systems

MDPI

Article

Digital Innovation, Business Models Transformations, and Agricultural SMEs: A PRISMA-Based Review of Challenges and Prospects

Bingfeng Sun [1], Jianping Yu [1], Shoukat Iqbal Khattak [1,*], Sadia Tariq [2] and Muhammad Zahid [3]

[1] School of Business Administration, Jimei University, Xiamen 361021, China; bfsun@jmu.edu.cn (B.S.); jianping@jmu.edu.cn (J.Y.)
[2] Department of Environmental Science, International Islamic University, Islamabad 44000, Pakistan; sadia.phdes109@student.iiu.edu.pk
[3] Bahria Business School, Bahria University, Islamabad 44000, Pakistan
* Correspondence: 201961000012@jmu.edu.cn

Abstract

Digital innovation is rapidly transforming the agriculture sector, drawing attention from global development institutions, policymakers, tech firms, and scholars aimed at aligning food systems with international goals like Zero Hunger and the FAO agendas. Small and medium enterprises in agriculture (Agri-SMEs) represent a significant portion of processing and production units but face challenges in digital transformation despite their importance. Technologies such as Artificial Intelligence (AI), blockchain, cloud services, IoT, and mobile platforms offer tools to improve efficiency, access, value creation, and traceability. However, the patterns and applications of these transformations in Agri-SMEs remain fragmented and under-theorized. This paper presents a systematic review of interactions between digital transformation and innovation in Agri-SMEs based on findings from ninety-five peer-reviewed studies. Key themes identified include AI-based decision support, blockchain traceability, cloud platforms, IoT precision agriculture, and mobile technologies for financial integration. The review maps these themes against business model values and highlights barriers like capacity gaps and infrastructure deficiencies that hinder scalable adoption. It concludes with recommendations for future research, policy, and ecosystem coordination to promote the sustainable development of digitally robust Agri-SMEs.

Keywords: digital transformation; agri-SMEs; artificial intelligence (AI); blockchain traceability; precision agriculture; sustainable development

check for updates

Academic Editor: Agostinho Da Silva

Received: 27 May 2025
Revised: 22 July 2025
Accepted: 26 July 2025
Published: 8 August 2025

Citation: Sun, B.; Yu, J.; Khattak, S.I.; Tariq, S.; Zahid, M. Digital Innovation, Business Models Transformations, and Agricultural SMEs: A PRISMA-Based Review of Challenges and Prospects. *Systems* **2025**, *13*, 673. https://doi.org/10.3390/systems13080673

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Global agriculture faces a simultaneous convergence of numerous challenges, including supply chain interruptions, climate volatility, increasing food security, and demographic expansion. As per the Food and Agriculture Organization (FAO), agricultural production must increase by a minimum of 70% to fulfil the needs of an estimated 9.7 billion population by 2050 [1]. However, this imperative is delayed by structural inefficiencies, environmental degradation, and stagnant productivity, particularly in middle- and low-income economies (LMICs) [2,3]. The traditional agricultural progress model, based on extensive mechanization and productivity intensification, has struggled to provide sustainable and inclusive gains in these regions. Digital innovations (DI) have emerged as an architecture for transformation in agricultural supply chain systems and as supporting tools to extensively

integrate social, environmental, technological, and economic resources [4,5]. DI encompasses a set of enabling technologies, including AI, blockchain, cloud computing, data analytics, IoTs, mobile platforms, and satellite imaging [6–8], which collectively serve as integrated solutions and infrastructural supports that enable stakeholders to the collection, analysis, and response to data in real-time, build transactional trust, create pathways for value delivery, and automate operations [9,10]. That said, digitalizing agriculture is not just technological progress but a more profound and systematic transformation in how value is created, delivered, and captured, specifically for organizational stakeholders such as SMEs in the agriculture sector. Notably, Agri-SMEs, including food processors, produce aggregators, input suppliers, service intermediaries, and distributors, play a key role in enabling rural progress and resilience of food systems [11]. Although these SMEs account for almost 60% of produce post-harvest and commonly serve as the primary economic anchors in rural communities [12,13], they face considerable constraints such as inadequate infrastructure, severe deficiency in operations, and omission from policy networks [14,15]. Agri-SMEs represent the missing intermediary between progress that is too big to attract microfinance, and that is too small in size to attract commercial financing [16]. Figure 1 represents the characteristics of blockchain, IoT, artificial intelligence (AI), and big data for the agricultural sector.

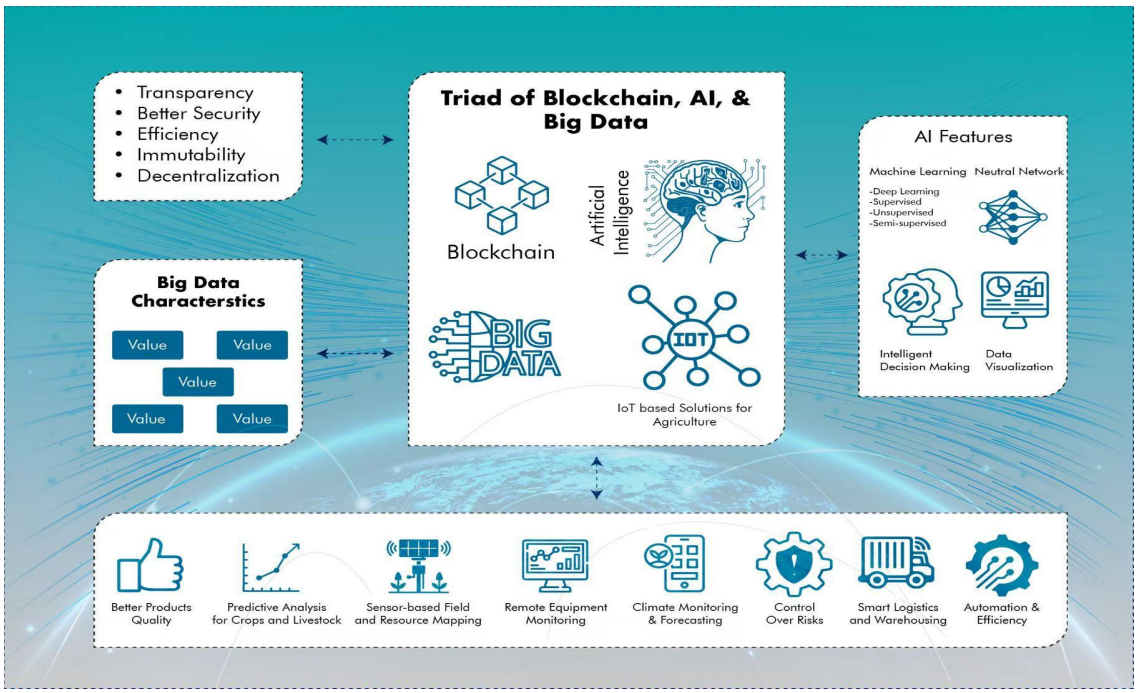


Figure 1. Characteristics of blockchain, AI, IoT, and big data for smart farming [6].

Digital technologies can help address the above constraints. For instance, mobile platforms allow these entities to connect with farmers, control inventories, and remotely manage transactions [17]. While AI-driven advisory and consultation tools assist in optimizing the allocation of resources, blockchains can improve supply chain traceability and transparency [18–20]. In Asia (India), an innovative AI platform called DeHaat is leveraging technology to provide advisory services, connecting 1.5 million farmers to financial institutions and markets [21,22]. AgroCenta, another AI platform in Africa (Haatso, Ghana), facilitates market access tools, mobile payments, and logistics to augment price comparisons for grain traders and minimize post-harvest losses [23]. In Latin America (Colombia), Agrapp utilizes blockchain to maintain records of transactions, ensuring compliance with global quality standards for crops of high value [24]. Given that the influence

of digital innovations on Agri-SMEs cannot be holistically captured through the lens of technology acceptance alone, an investigation is required to explain how such technologies are altering business frameworks, the systematic logic that underscores how these SMEs organize and deliver value and create revenues [25]. These SMEs are different from large agribusinesses as they typically exhibit low capital intensity, informal structures, and high sensitivity to market fluctuations. Rapid transformations in the digital landscape affect not only the operations of Agri-SMEs but also their very identity within the ecosystems of the agriculture sector [26].

Business model transformation (BMT) offers a theoretical framework to evaluate this reconfiguration and understand the architecture of value: value creation, delivery, and capture via a network of transactions, resources, and actors [27,28]. BMT signifies the shift from conventional and informal structures to digitally infused and strategically agile frameworks, including repositioning as logistic hubs, data brokers, bundled service aggregators, and platform providers [29,30]. Transformative models often integrate digital technologies and innovations (e.g., AI-led analytics and blockchain-centric traceability with financial services) to provide context-specific, adaptive services [31,32]. Such transformation occurs across three interdependent areas: a) value creation, the capacity to package new facilities (e.g., inputs, finance, and advisory) via digital tools to improve trust and productivity; b) value delivery, the capacity to reorganize partner networks and distribution channels, commonly leveraging cloud-based and mobile platforms; and c) value capture the capacity to diversify revenue streams via subscription models, transaction fees, value-added certification, and data monetization. The digital transformation of Agri-SMEs hinges on three interconnected trust dimensions: Technological trust begins with innovators creating digital tools, but requires the farmer-centric design to overcome adoption barriers like interoperability gaps. Emotional trust develops gradually as smallholders experience tangible benefits through platforms like DeHaat, facilitated by local intermediaries who bridge the tech-reality divide. Institutional trust, while initiated through policy support and funding, often weakens when implementation reveals systemic challenges, infrastructure limitations, and regulatory instability, which confine innovations to pilot stages rather than enabling scalable transformation [33–35].

To understand these multifaceted transformations, this systematic review applies a multi-theoretical framework, combining four intertwined perspectives: (i) Dynamic capabilities theory (DCT) elucidates how organizations create, adapt, and reconfigure diverse resources to respond to environmental and market volatility [36]. Dynamic capabilities (e.g., adopting new technologies, sensing opportunities, and reconfiguring value proposition) are crucial for Agri-SMEs operating in markets with high volatility, instability, and policy fluctuations [37]. (ii) Business model canvas (BMC) provides a nine-element framework, including activities, channels, cost structures, customer relationships, customer segments, key resources, partnerships, revenue streams, and value propositions, which allows systematic categorization of how digital technologies reshape organizational logic [38–40]. (iii) The technology–organization–environment (TOE) model contextualizes technology and innovation adoption decisions within three spheres: technological (e.g., compatibility, usability), environmental (e.g., regulations, market dynamics, infrastructure), and organizational (e.g., resource capacity, leadership) [41,42]. This analytical framework matches the Agri-SME context in capturing unique variance in the three dimensions across diverse regions. (iv) Diffusion of innovation theory (DOI) explains the impact of different characteristics of innovation (e.g., trialability, complexity, relative advantage, and observability) on acceptance across a diverse range of firms [41,43]. The DOI helps a nuanced understanding of differences concerning institutional cultures and geographies, specifically when peer influence, market visibility, or digital trust are critical. Collectively, the pre-stated perspec-

tives facilitate a multi-level understanding of how innovations interplay with contextual and organizational dynamics to steer or restrict BMT.

