The Economic Impacts of Digital Agriculture Apps in Developing Countries: Focus on India, Bangladesh, Nepal, and Sri Lanka.

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Abstract

Digital agriculture applications are transforming agricultural practices across South Asia, providing smallholder farmers with unprecedented access to agronomic, extension, advisory, market, weather, financial, and input services through a range of mobile apps offered by public and private organizations. This research paper examines the economic impacts of digital agriculture apps in India, Bangladesh, Nepal, and Sri Lanka, synthesizing evidence from experimental studies, meta-analyses, and platform evaluations. Findings reveal significant positive impacts: digital interventions increase crop yields by 2-21%, boost farmer incomes by 6-29%, and enhance input adoption rates by 2-23%. However, adoption remains constrained by infrastructure gaps, digital literacy barriers, and socioeconomic factors. India has the most advanced agritech ecosystem, with platforms like DeHaat and AgroStar serving millions of farmers, while Bangladesh, Nepal, and Sri Lanka show emerging but promising digital agriculture landscapes. The study recommends targeted policy interventions, including expanding digital infrastructure, developing localized content, and adopting hybrid digital-physical extension models to maximize economic benefits for smallholder farmers.

Keywords: Digital agriculture, mobile apps, smallholder farmers, South Asia, agricultural productivity, economic impact, technology adoption,

1. Introduction

Agriculture remains the backbone of South Asian economies, employing 40 to 60 percent of the population and contributing significantly to GDP in countries like India, Bangladesh, Nepal, and Sri Lanka. As noted by the World Economic Forum (2024) and Virginia Tech News (2024), the sector is crucial for regional stability and growth. However, it faces ongoing challenges, including low productivity, limited extension services, information gaps between farmers and providers, and vulnerability to climate change, as reported by the Nepal Economic Forum (2025) and McKinsey (2023). Traditional extension systems, hindered by funding, reach, and outdated methods, now serve only a small portion of over 150 million smallholder farmers, many lacking access to timely, personalized advice to improve yields and livelihoods. Addressing these gaps requires expanded global training and capacity-building, leveraging technology to reach underserved farmers and promote sustainable, resilient farming practices (S. Madan et al., 2022).

Mobile technology's rapid growth offers key opportunities for agricultural development. In South Asia, mobile subscriptions increased from 12 per 100 people in 2000 to over 100 in 2022, enabling digital interventions that improve productivity and access (Silicon India, 202; Forbes, 2024). Studies show that ICT use for real-time price info boosted incomes by an average of 36% in developing countries (Halewood and Surya, 2012), and mobile phones reduced price volatility and waste among fishermen in Kerala, raising earnings (Jensen, 2007).

Despite increased investments in agritech, its full economic impact remains unclear. India alone received about $1.7 billion in agritech funding from 2014 to 2019 (Boston Consulting Group, 2025). Critical questions persist: how much do digital tools raise incomes and productivity? Which interventions have the greatest effects? And what are the barriers for resource-poor smallholders? Addressing these is key to realizing agritech's potential across South Asian farming communities. This research paper addresses these gaps by synthesizing quantitative evidence on the economic impacts of digital agriculture apps across four South Asian countries: India, Bangladesh, Nepal, and Sri Lanka. The study examines yield improvements, income effects, adoption patterns, and implementation barriers, and provides policy-relevant insights for scaling digital agriculture interventions.

