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Digital Farming and Rural Livelihoods Assessing Economic Growth and Social Transformation

Samir Biswas
Assistant Professor, Department of Sociology, Gazole Mahavidyalaya
Malda, West Bengal, India, Email: samir.biswas08@gmail.com
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Abstract:

Digital farming, often discussed under the labels of smart or precision agriculture, is reshaping agricultural practice through ICT, artificial intelligence, and data-driven decision tools. Drawing on a qualitative review of secondary sources, this study examines how these technologies are affecting rural livelihoods, with particular attention to economic change and social reorganization. The evidence suggests that digital farming can raise productivity and improve efficiency by sharpening resource management, supporting quicker decisions, and expanding access to weather and market information. In practical terms, that often translates into lower input costs, higher farm returns, and a modest but important widening of financial inclusion in rural settings. It also helps some farmers bypass intermediaries and reach markets more directly, which can strengthen their bargaining position. The social effects are more uneven, though still significant. Digital tools can improve access to knowledge, support learning, and create new opportunities for women and other marginalized farmers. At the same time, these gains are constrained by weak infrastructure, limited digital literacy, and the initial cost of adoption, all of which may deepen existing inequalities. The study concludes that digital farming holds real promise, but only under inclusive policy frameworks and sustained investment in infrastructure and capacity building.

Keywords:

Digital farming;
Rural livelihoods;
Economic growth;
Social transformation;
Digital divide

Introduction

Agriculture has long anchored rural economies, not only as a source of food but also as a dense web of employment, household income, and social reproduction. In much of the developing world, rural livelihoods still remain tied to farming in direct or indirect ways. That said, the older assumption that agriculture can absorb mounting pressure with the same tools and habits is increasingly difficult to sustain. Climate variability, soil depletion, price volatility, fragmented market access, and thin financial services have made conventional production systems more vulnerable than they once appeared. The pressure is practical, not abstract. Against this backdrop, digital farming has emerged as more than a technical upgrade. It refers to the growing use of ICT platforms, mobile applications, sensors, remote sensing, artificial intelligence, and connected devices to guide farm decisions in real time. The promise is straightforward enough: better information, more precise input use, and tighter responses to weather, pests, and market conditions. Scholars have rightly noted, however, that digital agriculture is not a neutral intervention. It can improve efficiency and coordination, but it can also reproduce older inequalities when infrastructure is weak, devices are costly, or digital skills are unevenly distributed (Wolfert et al. 2017; Bronson and Knezevic 2016). The literature therefore reads less like a

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celebration than an ongoing debate about who benefits, under what conditions, and at what social cost (Klerkx, Jakku, and Labarthe 2019).

The significance of this shift is especially visible in rural areas where farmers can now check weather forecasts, pest advisories, and market prices from a phone rather than relying entirely on intermediaries. Such changes may appear modest, yet they often reduce uncertainty in ways that matter for smallholders managing narrow margins. At the same time, digital farming is not only altering production. It is also reshaping rural social relations by widening access to knowledge, supporting skill formation, and creating new openings for women and marginal farmers, even if those openings remain uneven and fragile (Rotz et al. 2019; Fielke, Taylor, and Jakku 2020).

This study examines the role of digital farming in transforming rural livelihoods, with particular attention to its economic and social implications. It also considers the frictions that accompany adoption, including affordability, infrastructure gaps, and digital exclusion, since these constraints often determine whether innovation becomes inclusive development or a selective advantage for already better-positioned farmers.

Literature Review

The strongest strand of the literature treats digital farming first as a productivity story. Precision agriculture, remote sensing, and sensor-based irrigation are repeatedly linked to tighter input management, especially for water, fertilizer, and pesticides. Sishodia, Ray, and Singh (2020) show that remote sensing is not merely a monitoring tool; it supports crop diagnosis, yield estimation, and more timely intervention when conditions begin to deteriorate. Choruma et al. (2024) reach a similar conclusion in their review of smallholder digitalisation in sub-Saharan Africa, though they are more cautious about generalisation: the gains are real, but uneven, and often constrained by infrastructure. The literature therefore leans toward a balanced view. Digital farming can raise technical efficiency, yet it does so best where advisory systems, connectivity, and farm-level capacity already exist. In other words, technology alone is not the intervention; the surrounding institutional environment matters just as much.

