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Digital Technology Adoption and Economic Decision-Making in Urban Agriculture Enterprises: A Systematic Review

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Abstract

Urban agriculture enterprises (UAEs) have been increasingly encouraged as a commercial response to urbanization, the scarcity of peri-urban land and the growing demand for fresh, high value produce. The sustainability of UAEs' economy is always a worry. The literature has been very positive about the potential of technological innovation, controlled-environment agriculture, hydroponics, and the use of IoT and digital platforms for monitoring and controlling operations to address the structural cost and land limitations of urban enterprises, but there is a lack of comprehensive synthesis of the relationship between technology adoption and enterprise-level economic sustainability. This review fills this gap by providing a structured thematic literature review based on the principles of PRISMA 2020. Nine core academic sources were identified using a transparent keyword-based search and screening process and analyzed using deductive thematic coding. Based on the literature reviewed to date, the methodology has been disjointed: the general reviews of urban agriculture have not focused on the economic sustainability of urban agriculture; the economic reviews have been limited to OECD countries; and the technology reviews or agri-SME reviews have not distinguished urban commercial enterprises as a separate population. We combine four technology domains on three mediating economic mechanisms, and conclude that capital cost and digital literacy are the most significant barriers to adoption, and that there is a clear evidence gap on developing-economy contexts, particularly the exotic fruit and vegetable urban enterprise sub-sector in India. A conceptual framework and future research agenda are presented.

Keywords: urban agriculture enterprises; technological innovation; economic sustainability; systematic literature review; smart agriculture; digital agriculture; controlled-environment agriculture.

1.Introduction

In many parts of the world, urban agriculture has evolved from a subsistence and community activity to a commercial enterprise model due to rapid urbanisation, climate pressure on peri-urban land and increasing consumer demand for fresh and traceable food (Senthamizh & Anbarasan, 2025). Meanwhile, a concurrent technological revolution – controlled-environment agriculture, hydroponics and vertical farming, Internet of Things (IoT) monitoring, precision irrigation, and digital marketing platforms – has been widely touted as the path to how urban agriculture enterprises (UAEs) can overcome the structural cost and land constraints that conventional farming does not face to the same extent (Fei et al., 2025). Although this promotion is ongoing, the literature on urban agriculture has tended to prioritize environmental performance, food security, and community or social outcomes, while economic sustainability at the level of the individual commercial enterprise has been secondary or implicit (Pickles et al., 2025). In cases where technological innovation has been directly studied, a significant focus has been on the factors and obstacles to adoption, and not on how adoption impacts the revenue, cost and resilience of the enterprises involved (John et al., 2023; Nagy et al., 2025). To understand the need for an integrated synthesis, a review of previous review-level studies (Table 1) is helpful. On the other hand, recent comprehensive reviews of urban agriculture have integrated environmental, social, and governance and technological themes, with economic sustainability being one of several themes (Elahi Mirza et al., 2025; Senthamizh & Anbarasan, 2025). Conversely, the review most directly related to economic sustainability is limited to soil-based farms in OECD countries (Pickles et al., 2025), and technology-focused and agricultural-SME reviews either do not consider economic feasibility as a factor for adoption (Fei et al., 2025) or do not

distinguish urban enterprises as a specific group (Sun et al., 2025; John et al., 2023; Nagy et al., 2025). This split between reviews that focus on economics and have a broad geographic scope, and reviews that focus on technology and adoption and lack a specific urban-enterprise economic lens, is the gap that this review addresses.

Table 1: Review of Reviews

Gap in existing review studies	Description	Relevant review studies
Broad urban-agriculture reviews with limited economic-sustainability specificity	Recent broad reviews map urban agriculture across environmental, social, governance, and technological themes but treat economic sustainability as one theme among many rather than the central object of analysis.	Elahi Mirza et al. (2025); Senthamizh & Anbarasan (2025)
Economic-sustainability-focused reviews with narrow geographic and production-system scope	The most economics-focused review identified restricts its scope to soil-based farms in OECD member countries, leaving controlled-environment/technology-driven enterprises and developing-economy contexts largely outside its frame.	Pickles et al. (2025)
Technology-focused urban-agriculture reviews with limited enterprise-level economic outcome depth	This review catalogues urban agriculture technologies by function and innovation stage in detail but discusses economic feasibility mainly as a commercialization barrier rather than measuring enterprise-level economic outcomes directly.	Fei et al. (2025)
Agricultural-SME digital-innovation reviews not specific to urban agriculture	This review offers a strong PRISMA-based synthesis of digital transformation in agricultural SMEs generally, but does not isolate urban or peri-urban enterprises as a distinct sub-population.	Sun et al. (2025)

