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Strengthening Climate Resilience for Smallholder farmers in Isingiro District, Uganda: A Documentary Review

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ABSTRACT: Climate resilience was a lifeline for millions of smallholder farmers amidst the escalating climatic crises. This paper aimed to evaluate several resilience approaches utilized by smallholder farmers under underlying constraints and enabling environments in the Isingiro District. A documentary review was utilized in which secondary data were gathered from peer-reviewed articles and other credible sources. The study findings revealed the continued utilization of agronomic practices such as mulching, intercropping, and crop rotation, while transformative practices were adopted to a lesser extent despite high levels of climate change awareness. This indicated the presence of structural and institutional constraints that hindered the translation of climate awareness into practice. Various institutional and systemic barriers emerged throughout the analysis, with limited access to finance, inadequate extension services, and poor land tenure systems appearing recurrently in most of the reviewed literature. Climate resilience was found to be a highly dynamic and evolving process, implying the need for flexible and adaptive local governance to allow the integration of local realities into policies, plans, and budgets. It was further revealed that the adoption and effectiveness of resilience approaches depended heavily on governance structures and institutions that moderated the options available and affordable to smallholder farmers. Therefore, creating sustainable resilience for smallholder farmers in Isingiro required approaches that addressed underlying limitations, created a supportive environment, and blended traditional and technical solutions.

KEYWORDS: Sustainability; smallholder; effectiveness; constraints; enabling environment; policy.

1. Introduction

Isingiro District faced fluctuating rainfall, prolonged droughts, and declining soil fertility, making the survival of agrarian communities increasingly precarious. Therefore, climate resilience was not merely an agricultural strategy but a lifeline for these communities. According to the Intergovernmental Panel on Climate Change [1], the climate crisis remained one of the most urgent and compelling challenges of the twenty-first century, with

disproportionate effects on East Africa. Climate models consistently projected that the region would warm faster than the global average, implying more frequent and intense floods, droughts, rainfall variability, and dry spells [1, 2]. Relatedly, Nhemachena et al. [3] predicted that agricultural productivity could decline by 30% by 2050, with potential losses in farm revenue reaching up to 90% by the end of the twenty-first century if additional adaptation efforts were not implemented. Isingiro District could be severely affected under such conditions, as farmers were already experiencing total crop failures triggered by prolonged drought. These findings emphasized the need for resilient farming systems that could be achieved through well-planned and context-specific resilience approaches.

Smallholder farmers in Isingiro recognized noticeable shifts in climatic conditions. Approximately 98% of selected respondents reported an increase in the intensity and frequency of droughts, 92.7% observed higher daytime temperatures, 92.1% reported reduced rainfall, and 90% observed changes in rainfall distribution [4]. These climatic changes altered farming activities in terms of seasons, crop types, and farming practices. This transition introduced a high level of uncertainty, which resulted in reduced household income and increased food insecurity. Consequently, farming communities became more vulnerable and were often unable to utilize even readily available resilience strategies. The uncertainty surrounding future climatic conditions reduced farmers' incentives to invest in adaptive approaches that could support agricultural productivity, thereby increasing vulnerability and risk.

Even farmers who took risks and invested in traditional practices to respond to climate crises faced significant limitations. Although traditional approaches such as diversification and reciprocity helped hedge against climate change impacts, the increasing frequency and severity of climate variability weakened their effectiveness. In such situations, smallholder farmers needed to integrate traditional practices with scientific innovations to keep pace with climatic shifts. Several climate change policy frameworks, such as the Uganda National Climate Change Policy and the National Adaptation Plan of Action of Uganda, emphasized the need for contextualized strategies that integrated scientific approaches with local realities [5]. However, empirical evidence indicated limited integration of such approaches in existing resilience interventions, which constrained their implementation in local contexts. Kisambira et al., [6] pointed out that climate policies in Uganda were largely formulated at the central government level without meaningful involvement of local communities, leading to implementation challenges where local authorities and communities were the primary actors. Similarly, Mastenbroek et al., [7] presented evidence that neglecting socio-cultural values hindered the adoption of Climate-Smart Agriculture (CSA) initiatives among agrarian communities. This situation created a disconnect between policy aspirations and actual policy outcomes. Consequently, many smallholder farmers in Isingiro District showed low adoption rates of technical and modernized resilience approaches despite their awareness of climate change impacts.

Located within Uganda's southwestern cattle corridor, Isingiro District represented an important context for understanding climate resilience due to its semi-arid conditions, bimodal rainfall system, and reliance on mixed farming systems and rain-fed agriculture [8]. Livelihoods in Isingiro depended heavily on crop–livestock integration, an indigenous adaptation system that helped distribute climate risks and sustain household food security. However, the increasing intensity of climatic crises was likely to worsen losses within farming systems that had limited adaptive capacity. More broadly, Uganda remained highly vulnerable

to climate-related challenges due to the dominance of agrarian livelihoods that depended heavily on natural conditions. This vulnerability highlighted the urgent need for sustainable and responsive interventions.

