (Keogh and Henry, 2016). The successful implementation of big data in agriculture relies on various factors, such as user acceptance of new technology, stakeholder willingness, data ownership, privacy, and control. Despite these considerations, big data proves effective at the field level (Schuster, 2017). Farmers' decisions to adopt new technology are shaped by a range of social and economic factors. The complexity of digital agriculture is amplified by the inclusion of advanced technologies like smart devices, network infrastructure, technical expertise, and analytics knowledge. However, despite these challenges, digital agriculture has the potential to generate precise information on soil status, crop conditions, weather patterns, and intercultural management requirements (Rose *et al.* 2015). This valuable information can greatly assist farmers in effectively managing their crops (Kearney, 2016). Within the realm of agricultural production, supply chains, and the broader food systems, several ideas have surfaced to illustrate different ways of digitalization. These ideas encompass smart agriculture (Blok and Gremmen, 2018), precision agriculture (Wolf and Buttel, 1996), agricultural decision-making (Keogh and Henry, 2016), agriculture 4.0 (Rose and Chilvers, 2018), and the French term "digital agriculture" (Bellon-Maurel and Huyghe, 2016). Emerging ICT Intervention to make the process swifter and more effective and a strength of mobile telephony may be tapped for replication and up scaling of location specific good work done by farmers using this source through WhatsApp application etc. (Ashok Kumar and Akkamahadevi, 2021).

Objective of the study

Digitalization can serve as a powerful tool for modern extension activities, providing numerous benefits to various sectors. Implementing digital tools can help in automating routine tasks, reducing paperwork, and streamlining processes. This efficiency allows extension workers to focus more on delivering impactful services. Digitalization enables extension workers to reach a larger audience through various communication channels, such as social media, websites, and mobile apps. This broader outreach helps disseminate information more effectively. Digital tools provide a platform for the quick and accurate exchange of information. Extension services can deliver timely updates, research findings, and relevant data to farmers or target audiences. Digital technologies, such as sensors and data analytics, enable precision agriculture. This involves optimizing the use of resources like water, fertilizers, and pesticides based on real-time data, leading to increased productivity and sustainability. Digital tools enable the monitoring and evaluation of extension programs. This helps in assessing the impact of interventions and refining strategies for better outcomes.

Digitalization of Agriculture

Big data-based digital agricultural technology offers extensive support to farmers throughout the entire farming process, spanning from field preparation to harvesting (Chergui and Kechadi, 2022). This advanced technology encompasses various crucial aspects, including weather forecasting, predicting crop yields, guiding crop selection, managing irrigation, addressing crop diseases and pest infestations, as well as facilitating agricultural marketing.

1. Weather Forecasting: Crop cultivation, fish cultivation, and livestock management are significantly impacted by edaphic and environmental factors. As different stages of crop growth necessitate specific temperature and humidity conditions, it becomes crucial for farmers to be knowledgeable about these optimal parameters, which can be easily obtained through big data analytics. Big data

Table 1: Digital Agriculture Typologies

Typology	Features	Researchers
The use of big data in agriculture	Significant volumes of information are collected from different segments and phases of agriculture. Subsequently, this data is stored and processed within computers for the purpose of being employed and reused in decision-making processes.	Zhang *et al.* (2018).
Precision agriculture	Using modern technology, sensor-enabled hardware and software tools are employed to oversee and control all aspects of agriculture.	Coble *et al.* (2018), Pham *et al.* (2018), Reddy (2017).
Prescription agriculture	Prescription for agronomic practices, enabled by computer algorithms, is utilized to optimize yield outcomes through the combination of various methods.	Himesh *et al.* (2018).
Automated agriculture	Robotic technology and intelligent programs are employed in agriculture to automate tasks by utilizing farm data and environmental information.	Wu *et al.* (2016), Bronson and Knezevic (2016).

technology presents farmers with the chance to make informed decisions and enhance crop management throughout various stages, including planting, intercultural operations, fertilization, pesticide management, and harvesting (Waga and Rabah, 2014). Through weather forecasting, farmers can readily mitigate potential adverse impacts caused by unfavourable weather conditions. Similarly, soil management decisions can be made by farmers, considering the influence of soil on environmental factors. Employing Support Vector Machine, a machine learning technique, farmers can obtain weather forecasts (Bendre *et al.* 2016).

2. Crop Yield Prediction: Utilizing modern technology, farmers can access precise data to forecast the likely harvesting time and yield with accuracy. This valuable information enables them to prevent harvest losses and effectively manage post-harvest activities (Bendre *et al.* 2016). Big data technologies further aid farmers in increasing production by identifying the best time to harvest, thereby mitigating the impact of unfavourable weather conditions.

