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Adapting To A Changing Climate: A Qualitative Analysis Of Community And Institutional Perspectives From Uganda's Smallholder Rice Systems

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Abstract: ***Climate variability increasingly threatens rice production in Uganda, yet the perspectives of smallholder farmers and local institutions remain underrepresented in adaptation research. Understanding how these actors perceive and respond to climate risks is vital for designing context-specific resilience strategies. This study explores the experiences of farmers and District Agricultural Officers (DAOs) in Uganda's major rice-producing districts Butaleja, Bugiri, Lira, and Nwoya. A qualitative design combining focus group discussions (FGDs) and key informant interviews (KIIs) examined experiential knowledge, institutional responses, and adaptation gaps across three rice production systems. Data were collected between September and November 2025 through five FGDs (50 participants) and four KIIs with DAOs. Thematic analysis following Braun and Clarke's framework identified recurring patterns and contextual contrasts. Farmers demonstrated strong awareness of climate risks delayed rainfall, floods, prolonged droughts, and pest outbreaks but limited resources constrained adaptation. Institutional perspectives confirmed these challenges: adaptation programs such as seed multiplication, farmer training, and irrigation remain hindered by weak extension coverage, limited financing, and fragmented coordination. Flooding in Butaleja's Doho scheme and droughts in Nwoya illustrate localized vulnerabilities despite initiatives like ACDP and PRELNOR. Resilience in Uganda's rice systems depends on the synergy between farmer innovation, institutional capacity, and infrastructure. Strengthening district-level coordination, expanding irrigation and climate-information services, and revitalizing farmer cooperatives could transform coping into sustained adaptation, advancing Uganda's Climate-Smart Agriculture Framework and National Development Plan IV toward SDGs 2, 8, 13, and 17.***

Keywords: ***Climate change, adaptation, rice production, smallholder farmers, institutional capacity, Uganda, resilience***

I. INTRODUCTION

Rice has become a pivotal crop in Uganda's agricultural and food systems. It contributes significantly to food security, employment, and rural livelihoods. However, production remains highly sensitive to climatic variability, particularly shifts in rainfall and temperature regimes (Muthoni et al., 2023; Nsubuga & Kiwanuka, 2023). Farmers increasingly describe unpredictable rainfall seasons starting late or ending abruptly and longer dry spells that result in yield instability and income losses. These patterns mirror broader climate variability across East Africa (Rurinda et al., 2022).

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Although previous studies have quantified yield gaps and production efficiency among smallholder rice farmers (Musinguzi et al., 2024; Wang et al., 2021), few have centred on farmers' experiential knowledge or the institutional realities influencing adaptation capacity. Yet local understanding often drives behavioural change more effectively than external interventions (Ampaire et al., 2021).

This study therefore aimed to examine how smallholder farmers and district-level institutions perceive and respond to climate variability across Uganda's rice systems. It anchors adaptation within the realities of smallholder farmers and the operational contexts of district agricultural offices, complementing Uganda's National Adaptation Plan (NAP) and National Development Plan IV (NDP IV). It also advances continental and global goals under Agenda 2063 and the Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger) and SDG 13 (Climate Action).

II. METHODOLOGY

A. STUDY DESIGN

A qualitative descriptive design was adopted to capture the perceptions and experiences of farmers and DAOs regarding climate variability and adaptation. FGDs and KIIs were used to obtain detailed insights into community knowledge, institutional challenges, and adaptation practices (Krueger & Casey, 2021).

B. STUDY SITES AND PARTICIPANTS

The study was conducted in four major rice-producing districts of Butaleja, Bugiri, Lira, and Nwoya, representing Uganda's main rice ecologies and diverse production systems. Butaleja features both irrigated and rain-fed lowland systems linked to the Doho Irrigation Scheme; Bugiri represents rain-fed lowlands; while Lira and Nwoya represent upland systems. These districts capture the range of agroecological conditions, climatic risks, and institutional contexts faced by smallholder rice farmers in Uganda. In each district, one focus group discussion (FGD) comprising ten purposively selected participants was conducted, except for Butaleja, which hosted two FGDs to reflect its two production systems of irrigated and rain-fed lowland. Participants were selected to ensure diversity in gender, age, and production level. In addition, four District Agricultural Officers (DAOs), one from each district, participated in key informant interviews (KIIs). Table 1 summarizes the main characteristics of the study districts, including predominant production systems, major climate risks, adaptation practices, and ongoing institutional programs.