A second group of studies moves beyond yields and asks whether digital agriculture actually improves incomes. The evidence is increasingly affirmative, although the channels are not identical. In Eastern India, Sharma et al. (2025) report that access to UPI, net banking, and agriculture-related digital services is associated with higher per-acre farm income, but the gains are not distributed evenly. Marginal farmers remain behind, which is an important reminder that digitalisation can widen pre-existing inequalities even when it generates aggregate benefits. Related work on digital finance points in the same direction. Wang, Weng, and Huo (2023) find that digital finance promotes income growth among professional farmers in China, while Su et al. (2021) show that e-commerce participation expands farmers' engagement in digital financial markets, with digital financial literacy playing a mediating role. The implication is fairly clear: market access, payment systems, and financial inclusion are intertwined. Digital platforms may reduce dependence on intermediaries and sharpen price discovery, but their income effects are strongest when farmers can actually use the services with confidence.

The social literature is more attentive to who benefits and who does not. Tsige, Synnevåg, and Aune (2020) demonstrate that gendered constraints shape adoption through credit, extension, land rights, mobility, and training. Their argument is useful because it resists the tendency to treat adoption as a simple matter of attitude or awareness. Choruma et al. (2024) add that limited connectivity, low literacy, weak infrastructure, and affordability problems remain central barriers, especially for smallholders. Taken together, these studies suggest a research gap that is still substantive: many accounts document productivity or income effects, but fewer examine how digital farming reshapes rural social relations, gendered access, and local power structures at the same time. That omission matters, because digital agriculture is not only an economic transition. It is also a social reordering, and the consequences of that reordering are still not fully understood.

Research Methodology

The article adopts a qualitative, document-based design to examine how digital farming intersects with rural livelihoods, especially economic change and social reconfiguration. A descriptive and exploratory orientation is appropriate because the field remains uneven, with relevant evidence dispersed across disciplinary and policy literatures rather than gathered in a single empirical archive (Snyder 2019). The corpus was assembled through a systematic review of peer-reviewed journal articles, government reports, institutional publications, and research monographs on digital agriculture and rural development, with priority given to recent sources and to studies that offered usable conceptual or empirical detail (Tranfield, Denyer, and Smart 2003).

The selected material was then examined through qualitative content analysis, which makes it possible to trace recurring themes without stripping away context or flattening differences between cases (Elo and Kyngäs 2008). Coding focused on productivity, income generation, market access, social empowerment, education, gender relations, and community development, although the reading remained open to more unsettled findings. That mattered, because digital tools do not always translate into broad rural gains. In some settings, they appear to deepen existing inequalities, especially where infrastructure is weak, devices are costly, or digital literacy is limited. Comparative reading across regions was used to identify both recurring patterns and the limits of transferability.

The main limitation is straightforward. Reliance on secondary sources means that the findings depend on the quality, scope, and recency of the available literature, while local variation can easily remain underrepresented. Even so, this approach provides a disciplined way to synthesise dispersed evidence and to map both the promise and the frictions of digital farming in rural settings.

Digital Farming and Economic Growth

Digital farming has come to matter for economic growth not because it replaces agriculture's basic functions, but because it changes how those functions are carried out. The strongest gains usually appear where information was previously thin, delayed, or simply unreliable. Precision agriculture, for example, allows inputs to be applied with more discrimination across space and time, rather than by habit or rough estimate. Gebbers and Adamchuk (2010) link this logic to food security, while later reviews by Wolfert et al. (2017) and Erickson and Lowenberg-DeBoer (2021) suggest that the economic value lies less in any single device than in the coordination of sensors, data, and decision-making. In practical terms, this can mean a farmer in Bihar or northern Ghana irrigates only when moisture data actually justify it, rather than according to a fixed routine. The result is usually higher output per unit of land, water, and fertilizer, though the scale of the effect varies by crop, farm size, and local infrastructure.