Despite the above, the current academic literature on the impact of digital innovation and BMT in agriculture, specifically related to SMEs, remains inadequately synthesized and fragmented. Firstly, most prior works present a discrete analysis of specific digital technologies and innovations (e.g., precision agriculture tools, mobile apps, IoT), undermining the dynamics of how these innovations interact or coevolve within organizational transformation pathways [44,45]. Secondly, most researchers often focus on adopting tools at the farm level, neglecting the institutional dynamics of Agri-SMEs and their embeddedness in intricate value networks of agriculture [46,47]. Thirdly, only a few robust conceptual frameworks present digital innovation from a strategic transformation perspective rather than mere technological adoption [48]. Congruent with the above, many existing reviews are either scoping in nature or narrative, lacking systematic exclusion criteria, transparent source selection methods, and methodological consistency [49,50]. Although rich in market forecasts and case examples, reports from consultancies and agencies lack reproducibility and theoretical rigor [51–53], ultimately leaving researchers, policymakers, and investors without a comprehensive, evidence-based roadmap capturing generalizability and granularity of the multi-dimensional impact of digital technologies on business models in Agri-SMEs [11]. Another challenge is the methodological and regional biases. Significant underrepresentation exists in specific contexts (e.g., Southeast and Central Asia and Pacific Island countries), with most studies focusing on South Asia, West and East Africa, and Latin American economies [54,55]. Methodologically, past empirical works vary extensively, ranging from exploratory studies and subjective case studies to well-crafted cross-national surveys and field experiments. Despite that, only limited studies employ rigorous, robust comparative research designs or formalize the business model implications in their conclusions [56].

Considering the above knowledge gaps, the article presents a systematic review (PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses compliant) synthesizing evidence from ninety-five peer-reviewed papers (2013–2025) retrieved from leading global databases, e.g., Web of Science and Scopus. The review applies rigorous screening criteria for exclusion and inclusion to ensure that the analysis exhibits robust empirical validity, thematic alignment, and relevance to Agri-SMEs. The subsequent synthesis examines the impact of digital innovation (as an enabler or inhibitor) on BMT in Agri-SMEs, with attention to technological modality, geographic context, and organizational transformation processes.

The main contributions of this work to policy discourse and theory are discussed hereafter. First, the paper presents the first theory-informed, systematic review of digital innovations and BMT in Agri-SMEs, combining strategic insight with empirical patterns. Second, it organizes innovations into five clusters, i.e., AI/deep analytics, blockchain/traceability, cloud-based services, IoT/automation, and mobile-integrated platforms. It explains their impact on business models across three value domains. Third, for the first time, the paper applies a multi-conceptual diagnostic lens, i.e., BMC, DCT, DOI, and TOE, to investigate enterprise reconfiguration typologies, pathways of organizational transformation, and intermediatory factors. Fourth, the paper highlights four structural barriers to BMT, i.e., interoperability failures, regulatory gaps, digital illiteracy, and weak digital ecosystems inhibiting equitable expansion. Fifth, the paper offers a forward-looking agenda for practice and theory, suggesting strategies to establish inclusive, sustainable, and adaptive policy frameworks, innovation ecosystems, and BMT in Agri-SMEs.

The rest of the article is organized into the following parts: Section 2 outlines the methodology of review; Section 3 reports findings, structured around clusters of innovation

and mapped across dimensions of BMT; Section 4 presents the practical and theoretical implications of key findings, highlighting enablers, cross-cutting patterns, constraints; and discusses policy recommendations, identifying essential priorities for future cross-disciplinary research.

2. Materials and Methods

A multi-staged approach was employed to retrieve the data for the systematic review. As seen in Figure 2, following the PRISMA 2020 guidelines [57,58], a well-defined study protocol for synthesizing data enabled the exclusion of redundant, irrelevant, and low-quality studies. Figure 2 depicts the PRISMA 2020 flow diagram for a systematic review, which includes searches of databases and registers. A hybrid approach was adopted to ensure interpretive depth and empirical comprehensiveness, while specific objectives guided the systematic review. The scope was bounded along four dimensions (e.g., sectoral) to capture the contextual variances, the heterogeneity of digital innovation pathways, and sector-specific trends across global agricultural systems. Articles containing the keywords ("agricultural SME*" OR "agri-enterprise*" OR "smallholder business" OR "rural enterprise") AND ("digital innovation" OR "IoT" OR "blockchain" OR "mobile platform" OR "AI" OR "cloud computing") AND ("business model" OR "value creation" OR "platform economy" OR "revenue structure" OR "digital transformation") were retrieved from five prominent academic databases (Scopus, Web of Science, DOAJ, Google Scholar and PubMed), the search queries were matched to the syntax of the selected platforms to enhance sensitivity. After exporting retrieved papers (2138) to data management tools (i.e., MS Excel), duplicate entries (n = 930) were removed to attain preliminary categorization (1208) for processing in the screening. Based on PRISMA 2020 standards, the process followed a multi-stage protocol. Third-party arbitration (i.e., subject experts) was acquired to address discrepancies and develop consensus for exclusion. After the initial screening of 1208 studies, 108 were included based on five criteria (e.g., relevance to Agri-SMEs), which were imported into Excel and NVivo 14 software to extract data for synthesis preparation. Key metadata (e.g., innovation type) were accumulated into a coding matrix for thematic analysis. As seen in Figure 2 below, the inclusion and exclusion criteria, designed post-data collection and iteratively refined during the screening, were structured to ensure methodological rigor, thematic focus, and cross-contextual comparability, reflecting a balance of case studies, experiments, mixed-methods, and survey designs across Africa, Asia, Europe, and Latin America.

The study employed a mixed-method appraisal tool (MMAT) for quality appraisal, given its flexibility to assess diverse studies. Quality and methodological robustness were gauged in five dimensions (e.g., validity and reliability of results). While a predefined coding matrix was used to collect content variables and metadata (e.g., author(s), journal, and year; business model component/s addressed), articles were tagged by innovation integration complexity (standalone tools vs. multi-layered platforms), digital maturity level, and region. The complete application of the coding protocol followed a pilot test on five randomly selected studies.

Thematic synthesis, as the core assessment strategy, facilitated methodological heterogeneity and theory-driven generalization [59] through a three-stage process: textual coding (primary data) [60], descriptive themes development, and analytical construct generation. The thematic capacity was reached after around 95 coded papers, with the remaining 13 utilized for emergent pattern confirmation and triangulation. Next, the findings were interpreted and synthesized systematically using a hybrid analytical model by integrating the BMC [61], TOE [62], DCT [63], and DOI [64] to enable simultaneous assessment of adopted innovations, business models, and acceptance differences across contexts. An

intercoder consensus was evaluated to ensure coding and thematic interpretation robustness using Cohen's Kappa coefficient on a twenty percent study sample, which reflected strong agreement with a score of 0.84, per [65]. Potential biases of reviewers were mitigated by following standard procedures, e.g., coder triangulation. Strict ethical standards were upheld through robust inclusion/exclusion criteria, proper attribution, avoiding selective reporting, and keeping neutrality in interpretations.



Figure 2. PRISMA 2020 flow diagram.

3. Reporting of Results

3.1. Agri-SMEs: Clusters of Digital Innovations

The systematic review highlighted five main clusters of innovative digital technologies Agri-SMEs use to reconfigure business models: mobile platforms, AI, IoT, blockchain, traceability systems, and cloud-based data Infrastructure. Even though these clusters varied in technological capacity, adoption patterns, and integration depth, they acted as strategic levers for BMT in three value dimensions. The following section briefly outlines key insights relating to these clusters.

3.1.1. Mobile Platforms

Mobile platforms were the most dominant (n = 35) among other digital innovations, mainly in South Asia and Sub-Saharan Africa, where mobile proliferation outpaced broadband infrastructure. Such innovations included smartphone-based apps, unstructured supplementary service data (USSD)-based advisory systems, and mobile money integration [12,66,67]. For instance, AgriWallet (Kenya) and Kisaan Network (India) allowed Agri-SMEs to revolutionize output procurement, inventory management, and financial planning via localized content delivery and mobile money [14,68] while expanding the reach of SMEs, particularly in remote and underserved areas. Agri-based mobile service platforms, for example, iShamba and Tulaa, transformed disjointed and less formal input markets into organized mobile transaction ecosystems [23,27]. EzyAgric (Uganda) utilized mobile apps with geotagging to connect supply chain analytics with farmer profiles, facilitating logistical accuracy [50]. In short, these mobile platforms were central in bundling service offerings like insurance, loans, advisory, and inputs in single-user interfaces, similar to Apollo Agriculture and DeHaat (India). More so, these mobile apps enabled constant engagement through voice interfaces, multi-language support, and SMS alerts to maintain continuous customer interactions across diverse digital literacy levels [48,49].

3.1.2. AI-Integrated Services

The application of AI frequently appeared in fourteen studies, often structured into platform architectures to enable recommendation systems, predictive analytics, or automatic diagnostics. These AI tools helped Agri-SMEs to personalize and customize services for actors at scale while minimizing dependency on manual decision-making. CrospIn and Fasal employed AI models to forecast pest outbreaks and crop yield through real-time soil and water data monitoring, enabling robust advisory support to farmers [7,29]. Sero.ai (Vietnam) combined image detection into mobile tools to mechanize crop disease prediction, enhancing diagnostic precision for Agri-SMEs providing agronomics services [69]. Zenvus (Nigeria) applied AI to transform sensor Agri data into real-time information for fertilizer and irrigation applications [70]. That said, the review indicated that AI applications remained largely unevenly dispersed. While the integration of AI was found in East Africa and India, most Agri-SMEs in West Africa and Latin America faced skill gaps, data access, and model adaptation issues [41,43,71]. With just 3/14 papers discussing local adaptation and algorithm bias, data indicated a crucial gap in the research and development of AI for Agri-SMEs [72].

3.1.3. IoTs

Seventeen studies featured IoT technologies, including perishable (e.g., horticulture) or logistic-intensive value chains, while devices comprised cold-chain trackers, climate monitors, GPS trackers, and soil monitors [6]. Ghanaian Agri-SMEs in cocoa value chains utilized IoT sensors to monitor storage humidity and improve drying processes, minimizing decomposition and increasing quality consistency [23]. For instance, Hello Tractor (Nigeria) installed GPS devices to monitor tractor consumption and guarantee real-time bookings through mobile platforms to reduce idle time and augment equipment efficiency. In Vietnam and Kenya, IoT platforms allowed Agri-SMEs to manage aquaculture environments dynamically, adjusting pH and oxygen levels through automated alerts [36]. The analysis indicated that IoT thrived when paired with AI backends or cloud dashboards, offering SMEs actionable information instead of sensor data. The IOT papers reported several barriers, including high capital costs, unreliable connectivity, and device maintenance challenges [7,72]. Figure 3 outlines the flow of products and data in an IoT-based blockchain supply chain system. The traceability system tracks all details of food produc-

tion, processing, transportation, and storage conditions. Consumers can access precise information about each step, including every ingredient in the final product.