Although a wide range of studies had examined climate change and response measures within smallholder farming systems in Uganda, Isingiro District remained underrepresented despite being one of the most vulnerable districts in the country. This limited the understanding of how smallholder farmers in Isingiro responded to climate crises to build resilience, even though national-level evidence was relatively extensive. Of the 41 documents reviewed, only three specifically addressed Isingiro District, focusing mainly on farmers' adoption rates and perceptions of climate resilience strategies without examining how policy frameworks, governance structures, and traditional practices influenced long-term resilience [4, 9]. Therefore, this study sought to fill this gap by conducting an extensive literature review of peer-reviewed articles, policy documents, and government and agency reports to analyze how policy frameworks, governance structures, and traditional practices shaped the effectiveness of resilience approaches used by smallholder farmers. The study also evaluated the constraining and enabling environments navigated by farmers in Isingiro District. In doing so, the study situated climate resilience within Isingiro's socio-ecological system and treated it as an integrative process combining inputs from policy, institutions, and communities.

Conway & Schipper [10] argued that, amid intensifying climate change, understanding context-specific resilience interventions was essential for informing regional and international resilience planning. Therefore, this review contributed to broader regional and global discussions on climate change, including the achievement of the African Agenda 2063 and the Sustainable Development Goals. Specifically, the study contributed to the advancement of SDG 2 (Zero Hunger) and SDG 13 (Climate Action). In this regard, the study provided insights beyond the geographical boundaries of Isingiro District. Lessons drawn from Isingiro could inform knowledge and practices in other areas, particularly those with similar agro-ecological conditions and climate change experiences. Accordingly, the aim of this study was to examine the effectiveness of resilience strategies used by smallholder farmers in Isingiro District while assessing the institutional and structural challenges and opportunities influencing their adoption.

2. Materials and Methods

2.1. Research design and data sources.

A documentary review design was utilized in this study, extensively using secondary data sources to evaluate the resilience approaches of smallholder farmers in Isingiro District. As noted by Kumara [11], the use of secondary data allowed researchers to access extensive datasets collected over long periods. This facilitated longitudinal analysis and enabled research to be conducted at a relatively lower cost in terms of time and resources. Consequently, secondary data provided an effective means of addressing urgent research questions in a timely manner. In addition, documentary review enabled methodological triangulation, allowing the researcher to integrate evidence derived from quantitative, qualitative, and mixed-methods studies. The integration of diverse forms of evidence enhanced the credibility and rigor of the research process. Overall, documentary review enabled the exploration of complex phenomena

such as climate change resilience, which would otherwise have been difficult to investigate within a short timeframe using primary data collection alone.

The documentary review followed a systematic review procedure to enhance the credibility of the selected sources. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework was adopted to ensure quality, transparency, and structured reporting of the review process. A systematic literature search was conducted for the period between 2007 and 2026 using several indexed databases, including Scopus, Google Scholar, ScienceDirect, Web of Science, and AGRIS. Additional sources included Government of Uganda policy archives and institutional repositories.

To ensure the retrieval of relevant documents, specific keywords and search phrases were applied during the database search. These included "climate resilience and smallholder farmers," "agricultural adaptation and institutional capacity," "climate change and Isingiro District," "local governance and climate change," "climate-smart agriculture and Sub-Saharan Africa," and "climate adaptation and Uganda." These keywords and phrases were derived from the main conceptual themes of the study and provided a focused approach for identifying relevant literature from large databases. The overall article identification, screening, assessment, inclusion, and exclusion process is illustrated in Figure 1.

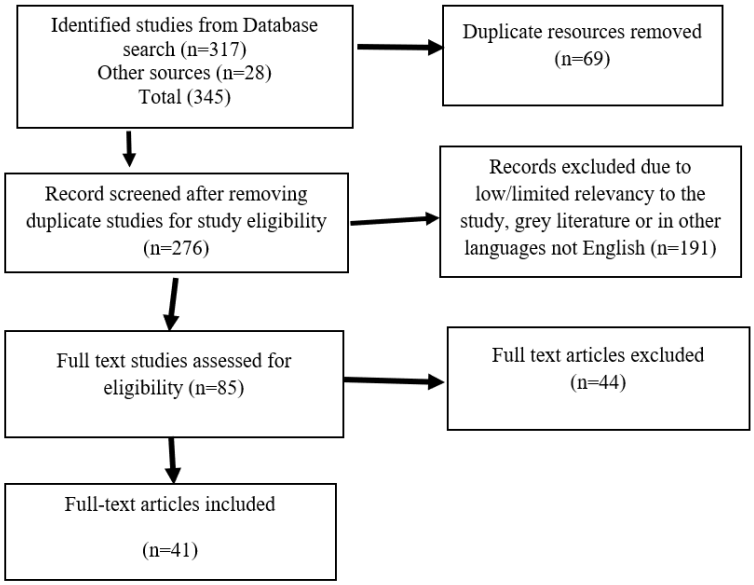

Figure 1. A flow chart of article identification, screening, assessment, inclusion and exclusion.

2.2. Inclusion and exclusion criteria.

Studies and resources were included in the review if they met several criteria. First, the sources had to consist of peer-reviewed journal articles, books, book chapters, policy documents, or reports from recognized organizational repositories. Second, the resources needed to focus on climate change, climate adaptation, or climate resilience in contexts relevant to Isingiro District, Uganda, East Africa, Sub-Saharan Africa, or other regions with comparable resilience-related themes. Third, the documents had to be written in English and provide relevant information that supported the analytical framework of the study. Conversely, resources were excluded if they were not written in English, were not peer-reviewed, or did not originate from credible organizational repositories. Studies were also excluded if they lacked relevant information for the objectives of this research or if they consisted of grey literature with

insufficient methodological transparency. A summary of the article selection process and characteristics of the 41 selected sources used in this study are summarized in Table 1.

Table 1. The summary of the selected 41 resources for the study.