District	Production System	Major Climate Risk	Key Adaptation Practices	Institutional Program(s)
Butaleja	Irrigated lowland & rain-fed lowland	Flooding, canal overflows	Canal maintenance, collective water control	ACDP, Doho Irrigation Scheme
Bugiri	Rain-fed lowland	Erratic rainfall, flooding	Staggered planting, early maturing varieties	ACDP
Lira	Upland	Delayed rainfall, floods	Drought-tolerant seed, soil bunds	PRELNOR
Nwoya	Upland	Droughts, erratic rainfall	Early planting, mechanization, savings groups	PRELNOR, PRIDE

Table 1: Summary of the main characteristics of the study districts, highlighting production systems, dominant climate risks, farmer adaptation practices, and active institutional programs

As shown in Table 1, districts such as Butaleja and Bugiri experience recurrent flooding and erratic rainfall, while Lira and Nwoya face increasing drought stress. These variations provide a comparative context for understanding the adaptation patterns discussed in subsequent sections.

C. DATA COLLECTION

Data were collected between September and November 2025. Each FGD lasted 60–90 minutes, and KIIs averaged 45 minutes. Discussions explored perceptions of climate change, observed impacts, coping strategies, and institutional support. Interviews elicited district-level insights on programs such as the Agricultural Cluster Development Project (ACDP) and Project for the Restoration of Livelihoods in the Northern Region (PRELNOR). Sessions were conducted in local languages, recorded with consent, and transcribed into English.

D. DATA ANALYSIS

Data were analyzed thematically using Braun and Clarke's (2019) six-step framework. Coding was iterative, comparing themes across districts and rice systems. Findings were validated through follow-up consultations with local extension officers to ensure accuracy and consistency (Guest et al., 2021).

E. ETHICAL CONSIDERATIONS

Ethical approval was obtained from the Kampala International University Research and Ethics Committee and the National Agricultural Research Organisation (NARO). All participants gave informed consent, and identifiers were anonymized (e.g., Farmer, Lira FGD).

F. CONCEPTUAL FRAMEWORK

The study adopted a conceptual framework that links climate variability, farmer innovation, and institutional capacity as the main determinants of resilience in smallholder rice systems. The framework (Table 2) illustrates how climatic stressors influence adaptive responses through the interaction between farmers' experiential knowledge and institutional support structures. Farmer knowledge and innovation encompassing local awareness, adaptive practices, and collective action form the foundation for adaptive behavior, while institutional capacity expressed through extension services, financing, irrigation, and coordination mechanisms either enables or constrains these practices.

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The framework emphasizes that resilience outcomes emerge when farmer innovation and institutional mechanisms operate in in tandem. When this interaction is strong, smallholders can transition from short-term coping to sustained adaptation; when it is weak, vulnerability persists. Overall, the framework guided both data collection and thematic analysis by highlighting how adaptation in smallholder rice systems is co-produced through the integration of knowledge, institutions, and resources.

Component	Key Elements	Interaction
Climate Variability & Risks	Rainfall shifts, droughts, floods, temperature variability	Drives adaptation needs and local responses
Farmer Knowledge & Innovation	Local awareness, adaptive practices, cooperative networks	Knowledge enables adaptive decisions
Institutional Capacity	Extension services, financing, irrigation, coordination	Institutions enable or constrain adaptation
Resilience Outcomes	Stable yields, improved livelihoods, reduced vulnerability	Outcome of synergy between knowledge and capacity

Table 2: Conceptual framework linking farmer knowledge, institutional capacity, and climate resilience in Uganda's smallholder rice systems

As shown in Table 2, the framework emphasizes that resilience emerges when farmer innovation and institutional mechanisms operate synergistically. Strong coordination and access to resources enable households to transition from coping to sustained adaptation, while weak institutional support perpetuates vulnerability.