Precision-agriculture adoption reviews centred on small-scale/rural farmers rather than urban commercial enterprises	These reviews and meta-analyses provide rigorous evidence on adoption determinants and TOE-framework performance effects, but their samples are drawn predominantly from rural and smallholder contexts rather than urban commercial enterprises.	John et al. (2023); Nagy et al. (2025)
Absence of a dedicated India/exotic fruit-and-vegetable enterprise focus	India-focused sources address agricultural entrepreneurship or urban food-security policy, but neither links technology adoption to enterprise-level economic sustainability for the high-value exotic fruit and vegetable sub-sector specifically.	Sonawane (2022); Jha (2022)

Source: Compiled for the present study from the nine core sources identified in the search and selection process (Figure 1).

This review therefore combines evidence from the three strands of commercial urban and peri-urban agriculture, technological innovation in agriculture and enterprise-level economic sustainability, and focuses on the developing-economy and South Asian contexts which are under-represented in the literature. The main goal of this systematic review is 'to develop an integrative framework of how technological innovation relates to the economic sustainability of urban agriculture enterprises, identify the principal theoretical and geographic gaps in current research, and establish a forward-looking research agenda'.

- Research Question 1: What is the evolution of the scholarly literature linking technological innovation to urban agriculture enterprises and what is its conceptual structure?
- Research Question 3: What are the main mechanisms by which the literature indicates that technology adoption impacts the economic sustainability of urban agriculture enterprises?
- Research Question 3: What are the most important research gaps and future research directions, especially in the field of developing-economy and South Asian urban agriculture enterprises?

2. Conceptual Foundations

Urban and peri-urban agriculture (UPA) can take various forms and sizes, such as small-scale household and community farming practice, and large-scale commercial greenhouses and controlled-environment farms (CEF) (Fei et al., 2025). This review focuses on the commercial end of this spectrum enterprises that supply goods beyond immediate personal use where the economic sustainability as a money-oriented, profit-making entity is more directly relevant (Pickles et al., 2025). In this context, economic sustainability is seen as the monetary flows within an enterprise, the financial flows that are relevant for profitability and continued viability, and recognises the influence of broader factors such as access to finance and market linkages, regulation, or other structural influences (as was done in the recent scoping work). This is particularly because most of the wider urban agriculture literature is concerned with environmental and social sustainability, rather than economic sustainability. The researched literature indicates that technological innovations in urban agriculture fall into four main fields: controlled-environment agriculture, hydroponics and vertical/soilless systems, Internet of things (IoT)-enabled monitoring, sensors, and precision irrigation, digital marketing, e-commerce, and direct-to-consumer platforms, and data-driven farm management and decision-support tools (Fei et al., 2025; Sun et al., 2025). The synthesis below is organized into the four domains below.

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3. Research Methodology

This review is carried out using a systematic and transparent literature search and thematic synthesis based on the guideline of PRISMA 2020 (Page et al., 2021). It was done using keyword searching of academic search engines and publisher platforms (ScienceDirect, MDPI, Springer, SAGE, PLOS, Frontiers, Cambridge Core) without formal interrater reliability or direct institutional access to Scopus or Web of Science and without duplicate filtering. This is explicitly stated here, rather than expressed in the larger scale dual-reviewer protocol and represented in scope there.

