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Effects of Artificial Intelligence on Agribusiness in Nepal

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Abstract

Artificial Intelligence (AI) is increasingly shaping agribusiness transformation in Nepal by improving productivity, sustainability, and market integration within a largely smallholder-based agricultural economy. This article examines the current status, applications, opportunities, and constraints of AI adoption in Nepal's agribusiness sector using a comprehensive secondary desk review of academic literature, policy documents, and development reports. Key AI applications include precision farming, satellite-based crop classification, predictive analytics, and digital advisory services across crop, livestock, and supply chain management. Initiatives such as GeoKrishi, Connect Kisan AI, and the Omdena-UNWFP collaboration illustrate AI's potential to enhance resource efficiency and climate resilience. However, adoption remains limited due to infrastructure gaps, high costs for smallholders, data scarcity and localization challenges, low digital literacy, and evolving

policy and regulatory frameworks. Drawing on insights from other emerging markets, the study adapts the extended Technology Acceptance Model-Technology-Organization-Environment (TAM-TOE) framework to contextualize AI adoption in Nepal. The article concludes that inclusive and scalable AI-driven agribusiness transformation will require coordinated stakeholder engagement, targeted investments in digital infrastructure, skills development, and robust data governance mechanisms.

Keywords: *Artificial intelligence, agribusiness innovation, precision agriculture, emerging markets.*

Introduction

Artificial Intelligence (AI) is increasingly transforming agribusiness in Nepal by enhancing productivity, optimizing resource use, and addressing challenges like pest management and climate variability. In Nepal, where agriculture faces constraints such as limited arable land and unpredictable weather, AI applications include crop classification using satellite imagery to monitor staple crops like rice and wheat, as well as vegetables, thereby enabling better resource allocation (Omdena, 2025). Project collaboration with FruitPunch AI has developed AI tools to empower rural women farmers by leveraging cooperative data for improved livelihoods and decision-making. Furthermore, AI-driven precision farming models assist farmers in integrating technology for tasks such as soil analysis and pest detection, promoting sustainable practices (Giri, et.al., 2024). Initiatives like Project Saathi provide data-driven insights through sensors and machine learning to help farmers adopt scientific methods, combating issues like soil degradation and climate change. The National AI Policy 2025 emphasizes AI in agriculture for automated irrigation, pest management, and climate monitoring to boost overall productivity (The Annapurna Express, 2025). These advancements signify a shift toward smart farming, though challenges like high implementation costs and infrastructural limitations persist.

Agriculture remains a cornerstone of Nepal's economy, contributing significantly to gross domestic product (GDP) and employment, particularly in rural areas. As of 2025, the sector accounts for approximately 25-27% of Nepal's GDP, down from over 80% three decades ago, reflecting a gradual shift toward services and industry. It employs more than 60% of the population, serving as the primary livelihood for millions and providing raw

materials for related industries (Karna, 2025; Bhandari, 2024). Despite its importance, agriculture is largely subsistence-based, with challenges including soil erosion, climate change, and low productivity impacting growth (Nepal Economic Forum, 2025). Recent economic updates indicate a pickup in agricultural growth, contributing to overall GDP expansion of 4.9% in the first half of fiscal year 2025, driven by improved yields in key crops (World Bank, 2025). The sector's role extends beyond economics, supporting food security and rural development, though modernization is essential to address declining contributions and enhance sustainability.

The significance of technology in agribusiness is rapidly escalating, driven by the need to address global challenges such as food security, climate change, and resource scarcity. In 2025, innovations like AI, IoT, robotics, and precision farming are transforming traditional practices into data-driven, efficient systems that enhance productivity and sustainability (Folio3 AgTech, 2024). For instance, precision agriculture utilizes GPS, sensors, and analytics to optimize watering, fertilizing, and harvesting, leading to higher yields and reduced environmental impact, while AI predicts diseases and analyzes weather patterns to minimize risks (Folio3 AgTech, 2024). Globally, the agribusiness sector is poised for transformation through these advancements, with 81% of large farms and 76% of medium farms adopting or planning to adopt agtech solutions like drones and AI to improve efficiency amid volatile prices and weather risks. AI's role is particularly prominent, projected to grow from \$1.7 billion in 2023 to \$4.7 billion by 2028, enabling real-time crop monitoring, autonomous equipment for pest management, and regenerative practices that restore soil health and biodiversity (ICL Group, 2025). Additionally, trends like carbon utilization through monitoring technologies and blockchain for supply chain transparency are fostering sustainable growth, though barriers such as high costs and regulatory hurdles persist (Folio3 AgTech, 2024; ICL Group, 2025). These developments underscore technology's rising importance in making agribusiness more resilient and profitable. While talking about agribusiness, according to Bhandari (2024) Agribusiness development through value addition, agro-processing, contract farming, and improved logistics has been shown to enhance farm incomes, reduce post-harvest losses, and strengthen backward and forward linkages between farmers, traders, and processors. So, it will be significant for the effective

use of AI in agribusiness in Nepal.

