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Agricultural value chains and supply chain efficiency for farmer income and market competitiveness: A review

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Abstract

Agricultural value chains (AVCs) encompass the complete set of activities involved in moving agricultural products from production to final consumption, including processing, distribution, and marketing. This review consolidates findings to analyze how value chain structure influences supply chain efficiency, smallholder farmer income, and market competitiveness. The evidence highlights that inefficiencies such as significant post-harvest losses (15-40%), elevated transaction costs, poor infrastructure, and information asymmetry consistently reduce farm-gate prices and weaken the performance of agricultural systems, particularly in developing regions. Strengthening collective approaches, including farmer cooperatives, contract farming models, and the integration of digital technologies, has been identified as a major driver of improved efficiency and income gains. Studies show that lowering marketing margins and transaction costs, along with enhancing market access and compliance with quality standards, can raise smallholder incomes by approximately 15-35%. However, notable research gaps remain, especially concerning the long-term sustainability of value chain interventions and their gender-specific impacts. The findings suggest that coordinated policy efforts focusing on infrastructure development, institutional strengthening, and digital innovation are essential to improving agricultural supply chains and supporting rural livelihoods.

Keywords: Agricultural value chains, supply chain efficiency, smallholder farmers, post-harvest losses, market competitiveness, digital agriculture, cooperatives, contract farming, transaction costs, food systems

1. Introduction

It should be noted that agriculture is still seen as the basis of economy for developing countries and ensures livelihood for more than 2.5 billion people worldwide as well as almost 500 million smallholder farm households (World Bank, 2008) ^[69]. The significance of agriculture in terms of economic development is also well-understood in development economics. In particular, Hirschman (1958) ^[29] underlined the importance of agricultural backward and forward linkages, whereas Bairoch (1975) ^[3] studied the role of agriculture in historical transformations. However, despite all the importance of agriculture, this sector suffers from serious inefficiencies in terms of not allowing farmers earn enough from consumer expenditures, not providing them with sufficient income, and not letting agricultural systems develop their competitiveness. This is related primarily to the issue of the way agricultural value chains (AVCs) are organized (Gereffi *et al.*, 2005; Kaplinsky & Morris, 2001) ^[22, 35].

The agricultural value chain consists of all processes related to the provision of inputs, production, harvest, post-harvest, processing, distribution, marketing, and consumption of agricultural products. How these processes are structured, coordinated, and governed ultimately decides how the value is captured, its magnitude, and by whom (Porter, 1985; Gereffi, 1994) ^[21, 53]. For most developing countries, farmers are placed in the weakest position along the value chain and are likely to get merely 10-30% of the retail price of their agricultural products (Reardon *et al.*, 2003; FAO, 2019) ^[16, 55]. Agricultural commercialization also bears some nutritional consequences for the household involved in agricultural farming that go beyond the basic impact of higher incomes (Bouis & Haddad, 1990) ^[9]. Corporate consolidation along the food chain also plays a role in value distribution (Vorley, 2003) ^[65].

Efficiency in supply chains can be measured by using post-harvest losses, marketing margins, transaction costs, logistics, and market integration measures, and is critical in determining producer incomes and price competitiveness within agri-food systems (Barrett, 2008; Key *et al.*, 2000) ^[4, 36].

Efficiency in supply chains can be measured by using post-harvest losses, marketing margins, transaction costs, logistics, and market integration measures, and is critical in determining producer incomes and price competitiveness within agri-food systems (Barrett, 2008; Key *et al.*, 2000) ^[4, 36]. Globally, it is estimated that postharvest losses in fruit and vegetable crops amount to 30%-40% of total production levels, which results in huge economic inefficiencies for producers (FAO, 2011; World Bank, 2020) ^[71]. These inefficiencies may be worsened by the poor availability of rural infrastructure, market information inequalities, adverse institutional contexts, and lack of finance and technology (North, 1990; Dorward *et al.*, 2004) ^[13, 49].

Scholarship in agricultural value chains has come a long way in the last three decades, building on concepts from global value chains (GVCs) theory (Gereffi *et al.*, 2005) ^[22], transaction cost economics (Williamson, 1985) ^[67], institutional economics (North, 1990) ^[49], and industrial organization (Sexton & Lavoie, 2001) ^[57]. Developments in information and communication technologies (ICTs), particularly the use of mobile phones, blockchain, IoT, and AI, have led to innovations for boosting the efficiency of smallholder producers' supply chains (Nakasone *et al.*, 2014; Wolfert *et al.*, 2017) ^[47, 68].

The objectives of this review include the following:(1) synthesizing theories that form the basis of the value chain analysis in agriculture; (2) highlighting the major factors that contribute to the inefficiencies within the supply chains, as well as the consequences on farmers' earnings; (3) analyzing the effectiveness of initiatives such as collective action, contract farming, technology, and standards in improving value chain operations; (4) comparing the performance of value chains in different regions; and (5) suggesting policy implications and research needs.

