CHAPTER-22

IMPACT OF DIGITAL TECHNOLOGIES IN AGRICULTURE ON RURAL LIVELIHOOD

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Abstract

Digital technologies are transforming agriculture and significantly improving rural livelihoods. The integration of tools such as mobile applications, the Internet of Things (IoT), artificial intelligence (AI), and satellite-based systems has enabled farmers to adopt more efficient and sustainable farming practices. These technologies provide real-time information on weather forecasts, soil health, pest control, and crop management, helping farmers make informed decisions and reduce risks. One of the major impacts of digital agriculture is increased productivity and income. Precision farming techniques enable the optimal use of resources such as water, fertilisers, and seeds, leading to higher crop yields and reduced costs. Additionally, digital platforms such as e-NAM have improved market access by connecting farmers directly to buyers, ensuring better price transparency and reducing dependency on middlemen. Digital financial services, supported by initiatives like Digital India, have further enhanced rural livelihoods by promoting financial inclusion. Farmers can now access banking services, insurance, and credit facilities through digital means, which were previously difficult to obtain. This has strengthened economic stability in rural areas. Moreover, digital technologies have created new employment opportunities and encouraged skill development among rural youth. Women, in particular, have benefited from increased participation in digital platforms and agricultural activities. The challenges, such as a lack of digital literacy, poor internet connectivity, and high initial costs, still limit widespread adoption. Despite these barriers, the overall impact of digital technologies on agriculture is positive, as they contribute to increased productivity, improved incomes, and sustainable rural development.

Keywords: Digital Agriculture; Rural Livelihood; Smart Farming; Precision Farming; Agri-Tech

1. Introduction

Agriculture in Rural Areas and the Importance of Digital Technologies

Rural economies, like those in India, depend mainly on farming for livelihoods. Agrarian activities, such as crop cultivation and livestock rearing, shape these communities. Most farmers use traditional, labour-intensive methods and rely on natural factors such as rainfall, soil fertility, and weather. These practices have sustained people for years but yield low productivity and can be unreliable. In rural areas, agriculture ensures food security and boosts socio-economic progress. It creates jobs, supports markets, and helps fight poverty(Sarkar et al., 2023) . Yet, farmers face many issues. They often lack timely information, have poor market access, and few financial institutions or good infrastructure. These problems limit their productivity and quality of life. Digital

technologies have recently become powerful tools in agriculture. Tools like mobile apps, IoT, AI, and satellite systems have changed farming. Digital platforms provide real-time weather, crop, pest, and market data, enabling farmers to make better decisions. With online marketplaces and digital payments, rural farmers have more market options and better financial inclusion. Digital tools make agriculture more efficient, less risky, and more productive (Deichmann et al., 2016). They help farmers access knowledge and resources that were previously unavailable. Digital agriculture improves rural development and sustainable livelihoods. These tools help bridge the gap between traditional and modern farming and raise rural living standards.

Objectives of the Study

1. To analyses how digital technologies can enhance agricultural practices and outcomes in rural areas.
2. To determine the impact of digital tools on farmers' income and rural livelihoods.
3. To identify challenges faced by farmers in rural areas who do not utilize digital technologies.
4. To recommend practical actions for increasing the adoption and effective use of digital technologies to create sustainable agriculture.

2. Overview of Digital Technologies in Agriculture

Digital technologies are changing agriculture by adding new tools that improve farming and raise productivity. This shift, called digital agriculture, uses innovative technologies such as mobile apps, IoT, AI, drones, and satellites. These tools help farmers make better choices, lower risks, and use resources wisely. Real-time information is key to digital agriculture. Farmers now use apps and websites that give weather, crop, pest, and market updates. This helps them farm more efficiently and avoid sudden losses from weather or market changes. Quick weather forecasts let farmers know when to plant or harvest, improving yields and cutting losses. The Internet of Things (IoT) uses sensors and smart devices in farming (Gwaka, 2017). IoT tools track soil moisture, temperature, and crop conditions. With this data, farmers use water, fertilizers, and pesticides only when needed. This method, called precision farming, cuts costs and environmental impact. Artificial intelligence (AI) and machine learning are also becoming important. They process large amounts of data to identify patterns and make recommendations. For example, AI can detect crop disease early and suggest treatments. Drones and satellite images monitor fields and spot problems fast. Agriculture has moved from manual work to a tech-driven field. In the past, farmers relied mostly on labour and experience. Now, digital tools make farming smarter, faster, and more productive. As these technologies improve, they will become even more vital for food security and rural livelihoods (Duncan et al., 2021).

