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David Gongwe Mhando

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# Transforming smallholder orange farming in Tanzania: Institutional constraints and sustainability pathways in Muheza District

David Gongwe Mhando

Department of Policy Planning and Management, Sokoine University of Agriculture (SUA), Morogoro, Tanzania

**ABSTRACT**

This study examines sustainability constraints facing smallholder orange farmers in Muheza District, Tanzania, and identifies institutional and value-chain pathways for strengthening resilience. Using a mixed-methods design, household survey data were integrated with focus group discussions and key informant interviews conducted between January and March 2024. Descriptive statistics characterized household and production conditions, while thematic analysis captured institutional and market dynamics. A binary logistic regression model assessed factors associated with the adoption of at least one sustainable/climate-smart practice (e.g. mulching, water harvesting, intercropping). Results indicate that limited extension services, insecure land tenure, and demographic aging reduce adaptive capacity, while weak institutional support, especially exclusion from credit and limited extension coverage reinforces low-input production. Marketing is dominated by brokers and local spot markets, exposing farmers to seasonal price volatility and constraining bargaining power. Regression results show that education, land size, access to credit, access to extension services, and cooperative membership significantly increase the likelihood of adopting sustainable practices. The study concludes that vulnerabilities are interlocking: deficits in household livelihood capitals interact with structural asymmetries in value chain governance. By integrating the Sustainable Livelihoods Framework and Global Value Chain perspectives, the paper advances an analytically transferable approach for diagnosing sustainability constraints in perennial crop systems. Transferability is expected in settings characterized by constrained livelihood assets, limited credit and extension access, and broker-dominated spot markets with weak collective organization. The paper proposes policy options centered on tailored finance, strengthened extension, cooperative revitalization, and governance reforms that improve market access and incentives for sustainable practice adoption.

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## 1. Introduction

Across Sub-Saharan Africa, high-value agri-food value chains including fresh fruits and vegetables are increasingly viewed as a pathway for rural income growth, dietary diversification, and market-oriented agricultural transformation (Reardon et al., 2024; World Bank, 2017). Yet, these value chains also face distinctive sustainability constraints: the perishability of fresh produce raises quality-loss risks and tightens coordination requirements, while fragmented service delivery and weak market institutions can elevate transaction costs and amplify smallholder exposure to price and marketing risks (African Union Commission, 2024; Reardon et al., 2024). Consequently, adoption and sustained use of improved practices in fruit production often depend not only on agronomic knowledge but also on institutional arrangements that reduce coordination failures and transaction costs across input, service, and output markets (African Union Commission, 2024; World Bank, 2017).

**CONTACT** David Gongwe Mhando david_mhando@sua.ac.tz Department of Policy Planning and Management, Sokoine University of Agriculture (SUA), Morogoro, Tanzania

Orange production has emerged as a critical pillar of rural livelihoods and local economies in Tanzania, particularly in Muheza District of Tanga Region. Historically dominated by sisal plantations during the colonial and post-independence periods, Muheza experienced a major economic transition in the 1970s following the collapse of global sisal markets. Smallholder farmers began to diversify into orange production, with oranges becoming a dominant crop due to favorable agro-ecological conditions, high domestic demand, and growing opportunities for export within East Africa (Schoneveld & Weng, 2023; FAO, 2021). Today, an estimated 40% of farming households in Muheza are engaged in orange production, making the crop central not only to household food security and income but also to broader rural development strategies (National Bureau of Statistics [NBS], 2022).

Despite its growing importance, orange farming faces persistent challenges of sustainability. Productivity remains low compared to global averages due to declining soil fertility, limited access to organic and inorganic fertilizers, pest and disease pressures, and inadequate irrigation infrastructure (Kurgat et al., 2020; World Bank, 2021). Furthermore, climate change has heightened risks through erratic rainfall patterns and prolonged droughts, intensifying smallholder vulnerability (FAO, 2021). While technical solutions such as improved seedlings, integrated pest management, and climate-smart agriculture are frequently recommended, the adoption of these innovations by smallholders has been uneven and often constrained by broader socio-economic and institutional factors.

Literature indicates that decisions of the farmers to adopt sustainable agricultural practices cannot be understood solely through economic cost-benefit models or technological availability (Giller et al., 2021; Pretty et al., 2018). Instead, adoption is often embedded within webs of social relations, including trust, reciprocity, kinship, and membership in farmer groups or cooperatives (Chirwa & Dorward, 2013; Poteete & Ostrom, 2004). These social dynamics can either facilitate or hinder the uptake of sustainable practices by shaping information flows, labor-sharing arrangements, and collective action. Within the Sustainable Livelihoods Framework, these social relations are conceptualized as social capital that mediates access to information, extension services, finance, and collective capabilities that support livelihood strategies (Chambers & Conway, 1992; Scoones, 1998). From a Global Value Chain perspective, trust and cooperation influence coordination and governance shaping bargaining power, information flows, and the credibility of returns for smallholders operating in buyer-driven or broker-dominated market settings (Gereffi et al., 2005; Humphrey & Schmitz, 2002).

In Sub-Saharan Africa, studies on maize, rice, and coffee farming systems have shown that strong farmer networks and trust relations enhance resilience and innovation diffusion (De Blasis, 2020). However, relatively little research has examined how these dynamics operate within orange production systems in Tanzania, where smallholder farmers remain the backbone of supply.