Author	Key findings
[1]	immediate actions needed across regions and sectors, Adaptation limits being reached and compound risks increased by Climate change
[2]	Sub-Saharan African faces multi-dimensional effect of climate change like food insecurity, water stress, livelihood losses and they facilitate each other.
[3]	Integrated water resource management was found to offer opportunities for sustainable development. Climate change threatens both water resources and agriculture in Southern Africa.
[4]	Farmers in Isingiro have moderate CSA knowledge, with positive attitude but adoption is constrained by limited resources and poor/inadequate extension services.
[5]	Uganda identifies water and agriculture as priority sectors and calls for community-based adaptation.
[6]	Robust climate policy but weak sub-national implementation.
[7]	Females had limited access to drought-tolerant maize varieties due to patriarchal systems
[8]	Climate change shifts gender roles, women carry heavy burden, reducing household resilience
[9]	Water harvesting measure have positive benefits and farmers are willing to use them but limited by input costs
[10]	Institutional barriers like poor coordination constrain adaptation.
[11]	Documentary reviews are cost-effective but suffers contextual fit, data availability and reliability, recommends triangulation
[12−14]	Considers transformative adaptation to address root causes of vulnerability Resilience has three capacities, absorptive, adaptive and transformative.
[15]	Farmers have positive perceptions towards them but are constrained by input costs and technical knowledge
[16]	Gap between national plans and district-level practice, limiting adaptation effectiveness
[17]	Farmers face differentiated climate vulnerability due to landscape.
[18, 19]	Diversification offers resilience benefits but involves trade-offs as well.
[20−22]	Interventions build resilience when they address multiple dimensions. Local institutions facilitate collective management of resources and risks if policies address context-specific knowledge gap.
[23]	Household assets and show capital influence resilience.
[24]	Local institutions moderate livelihood and resilience approaches available in rural setups
[25]	Climate information is effective when it addresses farmers' needs and delivered through trusted channels.
[26, 27]	Socio-economic factors and gender differences influence the nature of resilience among smallholders.
[28]	Various factors shape livelihood decisions and adaptation among smallholder farmers.
[29]	Indigenous knowledge shapes and influences adoption of resilience strategies
[30]	Land rights improves agricultural investment while land tenure insecurity reduce adaptation
[31]	Access to finance and land shape adaptation strategies among smallholder farmers.
[32]	Agricultural transformation in Uganda requires scaling CSA, farmer support and institutional alignment.
[33]	Agricultural policies shape resilience, contextual factors mediate how policy translate into farm-level adaptive capacity
[34]	Agriculture and environment are the priorities for development.
[35]	Farmers apply diverse coping strategies; however, rainfall and market failure erode farm-level resilience.
[36]	Gender roles, household assets and education shape the perception of adaptation strategies.
[37]	Proper land governance reduces land degradation.
[38]	Societies requires integrated approaches across governance, social protection and economic and environmental sustainability to build resilient systems
[39]	Adaptive capacity modifies resilience outcomes.
[40]	Foreign investments increase adoption of soil and water conservation practices.
[41]	Local institutions facilitate collective management of resources and risks if policies address context-specific knowledge gap.

Although the documentary review provided valuable insights, it faced several limitations that should be acknowledged. First, the analysis lacked primary data validation, meaning that contextual factors and the lived experiences of smallholder farmers might not have been fully captured in the existing literature. Moreover, publication bias could have influenced the analysis and conclusions, as available literature might have presented only certain perspectives of the debate. Since climate resilience is a highly dynamic and context-dependent phenomenon, reliance on secondary sources also created temporal limitations. Some information in the literature might have evolved over time, particularly regarding climate change patterns, policy landscapes, and socio-economic conditions. Therefore, future primary research would be

valuable to further explore and validate the existing and emerging realities of climate resilience among smallholder farmers in Isingiro District.

3. Results and Discussion

3.1. Resilience strategies and types.

Resilience was categorized into three main types or levels: absorptive, adaptive, and transformative capacities. The absorptive level entailed short-term efforts to prevent, absorb, and recover from immediate shocks and stressors. Primarily, absorptive capacity aimed to maintain the stability of an individual, household, community, or system. Under the adaptive level of resilience, the focus was on the ability to make intentional incremental adjustments in response to, or in anticipation of, shocks [12]. This type was characterized by flexibility that allowed existing systems and structures to evolve in response to unfolding changes [13]. The transformative level focused on structural changes aimed at stopping or significantly reducing the causes of risks and vulnerabilities [14]. It primarily addressed underlying triggers and systemic failures. Smallholder farmers could choose among the three resilience capacities; however, this choice was often mediated by policy frameworks, institutional arrangements, and farmers' capacities.

In the context of climate resilience, transformation represented the ideal situation not only for smallholder farmers but also for other sectors facing climate change because it offered long-term solutions. However, limited farmer capacity, together with structural and institutional constraints, curtailed transformation in smallholder farming systems. The emphasis on absorptive capacity, although feasible under existing conditions for smallholder farmers, was often costlier in the long term. Farmers were required to make small but continuous investments to remain resilient in the short term, which demanded significant labor, financial resources, and time, often with limited effectiveness of outcomes.

Nevertheless, each resilience level remained unique and relevant to specific contexts. Absorptive capacity provided immediate responses to disasters and helped prevent long-term damage. Coping measures were also crucial for farmers who lacked sufficient resources to implement adaptive or transformative measures. Moreover, coping strategies were particularly useful in emergency situations where transformation was impossible due to time constraints. In some cases, transformation began with coping measures that reduced immediate damages before moving toward recovery or structural change. Thus, when disasters occurred, transformation often required an initial absorptive phase to manage immediate impacts.