2. Theoretical Frameworks for Agricultural Value Chain Analysis

2.1 Global Value Chain Theory

The GVC analysis approach, introduced by Gereffi (1994) ^[21] and further improved by Gereffi *et al.* (2005) ^[22], is the most extensively used tool for examining activities coordination in agricultural supply chains. According to the framework, chain governance is divided into five types - market, modular, relational, captive, and hierarchical - based on transaction complexity, information codifiability, and the capability of suppliers. In the case of smallholder-dominant agricultural chains, market and captive forms of governance are common, where power is weak and there is no scope for upgrading (Humphrey & Schmitz, 2002; Gibbon & Ponte, 2005) ^[30].

The use of GVC theory in agricultural supply chains indicates that lead firms, such as supermarkets, processors, and multinational exporters, play an important role in standardization, organization of supply, and creation of value

(Dolan & Humphrey, 2000; Swinnen, 2007) ^[12, 60]. The commodity specific application of GVC, for instance the global coffee chain study by Ponte (2002) ^[52], helps us understand how value is distributed through the chain depending on the type of governance and power dynamics. Although GVC involvement may help smallholders access markets and technologies, it may also lead to the exclusion of the poorest smallholders due to increasing quality and quantity standards (Van der Meer, 2006; Lee *et al.*, 2012) ^[38, 63].

2.2 Transaction Cost Economics

Transaction Cost Economics (TCE) is a theory formulated by Williamson (1985) ^[67] and used in the agricultural sector by Barrett (2008) ^[4] and Key *et al.* (2000) ^[36]. TCE theory provides another explanation for the emergence and perpetuation of certain forms of supply chain governance. High transaction costs, which include the costs of searching and gathering information, bargaining and negotiating costs, and monitoring and enforcement costs, in thin and segmented rural markets lead to market failure, thus hindering smallholder inclusion and efficiency. According to North (1990) ^[49], institutions lower transaction costs, and therefore, the lack of property rights, contract enforcement and market information systems works against smallholder farmers.

2.3 Value Chain Upgrading Frameworks

The concept of value chain upgrading refers to the process through which businesses, farmers, and economies can enhance their position in international value chains by creating higher-quality goods, increasing efficiencies, or engaging in more skill-intensive processes. Smallholder upgrading paths might include upgrading the product (product upgrading), upgrading the process used for producing the product (process upgrading), upgrading the skills (functional upgrading), or switching from lower-value to higher-value chains (inter-chain upgrading). Research shows that upgrading is made easier with collective action, standardization and certification, and market information (Bolwig *et al.*, 2010; Fischer & Qaim, 2012) ^[8, 18].

2.4 Institutional Approaches

Institutions are a key concept in the literature on new institutional economics based on North (1990) ^[49] and Williamson (1985) ^[67] because they argue that there is no escape from institutions when it comes to market performance and supply chain management. The deficiencies of institutions like insecure land ownership, poor cooperative law, and lack of quality grading in most developing countries' agricultural markets lead to market inefficiencies which cannot be solved through the market alone (Dorward *et al.*, 2004; Pingali *et al.*, 2005) ^[13].

3. Components of Agricultural Value Chains

Agricultural value chains are multi-actor systems with distinct but interconnected functional stages. Table 1 summarizes the key components, stakeholders, and critical success factors at each stage.

Table 1: Key Components of Agricultural Value Chains: Stages, Stakeholders, and Critical Success Factors

Value Chain Stage	Key Activities	Key Stakeholders	Critical Success Factors	
Input Supply	Seed, fertilizer, pesticide procurement; Credit and technology access	Input dealers, banks, NGOs, government agencies	Quality inputs, affordability, timely delivery	
Production	Land preparation, cultivation, harvesting; Good agricultural practices (GAP)	Farmers, cooperatives, extension services	Technical knowledge, climate resilience, mechanization	Kaplinsky & Morris (2001); Gereffi <i>et al.</i> (2005); FAO (2019)
Post-Harvest Handling	Sorting, grading, packaging, storage; Cold chain management	Aggregators, processors, cold-chain operators	Infrastructure, technology, hygiene standards	
Processing & Value Addition	Primary/secondary processing; Branding and packaging	Agro-processors, SMEs, cooperatives	Capital investment, food safety, market linkages	
Marketing & Distribution	Wholesale/retail channels; Export facilitation; Digital marketing	Traders, retailers, exporters, e-commerce platforms	Market intelligence, logistics, standards compliance	
Consumption	Consumer demand management; Feedback loops to producers	Consumers, supermarkets, food service industry	Quality, price competitiveness, consumer awareness	

The performance of agricultural value chains is determined not only by the efficiency of individual stages but also by the linkages between stages and the distribution of power, information, and value among actors (Gereffi *et al.*, 2005) ^[22].

Weak linkages—particularly between production and post-harvest handling, and between processing and marketing—are associated with high losses and value leakage in developing country contexts (FAO, 2011; Shiferaw *et al.*, 2011) ^[58].