This gap is significant because orange farming differs from other staple or cash crops in terms of input requirements, market structures, and perishability. Oranges are highly seasonal and perishable, requiring well-coordinated marketing channels and trust-based contractual relationships with traders, transporters, and processors (Ton et al., 2018). Weak collective action and fragmented farmer organizations can thus exacerbate market inefficiencies, reducing farm-gate prices and discouraging investments in sustainable practices. Moreover, Muheza District presents a unique case: it is both a historically important **orange** zone and a region where smallholders rely heavily on traditional social networks to navigate agricultural uncertainties. Understanding how social relations shape sustainability pathways in this context is therefore essential for informing policies that promote resilient and inclusive agricultural development.

Against this background, this study investigates how household constraints and institutional arrangements shape the adoption of sustainable agricultural practices among smallholder orange farmers in Muheza District. Specifically, it examines how land tenure conditions, access to credit and extension services, cooperative membership, and market governance influence farmers' ability to adopt practices such as intercropping/diversification, soil fertility management, and water conservation. The study contributes empirically by documenting the interlocking nature of livelihood-capital deficits and value chain constraints in a perennial horticultural system, and analytically by integrating the Sustainable Livelihoods Framework and Global Value Chain perspectives to explain why incremental coping persists despite the availability of recommended technical options.

## 2. Literature review

### 2.1. Sustainable agriculture in Sub-Saharan Africa

Sustainable agriculture has become a central policy and research priority across Sub-Saharan Africa (SSA) as smallholder systems confront interacting pressures from climate variability, soil fertility decline, land fragmentation, and market volatility. Recent synthesis evidence shows that widely promoted sustainable agricultural practices (SAPs), including integrated soil fertility management, mulching and cover management, diversified cropping, improved seed, and water-saving practicescan raise productivity and resilience, but adoption remains uneven because enabling conditions are frequently absent (Sithole & Olorunfemi, 2024). The most consistently reported constraints include limited access to credit and inputs, weak and uneven extension/climate information services, insecure or ambiguous land tenure for long-term investments, and high transaction costs for entering higher-value markets (Mnukwa et al., 2025; Olabanji & Chitakira, 2025). These barriers are not merely "technical"; they reflect the institutional and market context in which smallholders make livelihood decisions, including risk exposure and the credibility of expected returns from sustainability investments.

In Tanzania, the national push for agricultural transformation and commercialisation has increased attention to horticulture, yet evidence continues to show structural bottlenecks that constrain competitiveness and upgrading, particularly for perishable crops. Recent sector evidence highlights challenges linked to low-quality inputs, disease and pest pressure, prolonged transportation and logistics constraints, and limited market diversification, partly shaped by intermediation structures and contracting arrangements (African Union Commission, 2024; Bank of Tanzania, 2025). In this setting, sustained adoption of SAPs among smallholders depends on whether households can mobilise assets and capabilities while also accessing institutions and value-chain arrangements that make sustainability economically credible.

### 2.2. Social relations and agricultural innovation

A growing body of recent evidence shows that adoption and continued use of sustainability-oriented practices depend not only on farm resources and information but also on social relations, including group membership, trust-based ties, and linking relationships to extension and market actors. Social capital shapes who gets credible information, who can coordinate labour and investment, and who can reduce market and transaction risks through collective action. For example, recent empirical work demonstrates that access to bonding, bridging, and linking social capital is associated with improved smallholder capacity to mobilise other livelihood assets and engage with services that enable practice change (Tengapoe et al., 2024). Similarly, evidence from conservation-agriculture settings shows that social-capital elements such as group membership and relationships with local leadership can increase the intensity of adoption by improving coordination, information flows, and perceived feasibility (Mathanda et al., 2025).

These findings align with the logic of the Sustainable Livelihoods Framework (SLF), where social capital is not an "add-on" but a mediating asset that conditions access to financial services, extension, and markets. In contexts where market outlets are uncertain and bargaining power is low, trust and cooperative networks can reduce perceived risk and increase farmers' willingness to invest in longer-term practices whose benefits are realized over time. Therefore, analysing SAP adoption among orange farmers in Muheza requires treating social relations as a mechanism that links household assets to institutional access and value-chain participation, rather than as a background characteristic.

### 2.3. Gaps in orange farming research in Tanzania

Compared with staple-crop literature, the evidence base on sustainability pathways in smallholder horticulture, particularly perennial fruit systems, is thinner and often fragmented across agronomy, marketing, and livelihoods studies. Yet horticulture is increasingly recognised as economically significant and potentially growth-enhancing in Tanzania, even as it faces persistent constraints related to quality management, logistics, and market structure (Bank of Tanzania, 2025). For oranges in Muheza District specifically, verifiable value-chain evidence indicates a chain dominated by multiple layers of intermediaries, with

producers capturing the lowest margins and facing constraints such as weak bargaining power, post-harvest losses, and limited access to finance.

The gap that remains and that this study targets is not whether constraints exist, but how social relations and institutional access interact with household assets to shape (i) decisions to adopt sustainability-oriented practices and (ii) the ability to sustain those practices when market incentives and governance structures are weak. In other words, the missing analytical piece is the mechanism linking livelihood assets to value-chain inclusion/exclusion and to the feasibility of longer-term sustainability investments within orange farming systems in Muheza.

