



Why agro-startups need sector-specific innovation models

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Abstract

Innovation models such as the National Innovation System, open innovation, and the diffusion of innovation theory were built mainly from the experience of manufacturing and technology firms. Agro-based startups are increasingly asked to fit their growth into these same models, even though agriculture works under different conditions: biological time, fragmented landholding, weak rural infrastructure, and low-margin, trust-based markets. This paper reviews existing literature on innovation systems, agricultural innovation, and agro-startup practice to argue that generic innovation models do not capture the realities agro-startups face, and that sector-specific models are needed instead. The paper draws on recent empirical work on agro-based startup drivers and innovation capability to outline the building blocks of such a model and discusses what this means for founders, investors, and policymakers. The paper closes with the limits of this conceptual approach and directions for future research.

Keywords: Agro-startups, sector-specific innovation, agricultural innovation systems, agribusiness, startup ecosystem

Introduction

Startups working in agriculture and allied sectors have grown fast over the past decade. They bring digital tools, new financing structures, and new supply chain models into a sector that has traditionally been slow to change. Governments, incubators, and investors have supported this growth by applying innovation frameworks that were originally built for other industries. These frameworks include the National Innovation System (Freeman, 1987; Lundvall, 1992) ^[5, 10], open innovation (Chesbrough, 2003) ^[2], the diffusion of innovation theory (Rogers, 2003) ^[13], and the Triple Helix model of university–industry–government links (Etzkowitz & Leydesdorff, 2000) ^[3]. Each of these models has added real value to how researchers and practitioners think about innovation. However, they were developed mostly by studying manufacturing, electronics, pharmaceuticals, and software firms, where product cycles are short, markets are broad, and knowledge can move quickly between actors.

Agriculture does not follow the same rules. A crop cycle can take months to complete and cannot be shortened by better management alone. Most farmers still work small, fragmented plots, and their decisions depend heavily on weather, soil, and local custom rather than only on price signals. Pavitt (1984) ^[12] had already argued decades ago that agriculture behaves as a “supplier-dominated” sector, where firms rely on outside sources such as equipment makers and input suppliers for most of their technical progress, rather than generating it in-house. This structural pattern still holds and shapes how innovation moves through the sector today.

Agro-startups sit inside this structure. They must design products for smallholder farmers with limited capital, convince a farming community that often distrusts new technology, and work with weak rural infrastructure such as inconsistent internet access, poor cold storage, and uneven road networks (Kropff *et al.*, 2019) ^[9]. Many agro-tech pilots fail to move beyond a small trial group because the business model, built on ideas borrowed from software or

consumer-tech startups, does not match these ground realities. Recent studies confirm that awareness gaps, low technical literacy among users, and weak rural infrastructure remain the biggest barriers to agri-tech adoption in emerging economies (Adhikary, 2021) ^[11].

This paper asks a simple question: why do agro-startups need innovation models built specifically for their sector, instead of relying on models that work well in other industries? To answer this, the paper reviews literature on generic innovation models, on the sector-specific nature of agricultural innovation, and on the practical challenges agro-startups report in the field. It then draws on recent work on agro-based startup drivers (Tikkha *et al.*, 2025) ^[18] and innovation capability (Tikkha *et al.*, 2024) ^[17] to sketch what a sector-specific model could look like. The paper is conceptual and literature-based. It does not collect new primary data; instead, it brings together findings that are usually discussed separately and asks what they mean together for how agro-startups should be supported.

Literature Review

1. Generic innovation models and their assumptions

Most widely used innovation frameworks share a set of underlying assumptions. The National Innovation System approach, developed by Freeman (1987) and Lundvall (1992) ^[5, 10], treats innovation as the outcome of interaction between firms, universities, and government bodies inside a national economy. It works well for explaining how countries such as Japan or Denmark built strong technology industries, because it assumes reasonably dense networks of firms, researchers, and policymakers who can exchange knowledge on a regular basis. Open innovation, as described by Chesbrough (2003) ^[2], assumes that firms benefit from bringing in ideas from outside their own walls and from licensing out unused knowledge. This works best where intellectual property is well defined, where firms have research budgets, and where partners are easy to identify and reach.