Why AI is relevant for emerging markets like Nepal

AI holds substantial relevance for emerging markets like Nepal, where agriculture is subsistence-based and vulnerable to climate variability, limited resources, and a digital divide, offering tools to boost productivity, empower smallholders, and enhance food security. In Nepal, AI-driven crop classification using satellite imagery identifies staple crops like rice and wheat with 89% accuracy, enabling better resource allocation and combating hunger in a country where 80% of the population depends on agriculture and one-third lives in poverty (Omdena, 2025). Precision farming powered by AI, including drones for pest detection and sensors for soil analysis, optimizes water and fertilizer use, while predictive analytics helps farmers navigate unpredictable weather and market trends, addressing low productivity in a sector that employs over 60% of the population and contributes a quarter of GDP (The Annapurna Express, 2025). AI also bridges the digital divide for smallholder farmers through accessible platforms like chatbots for localized advice in local languages and data cooperatives that improve access to finance and markets, as seen in initiatives digitizing cooperative records to unlock capital and create revenue from data (Harvard ALI Social Impact Review, 2024). Furthermore, AI boosts crop yields via precision techniques, supporting economic growth in underserved areas, though it risks widening inequality if not inclusively implemented (Center for Global Development, 2024). AI's relevance lies in its potential to modernize agriculture, foster sustainability, and drive inclusive development in markets like Nepal. In the same way, AI can bridge information gaps and improve both productivity and market integration (FAO, 2025)

This research aims to investigate the integration of AI in Nepal's agribusiness sector, focusing on its potential to enhance productivity and sustainability while addressing implementation challenges. However, the research question seems to be what primary AI technologies are being utilized in Nepal's agribusiness, and how they contribute to productivity and resource efficiency. (The Annapurna Express, 2025; Omdena, 2025). How can AI help mitigate climate-related risks and enhance food security in emerging markets like Nepal?.

Methodology

This study employed a secondary desk review methodology over five years period, drawing on published academic literature, government reports, policy documents, and international agency publications related to artificial intelligence and agribusiness in emerging markets, with a particular focus on Nepal. Sources were systematically identified through databases such as Google Scholar, Scopus, and institutional repositories, as well as policy briefs from organizations including FAO, World Bank, and national government agencies. The review synthesized existing evidence on AI applications in crop and livestock production, supply chain management, and environmental sustainability. Emphasis was placed on identifying key trends, opportunities, and challenges relevant to Nepal's agribusiness sector, while also comparing lessons from other emerging economies to provide contextual insights

Global trends of AI in agribusiness

The integration of AI into agribusiness has emerged as a transformative force globally, addressing challenges such as food security, climate change, and resource optimization. By 2025, the global AI in agriculture market is projected to grow from \$1.7 billion in 2023 to \$4.7 billion by 2028, driven by advancements in precision farming, predictive analytics, and automation (ICL Group, 2025). AI technologies, including machine learning, computer vision, and IoT, are enabling farmers to monitor crops in real-time, predict yields, and mitigate risks from pests and weather variability (Folio3 AgTech, 2024). For instance, AI-powered drones and satellite imagery provide high-resolution data for crop health assessment, while autonomous machinery enhances efficiency in planting and harvesting. Additionally, AI supports regenerative agriculture by analyzing soil health and promoting biodiversity, aligning with global sustainability goals (ICL Group, 2025). Blockchain integration with AI is also gaining traction, enhancing supply chain transparency and traceability, though challenges like high costs and regulatory complexities persist (Folio3 AgTech, 2024). These trends highlight AI's role in revolutionizing agribusiness by improving productivity and resilience, particularly in response to global population growth and environmental pressures.

Applications of AI in crop, livestock, and supply chain management

AI applications in agribusiness span crop production, livestock management, and supply

chain optimization, offering innovative solutions to enhance efficiency and sustainability.

Crop management

In crop management, AI leverages machine learning and satellite imagery for precision agriculture, enabling tasks such as crop classification, yield prediction, and pest detection. For example, AI models analyzing satellite data achieve up to 89% accuracy in identifying staple crops like rice and wheat, optimizing resource allocation (Omdena, 2025). Predictive analytics also help farmers anticipate weather patterns and disease outbreaks, reducing crop losses (Giri, et. al., 2024). Technologies like AI-driven irrigation systems and soil sensors further enhance water and fertilizer efficiency, critical for sustainable farming in resource-scarce regions (The Annapurna Express, 2025).