3. Irrigation Management: Irrigation stands as a crucial intercultural practice for crop production. Timely and adequate water supply plays a vital role in enhancing plant health; otherwise, it may lead to issues such as stunted growth, pest infestations, and wilting. Many developing countries are grappling with the impacts of climate change, fluctuating rainfall, and droughts. To address this, the implementation of a smart irrigation system could offer farmers a suitable solution for making well-informed decisions on irrigation. Employing big data technology, an artificial neural network can accurately predict the irrigation needs of crops (Singh, 2016).

4. Crop Diseases and Pest Control: Crop diseases and pest infestations are common occurrences in crop production, yet they significantly diminish the crop's quality and yield (Sayad *et al.* 2015). By effectively managing and controlling these issues, farmers can enhance their crop yield. Big data offers a valuable opportunity to identify disease infestations on crops, enabling farmers to implement timely measures for disease control and crop protection. Additionally, big data technology can provide advance predictions of potential pest attacks (Thongboonnak and Sarapirome, 2011).

5. Agricultural Marketing: Access to market information is essential for maximizing profits from agricultural products. Lack of awareness about market data can lead farmers to suffer losses on their produce. Market data encompasses diverse aspects like input costs, price trends, demand and supply dynamics, cultivation expenses, labour wages, marketing expenses, and transportation costs. By analysing this wealth of market information through big data analytics, farmers can make informed decisions and improve their outcomes (Cai *et al.* 2015). Moreover, the government can also leverage big data technology for market analysis and effective monitoring of market trends.

Digital Extension Services

A significant number of farmers lack access to reliable and up-to-date information concerning extreme climate events like droughts, storms, floods, and other natural disasters (Yadav *et al.* 2020). Digital agricultural extension utilizes various digital tools and services to efficiently deliver information. Extension workers commonly employ methods such as Short Message Service (SMS), Interactive Voice Response (IVR), interactive radio, and low-cost videos to rapidly reach a large number of farmers. These digital extension services offer timely reminders, alerts, weather forecasts, and best practices, empowering farmers to improve their productivity. The conventional approach to extension, involving face-to-face information sharing, is both costly and time-consuming, often lacking significant value for the farming community. Nevertheless, the utilization of digital technology offers opportunities to expand the scope of extension services (USAID, 2018). Providing accurate information is crucial for enabling farmers to make well-informed decisions and unlock their full potential. Throughout each stage of the cropping cycle, it is essential for information providers to establish strong connections with farmers. Hence, digital technologies facilitate the creation of farmers' networks and ensure continuous communication with service and advisory providers (Yadav *et al.* 2020).

Farmers' Information Requirements

Having reliable, timely, and accurate information is crucial for farmers as it can effectively mitigate risks and uncertainties, enabling informed decision-making. However, the impact of this information is contingent upon factors such as market dynamics, institutional frameworks, policies, and the availability of resources. Numerous studies indicate that despite the abundance of information from various sources, there hasn't been a significant alteration in farmers' behaviour towards adopting new technologies. This is frequently attributed to information providers' insufficient comprehension of farmers' perspectives and requirements, which underscores the importance of addressing farmers' informational needs.

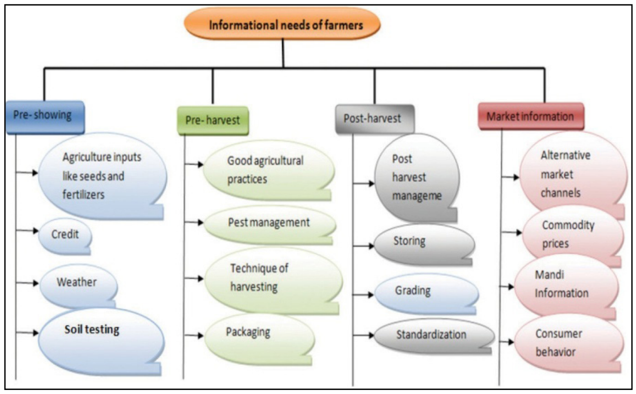

Fig. 1: Farmers' Information Requirements

Digitalization and Agricultural Knowledge and Innovation Systems (AKIS)