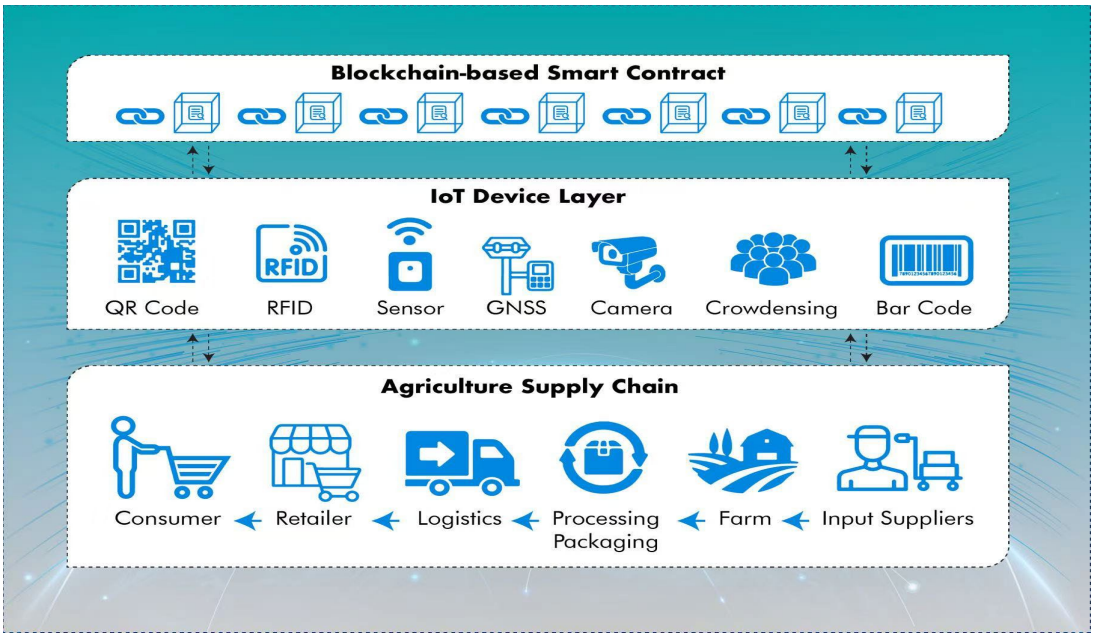


Figure 3. Blockchain-based smart agri-supply chain [6].

3.1.4. Blockchain and Traceability Systems

Almost 14 out of 95 selected studies documented blockchain innovations, primarily in export-oriented Agri-SMEs operating in ethically sensitive and high-value chains (e.g., coffee and cocoa). For instance, Agros (Colombia) employed these technologies to log farm transactions to augment traceability and minimize fraud in the organic certification process [18]. AgriLedger (Ghana) enabled Agri-SMEs to store inventory flow on decentralized ledgers, connecting payments to tested milestones and safeguarding buyer trust [51]. More so, traceability systems facilitated SMEs to ensure compliance with global standards and access price premiums. For instance, exporters of Peruvian quinoa used blockchain to satisfy the EU's transparency requirements, enabling them to claim 15–30% higher rates in verified markets. Although these innovations changed value propositions to product integrity and ethical sourcing to transform the value capture and value signaling of Agri-SMEs, their scalability was limited. In most cases, there was a high dependency on non-governmental organizations (NGOs) or donor support, with only a few self-sufficiently scaled beyond pilot phases. The main challenges were low understanding of users, inadequate legal appreciation of smart contracts, and lack of interoperability [72].

3.1.5. Cloud-Based Data Infrastructure

Nearly 15 studies discussed cloud-based systems, mainly as layers integrating AI models, mobile apps, partner application programming interfaces (APIs), and IoT devices. These innovations enabled Agri-SMEs to sustain distributed operations, predict procurement needs, monitor real-time inventories, and synthesize customer data [34]. Twiga Foods (Kenya) and Ninjacart (India) signified cloud-based supply chain optimization, which utilized enterprise resource planning (ERP) dashboards to forecast market demand, track wastage, and schedule delivery trends [14]. In the Philippines and Vietnam, the Agri-SMEs leveraged cloud technologies to integrate input suppliers, farmer coops, and microfinance banks into unified procurement ecosystems [4]. These tools facilitated modular innovation, enabling Agri-SMEs to connect new capabilities (e.g., e-certification and digital credits)

without revamping backend systems. The papers also reported enhanced Agri-SME resilience during COVID-19, as cloud-based platforms guaranteed service continuity during mobility constraints [10,27].

3.2. Agri-SMEs: Business Model Transformations

Applying the BMC framework to assess how the pre-stated digital innovations transformed business models in three key areas of value (creation, delivery, and capture) within Agri-SMEs revealed divergence and convergence in transformation patterns.

3.2.1. Value Creation

Value creation encompasses developing offerings, bundling services, and generating perceived customer value. Almost one-third of studies supported that digital innovation significantly altered value conception, operationalization, and scalability. Digital platforms enabled firms to evolve from vendors of products to service integrators. For instance, firms that previously traded just inputs started bundling them with embedded credit, crop insurance, mobile-based agronomic advice, and logistics scheduling. Such bundling was more profound in Kenya, India, and Nigeria, comprising various platforms, e.g., AgriWallet [21,45]. IoT and AI technologies improved value creation by providing predictability, precision, and personalization. While companies like CropIn and Zenvus offered AI-based diagnostics to personalize suggestions, producing customized value propositions reinforcing stickiness and trust among smallholder clients [12,50], many blockchain-enabled Agri-SMEs reconfigured their value creation logic around ethical sourcing, traceability, and regulatory compliance. In Ghana and Peru, SMEs used blockchain to show organic certification, origin, and fair-labor standards, facilitating access to high-value export markets [53].

Cloud systems facilitated modular innovations by allowing Agri-SMEs to arrange external service providers (e.g., certification agents, microfinance, logistics partners) via digital interfaces and APIs, moving from enterprise-centric to ecosystem-based value creation. This change exemplified a structural transformation in the role of SMEs from operators to orchestrators [68]. Likewise, digital technologies enabled firms to move from discrete product sales to integrated and intelligence-driven service bundles. This bundling allowed Agri-SMEs to offer financing, advisory, inputs, and insurance as an all-in-one package. For example, digital platforms in Kenya (AgriWallet and Apollo Agriculture) integrated satellite-based weather data and mobile money to customize planting schedules and input financing to individual farmers [31]. In India, AI-driven platforms (Fasal and CropIn) delivered customized advisory of crops based on real-time farm data, reforming value creation from typical suggestions to hyper-individualized agronomic support. These digital platforms moved Agri-SMEs from passive distributors to high-value information-disseminating intermediaries, developing high-frequency, feedback-based customer relations [25].

Moreover, the analysis indicated that IoT-based tools enabled process-centric value creation, predominantly in post-harvest management. In Colombia and Vietnam, applying humidity and temperature sensors mitigated wastage in high-value chains such as coffee and aquaculture [12]. This transformation to data-enhanced services permitted SMEs to offer transparency and consistency, key discriminators in fragmented supply chains. Similarly, blockchain technologies helped convert value creation into provenance and trust. Tamper-proof ledgers by AgriLedger (Ghana) and Agros (Colombia) enabled end-buyers to authenticate (e.g., organic status, origin, and payment fairness [11,35], offering a new standard of value propositions based on digital traceability and ethics.

3.2.2. Value Delivery

As per all fifty-eight studies, digital innovation transformed value distribution, exchange, and communication, often causing disaggregation of roles, disintermediation, and

delivery channel reengineering. Mobile platforms were vital to last-mile delivery innovations, particularly in LMICs with gaps in infrastructure. Firms (e.g., Tulaa and Apollo Agriculture) leveraged SMS, USSD, and smartphone apps to coordinate various services (e.g., delivery and collection of payments) and interact with customers remotely [6] to replace outdated input dealers and increase delivery reach. AI and IoT enhanced delivery through real-time predictions and scheduling feedback loops to optimize crop harvest times based on ripening cycles and weather conditions. GPS-driven IoT tracking aided cold chain workers to preempt interruptions and continue to produce integrity [49,73]. At the same time, blockchain strengthened delivery chain transparency and contract enforcement, particularly in Latin America, reducing turnaround times and disputes. Cloud-based platforms promoted partner monitoring, route optimization, real-time dashboards, and stock replenishment automation, enabling firms to serve as digitally distributed enterprises [18]. Almost 53 papers recognized radical transformation by digital tools in value delivery, reflecting a clear move toward orchestrated, multi-channel, and real-time delivery systems. Mobile platforms were central to disintermediation. Agri-SMEs like iProcure (Uganda) and Tulaa (Kenya) replaced conventional Agri dealers with app-based mobile payment verification and delivery scheduling, improving efficiency and minimizing leakages [4]. A micro-entrepreneur network (DeHaat, India) powered by a centralized mobile application transformed informal service providers into digitally enabled delivery agents [21].

Furthermore, cloud-based dashboards enhanced the synchronization of inventory, delivery tracking, and route planning. Twiga Foods utilized predictive analytics to improve consolidation from smallholder farms and plan urban market deliveries with minimal wastage. Tanihub (Indonesia) integrated cloud applications in Southeast Asia with fintech APIs, allowing automated invoicing and same-day payment clearance [72]. Similarly, IoT improved delivery precision. In Vietnam, aquaculture SMEs installed IoT-based pond management systems, transforming physical delivery of service into digitally controlled environments [69]. While blockchain was used for certified shipments via smart contracts in Latin America, Agros used these systems to facilitate digital contractual trust [51]. The review also discovered platform orchestration as a novel delivery architecture. Ninjacart advanced from linear collectors into multi-player platforms, managing retailers, farmers, financiers, and transporters. This value delivery method through coordination instead of operation or ownership points to a fundamental reorientation in the scale of impact on SMEs [11].

3.2.3. Value Capture

The review highlighted significant transformation in value capture, i.e., how SMEs retain and generate revenues. Thirty-seven studies hinted that Agri-SMEs transitioned from volume-driven, single-stream models to transaction-based, multi-stream, and performance-centric models. With mobile apps promoting consumption-based transactions and pricing fees, SMEs generated profits from interactions rather than markups, as AgUnity and DeHaat only charge subscription fees for premium tools [45]. Layered monetization strategies enabled by IoT and AI, comprising freemium models with access to free and paid services (e.g., disease diagnostics and yield predictions), were especially effective in East Africa and South Asia, where digital literacy was appropriate to promote differentiated offerings. The provision of tiered subscription services in India through Fasal offered basic crop tracking for free, yet charged premium prices for pest risk modeling, satellite-based insights, and tailored spray advisories. This approach enabled augmented inclusion while conserving revenue from digitally educated customers.

Equally, blockchain indirectly supported capturing value by enabling premium pricing and market differentiation. Traceability to show compliance with global standards

(e.g., EU) permitted SMEs to access higher-value markets, with customers willing to pay up to thirty percent more for ethically sourced and verified products [16,74]. More so, data monetization appeared as a unique value-capture practice in six studies. SMEs compiled, anonymized, and offered farm-level transaction data to agrochemical firms, insurers, or banks, positioning themselves as data intermediaries within value chains [5]. More so, cloud systems mitigated operational overheads, permitting scalability of operations without relative cost upsurges. The centralized prediction and distribution service by Ninjacart reduced inventory losses and supported higher volumes even when average transactions were small. This scale-to-cost decoupling, mentioned in twelve studies, enabled improved revenue margins even when average service prices decreased [45]. Almost thirty-seven papers supported that firms shifted from linear sales models to multi-layer, adaptive monetization models by combining data monetization, direct payments, subscription pricing, and commissions. Mobile apps used transaction-based pricing, where some firms charged transaction fees to access blockchain farmer networks, while others claimed a percentage-based markup for bundled loan packages [55]. Beyond the above, the SMEs established ecosystem monetization strategies. In Southeast Asia and India, firms generated revenues from third parties through affiliate commissions on their digital platforms, creating ecosystem rent that allowed value capture from coordinated value exchange rather than ownership [21].

