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Agrtech As A Service Model: Bridging Agricultural Constrains For Smallholder And Commercial Farmers

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***Abstract-** This paper examines Agritech as a Service (AaaS) model as a strategic response to the structural constraints confronting smallholder and commercial farmers. Drawing on secondary literature, industry reports and empirical case evidence, the analysis identifies the core logic of access-based service delivery and maps the principal business-model variants currently operating in low- and middle-income countries. Findings indicate that Technology as a Service, pay as you go, subscription, freemium and hybrid platforms lower capital barriers for smallholders while enabling data integration and operational optimisation for larger farms. Persistent challenges include demand density, digital literacy, working capital intensity and last mile reliability. The paper concludes that effective AaaS design must be scale differentiated and embedded within complementary finance, infrastructure and market systems if it is to contribute meaningfully to productivity, resource efficiency and climate resilience.*

***Keywords:** Agritech as a Service, Farming Service, precision agriculture, digital agriculture.*

I. INTRODUCTION

Agricultural production systems face persistent constraints whose character differs markedly between smallholder and commercial operators. Limited access to capital, machinery, timely information and markets continues to restrict productivity among smallholders, while commercial farms confront high operating costs, data overload, interoperability failures and climate related financial exposure. Precision agriculture technologies offer technical solutions to these problems, yet ownership models frequently place such tools beyond the reach of most farmers.

Agritech as a Service (AaaS), also referred to as Farming as a Service (FaaS), reframes the delivery of these technologies from asset ownership to access-based provision. Under AaaS arrangements, providers retain ownership of equipment or platforms and supply capabilities through subscription, pay-per-use or hybrid contracts. This conversion of capital expenditure into operating expenditure is particularly relevant in contexts where farm sizes are small, formal credit is scarce and technical capacity is unevenly distributed (Loukos & Arathoon, 2022). Recent scoping reviews confirm that while digital technologies hold transformative potential for smallholder farmers in sub-Saharan Africa, barriers such as limited connectivity, low digital literacy and affordability constraints continue to hinder widespread adoption (Mandikiana et al., 2024).

This paper critically examines the conceptual foundations, operational variants, empirical evidence and design implications of AaaS models. It argues that AaaS should not be treated as a uniform technological fix but as a continuum of service architectures that must be differentiated by farm scale and local institutional conditions if they are to address the information, resource allocation and operational problems identified in contemporary agricultural systems.

II. LITERATURE REVIEW: CONCEPTUALISING AGRITECH AS A SERVICE

The literature on digital agriculture increasingly emphasises on servicing the shift from selling products to delivering integrated product service systems (Benedettini, 2025). In agriculture this shift is expressed through Equipment as a Service, drone as a service, smart irrigation as a service and data analytics platforms. Recent scholarship on farming servicing shows that when farms operating under conventional product oriented models encounter sustainability pressures, many transition toward integrated product plus service systems in which the share of services within the business model expands significantly (Vidickienė, 2025). This reconfiguration aligns with broader Agriculture 4.0 trends in which equipment manufacturers bundle hardware with complementary digital services, retaining asset ownership while customers pay for access, usage or outcomes rather than for the product itself (Kanbach et al., 2026).

Drawing across the literature, six interrelated business-model families currently evident in low- and middle-income countries can be synthesised:
Technology as a Service arrangement in which the provider supplies both asset and skilled operation.
Pay as you go (PAYG) financing that transitions users from rental toward ownership.

Subscription or Software as a Service platform delivering continuous analytics and advisory services.

Premium or tiered-pricing models that offer basic functionality at no cost while charging for premium features or higher usage tiers.

Hybrid and outcome-based models linking payment to measured results.

Cooperative or aggregator models that pool demand to achieve viable service density.

Market estimates place the global FaaS sector at approximately USD 5–6 billion in the mid-2020s, with projected compound annual growth rates of 12–17 per cent through the early 2030s (Research Nester, 2025; Grand View Research, 2025). Growth is driven by rising input costs, climate variability, labour constraints and the need for capital-light access to precision tools.