### 2.4. Conceptual and theoretical framework

This study integrates the Sustainable Livelihoods Framework (SLF) with a Global Value Chain (GVC) perspective to explain sustainability pathways in smallholder orange farming. The SLF clarifies how households mobilise five livelihood capitals (human, natural, physical, financial, and social) and how institutional processes shape access to those capitals and associated livelihood strategies. The GVC lens complements this by explaining how governance arrangements, coordination structures, and intermediation affect incentives, risk allocation, and upgrading opportunities for producers in perishable crop chains. Recent SSA synthesis evidence underscores that constraints to adopting and sustaining climate-smart and sustainable practices are strongly conditioned by institutional support, market access, and the credibility of returns, precisely the interface where SLF and GVC interact (Mnukwa et al., 2025; Sithole & Olorunfemi, 2024).

Accordingly, the framework used here specifies that household capitals influence adoption capacity, but that outcomes are mediated by (i) institutional access (extension, finance, rules, local governance) and (ii) value-chain conditions (buyer requirements, intermediation, price formation, and coordination). Broader regional evidence on inclusive agricultural value chains further reinforces that smallholders' entry into higher-value markets is frequently constrained by quality/quantity standards, transaction costs, and logistics constraints that collective action and improved vertical/horizontal linkages can partially mitigate (African Union Commission, 2024). Figure 1 summarises these relationships by linking household assets and social relations to institutional access and value-chain participation, which together shape the feasibility and sustainability of SAP adoption among orange farmers in Muheza District.

## 3. Materials and methods

### 3.1. Study area

The study was conducted in Muheza District, located in Tanga Region, north-eastern Tanzania. Muheza is historically recognized as a leading **orange**-producing zone, with favorable agro-ecological conditions including deep loamy soils, annual rainfall averaging 1,200–1,400 mm, and moderate temperatures (United Republic of Tanzania, 2021). *Citrus sinensis*, particularly oranges, has become a dominant crop for

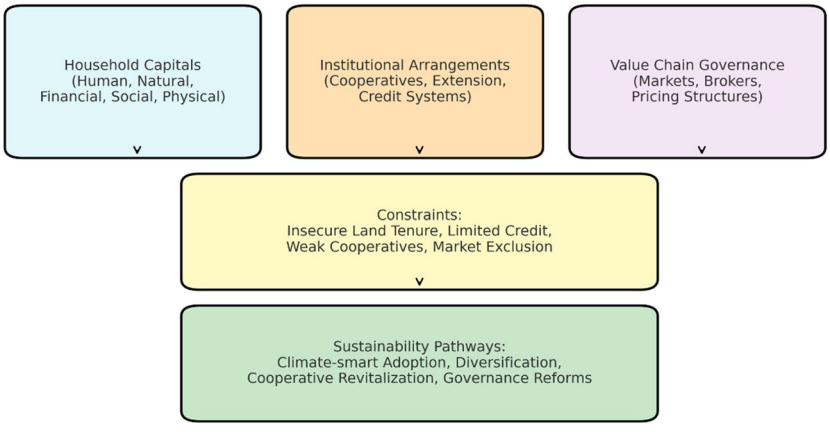


**Figure 1.** Conceptual framework.

smallholder farmers, contributing substantially to household income and regional market supply. Muheza District was purposively selected as the case study area because it has historically been a key zone for smallholder orange production in Tanzania, contributing substantially to both household incomes and regional trade. However, in recent years, the district has experienced significant production challenges, including declining yields, high input costs, and limited access to quality inputs. These issues are compounded by environmental pressures such as soil degradation and erratic rainfall, which threaten the long-term sustainability of orange farming systems. Moreover, farmers in the district face pronounced market uncertainties, including fluctuating prices and unstable demand patterns, which undermine their economic resilience and capacity to invest in improved practices (URT, 2021; FAO, 2021). These interlinked constraints make Muheza District a particularly relevant and insightful case for examining strategies toward sustainable agricultural practices and for identifying institutional and policy innovations that can enhance smallholder resilience in orange farming systems. In this paper, the empirical analysis focuses exclusively on *sweet orange (Citrus sinensis)*; the term 'citrus' is used only when discussing a broader horticultural context or comparative literature.

### 3.2. Research design

A cross-sectional research design was employed, enabling data collection from a representative sample of orange farmers at a single point in time. This design is widely applied in agricultural and rural development research for exploring relationships among variables and identifying factors influencing adoption (Bryman, 2016; Creswell, 2014). The design was appropriate for this study as it allowed for capturing household-level variations in socio-economic characteristics, social relations, and adoption of sustainable practices.

### 3.3. Population and sample size

The target population comprised all smallholder orange farmers in Muheza District. According to district agricultural reports, an estimated 5,400 households are engaged in orange farming (National Bureau of Statistics [NBS], 2022). Using Yamane's (1967) formula for sample size determination with a 95% confidence level and 8% margin of error, the required sample size was 150 households. This sample size ensured representativeness while balancing the resource constraints of the study.

### 3.4. Sampling procedure

A multi-stage sampling technique was adopted. First, Muheza District was purposively selected due to its prominence in orange farming. Second, four wards with the highest concentration of orange production (Kwafungo, Potwe, Magila, and Nkumba) were purposively chosen. Within each ward, villages were randomly selected to ensure coverage of different production zones. Finally, within the villages, lists of orange farmers obtained from agricultural extension officers were used as sampling frames, from which households were selected using simple random sampling. This approach minimized selection bias and ensured inclusion of both male- and female-headed households.