3.3. Contextual Dynamics and Regional Heterogeneities

The adoption of digital innovation among Agri-SMEs demonstrated unique regional patterns, exhibiting context-embedded pathways shaped by each region's institutional constraints and structural affordances rather than as disjoint phenomena. The following section explains five archetypes, each uncovering the co-evolution of innovative and technological capabilities, market logic, and governance modalities under varying specific contextual dynamics. In sub-Saharan Africa, as per 19 studies, the structurally fragmented ecosystem appeared to be characterized by transaction-based front-end and mobile-enabled innovations [35]. There was an apparent domination of penetrative mobile money ubiquity, mobile networks, and logistical precarity, an arrangement fostering low-cost transaction digitization but limiting backend transformation [75,76]. As noted in the case of iProcure and Apollo Agriculture, most province or state infrastructure was substituted by community-based agent models [43]. Digital innovations (e.g., IoT and AI) such as Hello Tractor were mainly non-scalable and dependent on large donors because of systemic barriers in digital literacy and data availability. Critically, the value architecture was shallow as transactional revenue dominated the region, with only a few actors striving for asset control or data valorization [77]. Agri-SMEs represented thin digital intermediation by serving as analog brokers (mobile-based transactional actors) rather than system integrators.

In South Asia, almost 14 studies offered sufficient evidence for the maturity of the digital ecosystem and deep integration of platforms, supported by public digital initiatives, API-ready infrastructure, and vibrant fintech ecosystems [2]. CropIn and DeHaat exemplified this regional trend, building multi-service platforms that integrated geospatial data, AI-driven advisories, and credit scoring algorithms to promote end-to-end agricultural services. The regional dynamics were characterized by a convergent digital-public infrastructure in India (e.g., UPI, Aadhaar, and AgriStack), enabling Agri-SMEs to expand swiftly across geographies and verticals [19]. Digital technologies were data-layered rather than product-centric, with monetization realized via freemium services, subscription models, and data analytics for buyers [47]. However, blockchain technologies appeared strategically defensive and functionally peripheral, as the application remained limited to export chains (e.g., turmeric and basmati) for compliance rather than transformation [77],

reflecting a regulatory innovation instrumentalization instead of ecosystem disruption. In the same way, in Southeast Asia (per nine studies), digital integration was institutionalized to promote coordinated agricultural systems, specifically in Indonesia, Vietnam, and the Philippines. Agricultural ministries, public–private partnerships, and cooperatives served as enablers and co-designers in creating digital pathways [3]. The IoT was embedded rather than experimental and was used in horticultural diagnostics, pond monitoring, and feed optimization, e.g., Tomoto and eFishery. The institutional fabric was the key to contextual success, mainly driven by municipal delivery networks, policy-driven coordination, and government-supported and subsidized digital expansion systems [75]. Value capture extended beyond the Agri-SMEs' level to public–private revenue-sharing models, including cost-plus pricing, B2B integrations, and co-investment with agribusinesses [67]. Blockchain use was rare and highly contingent on state-run export compliance programs (e.g., GAP protocols). This region represented innovation within the bounds of coordination, not disruption.

In Latin America (six studies), especially Brazil, Peru, and Colombia, the prevailing pattern was traceability-focused digitalization, with Agri-SMEs digitally certifying ethical sourcing, input provenance, and labor practices to meet export buyer standards [12]. Furthermore, blockchain was deployed not as a technological frontier but as a credibility layer, enabling price premiums and compliance assurance via QR codes, decentralized ledgers, and smart contracts [54]. The key contextual enablers were strong export orientation and the presence of buyer-driven governance. While digital innovation enhanced documentation and transparency, it rarely extended to farm-level productivity or supply chain optimization. SMEs often digitally augmented rather than replaced brokerage structures, maintaining power asymmetries. Government interventions, such as Peru's certification subsidies, further entrenched this compliance-centric innovation path [78].

In the EU (10 studies), particularly in Italy, Spain, and the Netherlands, Agri-SMEs operated in regulation-intensive ecosystems, where digital innovation was compliance-centric, subsidy-linked, and data-monetized [12]. The contextual fabric included robust digital public infrastructure, national Agri-data portals, and cloud-based ERP systems that facilitated automated traceability, subsidy workflows, and environmental monitoring. Innovation was less about experimentation than systemic optimization using AI for resource efficiency, digital twins for greenhouse control, and APIs for regulatory integration [45]. Revenue strategies, including subscriptions, benchmarking dashboards, and metadata services, were sophisticated and knowledge-intensive [79]. Here, SMEs functioned as information orchestrators, not just producers or intermediaries, a trajectory lacking in LMICs.

3.4. Multi-Framework Synthesis

This review strategically aligned synthesis findings with four interconnected theoretical frameworks: the Business Model Canvas [61], the Technology Organization Environment framework [62], the Dynamic Capabilities Theory [63], and the Diffusion of Innovation theory [64]. This approach facilitated a comprehensive understanding of how digital innovations transformed the structure, strategy, and positioning of Agri-SMEs worldwide.

3.4.1. BMC: Structural Reconfiguration of Enterprise Logic

The BMC framework, utilized by various authors [80–82], effectively highlights the business model components transformed by digital innovation, with Section 3.2 elaborating on value creation, delivery, and capture while acknowledging other notable changes. For instance, digital platforms have enabled agricultural SMES to categorize customers

by behavior, location, and creditworthiness, facilitating tailored service offerings like pay-as-you-go inputs and bundled loans [33]. Mobile technologies and chatbots support continuous engagement, transitioning SMES from sporadic interactions to ongoing relationship management, bolstered by trust mechanisms such as SMS notifications and loyalty rewards [83]. More so, integrating digital innovations has redefined distribution and communication. SMEs adopt digital delivery methods such as apps, SMS, and web dashboards, often in collaboration with community agents, to ensure offline accessibility [31]. Cloud-based APIs facilitate integrating services from banks, insurers, logistics providers, and certifiers, as seen in robust platforms like DeHaat and Twiga Foods, emphasizing coordination over ownership [34]. Likewise, digitization has led to lower marginal service delivery costs, allowing for significant scaling; however, challenges persist due to high fixed costs associated with IoT, AI development, and blockchain implementation [48]. Revenue models have evolved, with transaction fees, subscriptions, data monetization, and embedded commissions replacing traditional flat-margin sales, positioning some SMEs as digital brokers in ecosystem coordination rather than direct sales [16].

With the BMC concept applied across included studies, we examined how digital technologies transformed Agri-SME operations across the nine BMC building blocks. The review suggested that value Propositions were reshaped through bundling and personalization. For example, Apollo Agriculture and DeHaat moved from input sales to holistic bundles (advice, credit, logistics). AI-enhanced services by CropIn and Fasal enabled micro-targeted advisories, improving yield predictability [84]. Customer Segments evolved through real-time data tracking. In India, AgNext segmented clients by product quality thresholds, offering graded pricing tiers to institutional buyers [85]. Channels diversified across mobile, voice, app-based, and agent-assisted modalities. AgroCenta and Tulaa used agent-assisted mobile services in Ghana and Kenya to penetrate low-literacy markets [86]. Customer Relationships shifted from transactional to relational. AgUnity integrated blockchain and SMS alerts to maintain longitudinal relationships with smallholders. Key Partners were reconfigured via APIs. SMEs such as Ninjacart and Twiga Foods used cloud platforms to synchronize with insurers, financiers, and logistics partners [87]. Key Resources increasingly include intangible digital assets, such as dashboards, analytics engines, and datasets, as seen in EU-based SMEs like Agroptima. Cost Structures became front-heavy, with platform development and compliance integration dominating fixed costs, but variable costs declining with scale. Revenue Streams are diversified, ranging from transaction fees (e.g., AgriWallet) to subscriptions (e.g., Fasal) and data monetization (e.g., iShamba, AgNext) [88]. In short, this analysis showed that digital transformation facilitates transitioning from traditional, linear business model configurations to more modular, ecosystem-focused business models.

3.4.2. TOE Framework: Enablers and Barriers to Digital Transformation

The TOE framework [42] was used to interpret contextual factors influencing digital innovation adoption and internalization success or failure. This framework helped identify the internal and external factors influencing digital innovation adoption among Agri-SMEs [89]. Compatibility with mobile infrastructure drove the adoption of USSD-based tools in Africa (e.g., iProcure, Hello Tractor). At the same time, cloud-readiness enabled advanced platform orchestration in South Asia (e.g., CropIn) [90]. Firms with entrepreneurial leadership, technical teams, and data analytics capacity (e.g., DeHaat, AgNext) were better positioned to integrate AI and cloud platforms. SMEs with weak internal structures require external intermediaries (e.g., NGOs, co-ops) to bridge capability gaps [43]. Furthermore, government policies and ecosystem infrastructure were decisive. In Peru, blockchain adoption was subsidized by the export compliance program, while in the EU, cloud tools were

linked to regulatory portals [91]. Findings across 38 studies suggest extending the TOE model to include a fourth dimension, ecosystem embeddedness, which encompasses API availability, certification regimes, and trust networks. This would better explain successful orchestration by firms like Twiga Foods and Agros, which relied heavily on multi-actor digital alignment. Innovations aligned with existing mobile infrastructure (e.g., USSD) had faster uptake, especially in sub-Saharan Africa and South Asia. IoT and blockchain systems were often perceived as difficult to operate and maintain, especially in resource-constrained environments. Digital platforms offering bundled services or embedded finance had clear perceived benefits, accelerating adoption among SMEs with fragmented clientele. Figure 4 illustrates the potential impact pathways of digital tools [92].