Empirical studies further demonstrate that farm size is positively associated with the adoption of precision agriculture technologies, while financial cost, technical literacy, infrastructure quality and expected profitability remain decisive determinants of uptake (McKinsey & Company, 2023; Frimpong et al., 2026). Agritech as a Service (AaaS) models address the access barrier for smallholders and the integration barrier for commercial operators, yet their success depends on complementary institutional arrangements. A systematic review of digital innovations among agricultural small and medium enterprises reveals that these technologies are driving structural shifts in value creation, delivery and capture, with mobile platforms, AI-integrated services and IoT devices enabling firms to evolve from product vendors into service integrators that bundle inputs, credit, insurance and advisory into unified offerings (Nguyen et al., 2025).

III. MATERIALS AND METHODOLOGY

This analysis adopts a qualitative, desk-based synthesis of secondary sources. Materials include peer-reviewed journal articles, industry reports from GSMA and the Digital Agri Hub, market analyses, and documented case evidence from Nigeria and other sub-Saharan African contexts. Sources were selected for scholarly or institutional legitimacy, relevance to service-based delivery models, and publication between 2018 and 2026. Thematic analysis organised evidence around four domains: conceptual logic, model typology, scale-specific relevance, and implementation challenges. Triangulation across academic, practitioner and market sources was used to enhance robustness.

IV. RESULTS AND DISCUSSION

Core Logic and Model Variants

The central economic rationale of AaaS is the maximisation of asset utilisation across multiple users. Capital-intensive tools become viable when fixed costs are spread and technical complexity is externalised. Technology-as-a-Service models reduce farmer-side operational burden by supplying both equipment and skilled personnel for tasks such as precision spraying or soil diagnostics (FAO, 2026). PAYG arrangements allow smallholders to acquire machinery over time without large upfront capital outlays, with documented programmes enabling farmers to transition from renters to owners through structured payment plans (Heifer International, 2023). Freemium models lower adoption barriers by offering basic advisory or weather information at no cost, generating user bases that can later be monetised through premium subscriptions, input sales or financial product referrals (Loukos & Arathoon, 2022).

Contemporary evidence from sub-Saharan Africa indicates that digital technologies are already improving smallholder access to information and markets, with mobile phones representing the most widely adopted digital tool among farming populations (Mandikiana et al., 2024). In Nigeria specifically, empirical research on mobile agricultural advisory applications among rice

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farmers demonstrates that training, access to extension services and education are primary drivers of adoption, while older age and larger household size act as constraints (Abioye et al., 2025). These findings underscore that AaaS uptake is not automatic but contingent on human-capital and institutional preconditions.

Scale-Differentiated Value Propositions

For smallholders the primary benefit is access. Fragmented holdings and limited collateral render individual ownership of drones, sensors or advanced machinery uneconomic. AaaS lowers entry barriers and enables timely operations under climate variability (Frimpong et al., 2026). Clustering farmers by proximity further reduces per-unit service costs. A systematic review of precision agriculture for resource use efficiency in smallholder farming systems across sub-Saharan Africa confirms that while adoption remains low relative to other global regions, technologies such as GIS, satellite remote sensing, mobile phone-based advisory and variable-rate input application hold significant potential for improving productivity when appropriately adapted to local conditions (Njoroge et al., 2021).

Commercial farms, by contrast, already possess capital and machinery but face data integration, interoperability and optimisation challenges. Subscription analytics platforms and specialised service contracts allow these operators to convert heterogeneous data streams into site specific decisions without assuming the full risk of technological obsolescence (McKinsey & Company, 2023). The digital agriculture literature further reveals that current research on smallholder digital ecosystems remains heavily concentrated on platforms, infrastructure and fourth industrial revolution technologies, while comparatively limited attention has been directed toward business model innovation, affordability and digital literacy—the very domains in which AaaS models operate (Motaung & Mphahlele, 2023).