The search strings were boolean, e.g., ("urban agriculture" OR "urban farming" OR "peri-urban agriculture") AND ("technology" OR "innovation" OR "IoT" OR "hydroponic" OR "precision agriculture" OR "digital") AND ("economic sustainability" OR "viability" OR "profitability" OR "enterprise"). In addition to the main search, supplementary searches were conducted on Tech-spective and Indian/South Asian tech-spections. Sources were added if these were peer-reviewed journal articles or reviews, or if they were from reputable institutions and were more likely to have been published between 2021 and 2026, and focused on urban, peri-urban or controlled-environment agriculture and included a clear, technology, or economic-sustainability component. Those who were commercial blog posts or templates that were clearly off-topic, but fit the keywords were excluded.

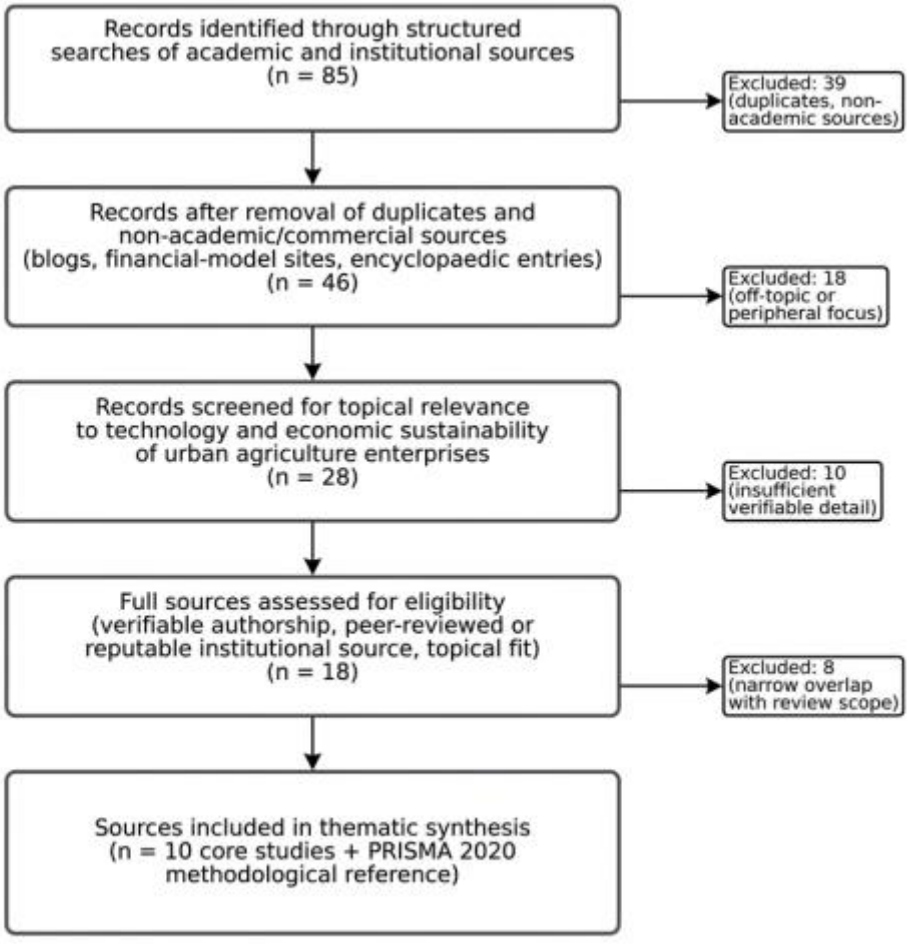

Figure 1. Literature search and selection process (single-reviewer, structured thematic review, informed by PRISMA 2020 principles; not a formal dual-blind systematic protocol).

The nine core sources are the main evidence basis for the thematic synthesis, with the PRISMA 2020 statement as a methodological reference. This is a small evidence base that is appropriate for a focused and targeted review, rather than a field wide systematic review, the scope of which is discussed in the limitations section. All nine core

sources and abstracts were read in full and themed by hand to the four technology domains and the mechanisms, barriers and enablers that were inductively generated as they were read. No formal interrater reliability statistic was reported, coding was done by a single reviewer, which is a limitation compared to multi-reviewer coding practices in SLRs, but expressly noted, and there is no report on the use of qualitative-data-analysis software.