III. RESULTS AND DISCUSSION

A. FARMER PERCEPTIONS OF CLIMATE VARIABILITY

Farmers consistently reported increasingly erratic rainfall, with delayed onset and abrupt cessation leading to crop failure. Flooding was common in lowland areas like Butaleja, where overflowing irrigation canals sometimes destroyed young rice. In upland Nwoya, prolonged droughts reduced grain filling and yields. Beyond rainfall shocks, farmers noted frequent pest and disease outbreaks linked to temperature and humidity fluctuations. Despite these challenges, farmers showed strong awareness of climate change, associating it with declining productivity and soil fertility. However, awareness has not always translated into adaptive action due to financial and resource constraints.

The analysis of farmer testimonies revealed that climatic impacts vary significantly across the three rice production systems irrigated lowland, rain-fed lowland, and upland. While farmers share common experiences of rainfall variability and temperature extremes, the type and severity of impacts depend on the production ecology. Table 3 summarizes these patterns, linking observed climatic impacts with coping and adaptation practices across systems.

Production System	Major Climatic Impacts Reported	Typical Coping/Adaptation Practices
Irrigated lowland	Floods damaging seedlings; canal overflow	Canal maintenance, staggered planting
Rain-fed lowland	Delayed rainfall, mid-season drought	Early planting, mixed cropping
Upland	Prolonged drought, high temperature stress	Use of drought-tolerant seed, mechanization, soil bunding

Table 3: Summary of reported climate impacts and corresponding adaptation practices across Uganda's rice production systems

As summarized in Table 3, flooding and canal overflows dominate in irrigated lowlands, whereas drought and rainfall delays are more pronounced in upland areas. These spatial differences explain why adaptation strategies vary farmers in lowlands prioritize drainage and early planting, while upland farmers focus on drought-tolerant varieties, mechanization, and soil conservation.

B. INSTITUTIONAL INSIGHTS AND ADAPTATION EFFORTS

District Agricultural Officers corroborated these experiences but highlighted systemic constraints. In Lira, DAO Dorcas Alum (field interview, September 2025) reported that unpredictable rainfall disrupts planting calendars and causes flooding. She noted that training on climate-smart agronomic practices is ongoing but limited by low adoption and input costs. In Butaleja and Bugiri, DAOs acknowledged the paradox of the Doho irrigation scheme a source of both opportunity and risk. Flooding sometimes washes away seedlings, yet the scheme remains vital for production. Officers emphasized the need for better drainage, cooperative-led credit access, and local water management (field interviews, September 2025). In Nwoya, DAO Alfred Kilama (field interview, November 2025) observed that recurrent droughts "cause flower abortion and poor grain filling," undermining yields despite mechanization and seed programs. He noted that one extension officer often serves over 2,000 farmers, underscoring the need for improved staffing and financing.

Collectively, these perspectives reveal that adaptation is limited less by awareness and more by systemic barriers weak coordination, inadequate funding, and fragmented institutional support.

District Agricultural Officers provided complementary perspectives highlighting how institutional contexts shape adaptation outcomes. Their accounts underscore the complexity of implementing climate interventions amid resource and coordination constraints. Table 4 summarizes key institutional challenges, ongoing adaptation efforts, and observed limitations across the four study districts.

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District	Key Institutional Challenge	Ongoing Adaptation Effort	Observed Limitation
Butaleja	Flooding in Doho irrigation scheme damages seedlings	Water management committees, ACDP activities	Limited drainage and weak cooperative governance
Bugiri	Irregular extension visits	Farmer trainings under ACDP	Few extension officers per sub-county
Lira	Unpredictable rainfall disrupting seasons	Farmer climate training programs	High cost of improved seed and low adoption
Nwoya	Drought and erratic rainfall	Seed multiplication under PRELNOR & PRIDE	Underfunded mechanization, limited credit access

Table 4: Summary of district-level institutional challenges, adaptation efforts, and observed limitations reported by District Agricultural Officers

As shown in Table 4, while projects such as ACDP and PRELNOR promote training and seed access, institutional gaps particularly in staffing, funding, and coordination limit their reach. The overlap of mandates and insufficient district-level integration further weaken long-term sustainability.

C. CROSS-CUTTING THEMES

Thematic synthesis across the study districts revealed three overarching themes that cut across all rice production systems: knowledge–practice gaps, institutional fragmentation, and emerging resilience. These themes capture the key drivers and constraints shaping adaptation among smallholder farmers. Table 5 summarizes each theme alongside corresponding field examples and policy implications that can inform climate-smart agricultural interventions.