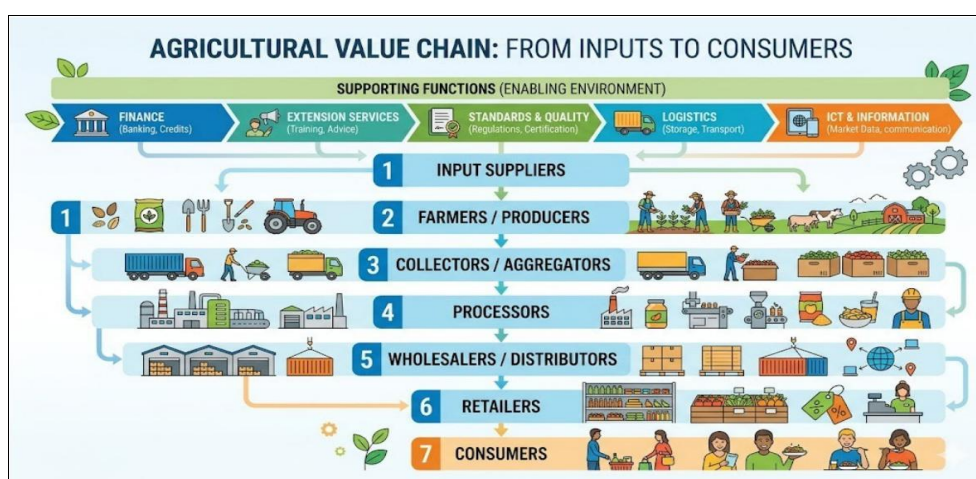


Fig 1: Generic structure of an agricultural value chain. Arrows indicate product and information flows. Supporting functions operate across all stages. Source: Authors' synthesis based on Porter (1985); Kaplinsky & Morris (2001).

4. Supply Chain Efficiency: Dimensions and Measurement

4.1 Post-Harvest Losses

Post-harvest losses (PHLs) stand out as some of the most significant inefficiencies in agricultural supply chains. According to estimates from the FAO (2011) ^[15], about one-third of the world's food that is intended for human consumption is wasted annually. Post-harvest losses are highest in developing countries, where they take place during both the farming stage and beyond due to issues of poor storage facilities, poor handling techniques, lack of cold chains, and long distribution chains (Kitinoja, 2013; World Bank, 2020) ^[37, 71].

Post-harvest losses vary depending on crops and context. Fruits and vegetables suffer from 25%-40% losses in sub-Saharan Africa (SSA) compared to 15%-25% losses in Southeast Asia (FAO, 2019) ^[16]. On the other hand, staple crops lose only 5%-15%, although this is still considerable since they have high volumes. Improved investment in cold chain facilities, hermetic storage technology, and post-harvest handling has been shown to decrease PHLs by 20%-50% (Kitinoja, 2013; World Bank, 2020) ^[37, 71].

4.2 Marketing Margins and Price Transmission

Marketing margins represent the difference between the farm-gate prices and the prices at the retail or wholesale level.

Marketing margins that are high in agricultural value chains may indicate an amalgam of market power, high transaction costs, inadequate infrastructure, and low competition (Sexton & Lavoie, 2001; Minten & Kyle, 1999) ^[45, 57]. In many markets of developing countries, marketing margins on fresh products may be about 50-70% of the retail price, and farmers get only 20-30% of the total consumer expenditure (Reardon *et al.*, 2003) ^[55].

Price integration represents the magnitude and speed of price transmission from one market level to another. Studies by Chamberlain & Jayne (2013) and Mather *et al.* (2013) ^[42] reveal considerable spatial price variations in African grain markets, which are indicative of high transaction costs resulting from inadequate road infrastructure and information. Better price transmission through market infrastructure and information can help lower marketing margins and raise the proportion of the consumer price received by the producer (Jensen, 2007; Aker, 2010) ^[1, 33].

4.3 Transaction Costs

Transaction cost considerations such as search, negotiation, monitoring, and enforcement costs determine market involvement by smallholder farmers. For instance, Key *et al.* (2000) ^[36] found that high fixed transaction costs lead to

'participation thresholds', making market involvement by smallholder farmers unprofitable. Smallholder farmers become self-reliant in terms of their livelihoods and unable to exploit their resources commercially. Additionally, Barrett (2008) ^[4] reviewed studies conducted in various African markets and concluded that transaction costs account for a significant portion of price variance and market segmentation.

Infrastructure development in rural areas mediates the impact of transaction costs on smallholder farmers. Fan & Zhang (2004) ^[14] proved that road construction in rural China had a substantial

effect on marketing costs, agricultural productivity, and incomes. Likewise, Minten & Kyle (1999) ^[45] revealed that the condition of roads accounted for the largest proportion of food marketing costs and trader wages in the Democratic Republic of Congo.

4.4 Key Efficiency Indicators: Summary

Table 2 provides a synthesis of key supply chain efficiency indicators, their measurement approaches, and documented impacts on farmer income.