Livestock management

AI is transforming livestock management by monitoring animal health and optimizing breeding and feeding practices. Wearable sensors and computer vision systems track livestock behavior, detecting early signs of disease or stress, which improves animal welfare and productivity (Folio3 AgTech, 2024). For instance, AI algorithms analyze data from IoT devices to adjust feed compositions, reducing costs and environmental impact (ICL Group, 2025). In emerging markets, such innovations are critical for smallholder farmers reliant on livestock for income (Harvard ALI Social Impact Review, 2024).

Supply chain management

In supply chain management, AI enhances efficiency through demand forecasting, inventory optimization, and logistics automation. Machine learning models predict market demand, reducing food waste, while blockchain-integrated AI ensures traceability from farm to consumer, addressing issues like fraud and contamination (Folio3 AgTech, 2024). In Nepal, initiatives like data cooperatives use AI to digitize records, improving access to markets and finance for smallholder farmers (Harvard ALI Social Impact Review, 2024). However, high implementation costs and limited digital infrastructure pose barriers, particularly in developing nations (Center for Global Development, 2024).

AI adoption in other emerging markets

AI adoption in emerging markets is accelerating, with countries like India, Bangladesh, and Kenya leveraging technologies to address agricultural challenges such as low productivity, climate vulnerability, and resource constraints. In India, AI is driving an agricultural revolution through precision farming, predictive analytics, and government-backed platforms, with the market projected to grow significantly by 2028 (World Economic Forum, 2025). For instance, AI tools enable farmers to optimize irrigation and pest management, potentially increasing yields by 20-30%, though adoption remains limited to under 20% due to infrastructural barriers (Medium, 2025; IEEE Spectrum, 2024). Bangladesh is utilizing AI for disease detection via smartphone apps and precision farming systems, enhancing crop health monitoring and resource efficiency in a sector prone to flooding and pests. Initiatives like AI-powered integrated pest management apps have empowered smallholders to reduce losses, with machine learning models achieving high accuracy in identifying issues (Chowdhary et al, 2024). In Kenya, AI strategies for 2025-2030 focus on advisory systems and disease detection, improving decision-making for smallholder farmers who dominate the sector (World Bank, 2025). Tools like mobile apps for cassava and maize disease identification, combined with cloud computing, are boosting yields by 20-30%, though data scarcity hinders broader implementation (RATIN, 2025). Across these markets, case studies highlight AI's role in sustainable practices, such as automated monitoring and yield prediction, but emphasize the need for affordable infrastructure to scale adoption (Digital Defynd, 2025). These examples provide insights for Nepal, where similar challenges exist, underscoring the potential for AI to transform subsistence farming into resilient, data-driven agribusiness.

Knowledge gaps in the Nepalese context

Despite growing interest in AI for agriculture, significant knowledge gaps persist in Nepal, particularly in infrastructure, data availability, and localized research, limiting effective adoption. Nepal's National AI Policy 2025 aims to integrate AI for crop monitoring and disaster prediction, but faces challenges like inadequate digital infrastructure and a lack of high-quality datasets, exacerbating the digital divide in rural areas (Mahat et al., 2025; Medium, 2025). Events like Digital Ag Nepal 2024 have identified gaps between technology

developers and farmers, including limited access to AI tools for soil testing and predictive analytics, hindering sustainable development (CIMMYT, 2024). Furthermore, there is a notable shortage of skilled engineers and educational resources in AI, with rural regions lacking training programs, which impedes innovation and research output (Fuse.ai, 2025). According to ScienceDirect (2025), unintended consequences, such as biases in AI models due to incomplete training data on local crops and climates, and broader issues like connectivity barriers that prevent real-time applications. Reviews of digital transformation in Nepalese agritech highlight stakeholder implementation gaps, including insufficient case studies on AI's impact on smallholder productivity, calling for more empirical research to bridge these voids. Addressing these gaps requires targeted investments in data infrastructure, education, and collaborative pilots to realize AI's potential in enhancing Nepal's agricultural resilience.

Research gaps and future directions

The literature reveals several research gaps in AI applications in Nepal's agribusiness. First, there is limited research on scalable AI solutions tailored to smallholder farmers in resource-constrained settings like Nepal (Bhat et al., 2025). Most studies focus on localized implementations, overlooking broader scalability and inclusivity (Cavazza et al., 2023). Second, ethical concerns, such as data privacy and algorithmic fairness, remain underexplored in Nepal's context (Shrestha, 2025). Finally, the potential for AI to drive new business models, such as cooperative platforms or subscription-based services, is under-investigated, despite its relevance for emerging markets.

