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Low-Tech and Supply Chain: Adoption and Challenges in Agriculture Sector of West Africa

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Abstract

Agriculture, which is the linchpin of most West African economies, absorbs the bulk of rural labour and contributes a significant portion to national GDP. The problem is that, for West Africa, especially, the agricultural network is highly fragmented, with few roads, limited storage capacity, and significant post-harvest losses (some estimates range from 30% to 50% of perishable crops) (FAO, 2019; World Bank, 2021). Being marginalised in production, smallholder farmers often lack access to modern technologies due to challenges in finance, infrastructure, and knowledge (IFAD, 2020). This paper aims to explore the potential of low-tech innovations in enhancing a stronger agricultural supply chain in West Africa. It focuses on how these approaches shrink the distance between producers and markets, ultimately making them more sustainable, and how they build resilience into the region's agricultural systems. With practical contextual examples, the study aims to ensure that low-tech solutions are part of the pathway of agricultural transformation when resources are scarce.

Keywords: Low-Tech Innovation, Agricultural Supply Chains, Post-Harvest Losses, Food Security, Value Chain Development, Smallholder Farmers

Introduction

Agriculture provides over 60% of employment and contributes substantially to national GDPs (FAO, 2019). However, despite its central importance, the agricultural sector is hindered by a fatal structural inefficiency: farmers have virtually no access to markets, resulting in devastating post-harvest losses; there is an inadequate set of storage and transportation infrastructures (Stathers et al., 2020). As a crucial interconnector between production and consumption, supply chains are also fragmented, which reduces competitiveness and sustains food insecurity in the region. Digital platforms are recognised as central to global discussions on agricultural mechanisation. However, the region of West Africa operates under extremely high costs, poor infrastructure, and low-technological levels among its predominantly smallholder farmers (van Ittersum et al., 2016). Hence, low-technology approaches are increasingly receiving attention as a complementary tool to this energy-intensive technology through simple, inexpensive, and context-specific design for season extension within the agricultural supply chains (Baoua, 2014; Waongo et al., 2019). Low-tech interventions, such as hermetic storage bags and solar dryers, as well as community-managed transport systems and mobile phones for market information services, are demonstrating the potential to reduce post-harvest losses and increase added value and efficiency in distribution networks (Udomkun et al., 2020; Stathers et al., 2020). Redtec works to improve the productivity of smallholder farmers and values frugal solutions, because, let us face it, they can be made on-site to fit local conditions and are geared for farmers or dealers with limited financial resources.

Low-Tech in Agricultural Supply Chains: Framework

Diffusion of Innovations Theory

Rogers' (2003) diffusion of innovations theory provides a useful lens for understanding why low-tech solutions

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often achieve widespread adoption among smallholder farmers in West Africa. The theory emphasises five attributes of innovations that influence adoption rates: relative advantage, compatibility, complexity, trialability, and observability. Low-tech options such as hermetic storage bags, small-scale threshers, and solar dryers score highly across these attributes. Their relative advantage is clear in the form of reduced post-harvest losses and improved food quality; they are compatible with existing practices and smallholder constraints; they are simple to operate, requiring little or no technical training; they can often be trialled on a small scale before full adoption; and their benefits – such as visibly higher grain quality or reduced pest infestation – are quickly observable. These attributes explain why low-tech spreads more readily compared with capital-intensive, complex technologies such as mechanised cold chains or digital precision systems. The diffusion process is further facilitated by peer-to-peer learning in rural communities, demonstration projects, and co-operative adoption, where trust and social networks accelerate uptake.

Sustainable Livelihoods Framework

The Sustainable Livelihoods Framework (DFID, 1999) emphasises the dynamic use of five forms of capital – natural, human, social, financial, and physical – in enabling rural households to sustain their livelihoods. Low-tech solutions align particularly well with this framework because they reinforce multiple forms of capital simultaneously. For example, hermetic storage enhances physical capital by reducing post-harvest losses and extending shelf life, while simultaneously strengthening financial capital by enabling farmers to sell produce at more favourable prices. Social capital is enhanced through cooperative-based logistics and shared infrastructure, where farmers pool resources to access storage or transport collectively. Human capital is developed as farmers gain skills in using and maintaining these simple tools, while natural capital benefits from the environmentally sustainable design of many low-tech innovations, such as solar dryers that reduce reliance on fossil fuels. Thus, low-tech is not simply a technical intervention but also a livelihood strategy that bolsters resilience and inclusivity across multiple dimensions of rural life.