However, transformation could also occur independently of absorptive and adaptive stages if responses were anticipatory in nature. In such cases, forward planning allowed structural adjustments that prevented or moderated the impact of disasters. When climatic crises were recurrent, adaptive responses were often appropriate because they allowed learning and incremental adjustments over time. In contrast, where disasters were highly uncertain and rapidly changing, absorptive measures were often necessary to inform future transformation strategies. Therefore, in Isingiro District, where drought occurred recurrently, a phased advancement toward adaptive capacity for drought-related shocks was necessary. This process needed to be informed by learning while acknowledging existing economic, institutional, and

policy constraints. Transformation was also expected to occur gradually because many farmers lacked the capacity to anticipate and prepare for disasters effectively. Consequently, a combination of absorptive, adaptive, and transformative approaches appeared most suitable for the local realities of Isingiro District. The interaction among these resilience capacities is illustrated in Figure 2.

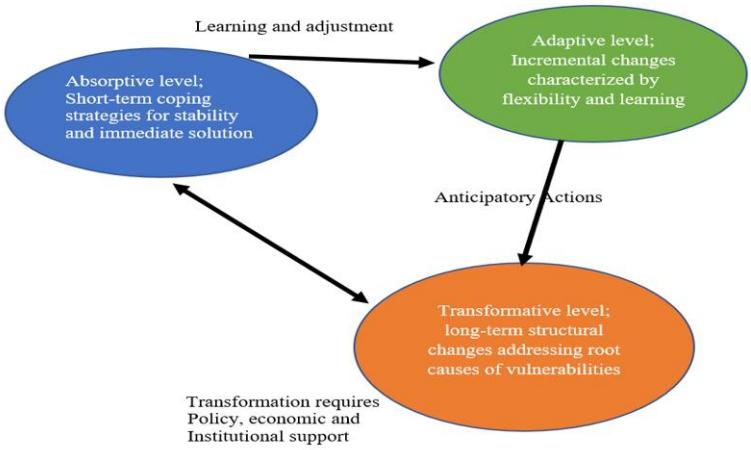

Figure 2. The interaction among absorptive, adaptive, and transformative resilience levels/capacities.

3.2. Agronomic practices as primary resilience strategies.

The documentary analysis revealed that smallholder farmers in Isingiro relied heavily on agronomic practices to build resilience. Studies by Aturihaihi et al., and Bwengye et al., [4, 9] provided evidence of the widespread use of agronomic and soil–water management practices such as mulching, contour bunding, intercropping, and crop rotation. These approaches demonstrated the alignment of resilience strategies with the local realities of smallholder farmers in Isingiro. The commonly utilized practices reflected cross-generational knowledge and limited financial capital, which made them economically and technologically feasible for farmers. As noted by Folke et al., [14], reliance on incremental adjustments without fundamental changes in livelihood structures often reflected local innovation within resource-constrained environments.

Similarly, Mfitumukiza et al., [15] documented that most smallholder farmers relied on labor-intensive strategies such as drip irrigation and watering cans, with little consideration of sprinkler systems or solar-powered irrigation despite increasing drought conditions. The findings further revealed that the adoption of improved livestock breeds, drought-resistant crop varieties, and productivity-enhancing technologies remained extremely low. These observations reflected limited farmer capacity and inadequate institutional support. Although reliance on low-capital strategies improved short-term resilience among smallholder farmers, it did not significantly transform agricultural systems toward long-term resilience, which remained essential in the context of intensifying climate crises.

3.3. Mixed farming and diversification strategies.

The findings further indicated that smallholder farmers in Isingiro adopted mixed farming and diversification as resilience strategies. According to Martikainen [16], mixed farming systems created resilience pathways by spreading risks and establishing both economic and ecological buffers. Farmers in Isingiro utilized traditional knowledge to implement mixed farming

systems as a resilience strategy. In most cases, crop–livestock integration was practiced to capture the synergetic benefits associated with such systems. Evidence presented by Muggaga et al., [17] showed that farmers engaged in mixed farming to buffer against climate shocks and enhance system stability. Livestock residues were used as manure for crops, while crop residues served as feed for animals. This interaction not only increased productivity but also reduced production costs by minimizing reliance on external inputs.

However, diversification was not always a universally beneficial strategy and could involve trade-offs or even potential losses [18, 19]. While diversification reduced income variability, it could also lower technical efficiency on farms. In some cases, diversification reduced productivity or increased resource management costs if it was not accompanied by sufficient knowledge and extension support. Therefore, smallholder farmers needed to combine diversification with efficiency-enhancing practices to mitigate these trade-offs.

Within the cattle corridor of Isingiro District, diversification alone might not provide full resilience because drought affected both crop and livestock production simultaneously. Integrating diversification with irrigation practices could therefore enhance and sustain resilience. Furthermore, diversification often increased labor demands, which smallholder farmers—who primarily depended on family labor—might not have been able to meet. This limitation could reduce productivity in both crop and livestock sectors and keep farmers within coping cycles without progressing toward adaptive or transformative resilience. At the same time, the increasing intensity and frequency of climatic crises suggested that the absorptive capacity of existing systems might already have been exceeded.