Future research should focus on developing affordable, scalable AI solutions for Nepal's smallholder farmers, integrating local knowledge with advanced technologies. Collaborative efforts between scholars, policymakers, and practitioners are needed to address ethical challenges and foster inclusive adoption. Additionally, exploring AI's role in export-oriented agriculture, such as organic produce, could enhance Nepal's competitiveness in global markets (Bhat et al., 2025).

AI is transforming Nepal's agribusiness by enhancing productivity, sustainability, and market access for smallholder farmers. Innovations like precision farming, AI-driven

financial platforms, and blockchain-based traceability are unlocking value in this emerging market. However, challenges such as high costs, infrastructure limitations, and regulatory gaps must be addressed to ensure inclusive adoption. Future research should prioritize scalable, ethical, and inclusive AI solutions to support Nepal's agricultural sector and contribute to global food security.

Link between AI adoption and agribusiness transformation

AI adoption fosters agribusiness transformation by enabling data-driven decision-making, automating processes, and bridging informational gaps, ultimately shifting traditional farming toward efficient, resilient systems. In emerging markets, AI integrates across the agricultural value chain from production to market, reducing inefficiencies and enhancing competitiveness (International Finance Corporation, 2020). For instance, machine learning and IoT facilitate precision agriculture, optimizing inputs like water and fertilizers to mitigate climate risks and boost yields, transforming subsistence models into commercial enterprises. The extended TAM-TOE framework posits that AI adoption, influenced by technological readiness and organizational factors, leads to innovation outcomes, with leadership support moderating the process in resource-constrained settings like Nepal (Khattak et al., 2025). In agricultural extension services, AI tools such as drones and sensors replace manual methods, improving advisory services and enabling sustainable practices that align with global SDGs. This linkage is particularly vital in Nepal, where AI can address challenges like terrain constraints and smallholder fragmentation, promoting a shift from low-productivity farming to tech-enabled agribusiness.

Current status of AI in Nepal's agribusiness

The current status of AI in Nepal's agribusiness reflects a nascent yet promising integration, driven by national policies and collaborative initiatives to address challenges like climate variability, low productivity, and food insecurity. As of 2025, Nepal's National AI Policy 2081 emphasizes AI applications in agriculture for automated irrigation, pest management, and climate monitoring, positioning the country as an AI innovation hub despite infrastructural limitations (Shrestha, 2025). Predictive models are enhancing productivity and decision-making, with tools like ChatGPT and DeepSeek offering advisory services to

farmers, though adoption remains limited due to digital divides (NACCFL, 2025). Projects such as the UN World Food Programme's collaboration with Omdena have developed machine learning models for crop classification using satellite imagery, achieving 89% accuracy for staples like rice and wheat to combat hunger (Omdena, 2025). Government efforts, including the Connect Kisan AI advisory system tested by former Prime Minister KP Sharma Oli, provide voice-based guidance on farming practices, signaling a shift toward data-driven agribusiness (ICT Frame, 2025a). However, challenges like inadequate datasets and rural connectivity hinder widespread implementation, with digitization efforts focusing on precision farming and sustainable practices (Giri et al., 2025). However, AI's role is expanding through policy support and pilots, but scaling requires addressing equity and infrastructure gaps.

Existing initiatives

Nepal's agribusiness is witnessing a surge in AI-driven initiatives from startups and government projects aimed at digitalizing farming for enhanced resilience and efficiency. GeoKrishi, a prominent agritech startup, offers a web and mobile platform that provides farmers with data-driven insights on soil health, weather, and climate-smart practices, reaching over 200,000 users and partnering with entities like Komunidad for real-time weather alerts (GeoKrishi, 2025; Komunidad, 2025). Through collaborations with GSMA and CIMMYT, GeoKrishi delivers digital learning content, SMS advisories, and IVR services to smallholders, promoting sustainable agriculture amid climate stressors (GSMA, 2025; CIMMYT, 2024). On the government side, the Digital Nepal Framework–2, set for rollout in 2025, prioritizes agriculture within eight key sectors, integrating AI for precision technology and climate resilience (Khabarhub, 2025). Initiatives like the FAO's Digital Villages Initiative tailor digital tools for rural advisory services, supporting sustainable practices in pilot areas (FAO, 2025). The Ministry of Agriculture has declared digital agriculture a priority, with projects like market feasibility studies and ADB-funded irrigation modernization enhancing productivity (Rising Nepal, 2025; ADB, 2024). These efforts, including the National AI Policy's focus on agribusiness, are fostering a digitized ecosystem, though accessibility remains a barrier.