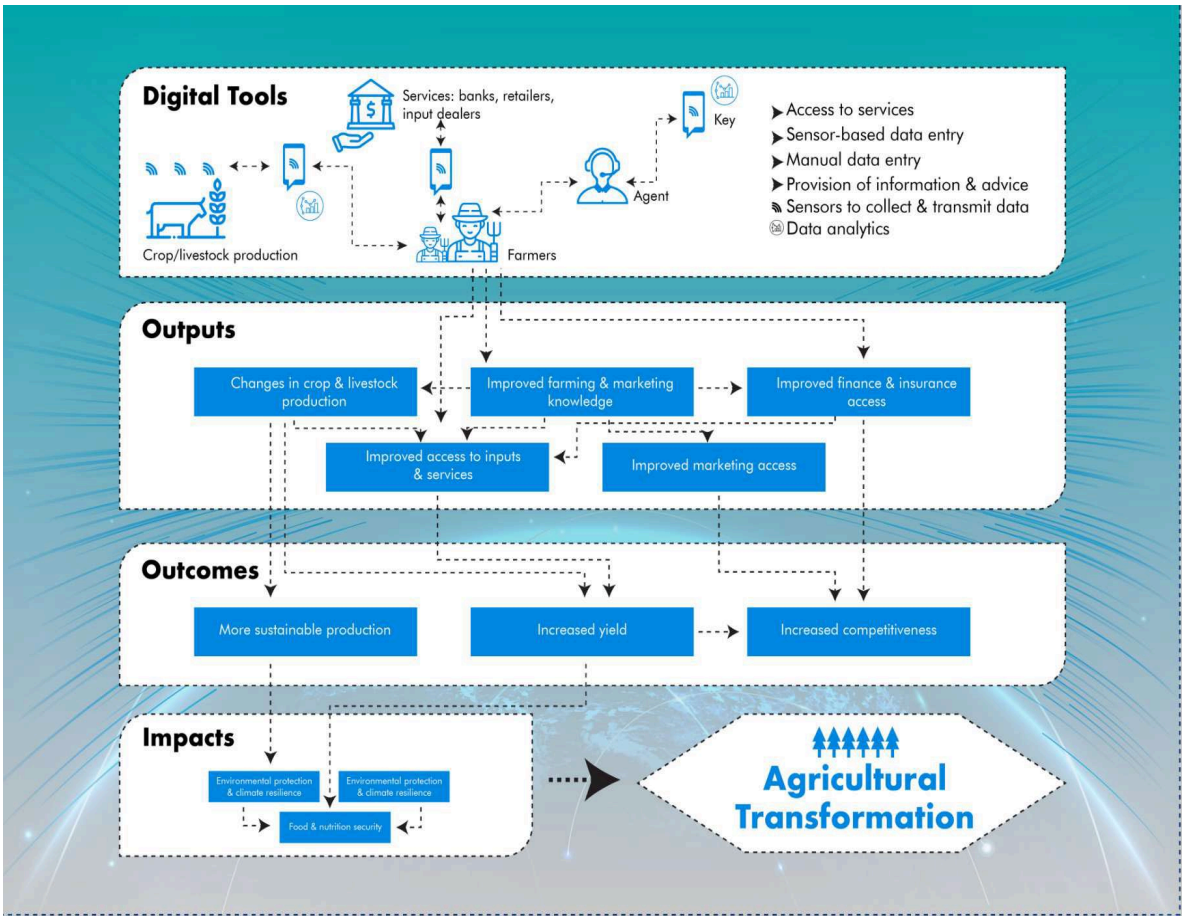


Figure 4. Potential impact pathways of digital tools [92].

Similarly, entrepreneurial leadership and digital fluency among founders emerged as key determinants of digital transformation success. Micro-enterprises struggled with upfront investment and lacked capacity for advanced tools like AI and blockchain [93,94]. Policy alignment and digital incentives facilitated adoption in Southeast Asia and the EU. In contrast, regulatory ambiguity constrained fintech integration in sub-Saharan Africa [95]. Competitive pressure in saturated markets (e.g., Indian input retail) accelerated digital adoption as a differentiation strategy. Collaborations with donors, development banks, or state agencies were critical enablers, especially for capital-intensive innovations like IoT and traceability systems [96,97].

3.4.3. DCT: Adaptation and Reconfiguration

DCT explained how Agri-SMEs developed strategic competencies to sense, seize, and transform resources in dynamic environments [24]. This framework has been especially

relevant for SMEs navigating shocks (e.g., climate variability, COVID-19) while undergoing digital transitions. The review indicated that SMEs had effectively utilized mobile applications, cloud dashboards, and real-time analytics to adapt to shifting customer needs and environmental challenges. By transforming value propositions from simple input supply to comprehensive service bundles, they had successfully captured emerging opportunities demonstrated by platforms like Apollo Agriculture, which integrated financial services with agronomic tools. Cloud-enabled coordination had underpinned this transformation, allowing SMEs to transition into integral nodes within digital ecosystems. For instance, AgUnity's swift pivot to a blockchain-based transaction platform illustrated this shift, as high-growth SMEs leveraged continuous platform iteration and feedback loops to enhance organizational learning as a strategic asset [98]. Moreover, the DCT showed how Agri-SMEs created competitive advantages by recognizing and seizing opportunities while adapting operations in response to environmental changes. AI-enabled dashboards, such as those from Fasal and Zenvus, empowered SMEs to detect pest risks and microclimate variations, prompting modifications to product offerings, as seen with AgriWallet's evolution from a savings tool to a comprehensive advisory service [99]. Notably, the transformation was not solely reliant on internal resource alterations; many Agri-SMEs accessed modular platforms and third-party APIs to reconfigure their business models, a trend that was confirmed by numerous studies in Asia and Africa. This finding underscored the importance of external ecosystem orchestration alongside internal adaptability in fostering dynamic capability in the digital age [100].

3.4.4. DOI: Patterns of Uptake and Normalization

The DOI theory [101] offered insight into the adoption of digital tools within SME populations and rural networks, emphasizing the importance of several constructs. Key findings indicated that mobile platforms with integrated financial features or discounts greatly enhanced adoption rates. Moreover, tools that supported local languages allowed offline access and employed voice interfaces tended to attract more users. Conversely, technologies that required complex data input, such as blockchain, faced pushback unless accompanied by adequate technical assistance. Freemium models and pilot projects facilitated experimentation, while visible branding, like traceability QR codes, significantly increased scaling potential due to social proof, particularly in closely knit rural communities [102]. Peer influence and partnerships with local influencers, such as cooperatives, substantially accelerated the digital normalization process for SMEs [103].

Adaptations of the DOI theory were necessary to reflect the multifaceted, social nature of innovation diffusion observed in this research. The relative advantage of digital solutions was maximized when they addressed immediate challenges, exemplified by platforms like Tulaa and Apollo, which provided time and cost savings [99]. Innovations increased adoption through heightened compatibility via localization efforts, as demonstrated by initiatives that offered Hindi-language prompts or region-specific content. The complexity of certain tools, such as blockchain, hinders uptake without comprehensive onboarding [104]. Finally, trialability and observability influenced acceptance; platforms like Fasal utilized freemium arrangements for testing, while community demonstrations significantly boosted user interest. This review revealed that trust networks and cooperatives were crucial for adoption. Social legitimacy often preceded technical efficiency in driving digital innovation uptake among Agri-SMEs [105–107].

4. Discussion

This synthesis revealed several patterns influenced by geographic factors, organizational capabilities, and ecosystem dynamics. Key themes identified were (1) the con-

vergence and divergence in innovation pathways, (2) the interdependence of business model elements, (3) the integration within digital ecosystems, (4) theoretical advancement, and (5) strategic considerations for growth. The analysis clarified how digital innovation transformed Agri-SME business models within varied institutional settings and proposed a comprehensive framework addressing the transformation's drivers, mechanisms, and barriers. The discussion emphasized overarching trends and the structural convergence surrounding modularization, platformization, and ecosystem orchestration.

4.1. Convergence and Divergence in Digital Innovation Pathways

The synthesis revealed a dual pattern of convergence and divergence in the digital transformation of Agri-SMEs. Digital innovations were clustered around mobile platforms, AI, IoT, blockchain, and cloud technologies. While mobile platforms were foundational in LMICs, their integration with AI and cloud technology in South and Southeast Asia indicated a higher digital maturity [50,86,96]. The analysis highlighted a stark contrast in adoption: 35 out of 95 studies utilized mobile platforms, while only 14 incorporated AI and 14 applied blockchains, indicating the varying capacities of organizations and ecosystems. Across regions, innovation convergence was evident in the dominant adoption of five digital innovation clusters. In sub-Saharan Africa, mobile-first solutions like M-Pesa facilitate transactions, whereas in India, SMEs such as DeHaat leverage AI and cloud for real-time analytics. Different value capture strategies emerge, with African SMEs concentrating on transaction models, while South Asian platforms adopt freemium and data monetization [88]. The findings underscored that digital innovation was not linear but contingent on contextual factors such as infrastructure and institutional support.

4.2. Interdependence of Business Model Components

The analysis across business model domains showed that digital transformation rarely impacted value creation, delivery, or capture alone. Instead, innovations simultaneously shifted many business model components, resulting in feedback loops and structural changes. For example, when companies adopted mobile-based delivery platforms, the changes went beyond just delivery channels. They also affected value propositions, such as offering bundled services, revenue models like transaction fees, and customer relationships through ongoing mobile engagement [101]. This interconnectedness challenged the traditional view of business models as separate elements and supported a systems perspective. In this view, changes in one component often lead to changes in others. However, this systemic transformation did not happen equally across all components. Key activities, customer segments, and partnerships developed more rapidly than internal processes, governance structures, or human resources. Few studies examined changes in internal decision-making, indicating that many transformations may have been superficial [99]. The habit of adopting digital tools without aligning them with shifts in organizational logic led to digital facades where technology was used without accompanying structural changes.

4.2.1. Embeddedness in Digital Ecosystems and Orchestrated Platforms

Transformative Agri-SMEs embedded in digital ecosystems rather than solely digitizing were more successful internally. These companies coordinated various actors through digital platforms, including farmers, buyers, input providers, financial institutions, and regulators [50]. The shift to platform-based business models fostered new interdependencies and value creation, creating challenges around governance, data ownership, and pricing transparency. Successful orchestrator models, like DeHaat and Twiga Foods, utilized APIs and algorithmic tools to integrate services. While they eliminated traditional brokers, they introduced new forms of digital intermediation, resulting in potential power disparities. Smaller, less digitally mature SMEs often participated in ecosystems as followers, strug-

gling with identity and value capture [21]. A key trend was the adoption of modular digital strategies by Agri-SMEs, which allowed them to integrate third-party tools for flexibility and cost efficiency. Examples included Twiga Foods and CropIn [12], which leveraged cloud-based APIs for enhanced logistics and analytics. However, this modular approach posed risks such as vendor lock-in and governance issues, with only a few studies addressing these challenges directly.

4.2.2. Platformization and Multi-Sided Value Creation

The platformization of SMEs transformed traditional business models by positioning them as orchestrators that connected various user groups, such as farmers, buyers, and logistics providers, within digital ecosystems. Notable examples included DeHaat, which digitally oversaw the entire agricultural value chain by managing input procurement and B2B sales, and AgroCenta in Ghana, which offered a marketplace for direct grain transactions while providing pricing analytics and financing. This shift fostered an ecosystem-centric approach, as demonstrated by Tanihub in Southeast Asia, which integrated warehousing, logistics, finance, and market access into a comprehensive digital platform [71]. Despite its advantages, platformization posed governance challenges, with many SMEs expressing concerns about platform dependency, unclear pricing, and unequal data control. While platform orchestrators benefited from economies of scale and network effects, peripheral participants risked losing power unless protected by transparent policies and robust enforcement mechanisms [89]. This evolution highlighted the necessity of balancing innovation in platform models with safeguarding the interests of all stakeholders involved.

4.2.3. Ecosystem Positioning and Trust Intermediation

Successful SMEs with augmented digital innovation structures achieved digitizing transactions and establishing themselves as trusted intermediaries within larger ecosystems. Notably, 26 out of the 95 selected studies highlighted that building trust is essential, particularly in asymmetric information, fragmented supply chains, and insufficient regulatory oversight. Notable blockchain-based firms such as AgriLedger and Agros have leveraged immutable ledgers to demonstrate ethical compliance and maintain origin integrity for buyers, donors, and certifiers [51]. Similarly, Agroptima and Dutch greenhouse operators have digitized traceability across the EU, minimizing paperwork and enhancing reputational assurance in sustainability markets. Even outside blockchain applications, SMEs have fostered trust through transparency in data, effective branding, and inclusive design practices. For example, AgUnity employed mobile applications to develop shared digital logs for cooperatives in Kenya, enabling farmers to verify deliveries and pricing collaboratively. In Peru, quinoa-producing SMEs utilized QR-code traceability to connect end-buyers with producers' stories, reinforcing affective trust through narrative marketing [31]. As a result, SMEs transition from mere logistics providers to credible certifiers of reputation facilitated communication between fragmented producers and discerning institutional buyers. Thus, trust-driven innovation emerged as a vital strategic asset rooted in digital advancements and the integration of SMEs within relational ecosystems [87].