Theme	Description	Illustrative Example (District)	Policy Implication
Knowledge–Practice Gaps	Farmers know adaptive methods but lack inputs/resources	Lira farmers aware of drought-tolerant varieties but cannot afford seed	Expand input subsidies and credit access
Institutional Fragmentation	Overlapping mandates and parallel programs reduce efficiency	ACDP & PREI duplicating train	
Emerging Resilience	Local innovation and cooperatives driving adaptation	Butaleja cooper pooling seed fu	

Table 5: Summary of cross-cutting themes emerging from focus group discussions and key informant interviews, with illustrative examples and policy implications

As summarized in Table 5, these themes are interdependent farmers' knowledge gaps persist partly due to institutional inefficiencies, while emerging resilience demonstrates how community innovation fills these gaps. Together, they emphasize that sustainable adaptation depends on bridging local knowledge with coordinated institutional action.

a. KNOWLEDGE–PRACTICE GAPS

Farmers understood adaptive practices early planting, drought-tolerant varieties, soil-water conservation but often lacked the resources to apply them. In Lira, trained farmers could not afford improved seed; in Butaleja, canal maintenance was hindered by limited tools and labour. Knowledge without enabling support structures remains insufficient for resilience.

b. INSTITUTIONAL FRAGMENTATION

DAOs highlighted overlapping mandates among adaptation projects. Programs like ACDP and PRELNOR sometimes operate in isolation, duplicating farmer training and input distribution. This weakens coordination and long-term sustainability. Integrating interventions under unified district frameworks could strengthen efficiency and accountability (Kimani et al., 2023).

c. EMERGING RESILIENCE

Despite constraints, local resilience is emerging. Farmers experiment with early-maturing varieties, adjust planting schedules, and exchange weather information via phones and farmer groups. Cooperatives in Butaleja and Bugiri pool resources for seed purchase, while savings groups in Nwoya finance tractor hire and inputs. These grassroots innovations illustrate that smallholders are proactive agents of adaptation. Such initiatives mirror resilience trends observed across sub-Saharan Africa (Ali et al., 2021; Ojo et al., 2023).

Collectively, these insights demonstrate that successful adaptation requires aligning farmer knowledge, institutional capacity, and financial access. The interaction between climatic stressors, farmer responses, and institutional support mechanisms defines the adaptive capacity of Uganda's smallholder rice systems. Figure 2 synthesizes the relationships identified from field discussions and key informant interviews, showing how climatic pressures translate into observed impacts, farmer actions, and institutional interventions that collectively influence adaptation outcomes.

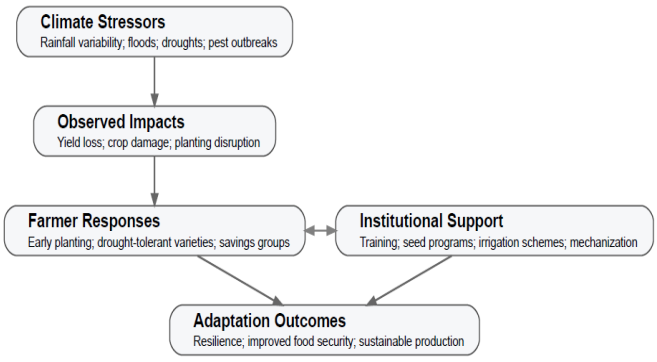

Figure 1: Climate Pressures and Adaptive Responses in Uganda's Smallholder Rice Systems

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Figure 1 illustrates the dynamic interaction between climatic variability, farmer innovation, and institutional capacity in shaping resilience within smallholder rice systems. Climatic stressors including rainfall variability, flooding, drought, and pest outbreaks—generate production impacts such as yield loss, crop damage, and disrupted planting calendars. Farmers respond through adaptive practices such as early planting, use of drought-tolerant varieties, and participation in savings or cooperative groups. Institutional mechanisms complement these actions through extension training, seed distribution programs, irrigation initiatives, and mechanization support. When the interaction between farmer strategies and institutional capacity is strong, adaptation outcomes are sustained and resilience is enhanced; conversely, when it is weak, vulnerability persists, reflected in unstable yields and food insecurity.