Role of cooperatives and the private sector

Cooperatives and the private sector play pivotal roles in advancing AI in Nepal's agribusiness, facilitating adoption through community networks and innovation investments. Cooperatives, which support over 400,000 families, leverage AI for data digitization and market access and AI challenge that empowers women farmers by converting paper records into actionable insights for financing and traceability (Harvard ALI Social Impact Review, 2024). They promote climate-smart practices and spillover effects on non-members, enhancing sustainability and performance via tools like ChatGPT for decision-making (NACCFL, 2025). The private sector drives initiatives like GeoKrishi's platforms and Komunidad's weather integrations, fostering competitiveness under the National AI Policy (GeoKrishi, 2025). Moreover, AI digitizes value chains, thereby improving financial inclusion and advisory services. Together, they address market failures, with cooperatives ensuring inclusivity and the private sector providing technological expertise for scalable AI solutions.

Opportunities

The integration of AI in Nepal's agribusiness presents transformative opportunities to address longstanding challenges in productivity, market access, sustainability, and youth engagement. By leveraging AI-driven tools, Nepal can enhance its agricultural sector, which contributes approximately 25-27% to GDP and employs over 60% of the population, aligning with the National AI Policy 2081's vision for innovation (Gupta, 2025; Shrestha, 2025). Below, the key opportunities are explored in the context of productivity and efficiency gains, market integration and price forecasting, climate-smart agriculture and sustainability, and youth engagement and the innovation ecosystem.

Productivity and efficiency gains

AI offers significant potential to boost productivity and efficiency in Nepal's agribusiness through precision agriculture and data-driven decision-making. Tools like GeoKrishi's platform, which serves over 200,000 farmers, use AI to provide insights on soil health, irrigation, and pest management, optimizing resource use and reducing losses (GeoKrishi, 2025). Machine learning models, such as those developed by Omdena for crop classification,

achieve 89% accuracy in identifying staples like rice and wheat, enabling precise resource allocation and yield improvements (Omdena, 2025). AI-driven drones and sensors streamline tasks like planting and monitoring, potentially increasing productivity by 20-30%, as seen in similar emerging markets like India (Medium, 2025). The Connect Kisan AI advisory system provides real-time, voice-based guidance, reducing inefficiencies in traditional extension services and enabling smallholders to adopt scientific methods (ICT Frame, 2025a). These advancements can address Nepal's low agricultural productivity, particularly in subsistence farming, by minimizing input waste and enhancing output quality.

Market integration and price forecasting

AI facilitates market integration and price forecasting, empowering Nepalese farmers to access broader markets and improve income stability. Machine learning models for demand forecasting and price prediction, as implemented in global contexts, can reduce post-harvest losses and stabilize incomes by aligning production with market needs (International Finance Corporation, 2020). In Nepal, initiatives like Heifer International's AI challenge digitize cooperative data, enabling smallholders to connect with buyers and access finance through alternative credit scoring, enhancing market linkages (Heifer International, 2024). GeoKrishi's partnerships with platforms like Komunidad provide market insights via SMS and IVR, helping farmers anticipate price fluctuations (GSMA, 2025). Blockchain-integrated AI systems, inspired by global trends, could further ensure traceability and quality assurance, opening premium markets for Nepalese produce (Folio3 AgTech, 2024). These tools bridge the gap between rural farmers and urban markets, addressing Nepal's fragmented supply chains and fostering economic inclusion.

Climate-smart agriculture and sustainability

AI is pivotal in promoting climate-smart agriculture and sustainability in Nepal, where agriculture is vulnerable to climate variability and soil degradation. AI-driven tools, such as satellite-based weather monitoring and predictive analytics, enable farmers to adapt to erratic weather patterns, as seen in Komunidad's collaboration with GeoKrishi for real-time climate alerts (Komunidad, 2025). Precision farming technologies, including AI-optimized irrigation

and fertilizer application, reduce environmental impact by minimizing resource overuse, aligning with sustainable development goals (Giri, et.al., 2024). The FAO's Digital Villages Initiative in Nepal integrates AI to promote climate-resilient practices, such as drought-resistant crop varieties, enhancing long-term sustainability (FAO, 2025). By analyzing soil health and pest risks, AI supports regenerative agriculture, which is critical for Nepal's hilly terrains prone to erosion (Gupta, 2025). These solutions not only mitigate climate risks but also ensure food security for Nepal's growing population.