Cost reduction is the other side of the same coin. Digital tools do not merely raise yields; they often reduce waste. A soil sensor that prevents unnecessary fertilizer use or an automated irrigation system that avoids overwatering can improve margins in ways that matter a great deal to small producers. This is why the economics of digital farming are often described in terms of efficiency rather than simple technological novelty. Deichmann, Goyal, and Mishra (2016) argue that digital technologies can loosen long-standing information frictions in developing-country agriculture, especially where farmers face high search costs and weak advisory systems. Mobile-based services extend that logic further. Emeana, Trenchard, and Dehnen-Schmutz (2020) show that mobile phone-enabled agricultural services can widen access to agronomic advice and market information, although sustainability remains uneven. There is also some evidence that SMS-based information services generate measurable economic benefits, but the effects are not automatic and tend to depend on real adoption rather than mere availability.

Market access is where the promise of digital farming becomes especially visible. In older market structures, farmers often sold through intermediaries who controlled price information and timing, which left producers with limited bargaining power. Digital marketplaces and price-information services can weaken that

asymmetry, at least in part. Deichmann et al. (2016) note that better information improves market participation, and work on mobile agricultural services shows that even simple phone-based platforms can help farmers check prices, locate buyers, and coordinate sales. That said, the gains are not evenly distributed. Farmers with stronger digital literacy, better network coverage, or closer links to extension systems usually benefit first. Wyche and colleagues' work on Kenyan farmers and MFarm points to a familiar problem: the design of digital systems does not always match the realities of smallholder practice. So, the issue is not whether price transparency matters. It clearly does. The harder question is whether the platform is usable, trusted, and locally relevant enough to change actual transactions.

Digital finance adds another layer. When farmers can access mobile payments, digital credit, or platform-based insurance, they face lower transaction costs and less exposure to liquidity shocks. Wang et al. (2023) find that digital finance supports income growth among professional farmers, while Gao et al. (2022) report positive associations between digital inclusive finance and agricultural green total factor productivity in China. These findings should not be read as a simple celebration of fintech. They point instead to a conditional mechanism: where financial services are accessible, affordable, and linked to productive investment, they can help farmers buy better seed, adopt improved machinery, or absorb climate-related losses without exiting agriculture altogether. In that sense, digital finance supports not only income but also continuity. It makes farming a little less fragile.

Even so, the broader literature is cautious, and rightly so. Digital agriculture does not distribute benefits automatically. Choruma et al. (2024) and Dibbern et al. (2024) point to persistent barriers such as poor connectivity, weak infrastructure, cost, and limited digital literacy. This matters because the economic upside of digital farming tends to concentrate where farms are already relatively well connected. The more marginal the farm, the less certain the payoff. A realistic assessment, then, is neither celebratory nor dismissive. Digital farming can raise productivity, reduce costs, strengthen market participation, and support rural incomes, but only under conditions that make technology usable in everyday agricultural life. Without that, the benefits remain partial, and sometimes quite modest.

Social Transformation in Rural Areas

Digital farming is often discussed as a matter of productivity, but that framing is too narrow. In rural settings, its social effects are just as consequential. The spread of mobile advisory services, platform-based market information, and data-driven extension has altered who knows what, who speaks to whom, and who can act with some confidence in daily farm decisions. A farmer checking rainfall forecasts before applying fertilizer, or comparing mandi prices on a phone rather than relying on a broker, is not merely using a new tool. That farmer is also shifting away from older dependencies that once structured rural life more tightly. Studies of digital agriculture repeatedly note that the most visible gains lie in access to information and increased knowledge, even if the longer-term social effects are more uneven and less settled than advocates sometimes suggest (Porciello et al. 2022; Emeana, Trenchard, and Dehnen-Schmutz 2020).