Building on the thematic findings presented in Tables 3–5, the study integrates farmer and institutional perspectives into a cohesive understanding of how adaptation unfolds within Uganda's smallholder rice systems. The synthesized framework connects climatic stressors, farmer innovation, and institutional capacity, demonstrating that adaptation is an iterative, multi-level process rather than a linear response to climate risk. Climatic shocks such as erratic rainfall, floods, and drought stimulate farmer actions including early planting, seed selection, and cooperative organization, which are either strengthened or constrained by institutional interventions in training, financing, irrigation, and mechanization.

Figure 2. Interaction Between Climate Stressors, Institutional Capacity, and Farmer Innovation in Uganda's Smallholder Rice Systems

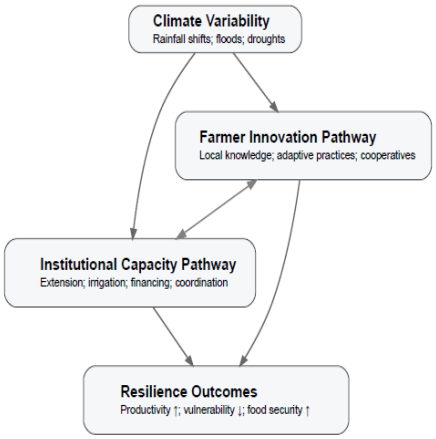

Figure 2: Interaction between climate stressors, institutional capacity, and farmer innovation in Uganda's smallholder rice systems

As illustrated in Figure 2, adaptation among smallholder rice farmers is shaped by the dynamic interaction between climatic stressors, farmer innovation, and institutional support systems. Climate variability triggers both community-level and institutional responses whose effectiveness depends on the strength of coordination, resource availability, and local participation. Ultimately, the integration of farmer experience, collective organization, and institutional mechanisms determines the level of resilience achieved across production systems, reflected in improved productivity, reduced vulnerability, and greater food security.

IV. CONCLUSION AND POLICY IMPLICATIONS

Adaptation in Uganda's smallholder rice systems is driven by both community innovation and institutional capacity. Farmers exhibit strong awareness and initiative but face barriers related to irrigation access, credit, and extension coverage. Institutional fragmentation further constrains effective adaptation.

To transform coping mechanisms into resilience, four policy priorities are essential:

- ✓ Expand small-scale irrigation using renewable energy to reduce dependence on rainfall.
- ✓ Revitalize farmer cooperatives to enhance access to credit, inputs, and marketing.
- ✓ Enhance extension services through digital platforms and increased staffing.
- ✓ Strengthen district-level coordination within Uganda's Climate-Smart Agriculture Framework (2021–2026).

The interaction between farmer-led innovation and institutional capacity contributes not only to local adaptation but also to the realization of broader development goals. Figure 3 depicts the pathway through which local and institutional adaptation processes enhance productivity, household incomes, food security, and climate resilience linking community-level adaptation to national and global objectives under Uganda's Climate-Smart Agriculture Framework and the Sustainable Development Goals (SDGs).

Figure 3. Pathway from Local & Institutional Adaptation to SDGs

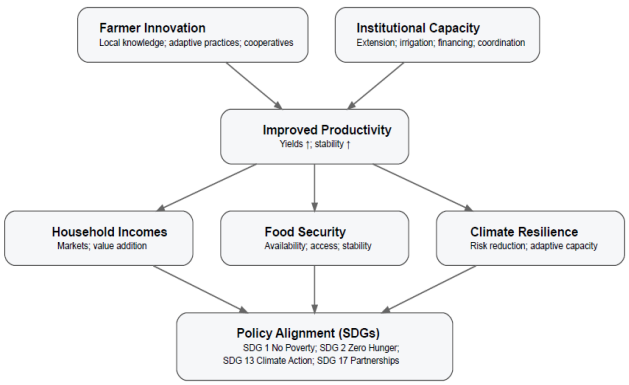

Figure 3: Pathway from local and institutional adaptation to the Sustainable Development Goals (SDGs)

Farmer innovation and institutional capacity jointly improve productivity, which translates into higher household incomes, greater food security, and strengthened climate resilience. These outcomes align with SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 17 (Partnerships for the Goals), emphasizing the multi-level significance of adaptive practices in Uganda's smallholder rice systems.