3.4. Water and soil management for climate resilience.

Water and soil management practices were found to be particularly relevant in drought-prone areas such as Isingiro for building resilience. These practices included irrigation, rainwater harvesting, drainage improvement, terraces, and water retention structures. Such approaches supported agricultural production throughout the year and reduced the risks associated with rainfall variability [9, 17]. Despite their potential benefits, several factors influenced farmers' adoption decisions beyond their willingness or priorities.

According to Byaruhanga et al. [20], smallholder farmers in Uganda adopted various soil and water conservation practices depending on terrain conditions, access to resources and information, and spill over effects from neighbouring farms. The authors further observed that farmers who received external agricultural investments or institutional support demonstrated higher adoption rates of soil and water conservation practices than those without such support. This finding highlighted the limited capacity of smallholder farmers to independently finance resilience-building investments.

Although these practices offered benefits such as improved soil moisture retention, reduced soil erosion, and stabilized crop yields, their success remained uneven due to the influence of underlying socio-economic and institutional factors. Given the cattle corridor context of southwestern Uganda, investments in valley dams, small-scale irrigation systems, and rainwater harvesting structures held significant potential for improving resilience. However, these approaches remained relatively underutilized.

The uptake of water management practices in Isingiro was notably lower compared with agronomic practices. For example, Mfitumukiza et al., [15] found that smallholder farmers primarily used drip irrigation, surface water tanks, and watering cans, with little attention given

to sprinkler irrigation, valley tanks, or solar-powered irrigation systems. Similarly, knowledge of rainwater harvesting among farmers in Isingiro was relatively low, with only 71.4% awareness reported compared with nearly universal awareness of other agronomic practices [4]. These findings suggested that farmers tended to adopt strategies that were financially and technically within their reach. Although drought conditions could theoretically encourage investment in more effective irrigation technologies, limited financial and technical capacity prevented such investments. As a result, agronomic strategies remained the most practical and widely adopted resilience approaches among smallholder farmers in Isingiro District.

3.5. Nature of climate resilience: enabling and constraining factors.

Climate change was highly dynamic and, therefore, climate resilience was also dynamic. Climate change affected communities in diverse ways, and responses also varied depending on respondents' capacities and capabilities. The way an individual built resilience differed from the way a community built it. For instance, in Isingiro, where prolonged drought was the primary climatic threat, farmers-built resilience in different ways. Some focused-on irrigation as a response, others opted for off-farm livelihoods such as trading, while others chose to lease land for farming in other areas that were less affected. However, when collective resilience was required, collaborative efforts from institutions, experts, and beneficiaries became indispensable. Local institutions moderated resilience pathways [21], while beneficiaries integrated local realities, ensuring tailored responses [22]. However, due to the diversity of climatic threats, reaching consensus was often a complex process, especially when considering local community realities. This sometimes paved the way for elite capture, where the ideas of only a few community members were considered, or political patronage, where individuals with strong political connections influenced resilience options. Therefore, the dynamic nature of climate resilience made it a technical, institutional, political, and community-driven process that required continuous innovation.

These innovations were possible only when a supportive environment facilitated creative processes. Uganda in general, and Isingiro in particular, leveraged existing enabling environments such as policy frameworks that defined and guided climate resilience initiatives. Moreover, the high level of awareness among smallholder farmers served as an asset for informing innovations that addressed underlying vulnerabilities. The documentary review revealed several constraints to climate resilience, including limited access to finance and agricultural inputs, insecure land tenure, and inadequate extension services. Strengthening the enabling environment was therefore essential. Through a strengthened enabling environment, underlying constraints could be overcome to drive sustainable resilience.

The agricultural nature of livelihood activities in Isingiro District further meant that climate resilience was closely linked to agricultural adaptation and transformation. Most smallholder farmers in Isingiro District pursued resilience through diversification, adjustment of planting seasons, and adoption of climate-smart agriculture practices. However, agricultural-oriented resilience did not function in isolation and required support from knowledge systems and access to markets. These elements supported the development of sustainable and resilient practices and created synergies that were critical for enhancing long-term resilience among smallholder farmers.

This nature of resilience determined food security, income stability, and economic development. Smallholder farmers depended entirely on agriculture for food, income, and

welfare. Thus, strengthening resilience through diversification, improved crop varieties, and climate-smart agriculture helped maintain stability among farming households. Conversely, when constraints limited the effectiveness of these practices, farmers became vulnerable to food insecurity, poverty, and adverse coping mechanisms such as selling productive assets, taking short-term loans with exorbitant interest rates, and sacrificing children's education [23]. These conditions not only created stressful situations for smallholder farmers in Isingiro but also impeded long-term resilience and economic development in Uganda.

The interplay between enabling and constraining factors significantly shaped the nature of resilience and the strategies farmers used to respond to climate variability. Studies indicated that access to climate-information services (CIS), extension training, farmer field schools, and peer networks enabled farmers to anticipate and respond effectively to climatic hazards [24, 25]. This implied that farmers with adequate knowledge of various interventions could make informed decisions. However, when farmers lacked the capacity to operationalize these strategies, their potential impact remained limited. Integrating knowledge systems with institution-driven support mechanisms therefore strengthened farmers' capacity to implement agronomic, diversification, and water-management strategies. These support systems were important for addressing structural and institutional limitations that smallholder farmers faced when adapting to shocks, including neglected contextual needs and insufficient follow-up by extension agents [26, 27]. Consequently, the success of resilience measures depended on a holistic system capable of counterbalancing the multidimensional constraints within small-scale farming systems.