The diffusion of innovation theory (Rogers, 2003) ^[13] explains how new ideas spread through a population over time, moving from innovators to early adopters and eventually to laggards. This theory has been applied to agriculture for decades, mostly to study how farmers adopt new seed varieties or farming practices. It is useful for describing the pace of adoption but says little about how an early-stage firm should design its product or business model to fit the adopting population. The Triple Helix model (Etzkowitz & Leydesdorff, 2000) ^[3] extends the innovation-system idea further by giving universities a central role alongside industry and government, assuming that academic research routinely moves into commercial products.

All four models assume some version of the following conditions: information moves quickly between actors, firms have some slack resources to experiment, intellectual property can be defined and protected, and the end user can absorb a new product or process within a reasonably short period. Agro-startups, and the smallholder farmers many of them serve, do not always meet these conditions. This gap is the starting point for this paper's argument.

2. The sector-specific nature of agricultural innovation

A separate stream of literature has long argued that agriculture cannot be treated the same as other economic sectors when studying innovation. Pavitt's (1984) ^[12] sectoral taxonomy placed agriculture among supplier-dominated sectors, where technical change mostly arrives embedded in machinery, seeds, and chemical inputs bought from outside firms, rather than from in-house research. This means the innovation process in agriculture is distributed across many small, disconnected actors instead of concentrated inside individual firms, which is very different from how innovation happens in electronics or pharmaceuticals.

Building on this idea, researchers developed the concept of Agricultural Innovation Systems (AIS), which frames innovation in the sector as the product of interaction among research organisations, extension services, farmer groups, and private companies, shaped strongly by local institutions and infrastructure (Gutiérrez Cano *et al.*, 2023) ^[6]. The Organisation for Economic Co-operation and Development has also used the AIS framework to study how government policy should support innovation in agriculture, noting that productivity growth, sustainable resource use, and resilience to market shocks all depend on how well these different actors are connected (OECD, 2013). More recent work has confirmed that agriculture retains features tied to its dependence on nature, land, and local social structures even as digital tools spread through the sector, meaning its sectoral specificity has not disappeared with modernisation (Falchenko *et al.*, 2024) ^[4].

Country-level studies support this view. Research on the agricultural sector in Ukraine found that any innovation model applied to the sector must take account of the specific technical, financial, and institutional conditions of agriculture, and cannot simply be copied from other industries or other countries without adjustment (Khalatur *et al.*, 2023) ^[8]. A separate study of the Turkish agri-food sector reached a similar conclusion, designing a model that combined technology transfer with an extension approach connecting universities, research stations, farmers, and food companies, arguing that this combination was needed because standard technology-transfer models used in

industry left out the extension and knowledge-sharing role that farmers depend on (Şerefoğlu, 2024). Together, these studies suggest that sector-specific adjustment is not an optional refinement; it is treated by researchers as a basic requirement for any innovation model applied to agriculture.

3. Agro-startups: characteristics, drivers, and constraints

Agro-startups are a relatively young category compared with the sector-level literature discussed above, and this is exactly where the mismatch with generic models becomes clearest. Studies of digital agriculture startups show that they build genuinely new kinds of business models rather than copying patterns from other digital sectors. A study of 116 agriculture startups and their 198 digital solutions identified eighteen distinct business model patterns, nine of which had not been documented anywhere in prior innovation literature, showing that agriculture pushes startups toward patterns not seen in general digital business model research (Schirmer *et al.*, 2021) ^[14]. This finding on its own is a strong argument for treating agro-startup innovation as its own category rather than an extension of general startup or digital innovation theory.

At the same time, empirical work on agro-startups highlights barriers that rarely appear with the same weight in generic startup literature. A study of agtech adoption among farmers in West Bengal found low awareness of agtech platforms, limited technical knowledge among users, and weak rural infrastructure as the main reasons adoption stayed low even where the technology itself worked well (Adhikary, 2021) ^[1]. A brief examining digital agribusiness startups across developing regions found that these ventures struggle to reach scale and stay financially independent because of the same infrastructure and market conditions (Kropff *et al.*, 2019) ^[9]. A study of the Hungarian agri-startup landscape found that agriculture-related unicorn companies remain concentrated in North America, with almost none based in Europe, suggesting that even well-resourced regions face structural limits on how large agro-startups can grow (Kézai & Kurucz, 2025) ^[7].