4.3. Theoretical Implications

From a theoretical perspective, the current review identified critical empirical trends that implied modifications to how these concepts were applied in data-intensive, platformatized, and ecosystem-mediated environments within the Agri-SME sector. Firstly, considering BMC [80], empirical results suggested that its fundamental assumptions of asset ownership, organizational boundedness, and flows of linear value were insufficient to capture the business rationale of digital Agri-SMEs, given that activities, value propositions,

and revenue streams were progressively designed across ecosystems that were modular and cloud-mediated. Thus, BMC was viewed as a dynamic orchestration infrastructure instead of a static blueprint. Secondly, the review supported the idea that the TOE framework application [43] mandated an extension to consider Digital Institutional Interoperability (DII). Data from several regions (e.g., sub-Saharan Africa and Latin America) showed that digital adoption among SMEs relied significantly on their capacity to align with regulatory portals, public digital infrastructures, and cross-sectoral data ecosystems, implying that TOE should integrate infrastructural and institutional embeddedness as important drivers of digital innovation success.

Thirdly, results concerning DCT [24] affirmed that digital Agri-SMEs develop competitiveness not only through the internal development of seizing, sensing, or transforming capabilities but also by focusing on curating external competencies through cloud services, fintech APIs, and modular collaborations. Thus, DCT applications should incorporate the concept of relational governance and interface fluidity beyond conventional firm-internal reconfiguration. Finally, concerning the DOI theory [13,64], the review elicited that the diffusion of innovation among Agri-SMEs occurred not through single adopters making decisions alone but through interactive cascades facilitated by NGOs, cooperatives, and communal influencers. With digital adoption often occurring in complementary services bundles instead of independent tools, the application of DOI in digitally robust agriculture environments should consider modeling multi-actor, bundled innovation dissemination processes entrenched within trust networks.

4.4. Limitations and Future Research Directions

Despite the methodological rigor of the PRISMA-aligned systematic review and the breadth of cross-regional empirical integration, several critical limitations remained. These limitations were not merely technical; they spoke to deeper epistemological, methodological, and ontological blind spots in the research on digital innovation and business model transformation in Agri-SMEs. Based on this, the paper proposed five strategic directions for a more generative and theoretically robust future research agenda. First, the review included 95 heterogeneous studies, revealing significant regional disparities: sub-Saharan Africa, India, and parts of Southeast Asia were well-represented, while Francophone Africa, Central Asia, and small island states were notably under-researched. The evidence leans toward pilot innovations and donor-funded platforms, neglecting longitudinal or commercial case studies, which impairs the understanding of sustainability and scalability. Future research should employ longitudinal, comparative, and mixed-method designs to track business model evolution over time and geography. Second, only a small fraction (11%) of the studies examined power dynamics, gender access, or digital marginalization. A reflexive research agenda is necessary to view platform politics, algorithmic discrimination, and gendered exclusion as structural issues within digital ecosystems. Third, most studies focused on technocratic metrics like yield and efficiency, overlooking subjective outcomes such as trust and autonomy, which are crucial for understanding sustainable community transformations. Future work should embrace diverse methodologies, including qualitative and ethnographic approaches, to capture real-world digital interactions. Fourth, the review's reliance on publicly available data limited participant consent and ethical approval, leading to several methodological limitations. Focusing on peer-reviewed sources may overlook valuable practitioner insights and localized studies, while restricting English publications could exclude critical regional studies published in other languages. Although the databases used were comprehensive, they may still miss essential empirical work. Furthermore, the thematic analysis remains subject to researcher bias despite its

validation. Nevertheless, despite these limitations, the review maintains methodological transparency and adheres to systematic coding rigor.

Additionally, future researchers should develop frameworks to analyze the evolving roles of Agri-SMEs as orchestrators, brokers, or data nodes within their ecosystems, utilizing game theory and network analysis. They should explore how interoperability functions as a strategic resource, shaped by public standards and political factors, particularly for SMEs lacking infrastructural advantages. Given that new theoretical models are needed to address multi-sided value creation and data brokerage that reflect the complexities of digital agriculture economics, scholars should create relational diffusion models that address how community dynamics and social trust influence technology adoption within agricultural contexts. Finally, there is a critical need to embed concepts of data justice, digital sovereignty, and ethical governance within digital agriculture research, ensuring voices from legal and ethical domains contribute to the discourse-based data governance protocols.

Author Contributions: Conceptualization, B.S., J.Y. and S.I.K.; methodology, B.S., J.Y. and S.I.K.; software, B.S., J.Y. and S.I.K.; validation, B.S., J.Y. and S.I.K.; formal analysis, B.S., J.Y. and S.I.K.; investigation, B.S., J.Y. and S.I.K.; resources, S.T. and M.Z.; data curation, S.T. and M.Z.; writing—original draft preparation, B.S., J.Y. and S.I.K.; writing—review and editing, B.S., J.Y. and S.I.K.; visualization, S.T.; supervision, B.S., J.Y. and S.I.K.; project administration, B.S., J.Y. and S.I.K.; funding acquisition, B.S. and J.Y. All authors have read and agreed to the published version of the manuscript.

Funding: This study is funded by the General Project of Humanities and Social Sciences Research of the Ministry of Education of the People's Republic of China, grant number 15YJCZH146.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing does not apply to this article. The studies included in this study are all cited in the references below.

Acknowledgments: I would like to express my sincere gratitude to Muhammad Imran Karim Khattak, Islamabad, Pakistan, for his invaluable guidance, insightful feedback, and continuous encouragement throughout the course of this work. His academic expertise and professional experience have been instrumental in shaping the direction and depth of this study.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Lezoche, M.; Panetto, H.; Kacprzyk, J.; Hernandez, J.E.; Díaz, M.M.E.A. *Agri-Food 4.0: A Survey of the Supply Chains and Technologies for the Future Agriculture*; Elsevier B.V.: Amsterdam, The Netherlands, 2020. [CrossRef]
2. Vasilyev, D.; Evans, B.; Sophia, C.; International Monetary Fund. Productivity, Digitalization, and Artificial Intelligence in Peru. Technology Diffusion and Access to Digital Services. 2021. Available online: https://www.elibrary.imf.org/view/journals/002/2024/134/article-A003-en.xml (accessed on 21 July 2025).
3. Allgood, K.; Bernucci, L.; World Economic Forum. Empowering Small and Medium-Sized Enterprises through Digital Business Model Innovation. 2024. Available online: https://www3.weforum.org/docs/WEF_Empowering_Small_and_Medium_Sized_Enterprises_through_Digital_Business_Model_Innovation_2024.pdf (accessed on 21 July 2025).
4. Say, S.M.; Keskin, M.; Sehri, M.; Sekerli, Y.E. Adoption of Precision Agriculture Technologies in Developed and Developing Countries. 2017. Available online: https://www.researchgate.net/publication/320908156 (accessed on 21 July 2025).
5. Sagala, G.H.; Őri, D. Toward SMEs digital transformation success: A systematic literature review. *Inf. Syst. E-Bus. Manag.* **2024**, *22*, 667–719. [CrossRef]
6. Alberti, L.; Bhat, S.A.; Huang, N.-F.; Sofi, I.B.; Sultan, M. Agriculture-Food Supply Chain Management Based on Blockchain and IoT: A Narrative on Enterprise Blockchain Interoperability. *Agriculture* **2021**, *12*, 40. [CrossRef]
7. Ayan, B.; Güner, E.; Son-Turan, S. Blockchain Technology and Sustainability in Supply Chains and a Closer Look at Different Industries: A Mixed Method Approach. *Logistics* **2022**, *6*, 85. [CrossRef]
8. Mohammed, A.; Potdar, V.; Quaddus, M.; Hui, W. *Blockchain Adoption in Food Supply Chains: A Systematic Literature Review on Enablers, Benefits, and Barriers*; Institute of Electrical and Electronics Engineers Inc.: Piscataway, NJ, USA, 2023. [CrossRef]
9. Oh, K.; Kho, H.; Choi, Y.; Lee, S. Determinants for Successful Digital Transformation. *Sustainability* **2022**, *14*, 1215. [CrossRef]