Literature Review

1.1 Theoretical Foundations: ICTs and Agricultural Development

Extension, community outreach, and advisory services are vital for spreading new knowledge and technologies to farmers and end users. Globally, governments, private sector entities, and international development agencies have allocated substantial resources to strengthen agricultural extension systems, acknowledging their key role in enhancing productivity and sustainability (Sunil Madan & Karim Maredia, 2021; Cudney et al., 2019). Digital agriculture interventions aim to reduce information asymmetries and lower transaction costs that hinder smallholder farmers' ability to optimize productivity and market engagement (IWMI, 2025; IPMI, 2022; GeoKrishi, 2017). ICTs like mobile phones and digital platforms can significantly reduce communication costs, streamline information flow, and boost market efficiency by facilitating faster data dissemination, encouraging innovative practices, and fostering economic growth (Invest India 2025; Alliance for Financial Inclusion 2025; Babl AI 2025). Mobile phones are particularly accessible and widely used, especially in developing regions, improving market access, farm productivity, and income, as evidenced by studies and pilot projects such as Cropwise Grower Bangladesh 2025, Nesta (2017), and Rajkhowa & Qaim (2021). As digital agriculture advances, integrating these tools with traditional extension services can accelerate rural development, resilience, and food security.

Adoption of digital apps by Farmer-Producer Companies (FPCs) in India, Kerala, is linked to better sustainability and profits, with larger, older FPCs showing higher adoption rates, facilitated by digital literacy and training (Sudha et al., 2024). In Nepal, digital advisory tools for conservation agriculture and pest management improved yields and reduced labor and pesticide use (Paudel et al., 2020). Similar benefits are suggested in Bangladesh and Sri Lanka, despite limited data (Panwar et al., 2025). Traditional extension services, while valuable, face limitations like restricted outreach, standardized advice that may not suit diverse farming conditions, and high costs that hinder scalability (McKinsey, 2023; Chowdhary et al., 2025). Digital platforms address these issues by offering personalized, site-specific recommendations based on weather, soil, pests, and market data, utilizing predictive analytics and machine learning to generate relevant insights. This approach enhances precision, reduces costs, and increases farmers' access, making extension more effective and inclusive (Md. Mahmud et al., 2025; DFC, 2024; Silicon India, 2024).

1.2 Digital Agriculture Modalities and Mechanisms

Digital agricultural interventions utilize various methods, each with unique costs and effectiveness. SMS and Voice Messaging: Text and IVR systems deliver information via basic phones. Meta-analyses show SMS extension boosts fertilizer use, with mixed yield results (Silicon India, 2024; UNCD, 2023). Voice messaging is effective in low-literacy areas (IPMIL, 2022; Amjed Babu et al., 2024; IFPRI, 2024). Smartphone apps provide pest diagnosis using AI, weather, market prices, and input platforms (Virginia Tech News, 2024; IPMI, 2022; Nesta 2017; USDFC, 2024). For example, Plantix in Bangladesh diagnoses 400+ crop issues via photos and offers treatment advice. Training videos via tablets or phones increase technology adoption. Meta-analyses find video extension raises fertilizer use by 24% (Silicon India, 2024).

Digital Green's locally produced videos with in-person facilitation cut costs by 90% compared to traditional methods (Silicon India, 2024). Platforms like India's DeHaat and AgroStar combine advice, inputs, credit, and market access, using AI for crop-specific guidance and direct marketing (FAO, 2021, 2024; Just Climate, 2025; USDFC, 2024).

1.3 Evidence on Economic Impacts: Meta-Analyses and Systematic Reviews

Recent meta-analyses estimate digital agriculture impacts. Beach et al. (2025) reviewed 20 studies in Africa, India, and Cambodia, finding digital info increases fertilizer use by 23%, yields by 6%, and income by 6% (Silicon India 2024). While effects vary, some exceed 40%, highlighting the need for context-specific design. Gouroubera et al. (2025) analyzed 18 studies with 10,757 farmers across 12 countries on mobile phone-based tech scaling. They found: mobile phones alone boost adoption by 2%, combined methods by 17%, with yields up 2%, profits up 5%, and learning outcomes up 3% (Forbes 2024). Digital tech works best with in-person support rather than replacing traditional extension (Forbes 2024; Nepal Economic Forum, 2025).