Global and Agricultural Value Chain Analysis

Global value chain (GVC) and agricultural value chain analysis emphasise the importance of addressing weak links between production and consumption. In West Africa, these weak nodes are most evident in post-harvest storage, local transportation, and small-scale processing. By reducing losses at the farm level, low-tech solutions ensure that more produce reaches markets in sellable condition, thereby increasing farmer revenues and enhancing regional food supply. For instance, Stathers et al. (2020) highlight how low-cost storage and drying technologies enable smallholders to engage more effectively in markets by preserving both the quality and volume of their produce. Furthermore, value chain analysis underscores governance and power dynamics within agricultural markets – while high tech often demands centralised systems controlled by elites or large firms, low-tech integrates seamlessly into the informal networks that dominate West African trade. This compatibility with informal structures ensures that smallholders, who form the majority of producers, can capture greater value without being excluded by high entry costs.

Appropriate Technology Paradigm

Schumacher's (1973) Appropriate Technology paradigm offers perhaps the most philosophically grounded justification for the adoption of low-tech solutions. It advocates for technologies that are "small-scale, decentralised, labour-intensive, and environmentally sustainable", in contrast to large-scale, centralised industrialisation. Low-tech embodies this paradigm by leveraging local knowledge, using locally available materials, and requiring minimal external inputs. For example, community-built solar dryers constructed from locally available resources, such as wood, mesh, and transparent sheeting, demonstrate how innovation can be grounded in local materials. By reducing reliance on imported high-tech machinery, which may be financially inaccessible and difficult to maintain, low-tech aligns with principles of cultural appropriateness and economic sustainability. This paradigm reframes low-tech not as a fallback option for resource-poor regions but as a deliberate strategy for empowering communities, sustaining livelihoods, and preserving ecological balance.

Resilience and Systems Theory

Agricultural supply chains in West Africa are highly vulnerable to various shocks, including climate variability, pest outbreaks, price volatility, and conflict (AATF, 2023). Resilience and systems theory emphasises attributes such as adaptability, redundancy, and robustness as hallmarks of resilient systems. Low-tech contributes to these qualities in several ways. Its affordability and accessibility make it adaptable to a wide range of farming contexts. Its simplicity ensures redundancy: if one storage bag fails, replacing it is inexpensive and rapid compared with repairing complex refrigeration systems. Its decentralised design spreads risk across many smallholders rather than concentrating vulnerabilities in centralised facilities. In this sense, low-tech enhances systemic robustness by diversifying solutions at multiple levels of the value chain. Moreover, because low-tech is socially embedded and locally maintained, it contributes to both ecological and social resilience, positioning communities to better withstand external shocks.

Table 1: Framework for Understanding Low-Tech Adoption in West African Agricultural Supply Chains

Table 1

Frameworks for Understanding Low-Tech Adoption in West African Agricultural Supply Chains