Table 2: Key Agricultural Supply Chain Efficiency Indicators and Their Impact on Farmer Income

Efficiency Indicator	Definition / Measurement	Impact on Farmer Income (%)	References
Post-Harvest Loss Rate	% of produce lost between farm gate and consumer	25-40% income loss in SSA; 15-30% in South Asia	FAO, 2019; World Bank, 2020
Marketing Margin	Price difference between farm gate and retail	Reduction by 10-20% raises net farm income by 8-15%	Reardon <i>et al.</i> , 2021
Transaction Cost Ratio	Transaction costs as% of total production costs	High TC (>15%) significantly depresses margins	Williamson, 1985; Barrett, 2008
Cold Chain Coverage	% of perishable produce under cold storage	50% increase in coverage cuts losses by 20%	World Bank, 2020; Kitinoja, 2013
Digital Market Access Index	% farmers using mobile/digital platforms for sales	Digital access raises price received by 10-25%	Aker, 2010; Nakasone <i>et al.</i> , 2014
Contract Farming Participation Rate	% farmers under formal contract arrangements	Income premium of 15-30% for CF participants	Singh, 2002; Minot, 2011
Cooperative Membership Rate	% farmers in formal cooperatives	Members earn 10-20% more than non-members	Bernard <i>et al.</i> , 2008; Verhofstadt & Maertens, 2014

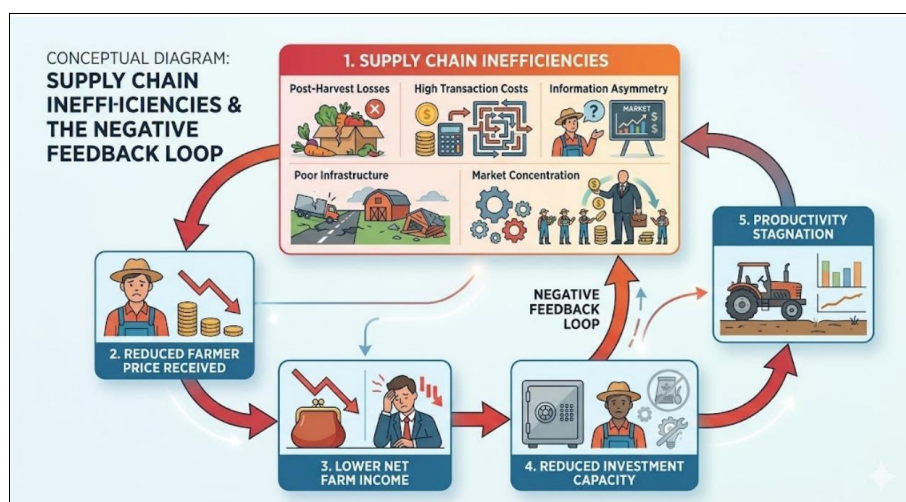


Fig 2: Conceptual pathways from agricultural supply chain inefficiencies to farmer income depression. Source: Authors' synthesis based on Barrett (2008); FAO (2019); Dorward *et al.* (2004).

5. Collective Action: Cooperatives and Farmer Organizations

5.1 The Role of Cooperatives in Value Chain Efficiency

Agricultural cooperatives constitute one of the most well-studied collective institutions in enhancing the smallholder access to markets and improving supply chains. Cooperatives, through their ability to pool resources, reduce transaction costs for each member, realize economies of scale in inputs and outputs, and negotiate effectively with buyers, can make smallholder members gain significantly from the market (Cook, 1995; Bernard *et al.*, 2008) ^[6, 11].

Bernard *et al.* (2008) ^[6] provide empirical evidence from Ethiopia indicating that the prices received by cooperative members were higher by a considerable margin than those received by non-member farmers, in addition to selling higher quantities. A study by Verhofstadt and Maertens (2014) ^[64] in Rwanda indicated that members of cooperatives were earning

10-20% more than their counterparts, controlling for selection effects. Another study by Fischer and Qaim (2012) ^[18] indicated gains in terms of better access to supermarkets and premium markets in Kenya through collective marketing efforts.

5.2 Constraints and Design Principles

Cooperatives have limitations despite their potential, which makes their implementation difficult. These limitations are the organizational, governance, and financial issues, among others, faced by cooperatives. As mentioned by Cook (1995) ^[11], horizon problem, portfolio problem, and control problem are structural difficulties that affect the effectiveness of cooperatives. Free-riders, elite capture, and poor financial management often prevent cooperatives from functioning properly (Amanor, 2009; Louw *et al.*, 2007) ^[12].

The effective design principles of cooperatives, according to literature sources, are as follows: (a) welldefined criteria for

membership and exit; (b) democratic governance with professionalism of management; (c) proper distribution of surpluses; (d) training of members; and (e) outside assistance in building market connections and finances (Zeuli & Cropp, 2004; Bernard *et al.*, 2008) ^[6, 73].

6. Contract Farming and Vertical Coordination

Contract farming (CF), which involves formal or informal agreements between buyers and farmers regarding prices, quantities, quality, and sometimes inputs, has gained recognition as a vital tool for enhancing smallholders' market participation and efficiency in their value chains. Through provision of assured markets, access to inputs, technical support, and price guarantees, CF can alleviate the transaction cost and risk factors inhibiting smallholder investment and commercialization (Singh, 2002; Minot, 2011) ^[44, 59].