1.4 Personalized Digital Extension Services

A key distinction exists between generic information dissemination and personalized agricultural advice tailored to individual farm conditions. Rajkhowa and Qaim (2021) examined India's Farmex platform, which offers site-specific recommendations on crop selection, input regimes, and timing based on farm-level data such as location, soil conditions, and historical performance. Using propensity score matching with 1,028 farmers in Odisha, the study found that adopters of personalized digital extension achieved 25-29% higher crop incomes, 18% higher productivity, 15-20% higher input intensity, and greater production diversity and commercialization (BSMIAB 2025). These impacts far exceed those reported for generic digital interventions, indicating that personalization—enabled by data integration and algorithms—may be key to maximizing economic returns (BSMIAB, 2025; USDFC, 2024).

1.5 Cost-Effectiveness and Scaling Challenges

Digital extension offers significant cost benefits over traditional methods, with benefit-cost ratios of 3:1 to 10:1 (Silicon India 2024; World Bank 2024). Digital Green's video extension costs $3-6 per farmer, versus higher traditional costs, and mobile advisories cost as low as $1 per farmer yearly (World Bank 2024). However, scaling digital impact remains tough: fewer than 15 solutions in Sub-Saharan Africa have over 1 million users, with only 15-30% active, and growth slowed from 33% (2012-2018) to 9% (2018-2022). Over 150 million smallholder farmers lack digital services despite investments (World Bank 2024).

1.6 Adoption Drivers and Barriers

Meta-analyses identify key drivers of digital agriculture adoption. Demographic factors: younger farmers have higher adoption rates (odds ratio = -0.0365 for age), while male farmers adopt 0.103 times more often than females (Forbes 2024). Education and digital literacy predict adoption (Forbes 2024; Nepal Economic Forum 2025; Swiss Contact 2024). Socioeconomic factors such as, Asset ownership, full-time farming (OR = 0.0197), and farmer organization membership (OR = 0.321) increase adoption (Forbes 2024). In developed economies, larger farms show lower adoption, possibly due to complexity or opportunity costs (Forbes 2024). Digital factors such as Digital skills (OR=1.15), IoT ownership (OR=0.497), and innovativeness (OR=0.299) predict adoption, emphasizing the digital divide (Forbes 2024; Nepal Economic Forum 2025). Infrastructure barriers like poor mobile coverage, unreliable electricity, and high data costs limit access, especially in remote areas (CIMMYT, 2024; Nepal Economic Forum 2025). In Nepal, 98% have mobile broadband, but only 54% use the internet regularly (Nepal Economic Forum 2025). Information and trust barriers: Farmers need demonstrations and are hindered by low awareness, language barriers (most apps in major languages), and distrust of digital platforms (CIMMYT, 2024; Nepal Economic Forum, 2025; AgFunder, 2024).

1.7 Gender and Inclusion Dimensions

Digital agriculture interventions risk exacerbating existing inequalities. Women farmers, who make up 58% of Bangladesh's agricultural labor force, face disproportionate barriers, including lower digital literacy, limited device ownership, and cultural norms that limit access to technology (FAO, 2021, 2023; Mulungu, K. et al., 2025). Several studies document lower female adoption rates (Forbes 2024; Swiss Connect 2024), though some interventions have successfully addressed gender gaps through targeted design features, such as voice-based interfaces and women-specific content (Mulungu, K. et al., 2025; FAO 2023).

1.8 Regional Context: South Asia

South Asia presents a distinctive digital agriculture landscape. India leads the region with a mature agritech ecosystem comprising over 450 startups, extensive government digital infrastructure initiatives (Digital Agriculture Mission, AgriStack), and significant private capital investment. Bangladesh has developed numerous mobile-based advisory platforms but faces implementation challenges related to connectivity and farmer capacity (Plantwise 2025; Raissa Fabregas et al., 2019). Nepal's digital agriculture sector remains nascent, dominated by technology replication rather than indigenous innovation, and farmers' awareness of available tools remains limited (Nepal Economic Forum, 2025). Sri Lanka has made notable progress through government-led platforms like GeoGoviya, which integrates geospatial data with farmer registries to deliver climate-smart advisories (IWMI, 2025; Market Development Facility, 2024).

2. Methodology

This research employs a systematic evidence synthesis of data from diverse sources to analyze digital agriculture's impacts across South Asia.