### 3.5. Data collection methods

This study combined primary and secondary data to develop a comprehensive empirical account of smallholder orange farming in Muheza District. Primary data were collected between January and March 2024 through a household survey, key informant interviews, and focus group discussions. The household questionnaire was developed using an explicit construct-mapping procedure grounded in the Sustainable Livelihoods Framework and Global Value Chain perspectives (SLF–GVC) (Chambers & Conway, 1992; Gereffi et al., 2005; Scoones, 1998). Item development followed two complementary routes. First, where conceptually equivalent measures existed, items were adapted from prior empirical instruments and commonly used indicators in the literature on sustainable practice adoption, institutional/service access, and value-chain governance, and then contextually tailored to the local production and marketing

conditions in Muheza (Chambers & Conway, 1992; Gereffi et al., 2005; Scoones, 1998). Second, context-specific items were newly designed for this study to capture locally salient agronomic practices and marketing/coordination arrangements not adequately represented in published questionnaires, while remaining theoretically consistent with SLF–GVC domains (DeVellis, 2017).

To address operationalization explicitly, each construct was translated into observable indicators and corresponding response formats. *Sustainable practice adoption* was operationalized using practice-specific indicators (e.g. item-level measures of whether particular practices were implemented) and where relevant intensity metrics (e.g. counts of practices adopted) suitable for household survey analysis (DeVellis, 2017). Institutional access was operationalized via indicators capturing households' access to and use of services and resources (e.g. extension, inputs, credit, and farmer organizations), measured through categorical and frequency-based responses consistent with livelihoods measurement approaches (Scoones, 1998). Value-chain governance was operationalized through structured items capturing marketing channels and coordination attributes (e.g. buyer relationships, terms of exchange, and other governance-related features), aligned with established GVC governance concepts (Gereffi et al., 2005). The instrument intentionally combined quantitative items with short, structured qualitative probes to facilitate methodological triangulation across survey evidence, key informant accounts, and group-level narratives.

Prior to full deployment, the questionnaire was pilot-tested with 15 farmers in a neighboring ward to assess clarity, sequencing, reliability, and contextual appropriateness; the instrument was then revised to improve wording and flow, consistent with best practice for pilot studies and questionnaire refinement (van Teijlingen & Hundley, 2001; Willis, 2007). The final structured questionnaire was administered to 150 household heads, covering socio-economic characteristics, land tenure, production practices, access to inputs and services, marketing channels, and adaptation strategies.

In addition to the survey, qualitative insights were gathered through key informant interviews with agricultural extension officers, cooperative leaders, and local traders. These interviews provided expert perspectives on institutional dynamics, value chain governance, and policy frameworks shaping orange production in the district. To further enrich the dataset, focus group discussions (FGDs) were conducted in each of the four wards selected for the study. The FGDs facilitated collective reflection on farming practices, challenges, and coping strategies, while also serving as a means to validate findings emerging from the household surveys and key informant interviews.

Secondary data were collected through a review of relevant policy documents, agricultural reports, and scholarly literature. Sources included government statistics, district agricultural development reports, and studies on sustainable agriculture and value chain dynamics in Tanzania and other Sub-Saharan African contexts. The integration of primary and secondary data enhanced both the reliability and depth of the study, ensuring that the empirical findings were situated within broader institutional and scholarly debates.

### 3.6. Data analysis

Data collected from household surveys were coded and entered into SPSS for cleaning and analysis. Descriptive statistics, including frequencies, percentages, and cross-tabulations, were first employed to summarize demographic, institutional, and market characteristics of respondents. Qualitative data from focus group discussions and key informant interviews were analyzed thematically, allowing for triangulation of insights across data sources. In addition to descriptive and thematic approaches, inferential statistics were employed to strengthen explanatory depth. Specifically, a binary logistic regression model was estimated to examine the factors influencing the adoption of sustainable agricultural practices among smallholder farmers. This integration of descriptive, inferential, and qualitative analyses ensured both robustness and validity of the findings.

### 3.7. Ethical considerations

This study was conducted in accordance with the ethical principles for medical research involving human participants outlined in the Declaration of Helsinki. Ethical clearance was obtained from the Sokoine University of Agriculture Research Ethics Committee (SUA-REC/AG/2024/045). Administrative permission

to conduct the study was additionally granted by the President's Office Regional Administration and Local Government (TAMISEMI) (TAMISEMI/RSC/AT/2024/350), the office of the Ruvuma Regional Commissioner, and the Mbinga District Council.

Prior to data collection, informed consent was obtained from all participants after explanation of the study objectives, procedures, potential risks and benefits, and the voluntary nature of participation. Participants were informed that they could decline to answer any question and could withdraw from the study at any time without penalty or loss of any entitled benefits. Confidentiality was emphasized, and no personally identifying information was included in transcripts, datasets, or reports. Data were anonymized, stored securely with restricted access, and used solely for research purposes to safeguard participants' privacy.

## 4. Results

This section presents the empirical findings from the survey, interviews, and focus group discussions conducted among smallholder orange farmers in Muheza District. Results are organized thematically into five main areas: socio-economic characteristics, land tenure and production constraints, input and institutional support, market access and value chain dynamics, and adaptation strategies.

### *4.1. Socio-economic characteristics of respondents*

Table 1 summarizes the socio-demographic characteristics of the 150 farmers surveyed. Most respondents were male (60%), reflecting male dominance in land inheritance and ownership, while female farmers comprised 40%. Age distribution showed that nearly half (46.7%) were aged 36–50 years, 26.7% above 50 years, and 26.7% below 35 years. Educational attainment was generally modest, with 56.7% completing only primary education and 6.7% reaching post-secondary levels. Household size ranged from 1 to more than 8 members, with 46.7% reporting 5–7 members.