3. Research Methodology

Research methodology is the logical procedure that is involved in gathering, examining and interpreting data during a research study. With the help of secondary data, the researcher does not have to collect and publish new data (primary) but he has to use information that has already been collected and published by others. The secondary data may be in the form of books, research articles, government reports, the internet, journals and databases. This kind of data is particularly applicable in conditions of time, cost, or accessibility of respondents. It enables researchers to expand upon the knowledge of previous ones and locate trends, patterns, and relationships without having to go into the field. The secondary data methodology usually starts with specifying the aim

of the research. Subsequently, the identification and evaluation of the relevance, reliability, and accuracy of the data sources are done. The researcher has to make sure that the data is recent and that it will meet the intended study purpose. After collection, data are arranged, analyzed and interpreted to be able to draw meaningful conclusions. A key benefit of secondary data includes resource and time savings. Nevertheless, it also has its limitations. The information might not be exactly what the research requires and there might be some problems of bias or aged data. Secondary research is an effective and feasible method of research, in particular, in exploratory and descriptive research, as long as the data is selected wisely and critically analyzed as shown in the figure 01.

Conceptual Framework Diagram

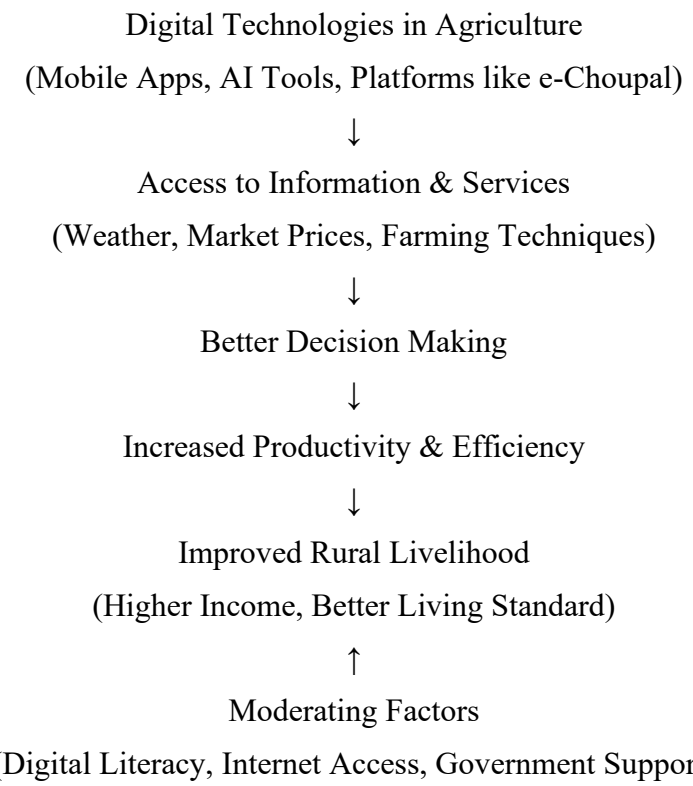

Figure 01: Conceptual Framework of the study: Source: Author Contributions

4. Digital Tools and Evolution of Technology in Farming

The field of digital agriculture includes a variety of tools that enable farmers to become more productive and make better decisions. The most common digital tools are mobile apps, the Internet of Things (IoT), artificial intelligence (AI) and drones. All these technologies make individual contributions to modern farming. One of the most available tools to farmers is mobile applications. Using smartphones, farmers can access information on weather forecasts, crop management, pest control, and market prices (Srivastav & Das, 2025). They can also provide advisory services through such apps to help farmers choose the right seeds, fertilizers, and farming techniques. Mobile applications have proven to be an efficient means of disseminating knowledge and awareness, as mobile phones are common even in villages. The Internet of Things (IoT) is a network of related devices, such as sensors and intelligent devices, employed in agriculture. These machines collect real-time data on soil moisture, temperature, humidity, and crop conditions. The