Education and skill formation are another part of the story. Digital farming creates pressure for new competencies, from basic smartphone use to interpreting advisory messages and navigating e-extension services. That matters because rural learning is no longer confined to the village school, the cooperative meeting, or the occasional visit from an extension worker. Younger farmers, in particular, are increasingly drawn into agri-tech work, digital marketing, and advisory services, which can broaden rural career horizons without fully severing ties to agriculture. Yet this is not a simple narrative of modernization. Rural youth may gain new options, but they also confront a more competitive economy in which digital literacy becomes a gatekeeping skill rather than a neutral asset (Daum, Zuazo, and Birner 2022; Rijswijk et al. 2021).

The gender dimension deserves separate attention because digital farming can widen opportunity while leaving older hierarchies intact. Evidence from rural Bangladesh and Kerala suggests that mobile technology can strengthen women's economic, social, and even political agency by improving access to information, markets,

and financial services (Rahman et al. 2023; Udisha and Ambily Philomina 2024). In practical terms, this may mean a woman farmer receiving price updates directly, joining a WhatsApp crop group, or applying for a scheme without asking a male intermediary to speak on her behalf. Still, the gains are not automatic. Social norms, handset ownership, literacy, and time poverty continue to shape who benefits and who remains peripheral. Hackfort's caution is useful here: digital agriculture can reproduce existing inequalities as easily as it can reduce them, especially where access is mediated by class, gender, and control over data or infrastructure (Hackfort 2021).

Rural social structure is also changing in subtler ways. Traditional authority figures such as middlemen, local input dealers, and informal advisers have not disappeared, but their monopoly over information is weaker than it once was. Farmers can now compare recommendations, cross-check prices, and contact institutions directly, which tends to make decision-making more decentralized and, in some cases, more transparent. That shift may sound benign, even inevitable, yet the literature on digital transformation in agriculture warns against romanticizing it. Digital systems require infrastructure, maintenance, and institutional trust; without these, the same technologies can deepen exclusion and leave smallholders exposed to market volatility or platform dependence (Rijswijk et al. 2021; Porciello et al. 2022).

The main constraint remains the digital divide. Older farmers, poorer households, and villages with weak connectivity often receive the least benefit from the very systems meant to democratize access. In that sense, digital farming is not a clean break with rural inequality. It is better understood as a contested field in which new forms of inclusion coexist with fresh asymmetries in skills, access, and power. The social transformation underway is real, but it is uneven, and sometimes uncomfortable. Rural life is becoming more connected, yes, though not equally so, and not without friction (Hackfort 2021; Daum, Zuazo, and Birner 2022).

Discussion

Drawing on the article's review of secondary evidence, the central pattern is fairly clear: digital farming is less a single technological advance than a bundle of changes that reorganises how information, risk, and market power circulate in rural life. The economic gains are real, but they are also conditional. Where connectivity, advisory systems, and financial services are reasonably in place, digital tools can sharpen input use, improve timing, and reduce waste. That logic runs through the precision agriculture literature, from the early optimism around data-enabled resource management to more recent reviews that stress integration rather than gadgets alone (Gebbers and Adamchuk 2010; Wolfert et al. 2017). The present discussion fits that line of argument, but with an important caveat: efficiency gains do not automatically translate into broad-based rural development. They often remain concentrated among farmers who already have stronger access to phones, networks, and institutional support.