In a study on the impact of contract farming in India's horticulture industries, Bithal *et al.* (2005) ^[7] revealed that contracted farmers received 20-30% better prices compared to their non-contracted peers and earned considerably higher incomes. Likewise, similar income gains for contracted farmers have been reported in Africa (Neven *et al.*, 2009) ^[48] and Southeast Asia (Wang & Zheng, 2014) ^[66]. Nevertheless, the impact of CF on distribution is controversial. For example, studies by Singh (2002) ^[59] and Minot (2011) ^[44] demonstrate that CF does not benefit smallholders with fewer resources since they lack adequate means to meet quality or quantity thresholds stipulated in contracts.

According to Swinnen (2007) ^[60] and Lee *et al.* (2012) ^[38], income benefits from CF are influenced greatly by power relations and the governance structure of the chain. Under captive chain governance where the leading firms have strict control over production variables, the farmers can be subject to

monopsony buyers and lack negotiation power. Policy measures are required to ensure contract clarity, resolution of disputes, and farmer negotiation power.

7. Digital Technologies and Agricultural Value Chain Modernization

7.1 Information and Communication Technologies

The swift penetration of mobile phones and internet services into rural communities in less developed nations has triggered a revolution in agricultural marketing information systems and value chains management. According to Aker (2010) ^[1], the deployment of mobile phone services in Niger has resulted in a 10-16% reduction in grain price differences across markets. Jensen (2007) ^[33] reported that the utilization of mobile phones by fisherfolk in Kerala, India, facilitated price equalization and minimized waste.

Nakasone *et al.* (2014) ^[47] assessed various studies and concluded that ICT-based market information systems invariably enhance price transparency, minimize information disparities, and aid small farmers in making superior marketing choices. Muto and Yamano (2009) ^[46] noted that the proliferation of mobile phone use in Uganda had increased smallholder market participation and improved crop sales to more profitable purchasers. The benefits are especially significant in perishable goods and highly valued produce.

7.2 Emerging Digital Technologies

Beyond mobile phones, a suite of emerging digital technologies including blockchain, Internet of Things (IoT), artificial intelligence (AI), and e-commerce platforms is increasingly being applied to agricultural value chains. Table 3 summarizes the evidence on these technologies.

Table 3: Digital Technologies in Agricultural Value Chains: Applications and Evidence of Impact

Technology	Application in Agricultural Value Chains	Evidence of Impact	Key Studies
Mobile Phones / SMS	Price information dissemination; Market linkage; Payment systems (M-Pesa)	15-25% improvement in price received; Reduced price dispersion	Aker (2010); Jensen (2007)
Blockchain	Traceability; Transparency in payment; Smart contracts; Certification	Reduced intermediary costs; Improved trust and quality verification	Ge <i>et al.</i> (2017); Tian (2017)
Internet of Things (IoT)	Precision agriculture; Smart storage monitoring; Supply chain tracking	Up to 30% reduction in losses with smart storage	Gubbi <i>et al.</i> (2013); Wolfert <i>et al.</i> (2017)
Artificial Intelligence / ML	Demand forecasting; Price prediction; Crop disease diagnosis	Improved planning efficiency; Reduced price volatility risk	Kamilaris <i>et al.</i> (2017); Liakos <i>et al.</i> (2018)
E-Commerce Platforms	Direct farmer-to-consumer sales; Reduced intermediation; Export access	10-20% price premium; Broader market access	Nakasone <i>et al.</i> (2014); Muto & Yamano (2009)
Remote Sensing / GIS	Crop monitoring; Yield forecasting; Risk mapping	Better insurance products; Improved planning	Becker-Reshef <i>et al.</i> (2010)

The use of blockchain in agriculture holds promise as far as traceability, transparency, and reliability in agricultural value chains are concerned (Ge *et al.*, 2017; Tian, 2017) ^[20, 61]. With the capacity to create permanent records of origin, storage conditions, and transaction details, blockchain helps eliminate fraud, facilitates certifications, and assists in setting premium prices for sustainably certified agricultural products. Unfortunately, the widespread deployment of blockchain faces obstacles such as costly adoption, digitalization, and the development of an institution-based ecosystem (Wolfert *et al.*,

2017) ^[68].

In terms of artificial intelligence and machine learning applications, agriculture uses technologies to detect crop diseases, forecast yields, anticipate demand, and analyze market prices (Liakos *et al.*, 2018; Kamilaris *et al.*, 2017) ^[34, 40]. Although promising results have already been observed, the practical application of such capabilities in increasing incomes from farming relies heavily on context and digital literacy among smallscale farmers.