farmers can use this information to control their irrigation, use fertilizers efficiently, and monitor crop welfare. IoT is used to minimize resource waste and enhance efficiency. Another powerful tool for examining vast quantities of agricultural data is artificial intelligence (AI) (Klerkx et al., 2019). AI systems can predict weather, diagnose crop ailments, and offer suggestions to enhance farming practices. With the help of AI, farmers can make well-informed decisions and minimize the risk of crop failure. The agricultural industry is also becoming dominated by aerial surveillance and field inspections using drones. They can take photos of crops, detect areas of damage, and even spray pesticides and fertilizers (Gaber et al., 2024). This saves time, reduces labour, and properly utilizes the inputs. Over the years, technological advancements in the agricultural field have been tremendous. The ancient mode of agriculture was highly reliant on manual labour and the natural conditions. Farming efficiency was improved through the introduction of machines such as tractors and irrigation systems. Nowadays, digital technologies have put agriculture on a different level and made it more precise and data-driven. Not only has this increased productivity, but it has also made farming more sustainable and profitable for rural communities (Bolfe et al., 2020). It is essential that digital technologies transform the current situation in agriculture and turn it into more efficient, productive, and sustainable. In rural areas, particularly where farmers are often faced with challenges such as limited information, unpredictable weather, and market unavailability, digital tools can help improve overall farming operations. One of the key roles of digital technologies is in precision farming. With sensors, GPS, and data analytics, farmers can monitor soil status, crop health, and water levels with a high degree of accuracy. This allows them to use resources such as water, fertilizers, and pesticides to their full potential, reducing waste and maximizing crop yields. Precision farming is not only less costly but also lessens environmental harm. The other role is to offer real-time information to farmers (Du et al., 2023). Mobile applications and web platforms can be used to get updates on the weather forecasts, pest outbreaks, and market prices. With this information, farmers will be well-positioned to decide when to plant, irrigate, or even harvest their crops. This minimizes the dangers involved in agriculture and helps maximize production. Digital technologies also enhance farmers' access to markets. Digital platforms and online marketplaces allow farmers to deal with buyers directly, without relying on middlemen, and they are assured of better prices for their harvests. This increases their profits and improves the rural economies. Also, financial transactions are quicker, safer and more transparent using digital payment systems. Financial inclusion is also a crucial area that is influenced by digital technologies. Through digital platforms, farmers can now access banking services, loans, and insurance. This helps them invest in more appropriate equipment and manage risks (Qin et al., 2022). Digital systems can also be implemented to deliver government schemes and subsidies directly to farmers, enhancing transparency and curbing corruption. Moreover, AI and other data analytics technologies can be utilized to predict crop diseases, improve farm management, and increase efficiency. They enable farmers to gain knowledge and minimize reliance on traditional guesswork. In conclusion, digital technologies are revolutionizing the agricultural industry by improving decision-making, boosting productivity, and making farmers' lives easier. Their higher utilization is one of the keys to sustainable agricultural growth and the prosperity of rural regions (Pauschinger & Klauser, 2022).

5. Impact on Rural Livelihoods: Increase in Farmers' Income and Employment Opportunities

Digital technologies have brought a range of positive changes to rural livelihoods, particularly by creating additional revenue and new employment opportunities for farmers. Under the traditional agricultural system, farmers faced several challenges, including low yields, limited market access,

and weather conditions. But with the introduction of digital tools, agriculture is more efficient, profitable, and sustainable. One of the major impacts of digital technologies is the increase in farmers' income (Salam et al., 2019). The use of mobile applications and online platforms allows farmers to get real-time market prices, weather forecasts, and new farming practices. This assists them in making better decisions regarding crop selection, planting, watering, and harvesting. Consequently, there is increased crop production and minimized losses. Distributing farmers' products directly to consumers through online markets also means farmers will not be forced to go through middlemen, ensuring prices are fair and just. This immediate market relationship will help farmers increase profits and enhance their financial stability. Additionally, resources can be efficiently managed with the help of IoT and AI technologies. The use of sensors and data analysis will allow farmers to use water, fertilizers, and pesticides only where necessary. This will reduce input costs and increase productivity, boosting revenue (Gabriel & Gandorfer, 2023). Financial security and the ability to invest in better farming equipment and practices are also achieved through access to digital banking, online payments and crop insurance. The new workplaces in the villages have also been brought about by digital technologies. With the growth of digital agriculture, the pool of skilled employees is also growing as they strive to operate and maintain the new digital agriculture equipment, such as drones, sensors, and computer-based systems. Young individuals in rural areas can work as drone operators, data analysts, agricultural advisors, and technicians (Vărzaru, 2025). This helps to control unemployment and migration to towns. Moreover, online media have encouraged the growth of agri-based start-ups and small businesses in rural settings. Some services that have opened new opportunities in entrepreneurship include online trading, farm management, and supply chain logistics. Rural youths are increasingly participating in these activities, which translates into economic development and improved living standards. Furthermore, government initiatives that motivate rural citizens to become digital citizens and learn new skills have made it possible to adopt technologies. This not only increases their chances of employment but also boosts the rural economy. In summary, the use of digital technologies can play a key role in improving rural livelihoods by increasing farmers' incomes and creating employment opportunities (Mushi et al., 2022). This may lead to long-term economic growth, and the livelihoods of rural communities would improve.