### *4.2. Land tenure and production constraints*

Land access was predominantly through inheritance (60%), followed by purchase (16.7%), rental (13.3%), and other mechanisms such as community or lease arrangements (10%). This indicates a heavy reliance on customary systems.

### *4.3. Input access, credit, and institutional support*

Findings indicate limited access to agricultural inputs and support services. Only 15% of respondents had adequate access to fertilizers, 20% to improved seedlings, and 18% to pesticides. Extension services were limited, with nearly half of farmers (48%) reporting no access at all. Formal credit was the least accessible, with 70% of farmers excluded.

**Table 1.** Socio-demographic characteristics of respondents (n = 150).

| Variable | Category | Frequency | Percentage (%) |
|---|---|---|---|
| Gender | Male | 90 | 60.0 |
| | Female | 60 | 40.0 |
| Age Group | 18–35 years | 40 | 26.7 |
| | 36–50 years | 70 | 46.7 |
| | 51+ years | 40 | 26.6 |
| Education | No formal education | 15 | 10.0 |
| | Primary | 85 | 56.7 |
| | Secondary | 40 | 26.6 |
| | Post-secondary | 10 | 6.7 |
| Household size | 1–4 | 50 | 33.3 |
| | 5–7 | 70 | 46.7 |
| | 8+ | 30 | 20.0 |

*Source:* Field survey, 2024.

### 4.4. Market access and value chain dynamics

Marketing channels were dominated by brokers and local markets. Approximately 43.3% of respondents sold through middlemen, 40% relied on local markets, and only 10% and 6.7% sold through cooperatives and direct exporters, respectively. Farmers reported high price volatility during peak harvest seasons, with prices falling by up to 50%.

### 4.5. Farmer adaptation strategies

Despite constraints, farmers employed a range of adaptation strategies. The most common were diversification and intercropping (36.7%), indigenous pest control (20%), and soil fertility management through composting or mulching (16.7%). Only 13.3% reported using climate-smart practices such as water harvesting, while another 13.3% leveraged social networks for labor sharing and marketing.

### 4.6. Inferential analysis of adoption of sustainable practices

To complement the descriptive findings, a binary logistic regression model was estimated to examine factors influencing the adoption of sustainable practices among smallholder orange farmers. Adoption was defined as whether a household reported uptake of at least one climate-smart agricultural practice (e.g. mulching, water harvesting, intercropping) in the past three years. Explanatory variables included age, education level, land size, access to credit, extension services, and cooperative membership. The model was statistically significant ($\chi^2 = 32.45$, $p < 0.001$), correctly classifying 78% of cases, indicating that it provides meaningful explanatory power. Table 2 presents a logistic regression on the adoption of sustainable practices.

Results show that education, land size, access to credit, extension services, and cooperative membership significantly increased the likelihood of adopting sustainable practices. For instance, farmers with access to extension services were over three times more likely to adopt sustainable practices compared to those without. Similarly, access to credit more than doubled the odds of adoption. By contrast, age was not a significant predictor, suggesting that both younger and older farmers adopt when resources and institutional support are available. These findings reinforce the importance of strengthening human capital, financial inclusion, and institutional arrangements to enhance sustainability transitions in smallholder **orange** farming.

## 5. Discussions

This study examined the sustainability challenges of smallholder orange farming in Muheza District, revealing how household-level vulnerabilities intersect with structural market dynamics. By employing the Sustainable Livelihoods Framework (SLF) and Global Value Chain (GVC) perspectives, the analysis shows that demographic constraints, insecure tenure, institutional exclusion, and asymmetrical value chain governance collectively reproduce vulnerability and limit opportunities for transformative adaptation. Importantly, the integration of SLF and GVC demonstrates that household assets and structural relations cannot be analyzed in isolation: resilience depends on addressing both micro-level capital deficits and macro-level governance failures.

**Table 2.** Logistic regression results on the adoption of sustainable practices.

| Variable | B | S.E. | Wald | Exp(B) | p-value |
|---|---|---|---|---|---|
| Age (years) | −0.012 | 0.009 | 1.78 | 0.988 | 0.182 |
| Education (years) | 0.084 | 0.028 | 8.91 | 1.088 | 0.003** |
| Land size (hectares) | 0.163 | 0.075 | 4.73 | 1.177 | 0.030* |
| Access to credit (1 = Yes) | 0.941 | 0.319 | 8.72 | 2.563 | 0.004** |
| Extension services (1 = Yes) | 1.224 | 0.342 | 12.78 | 3.402 | 0.000*** |
| Cooperative member (1 = Yes) | 0.657 | 0.295 | 4.95 | 1.929 | 0.026* |
| Constant | −2.134 | 0.711 | 9.00 | 0.118 | 0.003** |

Note: Dependent variable = Adoption of at least one sustainable practice (1 = Yes, 0 = No). Model $\chi^2 = 32.45$ ($p < 0.001$), Nagelkerke $R^2 = 0.29$, N = 150. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

### 5.1. Demographic characteristics and human capital

The predominance of middle-aged farmers and modest education levels (Table 1) highlights weak human capital within the SLF. Education has been widely recognized as a determinant of technology adoption and resilience (Sithole & Olorunfemi 2024). Better-educated orange farmers in India, for instance, were more likely to adopt water management and pest innovations. In contrast, Muheza's limited schooling and aging profile reduce adaptive capacity, particularly in perennial systems that demand long-term planning.