The growth of Agricultural Knowledge and Innovation Systems (AKIS) has been influenced significantly by the digitalization of agricultural information and innovation processes. This thematic cluster, with its macro, meso, and micro perspectives, explores separate research lines concerning information and innovation structures. From a macro standpoint, researchers investigate how innovative support mechanisms enable digitalization and adapt to changes brought about by digitization, including the application of big data analysis (Kamilaris *et al.* 2017). The shaping of AKIS for digital agriculture involves a diverse range of participants, including high-tech companies specializing in drones or satellites, service industries, and multinational manufacturers of cutting-edge farming equipment like self-driving tractors and automated milking machines (Eastwood *et al.* 2017). Given the ethical concerns outlined in cluster 3, there is an increasing amount of scholarly work investigating the application of Responsible Research and Innovation (RRI) principles (Owen *et al.* 2012) within the domain of innovation systems. This examination is particularly relevant in the context of digitizing agricultural production systems, value chains, and food systems. Additional research has explored the way in which user-generated data, obtained through the analysis of social media and the utilization of citizen science methods, contributes to instantaneous decision-making and influences policy choices (Cieslik *et al.* 2018; Leeuwis *et al.* 2018; Stevens *et al.* 2016). For instance, specific studies are exploring how digital networks and social media platforms facilitate the exchange and peer learning of information at both local and global levels (Kelly *et al.* 2017; Munthali *et al.* 2018). Other research has also explored how user-generated data contributes to real-time decision-making and influences policy decisions. This has been investigated through the analysis of social media and the application of citizen science approaches. At a more granular level within information systems, other studies have looked into user-centric automated decision support systems and the collaboration between consultants and farmers to bridge the gap between "digital knowledge systems" and "farmers' knowledge systems" (Tsouvalis *et al.*, 2000).

Classification of Information Technology

Farmers require up-to-date and pertinent information obtained through research and innovation to address challenges posed by severe weather conditions and diseases. This need persists even when farmers possess a comprehensive understanding of local conditions and substantial practical experience or expertise in utilizing the environment for optimal outcomes (Correa *et al.* 1997). Consequently, the media assumes a crucial role in disseminating agricultural information. Utilizing mass media enables the simultaneous broadcasting of messages to a vast audience within a specified timeframe. The IT is two types:

1. Traditional Information Technology: Radio, television, and print media collectively form this communication medium. Different nations can benefit from television and radio for informal education tailored to their specific educational needs. In developing countries, television emerges as the most crucial medium for reaching out to rural populations (FAO, 2001). Carpenter proved in 1983 that the combination of audiovisual elements has the potential to influence human behaviour positively and enhance farmers' learning skills. This medium can effectively disseminate information to a wide audience across diverse geographical areas where personal contact is impractical (Calvert, 1990). Radio serves as another important and effective tool in mass media. Following independence, initial experiments with information and communication technology (ICT) in agriculture commenced with radio. All India Radio (AIR) stations played a pivotal role in broadcasting programs in local languages established after independence.

2. Modern Information Technology: This encompasses the internet, portals, mobile devices, community radio, video, digital photography, and call centers. The advent of internet services and increasingly utilized communication channels, such as rural audio, has the potential to enrich the information and communication resources accessible to rural communities. Employees at countryside radio stations across various regions or countries can tap into regional and national marketplace information systems or extension information systems available online. Farmers can leverage information about current market prices disseminated by rural radio stations to negotiate more favourable prices with local buyers, encompassing both national and international market trends. Additionally, the global trend has seen a surge in the popularity of online buying and selling.

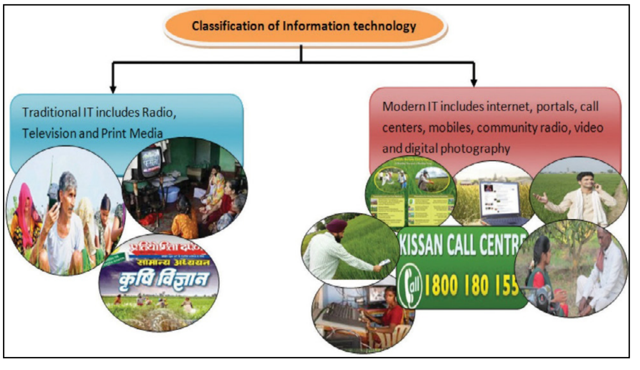

Fig. 2: Information Technology and its types, Nehra *et al.* 2018

Precision Agriculture

Precision agriculture enables farmers to optimize their economic returns by making well-informed decisions based on a multitude of variables. This approach incorporates Information and Communication Technology (ICT), automation, robotics, and decision-support technologies to enhance farming operations, leading to improved efficiency, profitability, and sustainability. By 2030, it is estimated that precision agriculture could benefit 80 to 150 million farmers, with a greater focus on large and midsize farms. This widespread adoption could result in the production of an additional 100 to 300 million tonnes of crops and a reduction of 5 to 20 mega tonnes of CO2-equivalent emissions, bringing about both production and environmental benefits. Moreover, the implementation of precision agriculture could potentially reduce farming costs by $40 to 100 billion and decrease water usage by 50 to 180 billion cubic meters (World Economic Forum, 2018).