6. Improvement in Productivity and Efficiency and Reduction in Risks and Losses

Digital technologies have not only been extremely productive and efficient in agriculture but have also helped reduce the risks and losses incurred by farmers. Conventional agriculture may be extremely low-yielding and high-loss, as evidenced by trial-and-error. However, with modern digital tools, farming has become more accurate, data-driven, and reliable. One of the main methods of enhancing productivity is better farm management, made possible by digital technologies. Some of the tools include sensors, GPS, and mobile applications that provide farmers with real-time information on soil health, soil moisture, and crop conditions. This will help farmers to make timely decisions such as irrigation, fertilizing, and pest control (Mackay & Singh, 2013). This puts the crops in better conditions, hence yielding high-quality produce. It is also more efficient through the use of accurate farming techniques. Farmers can spray water, fertilizers, and pesticides only in the required areas and at the required time, rather than applying them to the entire field. This reduces resource waste and lowers production costs (Vine et al., 2000). It also consumes less time and labour, so farming activities are quicker and more effective. Digital technologies can also be important in mitigating risks and losses. Weather forecasting applications provide accurate and timely information on rainfall, temperature, and extreme weather conditions such as storms or droughts. With this information, farmers can plan their activities in advance and

ensure their crops are not ruined. For example, they can postpone harvesting in the event of heavy rain or implement proactive strategies to protect against frost (Shirali et al., 2018). Moreover, modern technologies such as artificial intelligence can identify crop diseases and pest attacks at the earliest stages. Early detection would help farmers respond on time, prevent disease transmission, and result in minimal crop losses. Large fields and problem areas that might not be visible on the ground can also be tracked with satellite imagery and drones. Through government-provided digital platforms that provide access to crop insurance and support schemes, financial risks are also minimized (Yuasa et al., 2021). Farmers can be compensated for crop failures, thus protecting them against large financial losses. To sum up, digital technologies increase the productivity and efficiency of agriculture while dramatically reducing risks and losses. With their use, farmers can farm more with less, leading to more sustainable and stable farming practices (Zhang et al., 2011).

7. Case Studies

1. **Use of Mobile Apps by Farmers:** The application of mobile applications by farmers is one of the best examples of digital technology in agriculture. Applications such as Kisan Suvidha and AgriApp provide information on weather forecasts, soil health, crop protection, and market prices. To illustrate, in rural India, the majority of farmers check the daily weather report using such applications and then decide whether to irrigate or harvest. This will help them avoid wasting crops in the event of sudden rain or extreme weather. In addition, these apps provide expert advice on pest control and fertilizer use, which improves crop yield and quality. As a result, the farmers will be able to save on costs, increase production, and make better decisions, ultimately increasing their income and livelihood.
2. **Success Stories from Rural Areas:** Rural areas have many success stories of farmers benefiting from digital technologies. As an example, a group of farmers adopted soil-testing apps and digital advisory services in a village. Using the advice from such sites, they could select appropriate crops and apply the appropriate amount of manure. This resulted in a significant increase in the crop yield and income. Another example is that rural youths who have been trained in drone technology began providing crop monitoring and spraying services to farmers in their locality. This not only offered employment but also boosted agriculture in the village. These achievements focus on transforming rural agriculture with the help of digital tools and on improving livelihoods.
3. **e-Choupal (India):** This is among the most renowned ones in India. e-Choupal is a program initiated by ITC Limited and offers internet kiosk to farmers in the villages. Farmers are able to get information about weather, crop prices and best practices in real-time. Impact: Farmers get better prices by selling directly, reducing middlemen. It has raised the levels of awareness and income among rural farmers.
4. **Kisan Suvidha App:** This app, created by the Ministry of Agriculture and Farmers Welfare, can be used to check the weather forecasts, market prices, fertilizers, and pest control. Impact: Assists farmers to make informed choices, enhance productivity and minimize losses.
5. **AgriApp:** It offers professional services, crop advisory, and product recommendations at the local languages. Impact: Technical knowledge will be easily gained by small farmers, improving farm practices and productivity.