2.1 Literature Search and Selection

A systematic search in academic databases (Web of Science, Scopus, PubMed Central, Google Scholar) and repositories (World Bank, FAO, IFPRI) used keywords like "digital agriculture," "mobile apps," "agritech," "ICT agriculture," "smallholder farmers," "South Asia," "India," "Bangladesh," "Nepal," and "Sri Lanka," combined with terms like "impact," "adoption," "income," "yield," "productivity," and "economic effects."

Results yielded over 130 publications from 2005-2025, screened based on criteria:

- Empirical, quantitative impact studies
- Experimental or rigorous observational designs
- Focus on smallholders in South Asia or similar contexts
- Peer-reviewed or reputable grey literature

2.2 Data Extraction and Synthesis

Data collected included study design, sample size, location, intervention details, outcomes, effect sizes, and contextual factors. A narrative synthesis was used due to heterogeneity, prioritizing meta-analytic estimates where available.

2.3 Country Case Analysis

Profiles for India, Bangladesh, Nepal, and Sri Lanka covered digital platforms, government initiatives, economic impacts, adoption barriers, and ecosystem maturity.

2.4 Limitations

Data reliance on published sources may cause bias toward positive results. Cross-sectional studies can't establish causality. Variability in outcome measures complicates comparisons. Limited rigorous evaluations, notably in Nepal and Sri Lanka, restrict detailed analysis.

3. Results

3.1 Aggregate Economic Impacts: Meta-Analytic Evidence

3.1.1 Income and Profitability Effects

Digital agriculture consistently boosts farmer income and profitability, with effects varying by intervention and context. Meta-analysis of 20 studies in Sub-Saharan Africa, India, and Cambodia shows digital info increases income by 6% (95% CI: +2% to +9%) (Silicon India 2024). For price received, studies report 5% gains; for net income, 9% (Silicon India 2024). Digital tools improve market info and production decisions, boosting profits. Platform-specific studies in India show higher effects. Rajkhowa and Qaim (2021) found Farmex increased crop incomes by 25-29%, robust across analyses (BSMIAB, 2025), with estimates reaching 40%. These effects reflect Farmex's comprehensive services—crop advice, input recommendations, and market links—more than single-component efforts. Mobile phone-based profit data show a 5% increase, consistent across studies (I^2=0%) (Forbes 2024). The AI chili farming project in India doubled incomes to
$800 per acre per cycle (World Economic Forum 2024). AgroStar users report a 53% reduction in cultivation costs and higher yields, boosting net margins (IFPRI, 2024; Just Climate, 2025).

3.1.2 Yield and Productivity Improvements

Digital agriculture improves crop yields by an average of 6%, with some studies reporting negative or insignificant effects, while top performers see gains of 39-68% (Silicon India 2024). Mobile-based scaling adds 2%, with platforms like India's Farmex increasing productivity by 18% and AI advisory services in Khammam boosting yields by 21% (BSMIAB,2025; World Economic Forum,
2024). Bangladesh's Shufola app led to 17% higher yields, and Ethiopia and India experienced 18-39% improvements via Digital Green videos (IFPRI, 2024; Silicon India 2024). Gains are highest when advisories target specific practices such as optimized nutrient management (rice, wheat, sugarcane), pest/disease control through diagnostics, climate-informed planting, and precision irrigation (USDFC, 2024; Silicon India 2024; IPMI Lab, 2022; IFPRI, 2024; Forbes, 2024; IWMI,
2025; Market Development Facility, 2024).

3.1.3 Technology and Input Adoption

Digital interventions enhance adoption of agricultural practices. A meta-analysis shows fertilizer use increases by 23% (95% CI: +6% to +40%), despite high heterogeneity across intervention types and contexts (Silicon India 2024). Video-based extension has strong effects, with five studies reporting a 24% increase (95% CI: +14% to +33%). Seed adoption rises by 11%, but the confidence interval (-6% to +28%) includes zero, indicating statistical insignificance, possibly due to higher costs and perceived risks compared to fertilizers. Scaling mobile phone tech alone increases adoption by 2%, rising to 17% when combined with traditional methods, showing the benefit of integrated models. Digital tech enhances, not replaces, human extension agents. Specific outcomes include: Bangladesh's Shufola app: 75% of users applied at least one advisory; weather forecasts (58%) and pesticide guidance (58%) most common (IFPRI, 2024). India's AI platform: farmers adopting pest management practices at rates 42-68% higher than controls (Silicon India 2024).