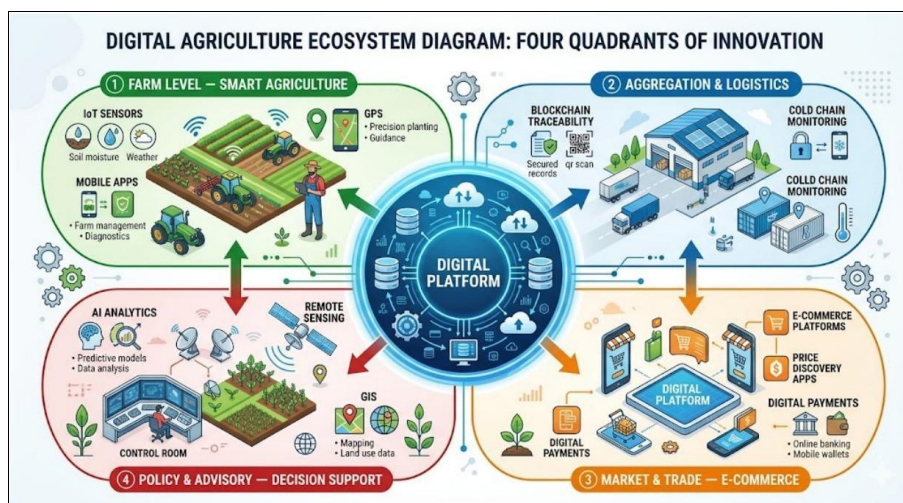


Fig 3: Digital technology ecosystem for agricultural value chain modernization. Source: Authors' synthesis based on Wolfert *et al.* (2017); Nakasone *et al.* (2014); World Bank (2019).

8. Quality Standards, Certification, and Market Access

The emergence of standards of food safety and quality in the public and private spheres has fundamentally transformed agri-food chains, offering both new possibilities and difficulties for smallholders. As Henson and

Humphrey (2010) observe, public standards refer to governmental regulations about food safety and phytosanitary conditions, whereas private standards refer to criteria set by retailers, processors or certification schemes like GlobalGAP, Fair Trade and organic certifications; the latter ones have been playing an increasing role in practice as market access criteria to lucrative export markets. One of the first authors to systematically identify the role of grading and standards as value chain coordination devices was Giovannucci & Reardon (2000) [24]. Lemeilleur & Tozanli (2006) [39] have additionally demonstrated how the implementation of private standards affects governance practices along the agri-food chains.

There is variation in the impact of standards on smallholder welfare depending on the situation and context. According to research conducted on the horticultural sector in Africa (Dolan & Humphrey, 2000; Louw *et al.*, 2007) [12] and the agri-food chains in Asia (Gulati *et al.*, 2007) [26], there have been observations where compliance with standards could result in access to premium market opportunities at higher prices but also deny farmers who could not afford the cost of compliance or could not develop the required skills. Farina & Reardon (2000) [17] found out that the adoption of private standards in the Latin American agri-food sector resulted in increasing supply by bigger producers.

Some of the policy measures that will enhance standards compliance among smallholders are as follows: collectivized certification via cooperatives (lower compliance costs); provision of extension services by the government; subsidies towards certification cost; and PPP for capacity enhancement (Henson & Humphrey, 2010; Lee *et al.*, 2012) [28, 38].

9. Infrastructure, Logistics, and Market Access

9.1 Physical Infrastructure

Institutional, physical, and human capital all play a critical role in shaping agricultural value chains and markets. In particular, physical capital like rural roads, market infrastructure, storage, irrigation, and cold chains is an essential component of efficient supply chains and integration of smallholders into markets.

Minten and Kyle (1999) [45] found that the quality of roads was the most important predictor of marketing costs, wage rates, and market integration in the Democratic Republic of Congo. Fan and Zhang (2004) [14] found extraordinarily high benefits from investment in rural roads in China for poverty reduction and agricultural income generation.

It is especially important to focus on cold chains, given the magnitude of post-harvest loss for perishables. Kitinoja (2013) [37] found that improving coverage of cold chain storage in developing countries could cut postharvest losses in horticultural produce by 30-50%, and bring about commensurate increases in producer income and food security. The World Bank (2020) [71] reports that while only 15% of perishables are covered by the cold chain in sub-Saharan Africa, up to 40-60% are covered in Latin America, accounting for much of the difference in post-harvest loss rates. Yamano and Jayne (2004) [72] further show that deficiencies in rural infrastructure such as roads and markets roads and market facilities compound the adverse income effects of adult mortality on small-scale farm households, illustrating the interconnected nature of infrastructure, institutional, and human capital constraints.

9.2 Market Facilities and Information Systems

The availability and effectiveness of physical infrastructure such as wholesale markets, rural assembly markets, grading and packaging facilities have an impact on the effectiveness of agricultural logistics (Chamberlin & Jayne, 2013) [10]. According to Shiferaw *et al.* (2011) [58], market accessibility was among the important factors affecting the commercialization and profitability of small-scale farmers in sub-Saharan Africa. Investments in market information systems, both technological and physical, for farmers to get information about market prices have always been proven to enhance market efficiency and decrease intermediary margins (Nakasone *et al.*, 2014; Aker, 2010) [1, 47].