Youth engagement and innovation ecosystem

AI presents opportunities to engage Nepal's youth, a demographic increasingly drawn to technology, in building an innovation ecosystem for agribusiness. Startups like GeoKrishi and events like Digital Ag Nepal 2024 are fostering youth-led innovation by developing accessible AI tools and providing training in digital agriculture (CIMMYT, 2024). The National AI Policy encourages youth participation through education and startup support, addressing the shortage of AI engineers noted in Nepal's agritech sector (Fuse.ai, 2025). Initiatives like the FruitPunch AI challenge engage young innovators in creating solutions for rural farmers, fostering entrepreneurship (Heifer International, 2024). Collaborations with universities and private firms, such as those under the Digital Nepal Framework-2, are creating platforms for youth to develop AI applications, enhancing the innovation ecosystem (Khabarhub, 2025). By involving youth, Nepal can build a sustainable pipeline of agritech solutions, reducing urban migration and revitalizing rural economies.

Infrastructure gaps

Nepal's rural areas, where most farming occurs, suffer from significant infrastructure deficits, particularly in internet connectivity and electricity access, which are critical for AI deployment. Only about 34% of rural Nepal has reliable internet, limiting the use of cloud-based AI tools like GeoKrishi's platform or real-time weather alerts from Komunidad (Medium, 2025; Komunidad, 2025). Erratic electricity supply, with frequent outages in rural regions, restricts the operation of AI-driven devices like sensors and drones (Mahat et al, 2025). These gaps impede the scalability of initiatives like the Digital Villages Initiative, which relies on digital infrastructure for advisory services (FAO Nepal, 2025). Without

robust connectivity and power, AI applications remain inaccessible to many smallholder farmers, exacerbating the digital divide.

Cost and affordability for smallholders

According to Harvard ALI Social Impact Review (2024) the high cost of AI technologies poses a significant barrier for Nepal's smallholder farmers, who dominate the agricultural sector and often operate on subsistence incomes. Implementing AI solutions like precision farming tools or IoT sensors requires substantial upfront investment, unaffordable for farmers with limited access to credit. For instance, while GeoKrishi offers free basic services, advanced features, or hardware like drones are cost-prohibitive for smallholders. Globally, high costs have limited AI adoption to less than 20% of farmers in emerging markets like India, a trend mirrored in Nepal. Subsidies and cooperative models, as seen in Heifer International's AI challenge, are emerging but insufficient to bridge affordability gaps for widespread adoption.

Data scarcity and localization

Data scarcity and the lack of localized datasets significantly hinder AI effectiveness in Nepal's agribusiness. AI models require high-quality, region-specific data to provide accurate predictions, but Nepal lacks comprehensive datasets on local crops, soil types, and climate patterns (Mahat et al, 2025). For example, the Omdena-UNWFP project achieved 89% accuracy in crop classification but highlighted the need for more granular local data to improve reliability (Omdena, 2025). Non-localized AI models risk biases, as they often fail to account for Nepal's diverse agroecological zones, leading to ineffective recommendations (ScienceDirect, 2025). ICT Frame (2025a) initiatives like Connect Kisan AI face challenges in tailoring voice-based advisories to Nepal's linguistic and cultural diversity, further complicating localization efforts.

Policy, regulation, and data governance

Nepal's policy and regulatory framework for AI in agriculture is still evolving, with gaps in data governance impeding progress. The National AI Policy 2081 outlines ambitions for AI in agribusiness but lacks clear guidelines on data privacy, ownership, and ethical use, raising

concerns about farmer data exploitation (Shrestha, 2025). Inadequate regulatory frameworks deter private sector investment, as seen in the limited scaling of startups like GeoKrishi (Gupta, 2025). Data governance issues, such as unclear protocols for sharing cooperative data, hinder initiatives like Heifer International's digitization efforts, risking inefficiencies and mistrust (Harvard ALI Social Impact Review, 2024). Aligning policies with global standards, as suggested by the Digital Nepal Framework-2, is critical but remains underdeveloped (Khabarhub, 2025).

Skills and digital literacy barriers

A significant barrier to AI adoption in Nepal is the lack of digital literacy and technical skills among farmers and agricultural stakeholders. Rural farmers, who form the backbone of Nepal's agriculture, often lack the training to use AI tools like mobile apps or IoT devices, with literacy rates in rural areas as low as 60% (Fuse.ai, 2025). The shortage of AI engineers and trainers, as noted in educational reports, limits the development and dissemination of user-friendly solutions. While initiatives like Digital Ag Nepal 2024 aim to bridge this gap through training, coverage remains limited, particularly for women and marginalized groups (CIMMYT, 2024). Low digital literacy also affects the adoption of platforms like Connect Kisan AI, which require basic smartphone proficiency (ICT Frame, 2025a). Building capacity through education and cooperative-led training is essential to overcome these barriers.