3.1.4 Learning Outcomes and Farmer Capacity

Beyond production impacts, digital agriculture boosts farmers' knowledge, skills, and efficiency. A meta-analysis of three studies finds that mobile advisory services increase learning outcomes by 3%, improving agronomic literacy, technical efficiency, and technology skills (Forbes 2024). These effects have long-term benefits, enabling continued productivity and adoption of new innovations. Digital Green's video-based extension model emphasizes learning through locally made, context-specific videos and community discussions, leading to measurable knowledge gains (Silicon India 2024; World Bank 2024).

3.2 Country-Specific Analysis

3.2.1 India: Leading Agritech Ecosystem

India has built South Asia's most advanced digital agriculture ecosystem, backed by private investment, government support, and large platform operations. DeHaat, founded in 2012, serves 1.8 million farmers across 12 states via 11,000+ micro-entrepreneur centers and 503 Farmer Producer Organizations (FPOs) (FAO, 2021, 2023). It offers AI crop advice for 30+ crops in regional languages, connects farmers to inputs, markets, and finance, and achieved ₹3,000 crore (~$360 million) revenue in FY2025, becoming profitable in Q1 FY2026 (FAO, 2023; The Economic Times, 2025). Its hybrid model uses satellite imagery, weather data, soil profiles, and pest records to customize recommendations along with field agents for last-mile delivery (DeHaat). AgroStar, founded in 2013, reaches over 10 million farmers through 10,000+ retail stores and digital platforms, providing real-time agronomic advice and over 200 inputs, including climate-smart seeds and fertilizers. Impact surveys show 81% increased production and 53% reduced costs. In FY2025, AgroStar saved 276 billion liters of water and avoided 120,000+ tonnes of CO_2 (Agrostar). India's agritech sector attracted $1.7 billion from 2014-2019, with 450+ startups offering advisory, input supply, marketing, and fintech services (McKinsey, 2023). Government initiatives like the Digital Agriculture Mission and AgriStack are creating digital farmer identities, digitizing land records, and building data infrastructure for precision farming (Abdus Salaam Seat & Shaun Pather, 2023). Over $750 million has been allocated to establish 10,000+ Farmer Producer Organizations as digital service hubs (McKinsey, 2023). McKinsey estimates a mature sector could raise farmers' incomes by 25-35% and add $95 billion to the economy through lower costs, higher productivity, better prices, easier credit, and alternative income streams.

3.2.2 Bangladesh: Emerging Mobile Advisory Landscape

Bangladesh's digital agriculture sector emphasizes mobile-based advisory services that address crop and livestock management challenges faced by smallholder farmers. Plantix, an AI app by PEAT GmbH tested with USAID's Feed the Future Bangladesh Digital Agriculture Activity, offers farmers crop diagnostics and treatment advice. It uses machine learning to identify over 400 crop issues across 60 species from user photos, providing instant pest, disease, and nutrition tips (IPMIB 2022). Users choose language, location, crops, and conditions for tailored water, light, pesticide, and fertilizer guidance. The app also monitors weather, alerting on rainfall, temperature, and environmental changes relevant to crops (IPMIB 2022). The Khamari app by Bangladesh Agricultural Research Council (BARC) offers site-specific crop and fertilizer recommendations aligned with Bangladesh's Crop Zoning System (Chowdhury et al. 2025). It guides farmers on suitable crops and balanced fertilizers for sustainable farming. iFarmer connects small farmers with inputs via partnerships, offering loans, inputs, and advice through mobile platforms suited forlow digital literacy (Alliance For Financial Inclusion 2025; UNCDF, 2023). Shufola, by Power Social, provides localized, actionable advice via mobile. In a mung bean pilot, 75% of farmers used at least one service, with weather forecasts (58%) and pesticide guidance (58%) most popular. Farmers saw a 17% yield increase to 0.84 tons/ha, mainly due to Shufola's advice (IFPRI, 2024). Bangladesh's Department of Agricultural Extension (DAE), with about 14,000 workers for 16.5 million smallholders, faces capacity issues—over 1,000 farmers per agent—addressed by digital solutions (IFPRI, 2024). Rural connectivity remains a challenge; a 2025 study showed farmers couldn't upload images or stream advice due to network issues (Plant wise 2025). Bangladesh combines digital advisories with microinsurance; since 2017, the Bangladesh Micro Insurance Market Development Project offers index-based crop insurance and voice advisory services. Insured farmers receive weekly weather forecasts and advice via calls, which is more effective given 75% literacy. These advisories enable timely actions, like delaying fertilizer before rain (Beach R.H. et al 2025).