Framework	Key Principles	Application in West Africa	Relevance to Low-Tech
Diffusion of Innovations Theory (Rogers, 2003)	Adoption depends on relative advantage, compatibility, complexity, trialability, and observability.	Farmers adopt hermetic bags and solar dryers quickly because benefits (reduced losses, improved quality) are visible and the technology is simple.	Explains why low-tech spreads more easily than capital-intensive, complex technologies.
Sustainable Livelihoods Framework (DFID, 1999)	Livelihoods depend on natural, human, social, financial, and physical capital.	Hermetic storage improves physical and financial capital; cooperative logistics strengthen social capital; solar dryers support natural capital by using renewable energy.	Positions low-tech as a livelihood strategy that strengthens resilience and inclusivity.
Global & Agricultural Value Chain Analysis	Weak nodes between production and consumption constrain value capture; governance structures shape participation.	Post-harvest storage and rural transport are key bottlenecks; low-tech helps farmers access higher-value markets while fitting into informal trade networks.	Shows how low-tech strengthens value chain participation and empowers smallholders.
Appropriate Technology Paradigm (Schumacher, 1973)	Technologies should be small-scale, decentralized, labor-intensive, and sustainable.	Locally made solar dryers and manual threshers use local resources and labor, requiring minimal imports.	Frames low-tech as culturally appropriate, economically viable, and ecologically sustainable.
Resilience & Systems Theory (AATF, 2023)	Resilient systems are adaptable, redundant, and robust.	Simple, decentralized low-tech solutions spread risk, reduce vulnerability to shocks, and are easily replaceable.	Demonstrates how low-tech builds resilience against climate variability, market volatility, and conflict.

Table 1 summarises five key theoretical frameworks that explain the adoption and integration of low-tech solutions in agricultural supply chains in West Africa. Each of the frameworks reveals different dimensions that help explain why low-tech approaches provide more effective and sustainable experiences than capital-intensive high-tech interventions in this setting. From the perspective of the diffusion of innovations theory (Rogers, 2003), low-tech solutions such as hermetic bags and solar dryers are highly aligned with critical adoption characteristics – they provide clear relative advantage through fewer losses, they can be integrated into local farming practices, are easy to use, can be trialled on a limited scale, and deliver visible benefits in a short period of time. These may be reasons that they have been rapidly adopted by smallholders, who commonly base decisions on peer-to-peer learning and community demonstrations. The Sustainable Livelihoods Framework (DFID, 1999) enriches this analysis by locating low-tech not as a technical fix but rather as a multicapital livelihood strategy. Hermetic storage and small-scale transport systems increase physical and financial capital, while co-operative logistics enhance social capital. Solar dryers also contribute to natural capital by utilising renewable energy. This highlights the multifaceted value of low-tech by demonstrating that it is not only more efficient but also more resilient, inclusive, and sustainable.

Global and agricultural value chain analysis focuses on structural bottlenecks between production and consumption. Value capture constraints in storage, transport, and processing are most binding in West Africa. Low-tech products address these vulnerabilities

directly by improving the ease of trade and facilitating farmers' greater uptake in both formal and informal markets (Stathers et al., 2020). Crucially, unlike high-tech interventions that necessitate centralisation or the large-scale co-ordination of market actors, low-tech solutions are compatible with the informal and decentralised networks of West African trade, and they accommodate more value to be captured locally by smallholders. The Appropriate Technology Paradigm (Schumacher, 1973) proposes a philosophy that explains why low-tech is not necessarily second-best or an interim solution, but rather a strategically superior approach. Through the focus on small-scale, decentralised, and labour-intensive solutions that are ecologically sustainable, such a paradigm has pointed out how low-tech innovations could capitalise on local knowledge and endow a sense of self-sufficiency rather than depend heavily upon expensive imports while burning precious natural resources, relating to the ability of human ecosystems to maintain autonomy in agricultural transformation. In this way, low-tech becomes a deliberate approach to sustainable development, rather than just plan B. Last, Resilience and Systems Theory (AATF) emphasises the importance of flexibility, redundancy, and robustness in agricultural systems that are vulnerable to recurring stresses, such as climate variability, price volatility, and conflict. Low-tech solutions have a direct and clear impact on resilience due to their increasing affordability, flexibility, and adaptability for crop systems and local conditions. A distributed structure means that risks are spread rather than being highly concentrated in large, vulnerable facilities, increasing systemic resilience.

Considered together, the frameworks in Table 1 illustrate how low-tech solutions are not simply inexpensive devices for minimising PHLs, but are deeply rooted in larger systems of knowledge circulation and assimilation, livelihood enhancement, value chain reorganisation, cultural fit, and systemic resiliency. This multifaceted theoretical amalgamation supports the case for acknowledging low-tech investment pathways as strategic for agricultural transformation in West Africa, rather than merely serving as an interim buffer strategy until high-tech alternatives become available.