Role of government, private sector, and cooperatives

The government's role in AI adoption includes policy leadership, infrastructure investment, and regulatory oversight to ensure equitable and ethical implementation. The National AI Policy 2081 is targeted for finalization within six months, alongside the establishment of the Data Protection Act and sector-specific AI regulations within two years to address data privacy and algorithmic bias (Shrestha, 2025). Invest in rural internet connectivity and high-performance computing facilities, aiming to 50% rural internet coverage by 2027, supporting AI-based solutions such as Connect Kisan AI (Mahat et al., 2025). Subsidies for AI-enabled technologies, including sensors and drones, and tax incentives for agritech startups are designed to reduce adoption costs for smallholder farmers. AI education is being integrated into agricultural extension services, with partnerships with universities planned to train

10,000 farmers annually on digital tools by 2030.

The private sector plays a key role in AI innovation and commercialization. Firms such as GeoKrishi are expanding their platforms to include localized AI models for crop disease detection and market forecasting, with outreach projected to reach 500,000 farmers by 2028 (Gupta, 2025). Public–private collaboration is supporting AI infrastructure development through cost-sharing models for rural data centers. The development of low-cost AI tools, including mobile-based advisory applications, is increasing affordability for smallholder farmers, drawing on experiences from neighboring countries.

Cooperatives, serving more than 400,000 farming families, are central to inclusive AI adoption and community-level implementation. Ongoing initiatives to digitize cooperative records are enabling data-driven access to finance and markets for approximately 100,000 farmers by 2027 (Heifer International, 2024). Cooperative-led training centers are being established to strengthen digital literacy, with a target of equipping 70% of members with basic AI skills by 2030 (NACCFL, 2025). AI applications are also being used to improve supply chain transparency and link cooperatives to higher-value markets through blockchain-integrated platforms.

Roadmap for AI Adoption

In the context of Nepal, the road map for AI adoption seems to relevant to be carried on three phases as mentioned below:

Short-Term (2025–2027)

The National AI Policy 2081 is enacted, and a Data Protection Act is initiated to promote ethical AI use (Adinovi, 2025). AI pilot projects are launched in 10 districts, focusing on precision farming and digital advisory systems such as GeoKrishi and Connect Kisan AI, reaching approximately 50,000 farmers. Rural internet access is expanded to 40% coverage, and five regional AI data centers are established (Mahat et al., 2025). Training programs reach 5,000 farmers and extension workers through cooperatives and national digital agriculture events.

Medium-Term (2028–2032)

AI adoption expands to 30% of smallholder farmers, integrating tools for pest detection and

yield prediction, informed by crop classification models developed by Omdena (Omdena, 2025). Sector-specific AI regulations are implemented, and an AI Regulatory Council is established to monitor compliance (Review of AI Law, 2024). A national AI database with localized crop and climate data is developed to reduce data scarcity (Mahat et al., 2025). Support mechanisms enable the growth of 50 agritech startups through incubators and venture capital programs, drawing on regional innovation models.

Long-Term (2033–2040)

Giri et al. (2024) analyze that AI adoption reaches 70% of farmers, with widespread use of autonomous tools and climate-smart solutions. Nepal's AI framework is aligned with international standards of OECD and UNESCO to facilitate trade in AI-enabled agricultural products. AI applications contribute to a 20% reduction in agricultural carbon emissions and improvements in soil health across 50% of arable land. AI Centers of Excellence are established in 10 universities, producing around 1,000 AI professionals annually.

Integration with national agriculture modernization plans

Integrating AI with Nepal's national agriculture modernization plans, such as the Agriculture Development Strategy (ADS) 2015–2035 and the Digital Nepal Framework–2, is essential for cohesive development. Incorporate AI into ADS priorities like productivity and commercialization by deploying precision farming tools in 20 priority districts by 2028 (Rising Nepal, 2025). Leverage the framework's focus on digital transformation to fund AI infrastructure, targeting 100 smart villages with AI advisory systems by 2030 (Khabarhub, 2025).

Gupta (2025) argues that the use of AI for climate-smart agriculture aligns with ADS goals to reduce climate risks through predictive analytics and automated irrigation. Integrate AI-driven market forecasting and blockchain traceability into ADS's value chain development, enhancing export competitiveness.

Partnerships with universities and international agencies

According to Adinovi (2025) collaborations with universities and international agencies are critical to building capacity, fostering innovation, and securing resources for AI adoption. Establish AI Centers of Excellence in universities like Tribhuvan and Kathmandu to develop

localized AI models and train 500 agricultural AI specialists annually by 2030.