4. Results and Analysis

Table 2 presents the deductive codebook organised in the recurring concept that appeared in the 9 core sources to aid in the organisation of the synthesis. Capital costs were the most frequently mentioned single barrier (in four of the nine key sources) and technology domains and economic mechanisms were mentioned consistently. Digital literacy and awareness gaps were identified as the strongest determinant of the adoption in one dedicated study (John et al., 2023) and were mentioned explicitly in only two sources.

Table 2: Deductive Codebook :Conceptual Content Analysis

Code name	Code hierarchy	Definition & coding instruction	Purpose in synthesis
CEA / Hydroponics	I. Technology domains	Reference to controlled-environment agriculture, hydroponic or vertical/soilless growing systems as an enterprise technology.	Track the most-discussed production technology and its economic framing.
IoT / Precision agriculture	I. Technology domains	Reference to sensors, IoT-based monitoring, precision irrigation, or automated data collection.	Identify links between precision technology and resource-use outcomes.
Digital marketing / platforms	I. Technology domains	Reference to e-commerce, direct-to-consumer platforms, or digital business-model tools.	Capture market-access and revenue-diversification pathways.
Cost / operational efficiency	II. Economic mechanisms	Statements linking a technology to reduced cost, labour saving, or efficiency gain.	Establish the dominant mechanism connecting technology to economic outcomes.

Capital cost barrier	III. Barriers	Reference to high upfront investment as an obstacle to technology adoption.	Quantify the most frequently cited adoption barrier.
Digital literacy / awareness barrier	III. Barriers	Reference to skills, training, or awareness gaps limiting adoption.	Assess the social/human-capital dimension of adoption, distinct from cost.
Policy / land-use enabler	IV. Enablers & context	Reference to zoning, land-use regulation, subsidy, or extension support enabling adoption.	Map the policy conditions associated with successful technology diffusion.
Geographic/economic context	IV. Enablers & context	Whether the study's setting is an OECD/developed economy or a developing-economy context (incl. India).	Track geographic concentration and identify contextual evidence gaps.

Table 3 provides a summary of the relationships between technology and contextual factors and the economic outcomes that are related to these as synthesised from the nine core sources. Seven themes emerged: technology uptake and barriers to cost/efficiency; precision technology and resource optimisation; digital platform and market access; capital cost as a barrier; social/awareness factors influencing uptake; policy and enabling context; and geographic concentration and contextual gaps.

Table 3: Relational Content Analysis of Technology–Economic Sustainability Determinants

Theme	Technology / contextual factor(s)	Outcome and supporting literature
Technology adoption and cost/efficiency outcomes	Controlled-environment agriculture; hydroponic and vertical systems	Technical innovations reduce labor requirements, improve precision, expand capacity, and minimize per-unit costs, particularly for small-scale urban and peri-urban farms operating under land and cost constraints.

		(Pickles et al., 2025; Fei et al., 2025)
Precision technology and resource optimisation	IoT-enabled sensing; precision irrigation; automated monitoring	IoT-based precision agriculture is one of five core digital-innovation clusters identified in agricultural SMEs, associated with more efficient resource use; under the TOE framework, technology adoption is linked to improved technological and organizational performance. (Sun et al., 2025; Nagy et al., 2025)
Digital platforms and market-access outcomes	Digital marketing; direct-to-consumer and mobile-integrated platforms	Mobile-integrated platforms and digital marketing tools are associated with revenue diversification and stronger customer relationships, contributing to enterprise resilience under volatile market conditions. (Sun et al., 2025; Elahi Mirza et al., 2025)
Capital cost and adoption barriers	High upfront investment; limited access to finance	High capital cost is the most consistently cited barrier to technology adoption among small and medium agricultural enterprises, compounded by capacity gaps and infrastructure deficiencies. (Fei et al., 2025; Sun et al., 2025)