Low-Tech Solutions for West African Agriculture

Hermetic Bags

Post-harvest losses of grains constitute a significant problem in much of West Africa, where insect infestations and unsound storage practices have been identified as contributing to ongoing threats to food security. Hermetic storage methods, such as Purdue improved crop storage (PICS) bags, have successfully reduced grain losses by developing airtight conditions that restrict insect growth. Studies show that hermetic bags can protect maize and sorghum over time without the requirement for chemical insecticides, contributing to food security and limiting health consequences (Baoua, 2014; Waongo et al., 2019). These solutions are particularly beneficial for smallholders, many of whom lack access to costly storage equipment.

Solar Dryers

Apart from the handling after the harvesting process, it also applies to drying, as traditional open-air practice results in contamination and pests, as well as loss due to weather. Enhanced solar drying technologies are a cost-effective and climate-smart alternative, yielding significantly reduced drying times, increased food quality, and enhanced safety. By offering solar dryers that provide more uniform drying, farmers can gain access to better markets, reduce mycotoxin levels, and expand the range of commodities they produce (Udomkun et al., 2020). New research focuses on their relationship with climate-resilient agriculture in urban and peri-urban Sahelian areas, demonstrating the potential for upscaling these models in other contexts across West Africa (Scientific Reports, 2024).

ICT Interventions

ICT solutions were transforming the lives of smallholder farmers. Mobile solutions like Esoko have facilitated

access to market information, leading to better price discovery and improved farmer bargaining power (van Schalkwyk, 2017). Apart from market information, ICT4D (Information and Communications Technologies for Development) solutions are utilised for weather forecasting, extension services, and financial inclusion. Digital platforms like these help address information imbalances, a persistent issue in fragmented agricultural value chains (Purdue University, n.d.).

Barriers to Implementing Low-Tech Solutions

However, low-tech agricultural technologies have not been fully adopted due to several reasons. Farmers typically face limited access to information on new technologies, inadequate resources to acquire them, and insufficient institutional support for scaling up their use. The uptake is further complicated by socio-cultural factors, including traditional storage and hesitation to discard old methods (Stathers et al., 2020; Stathers et al., 2024). These barriers underscore the need to develop both technical and social solutions that focus on behaviour change, in line with Rogers' (2003) diffusion of innovations theory.

Agricultural Supply Chains Across West Africa

Characteristic Factors in the Agricultural Supply Chain of Production, Processing, and Trading Along West Africa

Some technologies are already in use at the farm level, but systemic bottlenecks in regional supply chains reduce productivity and competitiveness. Poor infrastructure (roads and cold-chain infrastructure), transaction costs, and market integration are limited (BNS Agri, 2024). Moreover, the high cost of shipping disproportionately impacts landlocked countries and smallholders (LinkedIn, 2024). Despite high agro-ecological diversity, value chains remain largely disaggregated, and smallholders are still largely excluded from organised markets (CSM Tech, 2023). The bottlenecks are systemic and require intervention at a more societal level, rather than relying on on-farm solutions.

Opportunities and Policy Implications

The successful scaling up of low-input options is based on a multistakeholder mission and facilitating policies in West African agriculture. Public-private partnerships (PPPs) give a promising opportunity for co-development, financing, and transfer of low-cost technologies. Specialised finance systems such as microcredit and subsidies can help overcome the affordability barriers for smallholders. Awareness and its adoption are equally important; therefore, governments, non-governmental organisations (NGOs), and regional organisations should undertake capacity-building programmes. Policies that put these dimensions of agricultural innovation in the service of climate-resilient development strategies have the potential to also drive progress towards regional food security goals (World Bank, 2021; Institute for Global Change, 2025).