10. Regional Comparative Analysis

Agricultural value chain performance varies substantially across regional contexts, reflecting differences in agro-ecological conditions, infrastructure endowments, institutional environments, and policy frameworks. Table 4 presents a comparative analysis of key value chain performance dimensions across major developing regions.

Table 4: Regional Comparison of Agricultural Value Chain Performance Indicators

Dimension	Sub-Saharan Africa	South Asia	Southeast Asia	Latin America
Post-Harvest Losses (PHL)	25-40%	20-35%	15-25%	10-20%
Smallholder farm share	>80%	~75%	~70%	~50%
Cold chain coverage (perishables)	<15%	20-30%	30-50%	40-60%
Mobile penetration (rural)	55-65%	50-70%	60-80%	70-85%
Cooperative membership rate	5-20%	10-25%	20-40%	30-50%
Dominant	Market/	Market/	Relational/	Captive/
VC governance mode	Relational	Captive	Modular	Hierarchical

The region of sub-Saharan Africa suffers from the highest levels of inefficiencies in its supply chain networks, where post-harvest losses exceed 25%, cold chain coverage is less than 15%, and cooperative membership stands at 5% to 20% (FAO, 2019; World Bank, 2020) ^[16, 70, 71]. South Asian agricultural value chains have achieved considerable success due to the contributions of the Green Revolution, cooperative milk societies (e.g., AMUL in India), and contract farming within premium-value crops, but continue to be plagued by fragmented retail networks and high marketing margins for small-scale

farmers (Reardon & Timmer, 2014) ^[54]. The value chains of Southeast Asia exhibit more integration into global supply chains with respect to staple food items, including rice, palm oil, and rubber, with improved cold chain infrastructure and increased levels of cooperation membership (Gulati *et al.*, 2007) ^[26]. The value chains of Latin America boast the greatest supermarket presence, cold chain coverage, and contract farming operations, but struggle with smallholder marginalization amid supply chain modernization (Reardon *et al.*, 2003; Farina & Reardon, 2000) ^[17, 55].

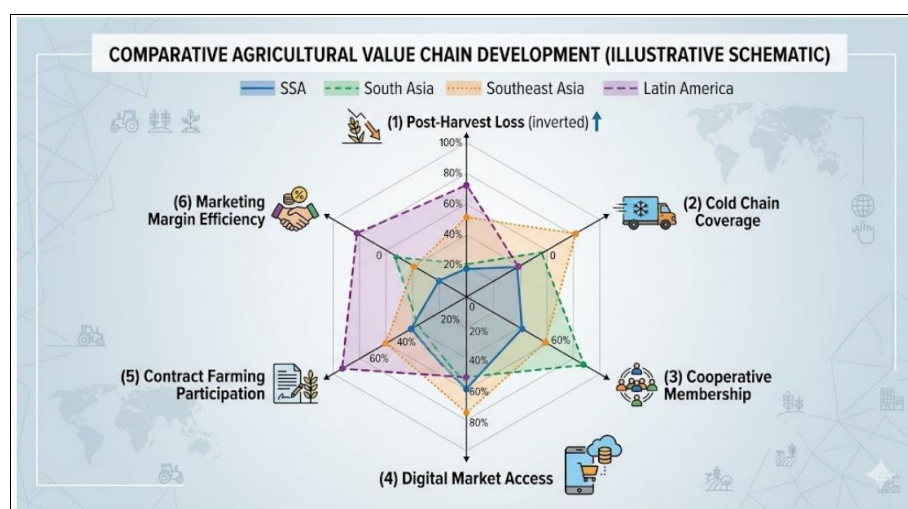


Fig 4: Comparative radar chart of agricultural value chain performance across developing regions. Higher values on all axes indicate better performance. Source: Authors' synthesis based on FAO (2019); World Bank (2020); Reardon *et al.* (2003).

11. Policy Implications

The evidence synthesized in this review points to a comprehensive set of policy recommendations for improving

agricultural value chain efficiency, farmer income, and market competitiveness. Table 5 summarizes the key policy areas, instruments, expected outcomes, and evidence base.

Table 5: Policy Frameworks for Agricultural Value Chain Development: Instruments and Expected Outcomes

Policy Area	Policy Instruments	Expected Outcomes	Evidence Base
Agricultural Finance	Subsidized credit; Crop insurance; Warehouse receipt systems	Reduced risk; Increased investment capacity	World Bank (2008); IFAD (2016)
Infrastructure Investment	Rural roads; Irrigation; Cold storage; Market infrastructure	Reduced transaction costs; Lower post-harvest losses	Fan & Zhang (2004); IFPRI (2002)
Standards & Certification	SPS regulations; GlobalGAP; Organic certification	Export market access; Premium prices	Henson & Humphrey (2010)
Cooperative Promotion	Legal frameworks; Tax incentives; Capacity building support	Collective bargaining; Economies of scale	Bernard <i>et al.</i> (2008); Cook (1995)
Digital Agriculture Policy	Rural connectivity; Digital literacy; E-government for farmers	Improved market information; Financial inclusion	World Bank (2019); ITU (2020)
Trade Policy	Tariff reduction; Trade facilitation; Regional integration (AfCFTA)	Expanded market access; Competitive pressure	Kaplinisky & Morris (2001); UNCTAD (2015)