Empirical Pathways and Limitations

Documented cases show measurable gains in input efficiency, labour savings and, in some instances, yield when services are reliably delivered and recommendations are acted upon (FAO, 2026; GSMA, 2025). There is emerging evidence that integrated platforms combining advisory, finance and market linkages may exhibit higher retention and repayment rates than pure technology offerings (GSMA, 2025). Nevertheless, impact remains contingent on service reliability, demand density, complementary infrastructure and farmer capacity.

A systematic review of mobile agricultural service applications across sub-Saharan Africa, applying the Technology Acceptance Model framework, found that perceived usefulness is a more influential driver of adoption than perceived ease of use, with farmers prioritising tangible outcomes such as productivity enhancement, information access and cost-effectiveness (Adeyanju et al., 2025). Ease of use remains important primarily as a facilitator that enables farmers to experience practical benefits, particularly when interfaces incorporate voice guidance, pictorial elements and local language support. External variables including education level, income, device type and network infrastructure significantly shape how farmers assess both usefulness and ease of use (Adeyanju et al., 2025).

Sparse rural demand, digital literacy gaps, working-capital intensity for providers and last-mile logistics continue to constrain scale (Loukos & Arathoon, 2022; GSMA, 2025). Recent mapping of climate and agronomic digital advisory services in West and Central Africa including Nigeria confirms that while mobile-based platforms providing weather forecasts, agronomic advice and financial services are expanding, inadequate infrastructure, high internet costs, gender disparities and data fragmentation remain critical barriers to equitable adoption (Ouedraogo et al., 2026). Women constitute a substantial share of the agricultural workforce yet remain underrepresented among digital technology users, limiting their access to advisory services and climate information (Ouedraogo et al., 2026).

Institutional and Design Implications

Effective AaaS architectures must be scale sensitive. Smallholder-oriented models prioritise simplicity, affordability, agent mediation and shared equipment. Commercial-oriented models prioritise data interoperability, predictive analytics and machinery optimisation. Hybrid arrangements that combine digital platforms with physical service hubs or cooperative aggregation appear more robust in low-infrastructure environments. In the Nigerian context, where smallholders constitute many the farming population and mechanisation rates remain low, AaaS addresses capital scarcity, timing risks and information deficits, yet success requires densification of demand and alignment with finance and market systems (GSMA, 2024; GSMA, 2025).

The climate resilience dimension of AaaS is increasingly salient. A review of digital innovations in climate-smart agriculture highlights that mobile-based advisory services, AI-driven decision-support tools and early warning systems can strengthen smallholder capacity to anticipate and respond to climate-related shocks such as droughts, floods and pest outbreaks (Munthali et al., 2026). However, realising this potential requires parallel investment in rural digital infrastructure, farmer training and digital extension services. Bundled service models that integrate climate information with market linkages, logistics and financial products appear particularly promising for building resilience, as they address multiple constraints simultaneously rather than in isolation (Ouedraogo et al., 2026).

V. CONCLUSION

Agritech as a Service reframes precision agriculture from a capital-intensive ownership proposition into a continuum of accessible, scalable services. The model holds potential to mitigate the distinct constraints faced by smallholder and commercial farmers, provided it is designed with attention to scale, local institutions and complementary systems. Regulation of digital harms is not the issue here; rather, the challenge is to construct service ecosystems that convert technological capability into timely, affordable and actionable support.

Recommendations

Differentiate service design by farm scale, prioritising affordable, agent-mediated access for smallholders and data integration platforms for commercial operators.

Support hybrid delivery models that combine digital platforms with physical hubs and cooperative aggregation to overcome demand density and last mile constraints.

Strengthen complementary systems rural connectivity, mobile money, credit and market linkages so that AaaS recommendations can be acted upon.

Encourage transparent, multi stakeholder governance of service platforms to build trust and protect user data rights.

Invest in continuous adaptation of interfaces, languages and agronomic content to local agro-ecological and literacy conditions.

A rights-based and economically viable approach to Agritech as a Service can contribute to more productive, resilient and inclusive agricultural systems. Realising this potential requires moving beyond the simple introduction of digital tools toward the deliberate construction of integrated technological ecosystems tailored to the financial, operational and informational realities of farmers at different scales.

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