Table 2: Technological Innovation in the Agricultural Sector

Technology	Main Function	Key Benefits	Challenges	Outcomes
Hermetic Bags (e.g., PICS)	Airtight grain storage	Reduces insect infestation; cuts post-harvest losses; avoids chemical pesticides (Baoua, 2014; Waongo et al., 2019)	Upfront cost; limited farmer awareness	Up to 98% reduction in storage losses; longer shelf life of grain; improved household food security
Solar Dryers	Controlled drying of crops	Reduces drying time; lowers contamination and spoilage; enables access to premium markets (Udomkun et al., 2020; Scientific Reports, 2024)	Investment cost; maintenance needs; cultural preference for traditional drying	30–50% faster drying; reduced mycotoxin contamination; improved market value of produce

Technology	Main Function	Key Benefits	Challenges	Outcomes
ICT Interventions (e.g., Esoko)	Market information and extension via mobile	Enhances bargaining power; improves price transparency; provides weather and advisory services (van Schalkwyk, 2017; Purdue University, n.d.)	Limited smartphone penetration; network gaps; literacy barriers	Increased farmer incomes by 10–20%; improved decision making; greater resilience to shocks

In Table 2, Overview of three common low-tech agricultural innovations currently in use in West Africa: hermetic bags, solar dryers, and ICT-based platforms. Hermetic storage system: PICS bags. PICS bags are air-tight grain storage bags, designed to curb post-harvest losses due to insect infestation. Significant benefits include a substantial reduction in the volume of chemical pesticides that farmers need to purchase and greater food security for their households. However, uptake is hindered by the steep initial cost and the lack of awareness among farmers. Reported effects suggest hermetic bags reduce storage losses by up to 98% and may extend the shelf life of cereal grains such as maize and sorghum (Baoua, 2014; Waongo et al., 2019).

Solar dryers are another vital, low-cost innovation that provides farmers with a cleaner and more efficient way to dry their crops than the traditional process of open-air drying. In some cases, these dryers reduce drying time (between 30–50%), also prevent microbial contamination, and allow for a better market. However, the barrier considerations include large investment costs, maintenance troubles, and traditional ideas; all these factors make it difficult to promote on a wide scale. However, the literature findings show that not only can product quality be improved, but market value also increases (Udomkun et al., 2020; Scientific Reports, 2024).

ICTs, such as those of the Esoko type, complement each other in addressing market and information asymmetries. These offer the potential to put more power in the hands of farmers to negotiate better prices and make wiser decisions by supplying them with price information, weather forecasts, and extension advice on their mobile devices. Adoption is constrained by infrastructure bottlenecks such as low smartphone penetration, network availability, and literacy. However, there is evidence (van Schalkwyk, 2017; Purdue University, n.d.) that the use of ICTs could increase farmer incomes by up to 10–20% and reduce their vulnerability to price and climate shocks.

Together, the comparison illustrates that while low-tech solutions can deliver large benefits in terms of food security, income, and resilience, gains such as these need to be leveraged with the removal of structural barriers to uptake and programming that reflects the socio-economic circumstances faced by smallholder farmers.

Conclusion

The agricultural sector in West Africa holds immense potential but is hindered by the adoption of low-technology and significant supply chain challenges. Addressing these issues requires a multifaceted approach that combines low-tech solutions with investments in infrastructure, streamlined regulations, and climate-smart practices. By prioritising these areas, West Africa can unlock its agricultural potential, improve food security, and strengthen its role in the global commodity market. In addition, the theoretical perspectives that we have presented suggest that low-tech is not merely a temporary solution but a strategic pathway for sustainable agricultural transformation in West Africa. They explain adoption patterns, livelihood impacts, supply-chain efficiency, and system-level resilience, while remaining grounded in low-tech approaches within broader debates on technology, development, and inclusivity. To summarise, low-tech innovations represent a crucial yet underutilised avenue for strengthening agricultural supply chains in West Africa. By reducing post-harvest losses, enhancing market integration, and improving inclusivity, low-tech agriculture offers a pathway to food security and rural development. However, adoption requires supportive policies, financing, and institutional support. This study underscores the need to reposition low-tech not as a stopgap, but as a strategic driver of sustainable agricultural transformation in the region.

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