Social/awareness factors in adoption	Digital literacy; knowledge dissemination; cultural norms	Social factors' awareness levels, knowledge dissemination pathways, and cultural norms emerge as the most significant determinant of precision technology adoption among small-scale farmers, ahead of purely economic or technical factors. (John et al., 2023)
Policy, land-use, and enabling context	Zoning and land-use regulation; extension services; institutional support	Supportive urban land-use regulation, knowledge inputs, and awareness programs delivered by local bodies are identified as conditions enabling commercial urban agriculture to scale in the Indian food-security context. (Jha, 2022)
Geographic concentration and contextual gaps	OECD/developed-economy settings vs. developing-economy settings	The economic-sustainability literature concentrates on OECD contexts, while India-focused work addresses agricultural entrepreneurship broadly rather than the urban, technology-driven, high-value exotic fruit and vegetable enterprise sub-sector specifically. (Pickles et al., 2025; Sonawane, 2022)

The data in Tables 2 and 3 strongly suggest that in the literature, cost/efficiency and resource-optimal mechanisms are more strongly highlighted than mechanisms of market access and resilience in the pathway from technology to economic sustainability. This is shown as an integrative conceptual framework in Fig. 2, where economic sustainability is not considered as a direct result of technology adoption, but rather as a result of the barriers and enablers as they relate to operational and market-facing mechanisms that are identified in Table 3.

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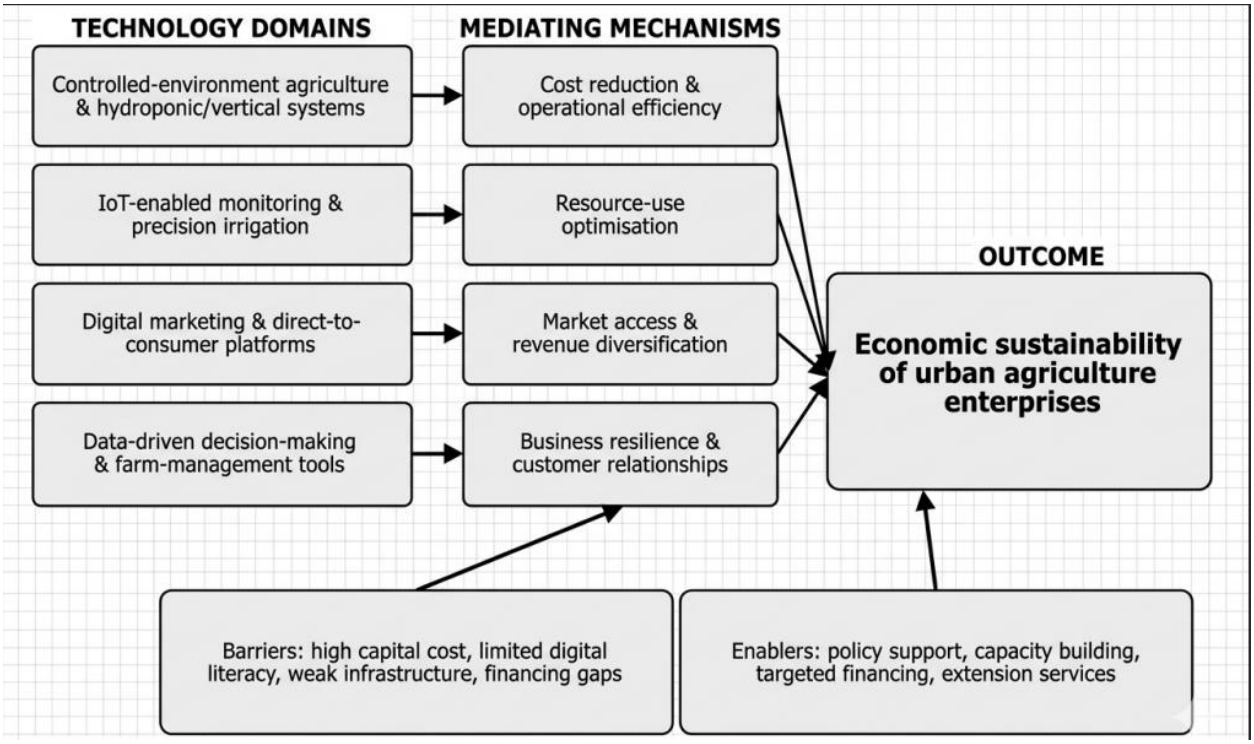

Figure 2. Conceptual framework linking technological innovation to the economic sustainability of urban agriculture enterprises, developed inductively from the reviewed literature.