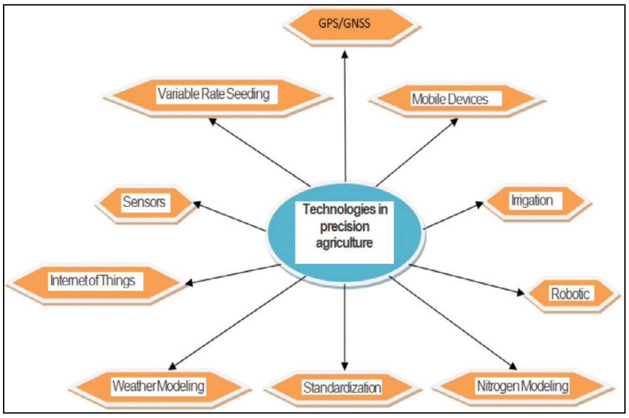

Fig. 3: Functions of Precision Farming

The agricultural sector finds various applications for the Internet of Things (IoT), utilizing a network of sensors and devices to convert actions or processes into data. IoT-enabled devices play a crucial role in monitoring water stock and flow, as well as measuring irrigation water usage (Yadav *et al.* 2020). Research has shown that implementing IoT in the USA resulted in a 2 percent increase in crop yield per hectare and an 8 percent reduction in water requirements for irrigation, while also contributing to energy conservation (Government of Maharashtra, 2021).

Remote Sensing

Remote sensing is both a science and an art dedicated to acquiring data about real-world objects or regions from a distance, eliminating the need for physical contact. This method of monitoring Earth's resources involves the integration of satellite technology with ground-based observations to achieve enhanced precision and accuracy. By utilizing the electromagnetic spectrum, encompassing visible, infrared, and microwaves, remote sensing discerns features such as plants, bare soil, and water, enabling a comprehensive assessment of Earth's properties. The technique relies on the distinctive responses of targets to various wavelength regions, facilitating the differentiation between plants, bare soil, water, and similar phenomena. Remote sensing finds applications in diverse areas, including crop growth monitoring, tracking land use patterns and changes in land cover, mapping water resources, assessing water status in field conditions, monitoring disease and pest infestations, forecasting harvest dates, estimating yields, enabling precision farming, and contributing to weather forecasting. This technology also supports field observations (Shanmugapriya *et al.* 2019).

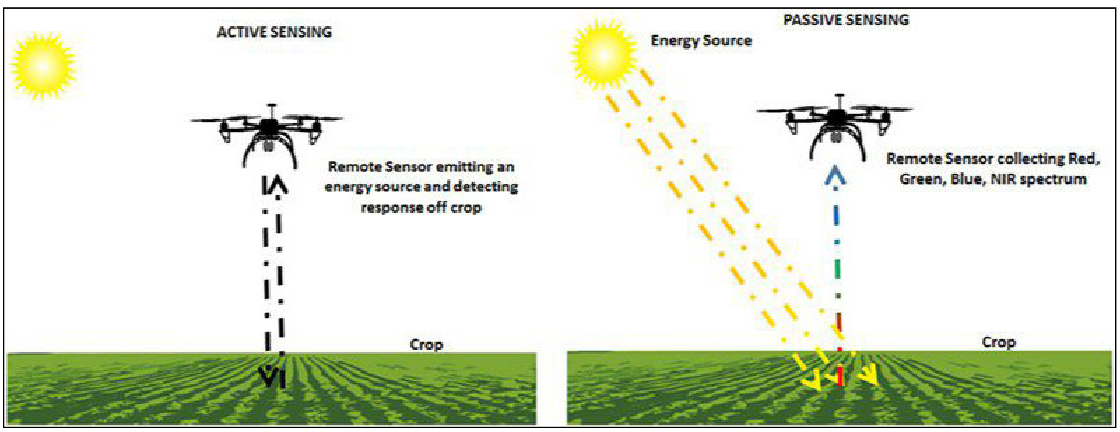

Fig. 4: Remote Sensing and its Types
(*Source:* GeoBipod.com)