8. Challenges in the Adoption of Digital Technologies

Although digital technologies have enormous potential to transform agriculture, their adoption in rural areas is hampered by several challenges. These barriers limit the utility of new technologies and prevent farmers from realizing the full benefits of digital innovations. Among farmers, a lack of digital literacy is a key challenge (Mhlanga & Ndhlovu, 2023). Not all farmers are conversant with smartphones, mobile apps, and internet-based services, particularly among older farmers. They might be unable to comprehend the use of these technologies or reluctant to become dependent on them. This leaves a disparity between the availability of digital tools and their use in farming practices. The other major issue is the lack of internet access in rural areas. The number of villages without high-speed, stable internet connections is significant, as without it, the use of digital platforms, mobile applications, and online services is not possible. In the absence of an appropriate connection, farmers are unable to access real-time information on weather, market prices, or government schemes (Mhlanga & Ndhlovu, 2023). This minimizes the usefulness of digital technologies and puts farmers off using them. The second obstacle is the high costs of digital tools and infrastructure (Hassan & Kumar, 2023). Devices like smartphones, sensors, drones and other high-tech devices may be costly to small and marginal farmers. In addition, maintenance and repair costs add to the financial burden. This implies that a significant proportion of farmers are unable to invest in such technologies even though they are aware of their benefits. Another issue with embracing digital agriculture is resistance to change. It is possible that farmers with years of experience using traditional methods may not readily accept new technologies. They lack trust in electronic systems or fear that such tools are likely to fail or cause losses. Such an attitude is a drag on the adoption of innovation and its spread in rural areas. The absence of effective training and awareness programs is also contributing to the issue (Al-Emran & Griffy-Brown, 2023). Many farmers do not know about the available digital tools or receive inappropriate advice on the tools to use to their advantage. Without the necessary support and education, they may find it hard to incorporate technology into their day-to-day farming operations. In addition, issues such as language barriers, data privacy concerns, and the unavailability of technical support also affect adoption. Many digital platforms cannot be accessed in local languages, so rural people cannot use them. In conclusion, despite the numerous benefits of digital technologies, there are particular threats that prevent them from becoming popular in the agricultural sector (David et al., 2023). It is important to address these concerns through enhanced infrastructure, training, and support systems to ensure that farmers have the opportunity to make the most of digital innovations and improve their livelihoods.

9. Government Policies and Support

The government has a significant role to play in encouraging the adoption of digital technologies in the agricultural sector through various policies and support mechanisms. Such initiatives are meant to modernize farming methods, increase farmers' incomes, and enhance rural livelihoods.

1. The government can help farmers use new technologies by launching digital agriculture programs, providing training and awareness, and offering subsidies and financial aid. One of the key areas of support is digital agriculture initiatives. Other initiatives include the National Agriculture Market (e-NAM), which provides farmers with an online platform to sell their goods to multiple markets at the right price, reducing the number of middlemen involved (Lencucha et al., 2020). Other projects aim to provide real-time information on weather forecasts, soil health, crop advisory services, and pest control through digital platforms and mobile apps. Such efforts make farming more effective and help farmers

make sound decisions. Awareness and training initiatives are also significant in promoting the use of digital technologies.

2. In rural areas, workshops, training, and awareness campaigns are carried out through the government, agricultural institutions and extension services. The programs inform farmers about using smartphones, mobile applications, and other digital tools. They also help farmers realize the benefits of modern technologies, such as precision farming, digital payments, and online markets.
3. The programs will empower farmers to adopt new strategies with confidence to improve their productivity through increasing their digital literacy. Another significant issue of government aid is subsidies and financial aid. Many farmers lack the finances to invest in modern equipment and technologies (Larionova, 2019). To address this issue, the government provides subsidies for the purchase of agricultural machinery, sensors, and other digital technologies. Furthermore, online sources offer cheap borrowing, farm cover, and direct benefit transfer to farmers. With this financial assistance, the economic toll on farmers is reduced, and they will be more likely to invest in advanced farming practices.
4. Governmental plans are also geared towards enhancing rural infrastructure, internet connectivity, and electricity supply, which are significant to digital agriculture. The improved infrastructure means that farmers will not have any problem accessing online services. Lastly, the encouragement of digital agriculture should heavily rely on government policies and support systems. The government assists farmers in overcoming obstacles and adopting new technologies through initiatives, training programs, and financial aid. The outcome of such an activity is greater productivity, higher income, and sustainable rural development.