Evidence also showed that climate adaptation was influenced by multiple factors, including social norms, prior experiences, informal institutions such as reciprocity and labor-sharing arrangements, and risk perceptions, which enabled adaptation even in the absence of formal extension services [28]. Similarly, previous studies noted that farmers worldwide used traditional and local knowledge to implement effective adaptation practices [29]. Communities often relied on locally embedded observation systems, forecasting practices, land management strategies, and crop and livestock practices to anticipate and respond to climatic variability. These mechanisms could operate independently of, or alongside, formal extension services. Weak formal extension systems therefore did not necessarily prevent meaningful and context-specific adaptation, as indigenous knowledge and community networks could compensate for, complement, or even outperform formal advisory services in certain contexts. Recognizing and integrating these non-formal adaptation pathways could therefore enhance the effectiveness and sustainability of resilience strategies.

Another key finding was that insecure land tenure reduced incentives for farmers to invest in long-term adaptation strategies such as irrigation systems, agroforestry, and other capital-intensive practices, as farmers feared losing the land before realizing long-term benefits [30]. In addition, insecure land tenure limited farmers' ability to access credit, since such land could not serve as collateral. Small land sizes further constrained farmers from maximizing the benefits of adaptation strategies. Limited land restricted opportunities for diversification, experimentation with new crop varieties, and space allocation for water management practices, often forcing farmers to reduce land available for food production [31]. In Isingiro, land scarcity and tenure insecurity posed significant obstacles, as farmers were unable to invest in large-scale and capital-intensive adaptive practices [4]. As a result, farmers were often locked into absorptive coping strategies that provided only short-term responses to climate shocks. A

summary of key resilience strategies, their effectiveness, and the associated enabling and constraining factors identified in the literature is presented in Table 2.

Table 2. Resilience strategies, effectiveness, enabling and constraining factors.

Resilience strategies	Effectiveness (yield, Income and risk reduction)	Enabling factors	Constraining Factors
Agronomic Practices like mulching, conservation tillage, agroforestry, soil fertility management, early maturing and drought-tolerant varieties	– improves soil moisture retention, reducing risk of crops drying faster during dry spells – Stabilizes yields during dry spells – agroforestry provides extra income sources through selling crops and woods from the trees.	– Moderate access to extension services and training – Indigenous knowledge by farmers – Government policy/programme of scaling up climate smart agriculture	– Gendered access to productive resource – Limited access to resources – High labour demands – Land fragmentation – Limited reach of extension services.
Diversification Strategies eg, crop diversification, crop-livestock integration, income diversification through on-farm and off-farm activities	– Buffers income shocks throughout the year/income stabilization – -creates synergies and spreads the risk reducing farmers' vulnerability – Increases yields and reduces input costs through manure generation and feed for the animals from plants	– Access to local markets – Indigenous farming knowledge – Farmer groups that facilitate knowledge sharing	– Land fragmentation – Climate intensification that exceeds coping thresholds – Possible trade-off between efficiency and diversification
Water management strategies like irrigation, water harvesting, Terracing	– stabilizes crop yields throughout the year – reduces vulnerability to erratic rainfall – supports livestock survival in semi-arid areas.	– Government/NGO support programmes – Land tenure security – Community-based water management initiatives	– High initial capital requirements – Maintenance challenges – Unequal community resource access.

Despite these constraints, farmers' awareness of climate change and existing policy frameworks created an enabling environment for building resilience. Previous studies reported that 98% of respondents observed an increase in drought frequency and 90% reported changes in rainfall distribution in the study area [4]. Such climate awareness was critical in informing adaptation, as farmers recognized the costs associated with failure to adapt. However, farmer knowledge alone needed to be complemented by additional support systems to enhance adaptive capacity. The Uganda policy framework supported resilience through several initiatives, including the Uganda Climate Smart Agricultural Transformation Project (UCSATP), which demonstrated the government's commitment to promoting climate-smart agriculture as a pathway toward climate resilience [32]. Although these initiatives were important for resilience-building, their effectiveness was often constrained by implementation challenges, particularly when project designs were insufficiently contextualized.

Overall, the effectiveness of resilience approaches among smallholder farmers in Isingiro District, and Uganda more broadly, depended on a complex system of interdependent factors. Institutional constraints, policy frameworks, and farmers' knowledge of climate change interacted to shape climate resilience outcomes. Farmers' knowledge alone often resulted in reliance on traditional approaches that might not remain effective in the long term. However, when farmers' awareness was complemented by institutional and policy support, the adoption of more capital-intensive and sustainable adaptation strategies became possible.

3.3. Policy, governance and climate resilience.

Although Uganda's policy and governance landscape for climate resilience presented an enabling environment, operationalization had not reached an optimal level to yield potential benefits. Evidence indicated that enabling policies existed but remained largely documented rather than implemented due to challenges related to resources, local support, and limited inclusion of community members [6, 33]. In Uganda's context, leveraging policy as an enabling environment began with addressing these implementation challenges to translate policy aspirations into actionable interventions. Addressing such challenges allowed the government to utilize high levels of climate awareness to implement interventions with farmer support, enhancing sustainability.

The literature further revealed that centralized decision-making and donor-driven agendas dominated most resilience projects in Uganda, reinforcing the marginalization of targeted communities. Climate change planning was largely managed by national ministries, with minimal involvement of districts and sub-counties due to weak institutional capacity, donor requirements, and limited access to information on climate crises [6]. Most local governments lacked financial resources, technical expertise, and systems to operate independently. Consequently, central government input was required to leverage existing trained staff, systems, and tools to make informed assessments and decisions. The urgency and volatility of climate resilience interventions also made reliance on existing systems more practical than developing local community capacity from scratch.