3.2.3 Nepal: Early-Stage Digital Agriculture Development

Nepal's digital agriculture sector is in early stages, with domestic startups guided by development partners. GeoKrishi offers farmers crop and pest info via an app, connecting markets and aiding farmers with limited education, who see it as a helpful 'friend' (GeoKrishi, 2017). Startups like Smart Krishi provide digital tools such as online markets, satellite advice, and farm monitoring, often replicating foreign tech rather than developing local innovations. The government emphasizes digital agriculture through policies like the Digital Nepal Strategy and the National Agriculture Development Strategy 2035. Digital infrastructure includes soil maps, weather alerts, and early warnings, supported by partners (Nepal Economic Forum, 2025). The draft Digital Agriculture Strategy seeks systematic transformation but faces capacity limits (CIMMYT, 2024). USAID's NSAF invests in IoT, data analytics, and remote sensing projects. The 2024 Digital Agriculture Forum advises stakeholder collaboration, local government leadership, and diverse information formats for varying literacy levels. Despite 98% mobile coverage, only 54% of Nepalese regularly use the internet, limiting digital tool adoption (Nepal Economic Forum, 2025). Farmers have low awareness and capacity to access or operate digital solutions, hindered by low education, language barriers, and poor connectivity. Most digital tools are only in Nepali and English, excluding other languages, and lack localized content for regional practices, reducing relevance and engagement.

3.2.4 Sri Lanka: Government-Led Digital Agriculture Transformation

Sri Lanka has pursued systematic development of digital agriculture through government-led platforms that integrate geospatial technology, farmer registries, and climate services. The GeoGoviya Smart Farming Platform, launched in 2022 by Sri Lanka's Department of Agrarian Development, IWMI, and Unmiti Pvt. Ltd., is the country's leading digital agriculture project (IWMI, 2025). It integrates climate services, geospatial analytics, and smart farming tools, providing real-time data on weather, land use, soil, crop health, and water (IWMI, 2025). The database includes 1.82 million paddy land records and 1.42 million farmers, supporting Cultivate, which offers tailored agro-climate advice based on recommendations from Sri Lanka's National Agriculture Information and Communication Centre (IWMI, 2025). It features drought monitoring, early warning systems via SADMS, land-use and soil assessments, and customized guidance on irrigation, pests, and fertilizer for smallholders with limited digital skills (IWMI, 2025). Despite progress, adoption constraints persist. Only about 35% of Sri Lankan farmers use smartphones, limiting access to advanced app features (Market Development Facility, 2024; Asian Development Bank, 2025). Low digital literacy calls for simplified interfaces and voice options (Asian Development Bank, 2025). Infrastructure gaps, like unreliable electricity and weak network coverage, also hinder platform use (Asian Development Bank, 2025).

