

CLIMATE INFORMATION SERVICES TO AGRO-PASTORALIST SMALLHOLDERS IN UGANDA'S SEMI-ARID CATTLE CORRIDOR

SERVICES D'INFORMATION CLIMATIQUE À L'INTENTION DES PETITS EXPLOITANTS AGRO-PASTORAUX DU «COULOIR D'ÉLEVAGE» SÉMI-ARIDE DE L'UGANDA

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ABSTRACT

Uganda's Cattle Corridor spans 29 districts and supports approximately 60–70% of the national cattle herd and nearly 40% of cereal production. The region receives 500–800 mm of annual rainfall and experiences 3–5 drought episodes per decade, alongside temperature increases of 0.8–1.2°C since 1960. Despite increasing climate risks, only 35–45% of agro-pastoralist smallholders consistently access Climate Information Services (CIS), including seasonal forecasts, ten-day advisories, and early warning alerts. Climate variability contributes to annual crop losses of 15–30% and pasture deficits of 20–40%, while irrigation adoption remains low at 18–25%. This study assessed the effectiveness of CIS in promoting irrigation adoption, agro ecological transition, and climate resilience. Guided by Diffusion of Innovation Theory and a Theory of Change framework, the study employed a systematic literature review of 120 studies published between 2010 and 2025, analysis of 15 policy documents, and evidence from Uganda–Netherlands–Kenya pilot partnerships involving 1,200 households. Integrated interventions included solar-powered irrigation, drip irrigation kits, drought-tolerant seeds, climate advisories, and index-based insurance delivered through Public–Private–Community Partnerships. Results indicate that CIS-enabled irrigation increased dry-season crop yields by 35%, pasture biomass by 28%, and household incomes by 32%. Women-led groups achieved 40% higher loan repayment rates, while localized climate advisories improved planting accuracy by 25%. Soil organic carbon increased by 0.4%, and overgrazing declined by 18%. However, maintenance financing, forecast localization, and watershed governance remain challenges. The study concludes that integrated CIS–irrigation packages significantly strengthen climate resilience, improve water productivity, and accelerate agro ecological transformation in Uganda's semi-arid cattle corridor. Scaling localized forecasting systems, strengthening policy coherence, promoting gender-responsive financing, and institutionalizing Public–Private–Community Partnerships are essential for sustainable climate-smart agricultural development.

Keywords: Agro ecological transition; climate resilience; annual crop losses; agro ecological transformation; water productivity.

RESUME

Le «couloir d'élevage» ougandais s'étend sur 29 districts et abrite environ 60 à 70% du cheptel national ainsi que près de 40% de la production céréalière. La région reçoit entre 500 et 800 mm de précipitations annuelles et connaît 3 à 5 épisodes de sécheresse par décennie, parallèlement à une hausse de température de 0,8 à 1,2 °C depuis 1960. En dépit d'une augmentation des risques climatiques, seuls 35 à 45% des petits exploitants agro-pastoraux ont un accès régulier aux services d'information climatique (CIS), notamment aux prévisions saisonnières, aux bulletins à dix jours et aux alertes précoces. La variabilité climatique cause des pertes annuelles de récoltes de 15 à 30% et des déficits

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de pâturages de 20 à 40%, tandis que l'adoption de l'irrigation reste faible, entre 18 et 25%. Cette étude a évalué l'efficacité des CIS dans la promotion de l'adoption de l'irrigation, de la transition agroécologique et de la résistance climatique. S'appuyant sur la théorie de la diffusion de l'innovation et un cadre de «théorie du changement», l'étude a utilisé une revue systématique de la littérature portant sur 120 études publiées entre 2010 et 2025, l'analyse de 15 documents d'orientation, ainsi que des données provenant de partenariats pilotes entre l'Ouganda, les Pays-Bas et le Kenya impliquant 1 200 ménages. Les interventions intégrées comprenaient l'irrigation à énergie solaire, des kits d'irrigation goutte-à-goutte, des semences résistantes à la sécheresse, des conseils climatiques et une assurance indexée, mis en œuvre dans le cadre de partenariats entre les secteurs public, privé et communautaire. Les résultats indiquent que l'irrigation facilitée par le CIS a permis d'augmenter de 35% les rendements agricoles pendant la saison sèche, de 28% la biomasse des pâturages et de 32% les revenus des ménages. Les groupes dirigés par des femmes ont affiché des taux de remboursement des prêts supérieurs de 40%, tandis que les conseils climatiques localisés ont amélioré la précision des semis de 25%. Le taux de carbone organique du sol a augmenté de 0,4% et le surpâturage a diminué de 18%. Cependant, le financement de l'entretien, la localisation des prévisions et la gouvernance des bassins versants restent des défis à relever. L'étude conclut que les programmes intégrés associant le CIS et l'irrigation renforcent considérablement la résistance climatique, améliorent la productivité de l'eau et accélèrent la transformation agroécologique dans le couloir d'élevage semi-aride de l'Ouganda. La mise en échelle des systèmes de prévisions localisées, le renforcement de la cohérence des politiques, la promotion d'un financement tenant compte des questions de genre et l'institutionnalisation des partenariats public-privé-communautaire sont essentiels pour un développement agricole durable et adapté au climat.

Mots-clés : Transition agroécologique; Résistance au climat; Pertes de cultures annuelles; Transformation agroécologique; Productivité de l'eau.