Collaboration between central and local governments was therefore imperative. Institutional challenges that impeded implementation included low citizen participation in governance decisions, weak alignment of district budgets with development plans, limited social accountability, and underutilization of data for planning and budgeting [34]. These obstacles constrained the operationalization of policy into actionable measures. Collaborative efforts between the central government and Isingiro District were necessary to streamline processes and enhance effectiveness.

Climate resilience was a multi-stage phenomenon that required multi-level coordination to achieve optimal outcomes. Uganda's decentralized governance system emphasized inclusion, participation, collaboration, accountability, and capacity building as pillars of service delivery. Implementing resilience programs followed similar principles, with central government, local government, and lower-level local governments needing to share common goals. One strategic objective of the Isingiro District Development Plan (2020/2021–2024/2025) was to coordinate interventions to reduce the impacts of natural and human-induced disasters [34]. As a central actor, the district was tasked with coordinating with central and lower-level governments and target beneficiaries to ensure that resources were secured, properly utilized, and stakeholders empowered to implement programs. Therefore, climate resilience was a multi-faceted phenomenon requiring multi-stakeholder engagement to achieve effective outcomes (Figure 3).

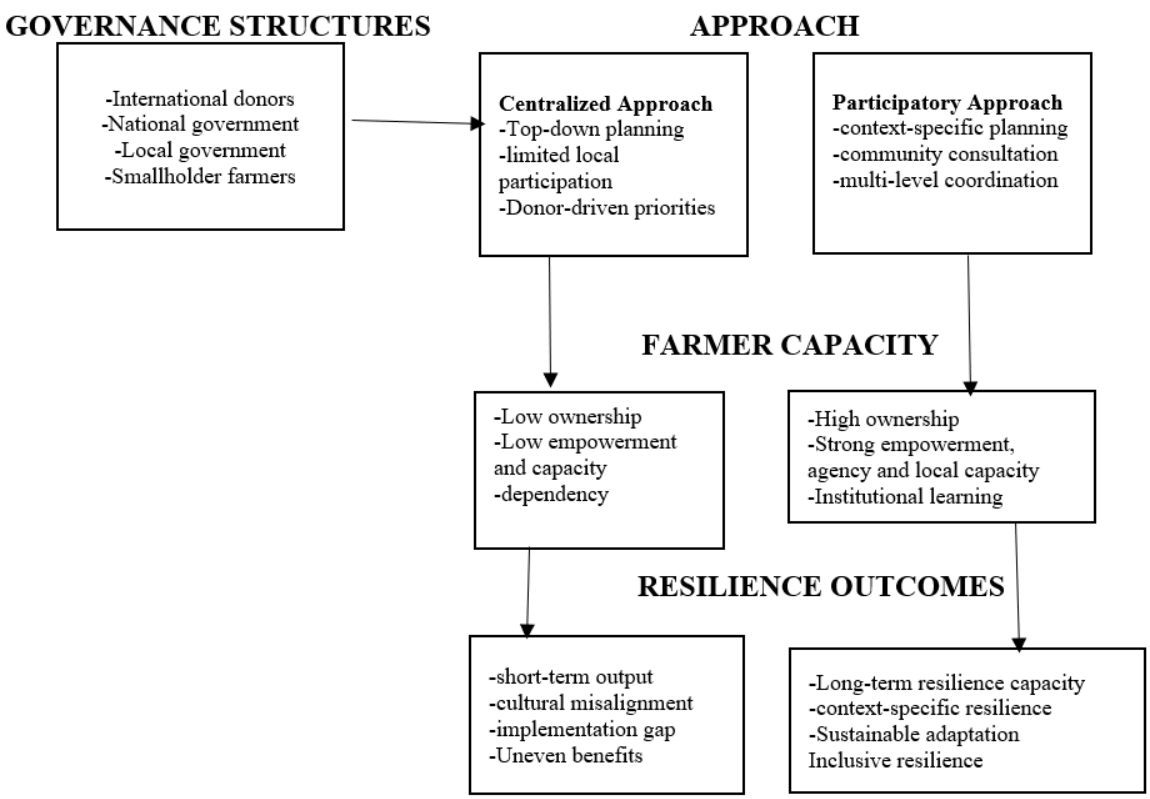

Figure 3. links governance structure, farmer capacity and resilience outcomes.

3.7. Discussion of the findings.

The findings indicated that resilience depended heavily on farmers' capabilities and local realities, which dictated the types of strategies they could implement. Local governance structures and institutions regulated resilience options through resource allocation and policy implementation. Alignment between farmers' capacities and institutional support was necessary; otherwise, interventions failed due to insufficient resources and lack of community or institutional support [6]. Consequently, all actors needed to collaborate to achieve positive resilience outcomes.

In southwestern Uganda, smallholder farmers experienced prolonged droughts and unpredictable rainfall, reducing yields of livestock, maize, and sorghum [17,35]. These conditions threatened food security and income in both the short and long term. Although national policies, such as the National Adaptation Programs of Action, recognized climate-smart agriculture, water harvesting, and drought-tolerant seed varieties as key interventions [5], implementation remained uneven. Farmers in Isingiro were aware of practices like intercropping, mulching, and soil and water conservation, but adoption was constrained by poor extension services, limited financial support, and limited access to certified seed varieties [4]. Institutions and local governments therefore needed to support farmers through aligned resource allocation, input access, and training, as they were critical intermediaries in mediating resilience options.