Future research should track how farmers' adaptive strategies evolve over time to assess the long-term outcomes of institutional interventions. This study contributes new empirical evidence on how institutional dynamics shape local adaptation processes in Uganda's rice subsector. By bridging community and institutional perspectives, this study contributes to participatory climate governance dialogue in sub-Saharan Africa. It emphasizes that building climate

resilience requires both empowered local institutions and sustained farmer-driven innovation.

The interconnected pathways through which farmer innovation and institutional capacity enhance productivity, food security, and resilience also align with Uganda's national and global development goals. Figure 3 illustrates how these adaptive processes contribute directly to the realization of Sustainable Development Goals (SDGs) 1, 2, 13, and 17, emphasizing that strengthening both local and institutional adaptation systems is central to achieving climate-smart agricultural transformation.

To translate the study's findings into actionable steps, Table 6 presents a policy actions matrix specifying priority interventions, responsible actors, and expected impacts.

Identified Gap	Recommended Action	Responsible Actors	Expected Impact
Weak extension coverage and low adoption	Scale digital advisory services; increase staffing and mobility for extension agents	MAAIF, District LGs, NARO	Improved reach and timely advisory; higher adoption of climate-smart practices
Limited access to irrigation and water control	Promote solar-powered small-scale irrigation; rehabilitate/maintain drainage in lowlands	District LGs, Private sector, MWE	Reduced rainfall dependence; lower seedling loss; yield stability
Underperforming or nascent cooperatives	Leadership and governance training; link cooperatives to credit and markets	MAAIF, MoTIC, NGOs	Stronger bargaining power; better input access; sustained adaptation
Fragmented project delivery and coordination	Establish district climate coordination units; integrate ACDP, PRELNOR, PRIDE activities	NPA, District LGs, MAAIF, Development partners	Reduced duplication; greater efficiency and accountability
High cost of improved seed and inputs	Targeted input subsidies/vouchers; bulk procurement through cooperatives	MAAIF, District LGs, Cooperatives	Higher uptake of improved varieties; productivity gains; risk reduction

*Note: Note: MAAIF = Ministry of Agriculture, Animal Industry and Fisheries; NARO = National Agricultural Research Organisation; LG = Local Government; MWE = Ministry of Water and Environment; MoTIC = Ministry of Trade, Industry and Cooperatives; NGO = Non-Governmental Organization; NPA = National Planning Authority; ACDP = Agricultural Cluster Development Project; PRELNOR = Project for the Restoration of Livelihoods in the Northern Region; PRIDE = Project for Inclusive Dairy and Enterprise Development.**

Table 6: Policy actions matrix translating study findings into priority interventions, responsible actors, and expected impacts

Implementing these actions in a coordinated manner would help districts move from short-term coping to sustained adaptation and resilience. The integrated framework in Figure 4 synthesizes the study's insights, showing how climate variability activates farmer-led and institutional pathways that converge into resilience outcomes and contribute to the SDGs.

Figure 4. Integrated Framework for Resilient Rice Systems

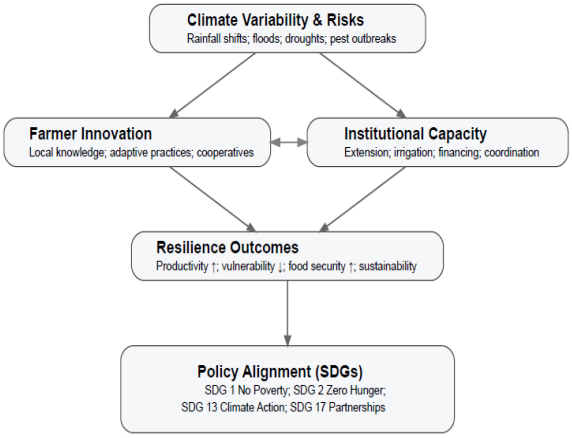

Figure 4: Integrated framework linking climate variability, farmer innovation, institutional capacity, and resilience outcomes with SDG alignment in Uganda's smallholder rice systems

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