A critical dimension here is the absence of youth. Rural-urban migration and disengagement of younger generations from farming hollow out the demographic base of innovation (Lindsjö et al., 2020). The lack of youth reduces labor supply for orchard renewal and diminishes intergenerational knowledge transfer. Globally, similar challenges are documented in Brazil, where youth exit has slowed modernization in orange systems (Schoneveld & Weng, 2023). In Muheza, this demographic stagnation creates a double burden: weak current adoption and uncertain generational continuity.

### 5.2. Land tenure and natural capital constraints

Over 60% of respondents relied on inherited land, often fragmented and insecure (Table 3). For perennial crops, tenure insecurity discourages investment in soil fertility, irrigation, or orchard replanting. Within the SLF, this represents weak natural capital, undermining the household's ability to build other capitals. Similar reluctance to invest under insecure tenure has been reported in Tanzania (Kurgat et al., 2020), Nigeria (Kurgat et al., 2020), and India (Mnukwa et al., 2025).

The situation in Muheza is distinctive because land insecurity coincides with weak institutional capital. In Brazil, for example, cooperatives sometimes mitigate land fragmentation by organizing pooled investment. By contrast, farmers in Muheza operate without cooperative support, leaving them exposed to direct risks of insecure natural capital. This interaction illustrates how institutional voids exacerbate natural resource constraints, reinforcing systemic vulnerability.

### 5.3. Institutional exclusion and weak financial capital

Institutional exclusion emerged as one of the strongest barriers to sustainability. With 70% of farmers excluded from formal credit and 48% lacking extension services (Table 4), households remain trapped in low-input, low-output cycles. Within the SLF, this reflects weak financial and institutional capital, both critical for enabling innovation.

Similar institutional weaknesses have been reported in East Africa. In Ethiopia, smallholders faced comparable credit and extension deficits, constraining adoption of improved seeds and practices (Ogisi & Begho, 2023). In Tanzania, Kurgat et al. (2020) found that exclusion from reliable input and credit systems perpetuated vulnerability in horticulture. In contrast, cooperative-led models in Colombia's coffee sector demonstrate how institutional innovations can offset financial exclusion (dos Santos Massoca et al., 2022).

**Table 3.** Land tenure and farm size distribution ($n = 150$).

| Land access mode | Frequency | Percentage (%) |
|---|---|---|
| Inherited family land | 90 | 60.0 |
| Purchased land | 25 | 16.7 |
| Rented land | 20 | 13.3 |
| Other (community/lease) | 15 | 10.0 |

*Source:* Field survey, 2024.

**Table 4.** Access to inputs, credit, and extension services ($n = 150$).

| Service/input | Adequate access (%) | Limited access (%) | No access (%) |
|---|---|---|---|
| Fertilizers | 15.0 | 55.0 | 30.0 |
| Improved seedlings | 20.0 | 50.0 | 30.0 |
| Pesticides | 18.0 | 47.0 | 35.0 |
| Extension services | 12.0 | 40.0 | 48.0 |
| Credit facilities | 10.0 | 20.0 | 70.0 |

*Source:* Field survey, 2024.

The case in Muheza highlights that institutional voids are not neutral; they actively reproduce inequality by forcing farmers to rely on exploitative informal borrowing and low-quality inputs. This confirms that without institutional reform, household-level agency cannot translate into resilience.

### 5.4. Market exclusion and global value chain dynamics

The dominance of brokers and middlemen (83.3% of sales) highlights systemic market exclusion (Table 5). From a GVC perspective, Muheza farmers are locked into low-value nodes, where prices are volatile and determined by intermediaries. Farmers reported price collapses of up to 50% during peak harvests, leaving them unable to cover costs.

This dynamic mirrors findings in Kenya, where orange farmers' dependence on brokers eroded bargaining power (Schoneveld & Weng, 2023). Across East Africa, weak logistics and fragmented farmer organizations similarly restrict access to higher-value markets (De Blasis, 2020). In contrast, Brazilian orange cooperatives improved bargaining power and facilitated entry into export markets (Reardon et al.,2024). Muheza diverges by lacking such organizational buffers.

Theoretically, this finding affirms GVC's insight that governance asymmetries systematically disadvantage smallholders. Yet it also illustrates that exclusion is not purely a market issue but reflects weak institutional capital (absence of strong cooperatives). This interaction between SLF and GVC dimensions highlights the need for integrated solutions.

### 5.5. Adaptation strategies and resilience pathways

Despite constraints, farmers demonstrated agency through diversification, indigenous pest control, and mulching (Table 6). However, uptake of climate-smart practices such as water harvesting was minimal (13.3%). Within the SLF, this reliance on social capital demonstrates incremental coping rather than transformative resilience. Similar incremental adaptation has been documented in Tanzania (Kurgat et al., 2020) and Kenya (Ndung'u et al., 2023). Globally, barriers to climate-smart adoption, such as high upfront costs and limited training, are reported in India (Sithole & Olorunfemi, 2024) and Mexico.

A critical, often overlooked factor is gender and socio-cultural norms. Although women contribute substantial labor, insecure tenure and limited decision-making power prevent them from driving adaptation. This mirrors broader findings in Sub-Saharan Africa, where gendered inequalities limit women's capacity to adopt sustainable practices. Thus, resilience cannot be understood without accounting for how adaptation is socially embedded.

### 5.6. Cross-cutting synthesis: Interlocking vulnerabilities

The results illustrate that vulnerabilities in Muheza are interdependent, not isolated. Weak human capital (aging, low education) constrains the uptake of innovations. Insecure natural capital (tenure) discourages

**Table 5.** Marketing channels and price variability ($n = 150$).

| Marketing channel | Frequency | Percentage (%) |
|---|---|---|
| Local markets | 60 | 40.0 |
| Middlemen/brokers | 65 | 43.3 |
| Cooperatives | 15 | 10.0 |
| Direct sales to exporters | 10 | 6.7 |

*Source:* Field survey, 2024.