3.3 Comparative Analysis across Countries

3.3.1 Ecosystem Maturity

India's digital agriculture ecosystem in South Asia is highly developed, with over 450 agritech startups, $1.7 billion in investment (2014-2019), platforms serving millions (DeHaat: 1.8M, AgroStar: 10M), government initiatives like AgriStack and Digital Agriculture Mission, and hybrid models combining digital and physical networks. Bangladesh's ecosystem development centers on mobile advisory services, featuring app-based platforms like Plantix diagnostics, Khamari recommendations, iFarmer market access. Supported by government initiatives (BARC, DAE) and donor pilots, it shows proof-of-concept. While private capital is limited compared to India, startup activity is growing. Nepal shows early development with emerging platforms like GeoKrishi and Smart Krishi, mainly copying foreign tech. Policies support digitization, but reliance on partners like USAID, FCDO, UNCDF is high. Farmers have limited awareness and adoption. Sri Lanka's government-led model includes large-scale platforms like GeoGoviya with detailed farmer data, geospatial tech and climate services, public-private partnerships like Dialog's Govi Mithuru, and strategic frameworks like IDAT for systematic transformation.

3.3.2 Digital Infrastructure and Enablers

Mobile penetration exceeds 90% across all four countries, but smartphone adoption and internet use vary. India leads in rural connectivity and 4G/5G coverage, driven by competitive markets reducing data costs

(McKinsey 2023; Syracuse University 2025). Bangladesh has strong mobile ownership but connectivity issues in remote areas (Plantwise 2025; Raissa Fabregas et al. 2019). Nepal has high broadband availability (98%) but low internet use (54%), indicating a gap (Nepal Economic Forum, 2024). Sri Lanka's ~35% smartphone penetration among farmers limits app access (Market Development Facility, 2024).

3.3.3 Business Models and Sustainability

Indian platforms like DeHaat and AgroStar demonstrate sustainable revenue models through input margins, processing fees, and B2B services, serving millions of smallholders. In contrast, platforms in Bangladesh, Nepal, and Sri Lanka rely on donor, government, or CSR funding, raising sustainability concerns. Some experiment with freemium or transaction fees, but farmers' willingness to pay is limited. While farmers value these services, scaling to cover costs depends on reaching network effect thresholds.

3.3.4 Synthesis of Drivers and Barriers to Adoption

Cross-country evidence reveals consistent patterns in the factors driving or constraining digital agriculture adoption. Infrastructure deficits: Poor mobile coverage and unreliable internet hinder remote regions (Nepal, Bangladesh). Quality affects access and function—farmers struggle with AI diagnostics or video tutorials (Plantwise, 2025). Electricity remains inconsistent, with frequent power outages (CASA Program, 2024). High data costs limit affordability, though prices are falling, especially in India (McKinsey, 2023; Bostan Consulting Group, 2024). Digital literacy is low, especially among older farmers, women, and marginalized groups, impacting navigation and understanding of apps (Raissa Fabregas et al. 2019; Nepal Economic Forum, 2025). Many are unaware of digital tools, requiring extensive promotion and hands-on support (Swiss Connect, 2024; CIMMYT, 2024). Most content is in major languages, excluding minorities, and often irrelevant to local conditions and practices (Nepal Economic Forum, 2025; FAO, 2023). Farmers need convincing demonstrations to adopt digital tools amid skepticism, data privacy concerns, and distrust of platforms. Building trust involves transparency, credible local institutions, and early success stories (Nepal Economic Forum, 2025; Swiss Connect, 2025). Women farmers face additional barriers: lower device ownership, limited mobility, social norms, and content not tailored for their needs. Addressing this requires voice interfaces, women-focused content, flexible training, and female extension agents (Mulungu et al. 2025; FAO, 2021). Economic constraints stem from device costs and competing needs, limiting usage of digital advice and apps (Forbes 2024; Nepal Economic Forum, 2025; Bostan Consulting Group, 2024).