Table 4 contrasts the concept areas that are well represented in the literature reviewed with those that are comparatively neglected, based on the number of times each concept was mentioned in the nine core sources.

Table 4: Comparison of Prominent and Neglected Research Areas

Concept type	Prominent in reviewed literature	Comparatively neglected
Technology domain	Controlled-environment agriculture / hydroponics; IoT-based precision agriculture (core focus of 4 of 9 core sources)	Blockchain traceability and AI-based decision support (named as clusters but not elaborated for urban contexts)
Economic mechanism	Cost/operational efficiency; resource optimisation	Direct, measured enterprise-level revenue or profitability outcomes (most sources discuss mechanisms conceptually rather than with enterprise financial data)

Barrier	High capital cost (cited in 4 of 9 core sources)	Digital literacy / awareness gap, despite being identified as the single strongest adoption determinant in one dedicated study (John et al., 2023)
Geographic context	OECD countries; East and Southeast Asia	India generally, and North India / exotic fruit-and-vegetable enterprises specifically (present in only 2–3 of 9 core sources, none with a direct technology–economics enterprise focus)

4. Directions for Future Research

The gaps in Tables 1 and 4 form the basis for the concrete suggestions for future empirical research in Table 5. The synthesis that emerges from the pattern clearly shows that there is still a huge evidence gap – enterprise-level economic outcome data – and that the data are geographically concentrated in OECD contexts, which means that the sub-sector of exotic fruits and vegetables in India, and specifically North India, has not received much attention.

Table 5: Research Gaps and Future Research Directions

Category	Research gap	Future research direction
Technology adoption	Studied mainly in relation to cost/efficiency and resource optimisation	Explore the connection between technology adoption and market-access/resilience outcomes specifically for urban commercial enterprises
Economic outcomes	Enterprise-level revenue, margin, and payback-period data are largely absent; mechanisms are asserted more often than measured	Conduct enterprise-level case or survey research that measures economic outcomes directly, rather than inferring them from adoption studies
Barriers	Capital cost is well documented; digital literacy and awareness gaps are comparatively under-examined for urban enterprises specifically	Investigate the role of digital literacy, training, and awareness programmes as adoption enablers for urban agriculture SMEs

Geographic context	India and North India remain thinly covered relative to OECD contexts; no core source addresses the exotic fruit and vegetable sub-sector directly	Prioritise enterprise-level empirical studies situated in developing-economy and South Asian urban agriculture contexts
Policy linkage	Few sources connect specific land-use, zoning, or financing instruments to measured changes in enterprise technology adoption or performance	Study the direct link between specific policy instruments (zoning, subsidy, extension services) and enterprise-level technology adoption outcomes

5. Conclusion

The purpose of this review was to identify the connections in the literature between technological innovation and the economic sustainability of urban agriculture enterprises. It identifies a body of research that is individually strong, including a comprehensive review of urban agriculture in general, the adoption of precision-agriculture and the digital transformation of agricultural SMEs; but which does not yet offer a single, clear evidence-base at the enterprise level on economic outcomes, particularly in non-OECD settings. The difference is not coincidental, as the review of reviews (Table 1) shows, the two strands of the literature, economics-oriented and technology-oriented, have been developing largely independently. The conceptual framework presented here (Figure 2) is offered as a suggestion to future empirical studies, such as enterprise level case studies, which would help to prove it directly in contexts that are under studied, such as the exotic fruit and vegetable sector in North India.

6. Limitations

There are a number of limitations in scope and depth to this review that should be explicitly noted. Although it was structured around PRISMA principles, it was not a full PRISMA-compliant systematic review as it was conducted by a single reviewer without independent duplicate screening or formal inter-rater reliability checks. Search access was restricted to publicly available academic search engines and publisher platforms and not to direct access to Scopus or Web of Science. The nine core sources synthesised here are not intended to be a comprehensive list of the literature, but rather a structured and targeted sample of the literature, and the frequency counts reported in Tables 2 and 4 are not intended to be statistically representative of the literature, but rather are a description of patterns in a small, targeted sample of the literature.

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