Climate resilience evolved to match the dynamic nature of climate change, occurring at three levels: coping, adaptive, and transformative [14]. Coping strategies provided short-term buffers using traditional practices. As climate impacts intensified, farmers gradually transitioned toward adaptive capacity. When ecological thresholds were exceeded and

incremental adjustments failed, structural changes became necessary, reinforcing transformative capacity [14]. This evolution occurred within the context of smallholder farming systems in Isingiro, often constrained by limited resources, discriminatory access, and power imbalances, highlighting the need for a supportive environment.

Access to resources and information determined the resilience strategies farmers could employ [13]. Institutions mediated these resources, shaping adaptation options and enabling integrative approaches that combined traditional knowledge with scientific interventions. Systemic constraints, such as weak institutional support, limited access to timely climate information and financial resources, and inadequate extension services, hindered effective resilience and increased vulnerability to climatic shocks [35,36]. These factors explained why smallholder farmers in Isingiro predominantly relied on agronomic measures despite awareness of increasing climate risks.

Farmers in semi-arid regions of Uganda, including Karamoja and northern districts, employed strategies aligned with traditional knowledge, labor and cost capacities, and controllable interventions. In these regions, capital-intensive strategies remained low due to limited institutional support, misalignment with socio-economic realities, and mindset barriers [31, 35–37]. These findings reinforced that climate resilience outcomes depended on farmers' knowledge, attitudes, and institutional arrangements that facilitated resource and information integration for planning and decision-making.

Participatory approaches were essential to address constraints and enhance the effectiveness of resilience interventions. Participatory planning, decision-making, and budgeting reduced farmers' resistance to interventions and improved implementation support [6]. They also enabled governments and NGOs to identify contextually appropriate strategies [38, 39] and facilitated the integration of traditional knowledge with scientific measures, producing blended strategies suitable for smallholder farmers facing intensifying climate risks [40].

Empowering farmers through community-based interventions enhanced ownership and sustainability. Real resilience was achieved when communities conducted vulnerability assessments using indigenous knowledge and lived experience [41]. Adaptive governance structures further enhanced resilience by integrating continuous learning into planning and decision-making. Therefore, building sustainable climate resilience required multi-dimensional, collaborative efforts involving farmers, institutions, and governance systems

4. Conclusions

From the documentary review, smallholder farmers were found to possess substantial knowledge and awareness of the climate change issues that affected their daily lives. Increasing daytime temperatures, shifts in rainfall patterns, and prolonged droughts were reported as the most significant challenges experienced in Isingiro District, continuously threatening livelihoods. These challenges were further compounded by systemic and institutional impediments that reduced farmers' ability to transform their farming systems to keep pace with evolving climate change. Most farmers reported using practices such as mulching, intercropping, crop rotation, and watering cans to counter climatic shocks. While these approaches helped address immediate impacts, their effectiveness in the long term was limited by the severity and recurrence of extreme climatic events. In situations where, traditional practices could no longer cope with the intensity of climate change, farmers needed to adopt

advanced strategies. Large-scale irrigation, including solar pump and sprinkler systems, and the use of drought-resistant crops and livestock breeds, could help maintain resilience aligned with evolving climatic conditions. However, such transformations required support in terms of policy guidance and financial resources. Most farmers lacked the capital to implement these measures, focusing instead on labour-intensive strategies despite knowing the interventions needed for sustainable resilience. Their intentions and motivation were often overpowered by prevailing constraints. Most smallholder farmers in Isingiro District were aware of climate-related shocks but faced a weak enabling environment that limited their ability to respond effectively. Extension services were fragmented and often non-responsive to local contextual needs. Moreover, Uganda's centralized policy-making process, despite formal decentralization policies, excluded local communities and their specific requirements. This misalignment reduced community engagement and limited support for implementing interventions that could address their unique vulnerabilities. To strengthen climate resilience, Uganda needed to adopt integrative and participatory policy-making approaches. Empowering decentralized climate governance was essential, including strengthening local governance structures, ensuring adequate resource allocation aligned with farmers' needs, improving data collection and monitoring systems, and implementing budget tagging specifically for resilience projects. Such approaches could mitigate underlying impediments and provide communities with a voice in resilience processes, thereby enhancing sustainability. With contextualized empowerment, smallholder farmers could actively influence resilience pathways and take ownership of planned interventions. The documentary analysis highlighted the need for future studies to focus on primary validation of climate resilience among smallholder farmers in Isingiro District. Primary data collection through surveys, interviews, focus group discussions, and participatory observations could reveal the lived realities of the community, which documentary reviews could not fully capture due to temporal limitations. Such studies could also assess the actual effectiveness of various resilience measures and determine which interventions are most appropriate for specific farmers. Given the dynamic nature of climate resilience, comparative studies across districts would provide additional insights into how factors such as individual income, knowledge systems, local governance structures, and formal institutional support influence resilience capacities.

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Author Contribution

All authors equally contributed to the conceptualization, analysis and reviewing. Judith Nahabwe led the writing part while Associate Professor Francis Akena Adyanga and Johnson Ocan (PhD) supearheaded the supervision process. The research was not funded.

Competing Interest

The authors declare that they have no competing interest that might have influenced this research.

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