Apart from sector-specific initiatives, this review highlights the need for an integrated strategy in overcoming a multiplicity of value chain constraints. Single-prong efforts such as the creation of rural roads without any improvement in market information provision, and promotion of cooperatives without any

institutional backing prove ineffective and unsustainable (Dorward *et al.*, 2004; Pingali *et al.*, 2005) ^[13]. The most effective value chain development programs have been those which have involved investment in infrastructure and institutions, technology adoption, and market linkages

(McCullough *et al.*, 2008) [43].

Value chain development strategies that incorporate considerations of gender should be accorded priority. Women form a majority of the agricultural workforce in developing countries, but have lower incomes than men because they face discrimination in access to land, finance, markets, and

information (Bolwig *et al.*, 2010) [8]. Policies focused on enhancing women's bargaining powers, through measures like land tenure reforms, formation of only-women cooperatives, and provision of women-specific extension services, can improve their incomes.

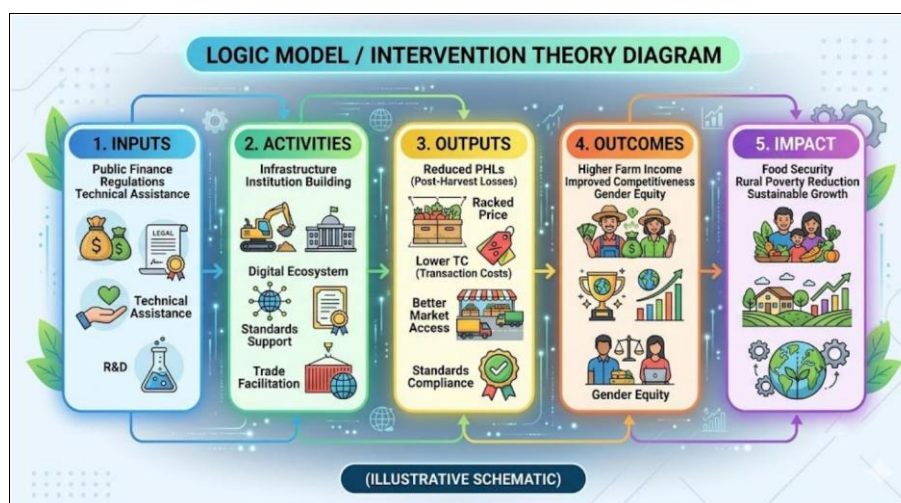


Figure 5: Policy intervention framework for agricultural value chain development. Source: Authors' synthesis based on World Bank (2008); McCullough *et al.* (2008); Kaplinsky & Morris (2001).

12. Research Gaps and Future Directions

Nevertheless, a number of critical gaps in this field persist despite the progress made so far. First, there is a lack of longitudinal studies that follow farmers' progress beyond five years since the majority of empirical studies rely on cross-sectional or very short panel analyses. In order to examine whether value chain intervention leads to sustainable changes in livelihoods and intergenerational mobility, longitudinal studies that monitor farmers' trajectories for at least 10 years are needed (Haggblade *et al.*, 2010) [27].

Second, while the adoption of digital technologies in agriculture becomes increasingly widespread, there is still little evidence on their effects on the livelihoods of the poorest smallholder farmers (Nakasone *et al.*, 2014; Wolfert *et al.*, 2017) [47, 68]. It is necessary to investigate the differences in technology adoption across genders, age groups, educational levels, and farm sizes in order to formulate appropriate digital agriculture policies. Finally, the linkages between climate change and agricultural value chains have been underresearched thus far (Reardon *et al.*, 2021) [56].

Fourth, the political economy of value chain policy reform is another issue which merits greater analysis. Although several interventions in value chains have technically been effective, most fail to succeed due to vested interests, institutional inertia, and the inability of multiple agencies to work together (Ochieng, 2010; [50]

Gebremedhin *et al.*, 2009) [19]. Lastly, the effects of value chain modernization on the economy at large need to be better understood since their cross-chain spillover effects are unknown (Haggblade *et al.*, 2010) [27].

13. Conclusion

Cooperatives and farmers' associations, contract farming practices with necessary measures, embracing digital technologies, and investments in infrastructure all constitute some of the proven routes to increase chain efficiency and farmer incomes. Yet, the scope of gains, and who is likely to

benefit from them, is highly contextual, and contingent upon various aspects of chain governance, institutional policy environment, and the profile of the farmers involved.

In terms of insights from the literature review, the region with the highest need for improvement of its supply chains is sub-Saharan Africa, as it suffers from the highest level of inefficiencies and needs a more complex approach to overcome this problem. At the same time, South and Southeast Asia provide great examples of how successful cooperatives in the dairy industry and effective implementation of contract farming can help increase farmers' income substantially.

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