Partner with FAO, CIMMYT, and the World Bank to scale initiatives like the Digital Villages Initiative, targeting 50,000 farmers with AI tools by 2028 (FAO, 2025; CIMMYT, 2024). Collaborate with global AI governance bodies to adopt best practices in ethical AI and data governance, ensuring compliance by 2030 (The Annapurna Express, 2025). Secure grants from ADB and GSMA to fund AI pilots and transfer technologies like drone-based monitoring from India and Kenya (GSMA, 2025).

Key findings

The integration of AI in Nepal's agribusiness is at an early but promising stage, driven by initiatives like GeoKrishi, Connect Kisan AI, and the National AI Policy 2081, which focus on precision farming, crop monitoring, and advisory services (GeoKrishi, n.d.; ICT Frame, 2025a; Shrestha, 2025). AI applications, such as machine learning for crop classification and predictive analytics, have demonstrated potential to enhance productivity by up to 20-30% and promote sustainability through climate-smart practices, as seen in projects achieving 89% accuracy in identifying staple crops (Omdena, 2025). However, significant challenges persist, including infrastructure gaps (e.g., only 34% rural internet coverage), high costs for smallholders, data scarcity, weak regulatory frameworks, and low digital literacy (Mahat et al, 2025; Medium, 2025). Cooperatives and the private sector, through initiatives like Heifer International's AI challenge, are pivotal in bridging these gaps by digitizing data and improving market access (Heifer International, 2024). Opportunities lie in productivity gains, market integration, and youth-led innovation, but scaling requires coordinated efforts across stakeholders.

Contribution to knowledge on AI in agribusiness in emerging markets

This study contributes to the understanding of AI in agribusiness within emerging markets by providing a Nepal-specific analysis, drawing parallels with countries like India and Kenya. It extends the extended TAM-TOE framework by incorporating contextual moderators like Nepal's digital divide and cooperative structures, offering a model for analyzing AI adoption in subsistence-based economies (Khattak et al., 2025). The research highlights the unique

role of cooperatives in fostering inclusive AI adoption, a less-explored aspect in global literature, and underscores the need for localized datasets to address biases in AI models (Harvard ALI Social Impact Review, 2024). Documenting initiatives like GeoKrishi and Omdena's crop classification, it adds empirical evidence on AI's practical applications and challenges in low-resource settings, enriching the discourse on digital transformation in emerging market agribusiness (Omdena, 2025;).

Implications for farmers, policymakers, and development partners

AI offers Nepalese farmers opportunities to increase yields, access markets, and adopt sustainable practices through tools like precision irrigation and price forecasting (Folio3 AgTech, 2024). However, affordability and digital literacy barriers necessitate cooperative-led training and subsidized AI tools to ensure inclusivity, particularly for women and smallholders (NACCFL, 2025).

Policymakers must prioritize infrastructure investments, such as rural internet expansion to 50% coverage by 2027, and finalize the National AI Policy 2081 with clear data governance protocols to prevent exploitation (Shrestha, 2025; Adinovi, 2025). Integrating AI into the Agriculture Development Strategy and Digital Nepal Framework–2 will align modernization efforts, fostering resilience and competitiveness (Khabarhub, 2025).

International agencies, such as FAO and CIMMYT, should support the development of localized AI models and fund pilot projects, scaling initiatives like the Digital Villages Initiative to 100 smart villages by 2030 (FAO, 2025). Partnerships with universities can build AI expertise, while funding from ADB and GSMA can address infrastructure gaps, ensuring equitable benefits (GSMA, 2025).

Conclusion

AI for smallholder and agribusiness sectors in Nepal holds significant potential to transform Nepal's agribusiness by improving productivity, climate resilience, sustainability, and market access. Emerging applications in digital services, supply chain management, and farming and business systems have the potential to deliver tangible benefits, driven by public, private, and cooperative-led initiatives. However, inadequate digital infrastructure, high costs, limited local-level data, low digital literacy, and evolving policy and regulatory frameworks have

hindered widespread adoption. Based on the studies, the AI-driven transformation of agribusiness in Nepal will depend on inclusive, scalable implementation models that prioritize affordability, capacity building, and secure data use. Integrating AI into national agricultural modernization efforts requires coordinated action between the government, private sector, cooperatives, and development partners. Addressing these structural barriers can enable AI to support sustainable agricultural growth, commercialize agribusiness, and develop modern technologies, thereby economically transforming rural and local economies in emerging market contexts. Its use can be expected to contribute to market development by improving agribusiness over the next decade.

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