That point matters because the economic literature is sometimes read too quickly as a story of productivity alone. Deichmann, Goyal, and Mishra (2016) are persuasive in showing how digital technologies reduce long-standing information frictions in developing-country agriculture, yet the gains they describe depend on usability and scale. The same is true of mobile-based advisory and financial services. Studies such as Sharma et al. (2025) and Wang et al. (2023) suggest that digital finance and service access can raise farm income, but these effects are uneven and often strongest among commercially positioned or better-connected farmers. In other words, digitalisation does not replace structural inequality with technical neutrality. It merely changes the form through which advantage is accumulated. That is a more sober conclusion than the celebratory language often attached to agri-tech, and probably a more defensible one.

The social consequences are equally important, though they are harder to measure neatly. One of the more useful insights in the literature is that digital farming alters rural social relations by redistributing information. Farmers who once depended on brokers, input dealers, or informal advisers can now compare prices, consult weather alerts, and access extension messages directly. This does not eliminate intermediaries, but it weakens their monopoly. Porciello et al. (2022) and Emeana, Trenchard, and Dehnen-Schmutz (2020) both show that

mobile services can widen access to knowledge, while Rijswijk et al. (2021) remind readers that such systems also impose new responsibilities on users, who must now interpret, verify, and act on digital advice. The shift is subtle, yet significant. Rural life becomes more connected, but also more dependent on new forms of competence.

Gender relations deserve particular attention here. The literature reviewed in the article points to genuine gains for women farmers, especially where mobile technologies improve access to market information, services, and financial tools. Rahman et al. (2023) and Udisha and Philomina (2024) present a strong case that phones can support women's agency in both economic and social terms. Still, the more cautious work should not be ignored. Tsige, Synnevåg, and Aune (2020) show that adoption is shaped by credit, land rights, mobility, and training, not simply by enthusiasm or willingness. Hackfort's (2021) systematic review makes a similar point in broader terms: digital agriculture can reproduce existing hierarchies as easily as it can soften them. That tension is central. A woman may have access to a phone and still lack the time, literacy, or household authority to use it effectively.

The broader implication is that digital farming should be understood as a contested rural transformation rather than a straightforward development fix. Its promise is genuine. It can reduce transaction costs, strengthen market participation, and support more resilient farm management. Yet the barriers identified across the literature, poor connectivity, upfront costs, limited digital literacy, and weak institutional support, are not marginal inconveniences. They are the very conditions that decide who benefits and who is left behind (Choruma et al. 2024; Daum, Zuazo, and Birner 2022). The practical lesson is therefore less about more technology in the abstract and more about the social organisation around it. Without public investment, locally relevant design, and serious attention to unequal access, digital farming will remain selective in its effects. With those supports, it can contribute not only to higher productivity, but to a more inclusive rural economy.

Conclusion

Digital farming is no longer a speculative add-on to rural development; it has become part of the practical terrain through which agricultural economies are being reorganised. The review suggests that its most immediate contribution lies in reducing uncertainty. Better weather information, more precise input use, faster market access, and digital payment systems can improve productivity and lower transaction costs, especially for smallholders operating under tight margins. In that sense, the economic case for digital farming is strong, but it is also conditional. The gains tend to appear where connectivity is stable, advisory systems are usable, and farmers possess enough digital competence to make the tools work in everyday life. Without those conditions, the promised efficiency remains partial and uneven.

The social implications are just as important, perhaps more so. Digital farming can widen access to knowledge, strengthen bargaining power, and create new openings for women and younger farmers. Yet it can also sharpen older inequalities when access to devices, literacy, land, and infrastructure is uneven. That tension runs through the literature and cannot be dismissed as a temporary adjustment problem. It is structural. Rural transformation through technology therefore needs to be read not only as innovation, but as a reallocation of advantage, responsibility, and voice.

A realistic policy response must move beyond enthusiasm for digitisation as such. Public investment in rural connectivity, affordable devices, vernacular platforms, extension support, and targeted capacity building is essential if digital farming is to serve inclusive development rather than deepen selective benefits. The broader lesson is fairly plain: technology can help rural livelihoods, but only when institutions, skills, and access are built around it with some seriousness. That is where the actual challenge lies.

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