4. Discussion

4.1 Magnitude and Mechanisms of Economic Impacts

Digital agriculture applications positively impact smallholder farmers in South Asia, though effects vary by intervention type, quality, and context. Meta-analyses suggest average yield and income increases of 6% (Silicon India 2024), which can mean $90-$120 for farmers earning $1,500-$2,000 annually. Across over 150 million smallholders, these gains add up to billions of dollars. Impact variability, from negative effects to over 40% gains, shows digital agriculture is not a cure-all. Success depends on intervention design, implementation, and fit. Well-designed platforms like Farmex (+25-29% income), AI for Agriculture (+100%), and Agro Star (+27% yield) demonstrate higher potential. Digital agriculture boosts the economy via several pathways: personalized advice reduces waste and increases yields; market info cuts middlemen margins and direct links raise prices; digital systems ensure access to certified inputs; weather alerts and pest warnings enable proactive protection; advisories improve farmer knowledge for long-term gains. Overall, it offers significant, variable economic benefits.

4.2 Policy Implications

This study highlights strategic policies to speed up digital agriculture adoption in South Asia. Key interventions include: expanding rural mobile broadband and viewing telecommunications as vitalas roads, exemplified by Sri Lanka; government investments in digital public goods like farmer identities and land records, as seen in India's AgriStack and Sri Lanka's GeoGoviya; public-private partnerships to develop infrastructure, regulations, and funding models; integrating digital tools into extension services with training and curriculum updates; policies mandating gender inclusion, such as reporting user data and involving women, supported by funding conditions; farmer digital literacy programs focusing on practical and critical skills, especially for women and marginalized groups; clear data governance frameworks protecting farmers' ownership and privacy, influenced by India's efforts; and support for localized digital content targeting neglected crops and underserved regions through public funding and incentives.

4.3 Limitations and Research Gaps

This study's evidence synthesis has limitations. Publication bias toward positive results may inflate impact estimates, especially because many studies from India limit generalizability to Bangladesh, Nepal, and Sri Lanka. Variability in outcome measurement hampers comparisons. Most studies use observational designs (even with sophisticated techniques) that can't definitively establish causality. RCTs are short-term and may miss long-term effects. Cross-sectional data limit understanding of adoption dynamics. Research gaps include: long-term impact persistence; variability in platform mechanisms; effects on inequality; sustainability and reach; environmental and nutritional impacts; comparisons of digital tools; and the need for research in Bangladesh, Nepal, and Sri Lanka.

5. Conclusion

Digital agriculture in South Asia delivers clear economic benefits, with yield increases of 2-21%, income gains of 6-29%, and rising adoption among smallholders. India's thriving agritech ecosystem, with platforms like DeHaat and AgroStar, demonstrates the viability of sustainable digital models. Bangladesh, Nepal, and Sri Lanka are also developing promising digital landscapes, with government and mobile services gaining scale. However, barriers remain: infrastructure gaps, low digital literacy, socioeconomic inequalities, and business model hurdles. Effective design principles include hybrid models with human agents, personalized, site-specific advice, integrated services, and localized content. Policymakers and developers should focus on investing in infrastructure, creating digital public goods, reforming extension systems, promoting gender-sensitive designs, and establishing trust through data regulation. The documented economic impacts—income boosts, food security, and lower input costs—highlight digital agriculture as a key pathway to rural development and poverty reduction, especially amid climate challenges. Future research should explore long-term impacts, equity, understudied countries, and alternative models. Generating this evidence will support tailored strategies to benefit over 150 million smallholders in South Asia.

Although digital agriculture apps, like DeHaat, AgroStar, Plantix, Shufola, GeoKrishi, and GeoGoviya, have demonstrated measurable gains in yield, income-revenue, and adoption across South Asia, their broader economic-financial impact lies in catalyzing systemic transformation. By nurturing data-driven ecosystems, these tools not only empower individual farmers but also reshape value chains, reduce ineptitudes, and create new market linkages that can stabilize rural economies. Notwithstanding, the long-term success of digital agriculture will depend on embedding inclusivity—ensuring women, transgenders, tribals, economically backward, subaltern-marginalized groups, and low-literacy farmers are not left behind—and on building sustainable business models that move beyond donor dependence. Eventually, digital agriculture in South Asia is not just a technological intervention but a pathway toward resistant, equitable, and climate-smart balanced rural development.

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