10. Romero, I.; Mammadov, H. Digital Transformation of Small and Medium-Sized Enterprises as an Innovation Process: A Holistic Study of its Determinants. *J. Knowl. Econ.* **2024**, *16*, 8496–8523. [CrossRef]
11. Zhao, Z.; Hönigsberg, S.; Mandviwalla, M. Digital driven success: The digitalization effect on SME performance. *Inf. Technol. Dev.* **2025**, 1–27. [CrossRef]
12. Kádárová, J.; Lachvajderová, L.; Sukopová, D. Impact of Digitalization on SME Performance of the EU27: Panel Data Analysis. *Sustainability* **2023**, *15*, 9973. [CrossRef]
13. Long, T.B.; Blok, V.; Poldner, K. Business models for maximizing the diffusion of technological innovations for climate-smart agriculture. *Int. Food Agribus. Manag. Rev.* **2017**, *20*, 5–23. [CrossRef]
14. Shahadat, M.M.H.; Nekmahmud, M.; Ebrahimi, P.; Fekete-Farkas, M. Digital Technology Adoption in SMEs: What Technological, Environmental and Organizational Factors Influence SMEs' ICT Adoption in Emerging Countries? *Glob. Bus. Rev.* **2023**, *24*, 09721509221137199. [CrossRef]
15. Saghaian, S.; Mohammadi, H.; Mohammadi, M. Factors Affecting Success of Entrepreneurship in Agribusinesses: Evidence from the City of Mashhad, Iran. *Sustainability* **2022**, *14*, 7700. [CrossRef]
16. Kahveci, E. Digital Transformation in SMEs: Enablers, Interconnections, and a Framework for Sustainable Competitive Advantage. *Adm. Sci.* **2025**, *15*, 107. [CrossRef]
17. Onegina, V.; Kucher, L.; Kucher, A.; Krupin, V.; Kłodziński, M.; Logos, V. Unlocking Innovation Capacity: Strategies for Micro-, Small, and Medium Enterprises in Ukrainian Agriculture. *Agriculture* **2025**, *15*, 65. [CrossRef]
18. Ordoñez, C.C.; Gonzales, G.R.; Corrales, J.C. Blockchain and agricultural Sustainability in South America: A systematic review. *Front. Sustain. Food Syst.* **2024**, *8*, 1347116. [CrossRef]
19. Kramer, M.P.; Bitsch, L.; Hanf, J. Blockchain and its impacts on agri-food supply chain network management. *Sustainability* **2021**, *13*, 2168. [CrossRef]
20. Kshetri, N. Blockchain and sustainable supply chain management in developing countries. *Int. J. Inf. Manag.* **2021**, *60*, 102376. [CrossRef]
21. Gupta, S.; Jagtap, S. Unlocking digital growth: Overcoming barriers to digital transformation for Indian food SMEs. *Discov. Food* **2024**, *4*, 55. [CrossRef]
22. Vernet, Pierre-Antoine. Business Models for Scaling Climate Smart Agriculture in Bihar, India. MSc ACT–Agro-ecology, Climate Change and Transition, National University of Ireland Galway. 2017. Available online: https://cgspace.cgiar.org/bitstreams/58a32d17-9437-4741-a3d1-f8d4542f06f9/download (accessed on 21 July 2025).
23. Selorm, O.; Selorm, A.; William, G. Adoption of electronic commerce by agribusiness small medium enterprises in the upper east region of Ghana. *J. Dev. Agric. Econ.* **2022**, *14*, 79–94. [CrossRef]
24. Cannas, R. Exploring digital transformation and dynamic capabilities in agrifood SMEs. *J. Small Bus. Manag.* **2023**, *61*, 1611–1637. [CrossRef]
25. Frau, M.; Moi, L.; Cabiddu, F. Digital Transformation Through the Lens of Digital Data Handling: An Exploratory Analysis of Agri-Food SMEs. *J. Small Bus. Strategy* **2022**, *32*, 84–97. [CrossRef]
26. Safi, M.; Abdallah, F.; Erturk, A.; Alkhayyat, R. Digital Readiness of the Workforce for Successful Digital Transformation: Exploring New Digital Competencies. *Proceedings* **2024**, *101*, 21. [CrossRef]
27. Merín-Rodrigáñez, J.; Dasí, À.; Alegre, J. Digital transformation and firm performance in innovative SMEs: The mediating role of business model innovation. *Technovation* **2024**, *134*, 103027. [CrossRef]
28. Basile, V. The Triple Layered Business Model Canvas in Smart Agriculture: The Case of Evja Startup. *Piccola Impresa/Small Bus.* **2021**, *2*, 79–113. [CrossRef]
29. International Finance Corporation. *Artificial Intelligence in Emerging Markets: Opportunities, Trends, and Emerging Business Models*, 2nd ed.; International Finance Corporation: Washington, DC, USA, 2021. Available online: https://www.ifc.org/en/insights-reports/2021/ai-in-ems-second-edition (accessed on 21 July 2025).
30. Menichini, T.; Salierno, G.; Strollo, N.M. Digital Transformation in the Agri-food Sector: A Comparative Analysis of Industry 4.0 Innovations by Italian Sustainability Leaders. In Proceedings of the 20th European Conference on Management, Leadership and Governance, Lisbon, Portugal, 14–15 November 2024; pp. 355–361. [CrossRef]
31. Bolwig, S.; Haselip, J.; Strange, L.; Hornum, S.T.; Pedersen, M.B. Digital Solutions for Agricultural Value Chains in Kenya: The Role of Private-Sector Actors. UNEP DTU Partnership. December 2021. Available online: https://tech-action.unepccc.org/wp-content/uploads/sites/2/2022/01/temarin-issue-brief-digital-solutions-for-agricultural-value-chains-in-kenya.pdf (accessed on 21 July 2025).
32. Llewellyn, R.; Ouzman, J.; CSIRO. Adoption of Precision Agriculture-Related Practices: Status, Opportunities and the Role of Farm Advisers. 2014. Available online: https://grdc.com.au/resources-and-publications/all-publications/publications/2014/12/adoption-of-precision-agriculture-related-practices (accessed on 21 July 2025).

33. OECD. The Digital Transformation of SMEs. In *OECD Studies on SMEs and Entrepreneurship*; OECD: Paris, France, 2021. [CrossRef]
34. Mkhize, A.; Mokhothu, K.; Tshikhotho, M.; Thango, B. Evaluating the Impact of Cloud Computing on SMEs Performance: A Systematic Review. *Businesses* **2025**, *5*, 23. [CrossRef]
35. Haq, I.U.; Huo, C. Digital strategy and environmental performance: The mediating role of digitalization in SMEs. *Digit. Econ. Sustain. Dev.* **2023**, *1*, 9. [CrossRef]
36. Shiferaw, R.M.; Kero, C.A. Dynamic capabilities view practices of business firms: A systematic literature review. *Cogent Bus. Manag.* **2024**, *11*, 2336309. [CrossRef]
37. Schiavon, O.P.; May, M.R.; de Mendonça, A.T.B.B. Dynamic capabilities and business model innovation in sustainable family farming. *Innov. Manag. Rev.* **2022**, *19*, 252–265. [CrossRef]
38. Garcia Altafin, B.; Morini, C.; Dario Capitani, D.H. Business Model Revisited: A Novel Canvas for Digital Transformation. *Rev. Gestão* **2025**, *32*, 81–98. [CrossRef]
39. Silvi, R.; Nielsen, C.; Pia, A. From Insights to Business Model Innovation and Results: Using the Digital Transformation Canvas. *J. Bus. Models* **2023**, *11*, 30–45. Available online: https://hdl.handle.net/11585/954692 (accessed on 21 July 2025).
40. Tell, J.; Hoveskog, M.; Ulvenblad, P.; Ulvenblad, P.O.; Barth, H.; Ståhl, J. Business model innovation in the agri-food sector: A literature review. *Br. Food J.* **2016**, *118*, 1462–1476. [CrossRef]
41. Oliveira, T.; Martins, M.F. Literature Review of Information Technology Adoption Models at Firm Level. *Electron. J. Inf. Syst. Eval.* **2011**, *14*, 110.
42. Baker, J. The Technology–Organization–Environment Framework. In *Information Systems Theory. Integrated Series in Information Systems*; Springer: New York, NY, USA, 2012; pp. 231–245. [CrossRef]
43. Nagy, A.; Tumiwa, J.; Arie, F.; László, E.; Alsoud, A.R.; Al-Dalahmeh, M. A meta-analysis of the impact of TOE adoption on smart Agriculture SMEs performance. *PLoS ONE* **2025**, *20*, e0310105. [CrossRef]
44. Kuo, H.M.; Chen, T.L.; Yang, C.S. The effects of institutional pressures on shipping digital transformation in Taiwan. *Marit. Bus. Rev.* **2022**, *7*, 175–191. [CrossRef]
45. Kamariotou, M.; Kitsios, F.; Charatsari, C.; Lioutas, E.D.; Talias, M.A. Digital strategy decision support systems: Agrifood supply chain management in smes. *Sensors* **2022**, *22*, 274. [CrossRef] [PubMed]
46. Kallmuenzer, A.; Mikhaylov, A.; Chelaru, M.; Czakon, W. Adoption and performance outcome of digitalization in small and medium-sized enterprises. *Rev. Manag. Sci.* **2024**, *19*, 2011–2038. [CrossRef]
47. Soomro, R.B.; Memon, S.G.; Dahri, N.A.; Al-Rahmi, W.M.; Aldriwish, K.; Salameh, A.A.; Al-Adwan, A.S.; Saleem, A. The Adoption of Digital Technologies by Small and Medium-Sized Enterprises for Sustainability and Value Creation in Pakistan: The Application of a Two-Staged Hybrid SEM-ANN Approach. *Sustainability* **2024**, *16*, 7351. [CrossRef]
48. Denmamode, L.; Panchoo, S. Digital transformation: A roadmap to leverage businesses for SMEs. *J. Bus. Enterp. Dev. (JOBED)* **2024**, *12*, 1. [CrossRef]
49. Yuan, Y.; Sun, Y. Practices, Challenges, and Future of Digital Transformation in Smallholder Agriculture: Insights from a Literature Review. *Agriculture* **2024**, *14*, 2193. [CrossRef]
50. Ndekwa, A.G.; Kalugendo, E.; Sood, K.; Grima, S. An Analysis of Agribusiness Digitalisation Transformation of the Sub-Saharan African Countries Small-Scale Farmers' Production Distribution. *Res. World Agric. Econ.* **2023**, *4*, 63–78. [CrossRef]
51. Sakthivel, V.; Prakash, P.; Lee, J.W.; Prabu, P. Enhancing Transparency and Trust in Agrifood Supply Chains through Novel Blockchain-based Architecture. *KSII Trans. Internet Inf. Syst.* **2024**, *18*, 1968–1985. [CrossRef]
52. Adewusi, A.O.; Chiekezie, N.R.; Eyo-Udo, N.L. Blockchain technology in agriculture: Enhancing supply chain transparency and traceability. *Financ. Account. Res. J.* **2023**, *5*, 479–501. [CrossRef]
53. Xinyan, Z.; Omain, S.Z.B.; Khatib, S.F.A.; Lei, J. A Systematic Review of the Application of Blockchain Technology in Agricultural Supply Chain. *Int. J. Acad. Res. Econ. Manag. Sci.* **2024**, *13*, 510–537. [CrossRef]
54. Sharabati, A.A.A.; Ali, A.A.A.; Allahham, M.I.; Hussein, A.A.; Alheet, A.F.; Mohammad, A.S. The Impact of Digital Marketing on the Performance of SMEs: An Analytical Study in Light of Modern Digital Transformations. *Sustainability* **2024**, *16*, 8667. [CrossRef]
55. Mueller-Saegebrecht, S. Business model innovation decisions: The role of group biases and risk willingness. *Manag. Decis.* **2024**, *62*, 116–155. [CrossRef]
56. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *J. Clin. Epidemiol.* **2021**, *134*, 178–189. [CrossRef] [PubMed]
57. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Moher, D. Updating guidance for reporting systematic reviews: Development of the PRISMA 2020 statement. *J. Clin. Epidemiol.* **2021**, *134*, 103–112. [CrossRef]