More recent research has tried to identify what actually drives success for these ventures. A fuzzy DEMATEL analysis of critical success factors for agri-tech startups found that policy coordination, rural ecosystem readiness, and innovation capacity carried the greatest influence over whether a startup could scale while still supporting sustainability goals (Sharma *et al.*, 2025) ^[16]. This points to success factors that sit largely outside the firm itself, in contrast to generic startup literature, which usually places more weight on factors internal to the firm, such as team quality or product-market fit. Work specific to agro-based startups in the Indian context adds further detail. An ISM-based study modelling the key drivers of agro-based startups found that drivers such as access to markets, institutional support, and technology adoption were arranged in a clear hierarchy, with some drivers acting as a foundation that other drivers depend on rather than all drivers carrying equal weight (Tikkha *et al.*, 2025) ^[18]. A related study of innovation capability in agro startups traced a path running from digitalisation through to sustainability outcomes, showing that digital adoption on its own does not automatically produce sustainable innovation outcomes; it has to be built up through stages of capability rather than adopted all at once (Tikkha *et al.*, 2024) ^[17].

Taken together, this body of work shows agro-startups operating inside a structure that is different from the one assumed by generic innovation models in three clear ways: their business model patterns are genuinely new rather than borrowed, their main constraints sit at the ecosystem level rather than only inside the firm, and their drivers of success follow a hierarchy rather than acting independently of one another.

Why Generic Innovation Models Fall Short for Agro-Startups

Bringing the two streams of literature together makes the mismatch clear. Generic models assume fast information flow; agro-startups work with farmers who often lack reliable internet access and who rely on word-of-mouth trust built over years rather than marketing campaigns (Adhikary, 2021) ^[1]. Generic models assume firms have slack resources for experimentation; most agro-startups in emerging markets operate on thin margins and cannot afford long, expensive pilots, which is one reason more than half of agri-tech pilots reportedly fail to move past the trial stage. Generic models assume that intellectual property can be clearly defined and protected; much of the value agro-startups create comes from adapting existing knowledge to local soil, crop, and market conditions, which is hard to patent and easy for competitors to copy once demonstrated. Generic models also treat the end user as a fairly uniform adopting population. Farmers are not uniform. They differ by landholding size, crop choice, access to credit, literacy, and local custom, and these differences change from one district to the next. The diffusion of innovation theory (Rogers, 2003) ^[13] can describe the shape of adoption over time, but it does not tell a startup how to design a product that works for a two-acre wheat farmer in one state and a five-acre vegetable grower in another. A sector-specific model needs to account for this variation directly, rather than treating it as noise around a general adoption curve. Finally, the driver-hierarchy finding from the ISM-based study (Tikkha *et al.*, 2025) ^[18] points to a structural feature that generic models do not usually build in: some drivers of agro-startup success are foundational and must be addressed before other drivers can have any effect. Market access, for example, may need to exist before technology adoption can produce any benefit at all. Generic innovation models tend to list success factors side by side, as if a firm could work on any of them in any order. Agriculture's dependence on land, season, and local institutions makes this assumption weaker than it is in other sectors.

Toward a Sector-Specific Innovation Model for Agro-Startups

Based on the literature reviewed above, a sector-specific innovation model for agro-startups should include at least five building blocks that generic models either miss or treat as secondary.

First, a staged capability path rather than a single innovation event. The finding that innovation capability in agro startups moves through stages from digitalisation toward sustainability, rather than appearing all at once (Tikkha *et al.*, 2024) ^[17], suggests that a sector-specific model should map out these stages explicitly. A startup should be able to see which capability it needs to build first, such as basic digital record-keeping, before moving toward more advanced sustainability-linked innovation. This differs from

generic innovation-management advice, which often treats capability building as a general organisational goal rather than a sequence tied to specific stages.

Second, an ecosystem-readiness layer built into the model itself. Because rural ecosystem readiness and policy coordination carry strong weight in agri-tech startup success (Sharma *et al.*, 2025) ^[16], a sector-specific model cannot treat the external environment as background context. It needs to include ecosystem conditions, such as extension services, rural connectivity, and input supply chains, as active variables that shape what kind of innovation is even possible in a given location. The Agricultural Innovation System framework already does some of this work at the country level (Gutiérrez Cano *et al.*, 2023 ^[6]; OECD, 2013); a sector-specific startup model should connect to this framework rather than replace it, using it as the outer layer within which the startup's own innovation process sits.