**Table 6.** Farmer adaptation strategies to production and market risks ($n = 150$).

| Adaptation strategy | Frequency | Percentage (%) |
|---|---|---|
| Intercropping/diversification | 55 | 36.7 |
| Indigenous pest control | 30 | 20.0 |
| Soil fertility management (compost/mulching) | 25 | 16.7 |
| Use of social networks (labour sharing/marketing) | 20 | 13.3 |
| Climate-smart practices (water harvesting, etc.) | 20 | 13.3 |

*Source: Field survey, 2024.*

investment. Weak financial and institutional capital (credit and extension) block access to resources. Finally, asymmetric GVC structures lock farmers into low-value markets.

Taken together, these dynamics form a systemic vulnerability trap: households attempt incremental adaptation, but structural conditions ensure they remain excluded from transformative change. This synthesis affirms that resilience cannot be built by addressing single constraints in isolation; it requires simultaneous interventions across household, institutional, and structural levels.

### 5.7. Theoretical contributions: beyond Muheza

This study contributes to theory by demonstrating how the integration of the Sustainable Livelihoods Framework (SLF) and Global Value Chain (GVC) perspectives provides a more holistic understanding of smallholder vulnerability in perennial crop systems. At the household level, the SLF lens reveals how deficits in human, financial, institutional, and natural capitals interact to constrain innovation and resilience. The findings from Muheza illustrate that weak educational attainment, insecure tenure, and limited access to credit and extension are not discrete challenges but mutually reinforcing barriers that undermine household adaptive capacity. At the same time, the GVC perspective illuminates the structural dimensions of exclusion, particularly how orange farmers remain locked into low-value marketing channels dominated by brokers and local traders. This governance asymmetry reflects a broader global pattern in which smallholders are structurally disadvantaged in value chains, preventing them from upgrading or capturing higher returns.

This study demonstrates that through integrating SLF and GVC insights, household vulnerability and structural exclusion are interdependent rather than parallel processes. The case of Muheza thus highlights the necessity of analyzing micro-level asset constraints alongside macro-level market dynamics to fully understand the reproduction of smallholder vulnerability. Beyond the immediate context of orange in Tanzania, the framework advanced here offers a transferable analytical lens for other perennial cash crops in Sub-Saharan Africa, such as coffee, cocoa, and cashew. In doing so, the study elevates the theoretical debate on agricultural sustainability by positioning SLF and GVC not as competing perspectives, but as complementary approaches that, when combined, yield richer explanations of resilience and exclusion in smallholder systems.

### 5.8. Limitations and future research

While this study provides valuable insights into the sustainability of smallholder orange farming in Muheza District, several limitations should be acknowledged. First, the cross-sectional design captures farmer practices and perceptions at a single point in time, which may not fully reflect seasonal dynamics or long-term adaptation processes. Future longitudinal studies could provide a deeper understanding of how resilience strategies evolve under changing climatic and market conditions. Second, the reliance on self-reported data from household surveys and focus group discussions may be subject to recall bias or social desirability bias. Incorporating complementary methods such as farm-level monitoring or remote sensing could enhance data validity. Third, the study focused on one district, which, while representative of orange farming in Tanzania, may limit generalizability to other regions or crops. Comparative studies across multiple districts and different perennial farming systems, such as cashew, cocoa, or coffeewould enrich the transferability of findings. Finally, although the study integrated SLF and GVC perspectives, it did not empirically measure gendered decision-making processes in depth. Future research should therefore adopt more gender-sensitive frameworks to explore how intra-household power relations shape adoption and resilience.

## 6. Conclusion

This study has examined the sustainability of smallholder orange farming in Muheza District through the combined lenses of the Sustainable Livelihoods Framework (SLF) and Global Value Chain (GVC) theory. The analysis revealed how demographic characteristics, insecure land tenure, limited institutional support, and asymmetrical market relations interlock to create a systemic vulnerability trap. While farmers

demonstrate agency through diversification and incremental adaptation, the absence of supportive institutional and structural mechanisms restricts their ability to achieve transformative resilience.

Theoretically, the study advances agricultural sustainability scholarship by showing that household-level vulnerabilities and structural market dynamics are mutually reinforcing. By integrating SLF and GVC perspectives, the analysis provides a holistic lens for understanding how smallholder exclusion is reproduced in perennial crop systems. This contribution is not confined to orange in Muheza but offers a transferable framework applicable to other high-value perennial crops in Sub-Saharan Africa, including coffee, cocoa, and cashew.

From a policy perspective, the findings underscore the need for interventions at multiple levels. Household resilience requires access to tailored credit instruments, youth-oriented training, and climate-smart extension services. Institutional strengthening, particularly through revitalized cooperatives and reliable input systems, is necessary to enhance collective bargaining power and knowledge flows. At the structural level, governance reforms and investment in infrastructure such as cold chains and transparent pricing systems are essential for breaking smallholders' dependence on brokers and integrating them into higher-value markets.