58. Thomas, J.; Harden, A. Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Med. Res. Methodol.* **2008**, *8*, 45. [CrossRef]
59. Osterwalder, A. *The Business Model Ontology—A Proposition in a Design Science Approach*; Universite de Lausanne Ecole des Hautes Etudes Commerciales: Lausanne, Switzerland, 2004.
60. Osterwalder, A. Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. *Afr. J. Bus. Manag.* **2011**, *5*. Available online: https://www.academia.edu/6582229/Business_Model_Generation_A_handbook_for_visionaries_game_changers_and_challengers (accessed on 21 July 2025).
61. Drazin, R. The Process of Technological Innovation. *J. Technol. Transfer* **1991**, *16*, 45–46. [CrossRef]
62. Teece, D.J.; Pisano, G.; Shuen, A. Dynamic Capabilities and Strategic Management. *Strateg. Manag. J.* **1997**, *18*, 509–533. [CrossRef]
63. Rogers, E.M. *Diffusion of Innovations*; Free Press: New York, NY, USA, 1995.
64. Fleiss, J.L.; Levin, B.; Paik, M.C. *Statistical Methods for Rates and Proportions*; John Wiley & Sons, Inc.: Hoboken, NJ, USA, 2003.
65. Dimoso, R.L.; Utonga, D. A systematic review of digital technology adoption in small and medium-sized enterprises: Implications for performance in developing countries. *Int. J. Dev. Manag. Rev.* **2024**, *19*, 58–71. [CrossRef]
66. Matoušková, D. Digitalization and Its Impact on Business. *Theory Methodol. Pract.* **2022**, *18*, 51–67. [CrossRef]
67. Sharma, A.; Sharma, A.; Singh, R.K.; Bhatia, T. Blockchain adoption in agri-food supply chain management: An empirical study of the main drivers using extended UTAUT. *Bus. Process Manag. J.* **2023**, *29*, 737–756. [CrossRef]
68. Nguyen, T.H.T.; Pham, S.T.; Phan, T.M.; Cuc, T.K.; Nguyen, N.G.H.; Do, T.D. Impact of digital transformation on SMEs' innovation capability and business performance: The case of Vietnam. *Int. J. Bus. Manag. Technol.* **2023**, *7*, 416–426. Available online: https://www.theijbmt.com/archive/0950/1517421071.pdf (accessed on 21 July 2025).
69. Ruzzante, S.; Labarta, R.; Bilton, A. Adoption of agricultural technology in the developing world: A meta-analysis of the empirical literature. *World Dev.* **2021**, *146*, 105599. [CrossRef]
70. Groot, A.E.; Bolt, J.S.; Jat, H.S.; Jat, M.L.; Kumar, M.; Agarwal, T.; Blok, V. Business models of SMEs as a mechanism for scaling climate smart technologies: The case of Punjab, India. *J. Clean. Prod.* **2019**, *210*, 1109–1119. [CrossRef]
71. Nogales, E.G.; Casari, G. *Promoting the Digitalization of Small and Medium-Sized Agrifood Enterprises in Asia and the Pacific*; FAO: Rome, Italy, 2023. [CrossRef]
72. Kant, A.; Sawhney, A.; Aggarwal , V.; Ranjan, J.; Jurgens, J.; World Economic Forum. Artificial Intelligence for Agriculture Innovation. 2021. Available online: https://www3.weforum.org/docs/WEF_Artificial_Intelligence_for_Agriculture_Innovation_2021.pdf (accessed on 21 July 2025).
73. Faiz, F.; Le, V.; Masli, E.K. Determinants of digital technology adoption in innovative SMEs. *J. Innov. Knowl.* **2024**, *9*, 100610. [CrossRef]
74. Mubarak, M.F.; Bhutto, S.Z.A.; Shaikh, F.A.; Mubarik, M.; Samo, K.A.; Mastoi, S. The Impact of Digital Transformation on Business Performance A Study of Pakistani SMEs. *Eng. Technol. Appl. Sci. Res.* **2019**, *9*, 5056–5061. [CrossRef]
75. Kituyi, G.M.; Noguera, J.H. Factors Affecting the Adoption of Electronic Customer Relationship Management Information Systems in SMEs. 2014. Available online: https://www.researchgate.net/publication/262567011 (accessed on 21 July 2025).
76. Lukonga, I. Harnessing Digital Technologies to Promote SMEs and Inclusive Growth in the MENAP Region. IMF Working Paper No. WP/20/135, International Monetary Fund. 2020. Available online: https://www.imf.org/-/media/Files/Publications/WP/2020/English/wpiea2020135-print-pdf.ashx (accessed on 21 July 2025).
77. Silva, R.P.; Mamede, H.; Santos, A. The Role of Digital Marketing in Increasing SMEs' Competitiveness. In Proceedings of the ICSBT International Conference on Smart Business Technologies, Science and Technology Publications, Rome, Italy, 11–13 July 2022; pp. 93–100. [CrossRef]
78. Restrepo-Morales, J.A.; Ararat-Herrera, J.A.; López-Cadavid, D.A.; Camacho-Vargas, A. Breaking the digitalization barrier for SMEs: A fuzzy logic approach to overcoming challenges in business transformation. *J. Innov. Entrep.* **2024**, *13*, 84. [CrossRef]
79. Kupczyk, T.; Dewalska-Opitek, A.; Witczak, O.; Budziński, M.; Kalita, D. Business Model Canvas Application in Start-up Stage Business Developments-Constraints and Challenges. *Eur. Res. Stud. J.* **2024**, *XXVII*, 921–940. [CrossRef]
80. Susanti, D.A.; Fithri, D.L.; Gunawan, B.; Budiman, N.A.; Mulyani, S.; Nugraha, F. The Influence of Business Model Canvas on Financial Performance of Micro, Small, and Medium Enterprises (MSMEs). *J. Ecohumanism* **2024**, *3*, 932–945. [CrossRef]
81. Partalidou, M.; Paltaki, A.; Lazaridou, D.; Vieri, M.; Lombardo, S.; Michailidis, A. Business model canvas analysis on Greek farms implementing Precision Agriculture. *Agric. Econ. Rev.* **2018**, *19*, 28–45.
82. Qiang, C.Z.; Kuek, S.C.; Dymond, A.; Esselaar, S. *Mobile Applications for Agriculture and Rural Development*; World Bank: Washington, DC, USA, 2012.
83. Etheredge, L.M. AI and Digital Technologies in Agricultural Machinery: A Global Policy Perspective. 2025. Available online: https://www.researchgate.net/publication/390563788 (accessed on 21 July 2025).
84. Giesenhagen, J. AgNext Research Report. Ag Next Colorado State University, United States. 2023. Available online: https://agnext.colostate.edu/wp-content/uploads/sites/14/2023/09/2023-AgNext-Research-Report.pdf (accessed on 21 July 2025).

85. Von Bismarck-Osten, M. Understanding Strategic Decisions of Digital Agricultural Platform Companies: Six Case Studies of Sub-Saharan African Platforms, ZEF Working Paper Series, No. 209. 2021. Available online: https://hdl.handle.net/10419/246478 (accessed on 21 July 2025).
86. Kristofikova, N.; Muskoke, I.; Agnew, J. Embedded Research Translation Report Exploring the Use of Blockchain Technology to Promote the Production and Consumption of African Indigenous Vegetables in Western Kenya. August 2021. Available online: https://vtechworks.lib.vt.edu/handle/10919/111503 (accessed on 21 July 2025).
87. Bett, A.K.H. Determinants of Participation in Mobile Platforms among Smallholder Agrienterprises: A Case of Agriwallet Platform. *Int. J. Sci. Res. (IJSR)* **2023**, *12*, 149–155. [CrossRef]
88. Vu, P.T.; Nguyen, H.X.; Pham, Q.T.T.; Nguyen, P.V. Unpacking the enablers and barriers to digital transformation in Vietnamese logistics companies: A qualitative analysis. *Int. J. Innov. Res. Sci. Stud.* **2025**, *8*, 4210–4218. [CrossRef]
89. Perez, D.; Risco, R.; Casaverde, L. Analysis of the implementation of Blockchain as a mechanism for digital and transparent food traceability in Peruvian social programs. In Proceedings of the 2020 IEEE 27th International Conference on Electronics, Electrical Engineering and Computing, INTERCON 2020, Lima, Peru, 3–5 September 2020; Institute of Electrical and Electronics Engineers Inc.: Piscataway, NJ, USA, 2020. [CrossRef]
90. Luyckx, M.; Reins, L. The Future of Farming: The (Non)-Sense of Big Data Predictive Tools for Sustainable EU Agriculture. *Sustainability* **2022**, *14*, 2968. [CrossRef]
91. Njuguna, E.; Daum, T.; Birner, R.; Mburu, J. Silicon Savannah and smallholder farming: How can digitalization contribute to sustainable agricultural transformation in Africa? *Agric. Syst.* **2025**, *222*, 104180. [CrossRef]
92. Civelek, M.; Krajčík, V.; Ključnikov, A. The impacts of dynamic capabilities on SMEs' digital transformation process: The resource-based view perspective. *Oeconomia Copernic.* **2023**, *14*, 1367–1392. [CrossRef]
93. Khiaonarong, T.; Goh, T. WP/20/75 Fintech and Payments Regulation: Analytical Framework. 2020. Available online: https://www.imf.org/en/Publications/WP/Issues/2020/05/29/Fintech-and-Payments-Regulation-Analytical-Framework-49086 (accessed on 21 July 2025).
94. Alabi, M. The Role of Leadership in Fostering a Technology-Driven Entrepreneurial Mindset. 2025. Available online: https://www.researchgate.net/publication/388724229 (accessed on 21 July 2025).
95. International Finance Corporation. Scaling Up Farmer Financing Through AgTechs in Sub-Saharan Africa: An IFC-BMZ Initiative. 2024. Available online: https://www.ifc.org/en/insights-reports/2024/scaling-up-farmer-financing-through-agtechs-in-sub-saharan-afric (accessed on 21 July 2025).
96. OECD. Policies for the Future of Farming and Food in the European Union. In *OECD Agriculture and Food Policy Reviews*; OECD: Paris, France, 2023. [CrossRef]
97. Van Tuijl, E.; Basajja, M.; Zambrano, J.C.I.; Knorringa, P. Drivers and Barriers of a Platform-Based Business Model in Agriculture: The Case of Apollo Agriculture. 2022. Available online: https://www.researchgate.net/publication/367149312_Drivers_and_barriers_of_a_platform-based_business_model_in_agriculture_The_case_of_Apollo_Agriculture (accessed on 21 July 2025).
98. Medennikov, V.I. The Impact of Digital Transformation on the Competitiveness of Small and Medium Agro-Industrial Enterprises. In Proceedings of the International Conference on Policicies and Economics Measures for Agricultural Development (AgroDevEco 2020), Voronezh, Russia, 25–26 May 2020.
99. Wu, S.; Cheng, P.; Yang, F. Study on the impact of digital transformation on green competitive advantage: The role of green innovation and government regulation. *PLoS ONE* **2024**, *19*, e0306603. [CrossRef] [PubMed]
100. David-West, O.; Oni, O.; Ashiru, F. Diffusion of Innovations: Mobile Money Utility and Financial Inclusion in Nigeria. Insights Agents Unbanked Poor End Users. *Inf. Syst. Front.* **2022**, *24*, 1753–1773. [CrossRef]
101. Kim, Y.G.; Woo, E. Consumer acceptance of a quick response (QR) code for the food traceability system: Application of an extended technology acceptance model (TAM). *Food Res. Int.* **2016**, *85*, 266–272. [CrossRef]
102. Geng, L.; Hui, H.; Liang, X.; Yan, S.; Xue, Y. Factors Affecting Intention Toward ICT Adoption in Rural Entrepreneurship: Understanding the Differences Between Business Types of Organizations and Previous Experience of Entrepreneurs. *SAGE Open* **2023**, *2023*, 21582440231197112. [CrossRef]
103. Wishart, M.; Roper, S. Digital Adoption in Rural SMEs Acknowledgements and Funding. 2021. Available online: https://nicre.co.uk/media/q3tp2oqu/nicre-research-report-no-3-june-2021-digital-adoption-in-rural-smes.pdf (accessed on 21 July 2025).
104. Ewim, C.P.-M.; Okeke, N.I.; Alabi, O.A.; Igwe, A.N.; Ofodile, O.C. Customer-Centric digital transformation framework: Enhancing service delivery in SMES for underserved populations. *ACCESS Int. J. Manag. Entrep. Res.* **2024**, *6*, 3493–3516. [CrossRef]
105. Jameel, A.S.; Alheety, A.S. Blockchain technology adoption in SMEs: The extended model of UTAUT. In Proceedings of the International Conference on Intelligent Technology, System and Service for Internet of Everything, ITSS-IoE 2022, Fuwwah, Yemen, 3–5 December 2020; Institute of Electrical and Electronics Engineers Inc.: Piscataway, NJ, USA, 2022. [CrossRef]

106. Cao, A.; Guo, L.; Li, H. Understanding farmer cooperatives' intention to adopt digital technology: Mediating effect of perceived ease of use and moderating effects of internet usage and training. *Int. J. Agric. Sustain.* **2025**, *23*, 2464523. [CrossRef]
107. Mili, S.; Loukil, T. Enhancing Sustainability with the Triple-Layered Business Model Canvas: Insights from the Fruit and Vegetable Industry in Spain. *Sustainability* **2023**, *15*, 6501. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.