Third, a driver hierarchy instead of a flat list of success factors. The ISM-based modelling of agro-based startup drivers (Tikkha *et al.*, 2025) ^[18] showed that drivers are not independent of one another. A sector-specific model should show which drivers act as a base, such as market access or institutional support, and which drivers depend on that base, such as technology adoption or scale of operations. This gives founders and support agencies a clearer sequence to follow instead of a checklist where every item appears equally urgent.

Fourth, a supplier-linked innovation channel. Because agriculture behaves as a supplier-dominated sector (Pavitt, 1984) ^[12], much of the technical change that reaches farmers arrives through equipment, seed, and input suppliers rather than through the startup's own research. A sector-specific model should treat these supplier relationships as a formal innovation channel, not an afterthought. This matches what the digital agriculture business-model study found: many of the new business model patterns identified in agro-startups were built around partnerships with input suppliers, equipment makers, and distribution networks rather than around the startup acting alone (Schirmer *et al.*, 2021) ^[14].

Fifth, a user-segmentation approach that respects local variation. Because farmer populations vary sharply by landholding size, crop, and local custom, a sector-specific model should require startups to define distinct user segments early, rather than assuming one product design will diffuse evenly across a whole region, as the general diffusion of innovation theory (Rogers, 2003) ^[13] tends to imply. The Turkish agri-food model, which built an extension component into its design specifically to close the knowledge gap between technology producers and farmers (Şerefoğlu, 2024) ^[17], offers one practical example of what this segmentation-and-extension approach can look like when built into a working model.

These five building blocks do not throw out the older innovation frameworks. They adapt them. The National Innovation System idea of interacting actors is still useful, but the actors and their roles need to be redrawn for agriculture, with extension workers, cooperatives, and input suppliers given a place they do not usually have in models built for manufacturing or technology sectors. Open innovation still applies to how agro-startups source ideas from outside their own walls, but the "outside" for an agro-startup often means a local farmer cooperative or a government research station rather than another private firm. The core argument of this paper is not that generic

models are wrong, but that they are incomplete for this sector unless adjusted along the lines set out above.

Implications for Practice and Policy

For agro-startup founders, this discussion suggests a practical shift in how they plan their growth. Rather than adopting a generic startup playbook built for software or consumer products, founders should map their own capability stage, identify which drivers in their local context are foundational, and build supplier and extension relationships into their business model from the start rather than treating them as distribution partners added later.

For investors and accelerators, the driver-hierarchy finding (Tikkha *et al.*, 2025) ^[18] is especially relevant. Funding decisions and mentoring support are often organised around generic milestones such as user growth or revenue. A sector-specific view would ask investors to check whether foundational drivers, such as market access or institutional support, are already in place before judging a startup on drivers that depend on that base, such as technology adoption rates.

For policymakers, the ecosystem-readiness finding (Sharma *et al.*, 2025) ^[16] and the Agricultural Innovation System literature (Gutiérrez Cano *et al.*, 2023 ^[6]; OECD, 2013) point toward the same conclusion: support for agro-startups cannot be limited to firm-level incentives such as tax breaks or seed funding. It needs to include investment in rural connectivity, extension services, and coordination between research institutions and private firms, because these ecosystem conditions determine whether firm-level support can have any effect at all.

Conclusion, Limitations, and Future Research

This paper has argued that agro-startups need innovation models built for their own sector rather than models borrowed from manufacturing, technology, or general startup literature. The argument rests on two points drawn from the literature: agriculture has long been recognised as a sector with distinct structural features, and agro-startups themselves report barriers and success patterns that do not fit neatly into generic innovation frameworks. Recent empirical work on agro-based startup drivers and innovation capability (Tikkha *et al.*, 2024, 2025) ^[17, 18] gives useful, India-based evidence for what a sector-specific model should include: a staged capability path, an ecosystem-readiness layer, a driver hierarchy, a supplier-linked innovation channel, and a user-segmentation approach.

This paper has clear limits. It is a conceptual, literature-based discussion rather than a study built on new primary data, so the sector-specific model outlined here has not been tested directly against firm-level performance data. The literature reviewed also leans toward developing-country and Indian contexts, which fits the paper's focus but means the argument may need adjustment before it is applied to agro-startups in fully industrialised farming systems. Future research could test the proposed building blocks empirically, for example by tracking a cohort of agro-startups over several years to see whether following a staged capability path leads to better survival and growth outcomes than a generic approach. Comparative work across countries with different levels of agricultural infrastructure would also help clarify how much of this sector-specific model travels across contexts and how much needs local adjustment.

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