Ultimately, the study highlights that fostering sustainability in smallholder orange farming demands more than incremental adjustments. It requires systemic reforms that simultaneously build household assets, strengthen institutional arrangements, and address value chain governance. By aligning these efforts with the Sustainable Development Goals, especially SDG 2 (Zero Hunger), SDG 8 (Decent Work and Economic Growth), and SDG 13 (Climate Action), Tanzania can chart a pathway toward resilient, inclusive, and climate-smart orange production. These insights extend beyond Muheza, contributing to broader debates on sustainable agricultural development and smallholder participation in global value chains.

## 7. Policy implications

The findings from this study also carry significant policy implications for enhancing the sustainability of smallholder orange farming in Tanzania. At the household level, interventions must address the deficits in human and financial capital that were evident in Muheza. Credit schemes tailored specifically to the needs of perennial crops are essential, as conventional short-term credit instruments remain ill-suited to the long gestation periods and cyclical returns characteristic of orange farming. Complementing financial support with targeted youth training and programs aimed at intergenerational transfer of farming knowledge would help mitigate the demographic stagnation observed in the study area. Extension services should also be reoriented to embed climate-smart practices, including soil and water management, within accessible farmer training modules.

At the institutional level, revitalizing farmer cooperatives is critical to strengthening bargaining power and reducing reliance on brokers. Cooperatives can serve as vehicles for collective investment in post-harvest technologies, quality input distribution, and coordinated marketing. Strengthening extension systems and improving the reliability of input supply chains would further enhance institutional capital and ensure that farmers are not left dependent on informal or unreliable sources.

At the structural level, reforms must address the governance asymmetries within orange value chains. Investments in rural infrastructure, including cold chain facilities and transport logistics, would help reduce post-harvest losses and open access to higher-value domestic and regional markets. Transparent pricing mechanisms, backed by regulatory oversight, are also necessary to reduce information asymmetries that currently allow brokers to capture disproportionate margins. Embedding orange farming within Tanzania's national climate-smart agriculture strategies would ensure policy coherence and elevate the sector's visibility within broader development agendas.

Combined, these policy directions align with global development priorities articulated in the Sustainable Development Goals (SDGs). Specifically, the recommended interventions advance SDG 2 (Zero Hunger) by improving productivity and livelihood security, SDG 8 (Decent Work and Economic Growth) by strengthening farm incomes and agribusiness linkages, and SDG 13 (Climate Action) by expanding the adoption of climate-smart practices in perennial crop systems. Situating orange farming within this sustainability framework highlights how local institutional reforms and market-governance improvements can contribute to national, regional, and international commitments.

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## Author contributions

CRediT: **David Gongwe Mhando**: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing, original draft, Writing review & editing.

## Contribution to knowledge

This study contributes to knowledge in three distinct ways. First, it demonstrates that smallholder vulnerability in perennial crop systems such as orange cannot be understood solely through household-level analysis or market dynamics in isolation; rather, it emerges from the interaction of deficits in human, financial, institutional, and natural capitals with structural value chain governance asymmetries. Second, it advances theory by integrating the Sustainable Livelihoods Framework and Global Value Chain perspectives, illustrating their complementarity and offering a more holistic lens for examining resilience and exclusion in smallholder agriculture. Third, it provides an empirically grounded framework that is transferable beyond Muheza District, offering comparative insights for other perennial crops, including coffee, cocoa, and cashew across Sub-Saharan Africa. In doing so, the study not only fills a critical empirical gap in orange farming research but also enriches broader debates on sustainable agriculture, rural development, and inclusive value chain participation.

## Disclosure statement

The author declares no conflict of interest regarding the publication of this paper.

AI Disclosure: AI-assisted tools were used to support language editing and improve clarity and structure of the manuscript. No AI system was used to generate or alter primary data, perform statistical analysis, or make substantive interpretive decisions. The author takes full responsibility for the content, accuracy, and integrity of the manuscript.

## Ethics statement

This study was conducted in full compliance with ethical research standards and received ethical approval from the Sokoine University of Agriculture Research Ethics Committee (SUA-REC/AG/2024/045). Written informed consent was obtained from all participants prior to data collection. Participants were informed about the purpose of the study, the voluntary nature of participation, confidentiality protections, and their right to withdraw at any time. All responses were handled anonymously and treated with strict confidentiality.

## Practical implications

The findings of this study hold direct implications for practitioners and development actors working in rural Tanzania and beyond. For agricultural extension officers, the results highlight the importance of tailoring training to the realities of smallholder perennial crops, including providing affordable and context-specific advice on orchard renewal, soil conservation, and water management. For cooperatives and farmer organizations, the evidence underscores the need to strengthen collective action mechanisms that enhance bargaining power and reduce reliance on middlemen. Non-governmental organizations (NGOs) and donor-funded projects can leverage these insights to design interventions that combine access to credit with skills development, thereby lowering entry barriers for climate-smart practices. Similarly, local government authorities and agribusiness firms can use these results to guide investments in post-harvest handling, cold chain infrastructure, and transparent market platforms that connect farmers more equitably to buyers. By applying these lessons in practice, stakeholders can help shift smallholder farmers in Muheza

and comparable regions from coping-oriented strategies toward pathways of resilience and sustainable participation in high-value horticultural systems.

## ORCID

David Gongwe Mhando http://orcid.org/0009-0002-7742-9457

## Data availability statement

The data that support the findings of this study are available from the corresponding author, David Gongwe Mhando, upon reasonable request. The datasets include anonymized survey responses, focus group transcripts, and key informant interview notes. Data sharing is subject to ethical restrictions imposed by the Institutional Review Board of Sokoine University of Agriculture to protect participant confidentiality. Requests for access will be reviewed in accordance with these ethical guidelines.

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