10. Future Prospects: Emerging Technologies, Rural Development, and Sustainable Agriculture

The future of agriculture is closely linked to the evolution of digital technologies. As the number of innovations continues to grow, new technologies will likely play a crucial role in transforming the lifestyles of rural communities and improving their lives. The developments offer significant opportunities to boost productivity, promote sustainability, and support long-term rural development. One of the most important aspects to consider in future agriculture is the use of emerging technologies. Advanced artificial intelligence (AI), machine learning, robotics, and blockchain are among the innovations likely to transform farming (Obaid et al., 2025). The implementation of AI-based systems will lead to more accurate forecasts of weather and soil and crop conditions, allowing farmers to make better decisions (Khan et al., 2021). Robotics can also be used to automate planting, harvesting, and weeding, and none of these tasks requires manual labour, which can save time. Blockchain technology can increase transparency in the supply chain, ensure equitable pricing, and reduce fraud. Such technologies will simplify the farming process, make it more precise and reliable. Rural development, as well, is given a broad area with the adoption of digital technologies. With agriculture moving towards a more technological base, rural areas will have new opportunities (Jararweh et al., 2023). This will also generate employment opportunities in data analysis, drone services, equipment repairs, and online services, providing jobs for rural youth. This will help reduce urban migration and boost the rural economy. In addition, the increased availability of digital media will allow farmers to have direct access to markets, financial institutions, and government services, thereby enhancing their living conditions.

Another important future prospect is sustainable technology-based agriculture (Prasad et al., 2017). Through digital technologies, farmers can be helped to utilize natural resources more efficiently, with less impact on the environment. Indicatively, precision farming techniques also imply that only water, fertilizers, and pesticides are used as required, thereby reducing waste and pollution. Environmentally-friendly farming practices can also be encouraged through farming that uses environmentally-friendly technologies, such as climate-saving agricultural practices and renewable energy sources, such as solar-powered irrigation systems (Talukder et al., 2025). The approaches contribute to protecting soil, water, and biodiversity, ensuring that agriculture will be fruitful for future generations. Furthermore, greater government understanding and support for digital agriculture will spur more people to embrace these technologies. As infrastructure and digital literacy improve, more farmers will be able to take advantage of new innovations. In conclusion, the outlook for agriculture is excellent as the latest technologies are being adopted. Not only will sustainably practices, new tools and rural opportunities improve the productivity of agriculture, but rural development and environmental protection in the long-run as well.

11. Conclusion

The research underscores the significant role of digital technologies in agriculture and rural life. Agriculture, the backbone of rural economies, is undergoing a major transformation as it integrates new digital technologies. Some of the technologies that have transformed farming into an efficient, productive, and sustainable process include mobile applications, the Internet of Things (IoT), artificial intelligence (AI) and drones. The paper shows that digital technologies play a vital role in improving farmers' incomes through the accessibility of real-time data, improved market opportunities, and better resource management. The farmers are now able to make informed decisions about the type of crop to plant, the amount of irrigation to use, and the timing of harvest, resulting in higher productivity and reduced losses. Secondly, jobs created in rural areas as a result of utilizing the digital platform have also provided new opportunities for the youth, thereby driving overall economic growth. Simultaneously, the research also identifies several issues with adopting digital technologies. Digital illiteracy, being online, the cost of being online, and resistance to change are among the challenges many farmers are grappling with. The challenges show that there is a need for adequate training, sensitization, and improved infrastructure to make digital tools more popular. Digital agriculture has been made easy by the government policies and initiatives. E-NAM and Digital India initiatives, subsidies, and training have helped farmers adapt to modern technologies. These initiatives are critical towards closing the divide between conventional agriculture and modernized agricultural systems. The future of agriculture is bright, with ever-evolving technologies. Not only do the innovations boost productivity, but they also allow sustainable farming and rural development.

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