Digital Technology Adoption, Use, and Adaptation on Farm

The first main section is well-elaborated, exploring the economic and compartmental aspects of adopting precise technology in farming. The focus of this document is on individual factors that influence adoption (Tey and Brindal, 2012) as well as the steps for expanding and promoting adoption (Kutter *et al.* 2011). Another area of research explores the utilization of precision farming, using terms like 'tinkering' and 'assemblies,' and its impact on agricultural activities and the process of adjusting to the technology after its adoption. Furthermore, this subject has been examined in a post-farm context, delving into the broader networks that shape technology and innovation processes, and the interplay between technology and the wider social and corporate environments (Tey and Brindal, 2012). The focal point of this group of studies revolves around a diverse range of methods, including cost and benefit modelling of precision agriculture, quantitative or econometric approaches to evaluate the impact of various factors on adoption, qualitative investigations that explore both adoption and non-adoption situations, and the examination of less apparent elements like resource constraints and cultural influences. Notably, while most industrial contexts prioritize the adoption of precision agricultural technology, research conducted in Africa places more significance on the adoptionof business knowledge systems (Wyche and Steinfield, 2016).

The following are the major initiatives of government-based ICT delivery services:

1. The Assam government has initiated Project SH (www.assamagribusiness.nic.in), which has been implemented statewide through an extensive ICT network.
2. Kerala has undertaken two distinct initiatives, namely Kissan Kerala (www.kissankerala.net) and e-Krishi (www.ekrishi.org/web/main/).
3. The Andhra Pradesh government, in partnership with ikishan, has launched the Rajiv Internet Village services to offer agribusiness services. Additionally, IIT Hyderabad is activelyinvolvedinthedevelopment of e-Sagu (http://agriculture.iit.net/esagu/esagu2004).
4. The Uttarakhand government is considering Kisan Soochna Kendras, while the Haryana government has opened the first agribusiness information centre.
5. Tamil Nadu and Maharashtra have pursued Comprehensive Agrisnet. Several SAUs have established telephone assistance lines.
6. The Bhoomi project, initiated by the Karnataka government, stands out as one of the highly successful public sector projects and is currently being considered for implementation in various other states.

LIMITATION

The effectiveness of digital tools in extension activities assumes that the target audience has access to the necessary technology. Limitations in technology accessibility, such as lack of internet connectivity or outdated devices, may hinder the widespread adoption of digital tools. Individuals and communities may resist the adoption of digital tools due to cultural, social, or psychological factors. This resistance can impact the successful implementation of digital extension activities. Digitalization brings forth concerns related to data security and privacy. The study may not thoroughly address potential risks associated with the collection, storage, and sharing of sensitive information in the context of extension activities. Digital tools may not be tailored to the specific needs and preferences of diverse communities. A one-size-fits-all approach may not effectively address the unique challenges and requirements of different contexts. Legal and regulatory frameworks surrounding digital activities may not be adequately addressed in the study. Changes in regulations or the absence of supportive policies can pose challenges to the seamless integration of digital tools in extension activities.

CONCLUSION

It is essential to recognize that the adoption of new digital technologies revolves around people rather than the technology itself. Therefore, the design and implementation of these technologies should be driven by the needs of individuals. As contemporary digital technologies continue to rapidly evolve and introduce new possibilities almost daily, the modern agricultural professional must also continuously adapt and enhance their skills in utilizing these technologies to support farmers effectively. Providing support and resources to extension practitioners for training in the appropriate use of these next-generation extension tools and media is crucial. The outlook for digital agriculture in India appears promising. The success of digital agriculture in the country will depend on several key factors, including the affordability of technology, ease of access and operation, simple system maintenance, timely grievance resolution, and appropriate policy support. Additionally, robust research and development that addresses ground-level challenges and ensures efficient last-mile delivery are necessary to empower Indian farmers through digital agriculture in a meaningful manner. The availability of digital infrastructure, such as internet connectivity, mobile phone networks, and the affordability of internet services and digital devices, holds significant importance for enabling widespread and continuous adoption of digital technology within the agricultural community. Consequently, the process of establishing digital infrastructure in rural areas might experience delays, consequently postponing the overall digital transformation of the agricultural sector. It is essential for policymakers to prioritize the swift establishment of digital infrastructure in rural regions. Simultaneously, they should promote the growth of AgriTech startups in each Gram Panchayat (GP). This approach will enable farmers to access the advantages of new technology, thereby augmenting their income levels.

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