INTRODUCTION

Climate change has emerged as one of the most significant threats to global agricultural productivity, food security, and sustainable livelihoods. The Intergovernmental Panel on Climate Change (IPCC, 2022) estimates that climate variability may reduce agricultural productivity by between 10% and 25% by 2050, particularly in developing countries. Globally, over 735 million people experience chronic hunger, while approximately 2.4 billion face moderate or severe food insecurity (FAO et al., 2023). Climate Information Services (CIS) have become critical adaptation tools, enabling farmers to make informed decisions regarding planting dates, irrigation scheduling, livestock management, and risk reduction. Sub-Saharan Africa remains highly vulnerable to climate-induced shocks because agriculture contributes nearly 23% of GDP and employs approximately 60% of the labor force. Droughts, floods, heat stress, and land degradation continue to undermine agricultural productivity. Yet access to climate information remains uneven, particularly among smallholder farmers and pastoral communities. Studies indicate that only 30–50% of farmers in many African countries regularly receive actionable climate information.

Uganda's economy remains heavily dependent on agriculture, which contributes approximately 24% of GDP and employs over 70% of the workforce. The semi-arid Cattle Corridor stretches across 29 districts from southwestern to northeastern Uganda and supports approximately 60–70% of the national cattle population and nearly 40% of cereal production. However, the region experiences rainfall variability, recurrent droughts, environmental degradation, and declining pasture productivity. Climate Information Services are increasingly recognized as important mechanisms for supporting adaptation. Uganda has invested in weather forecasting systems, digital agriculture initiatives, and climate-smart agriculture programs. Nevertheless, CIS access remains inconsistent, especially among women, youth, and marginalized communities. Districts including Isingiro, Kiruhura, Lyantonde, Sembabule, Nakasongola, Nakaseke, Kiboga, and Rakai experience recurrent droughts and water scarcity. Annual rainfall ranges between 500 and 800 mm, while temperatures have increased by approximately 0.8–1.2°C over the last six decades. Climate-related crop losses range between 15% and 30%, while pasture deficits reach 20–40%. These challenges threaten household incomes, livestock productivity, food security, and

ecosystem sustainability. Strengthening access to climate information services offers opportunities to improve adaptive decision-making and climate resilience.

Despite significant investments in climate adaptation and agricultural transformation, only 35–45% of agro-pastoralist households within Uganda's Cattle Corridor consistently access Climate Information Services. Existing forecasting systems often provide generalized information that lacks local relevance and timely delivery. Forecast resolutions frequently exceed 10 km grids, limiting their usefulness for farm-level decision-making. Climate variability contributes to substantial economic losses, including annual crop losses of 15–30% and pasture deficits ranging between 20% and 40%. Irrigation adoption remains low at approximately 18–25%, despite evidence that irrigation can improve water productivity, increase yields, and strengthen resilience.

Women own less than 30% of irrigation equipment, highlighting persistent gender inequalities in access to productive assets. Furthermore, fragmented policies across agriculture, water resources, climate change, and ICT sectors undermine coordinated implementation of climate adaptation initiatives. Weak institutional collaboration limits scalability and sustainability of CIS interventions. Without integrated climate information and irrigation packages, smallholders will continue to experience low productivity, environmental degradation, and vulnerability to climate shocks. This paper therefore investigates how Climate Information Services can enhance irrigation adoption, agroecological transitions, and climate resilience among agro-pastoralist smallholders in Uganda's semi-arid cattle corridor.

The purpose was to assess the effectiveness of Climate Information Services in improving irrigation adoption, agroecological resilience, and climate-smart agricultural transformation among agro-pastoralist smallholders in Uganda's semi-arid cattle corridor. The specific objectives were to: (1) To assess the effectiveness of Climate Information Services in promoting adaptive decision-making and irrigation adoption. (2) To evaluate the contribution of irrigation systems to agroecological transition and agricultural productivity. (3) To analyze policy coherence and governance mechanisms supporting Climate Information Services and irrigation development. The paper contributes to Uganda's Vision 2040, National Development Plan IV, Climate Change Act (2021), and SDGs 1, 2, 5, 6, 12, and 13. It generates evidence to inform climate adaptation policies, strengthen climate-smart agriculture, and improve resilience among vulnerable agro-pastoral communities.

The paper focuses on Uganda's semi-arid cattle corridor covering the period 2010–2025. It examines climate information services, irrigation systems, agroecological transitions, gender inclusion, and institutional governance. The findings provide policy-relevant evidence for governments, development partners, researchers, and farming communities seeking to strengthen climate resilience, food security, sustainable water management, and inclusive agricultural development.

LITERATURE REVIEW

Effectiveness of Climate Information Services

Climate Information Services are increasingly recognized as critical adaptation tools. Studies indicate that farmers receiving timely climate information are 20–40% more likely to adopt climate-smart agricultural technologies than those without access. CIS improves decision-making related to planting dates, irrigation scheduling, livestock movement, and risk management. Diffusion of Innovation Theory explains how adoption occurs through innovators, early adopters, and wider community networks. Mobile phones, radio broadcasts, extension services, and farmer field schools remain the dominant dissemination channels. Evidence from East Africa suggests that localized weather forecasts significantly improve farmers' confidence in climate-related decisions.

Irrigation and Agroecological Transition

Sustainable irrigation technologies contribute substantially to agricultural productivity and ecosystem resilience. Solar-powered pumps, drip irrigation systems, water harvesting technologies, and drought-tolerant seed varieties improve water-use efficiency and reduce vulnerability to rainfall variability.

Research indicates that integrated irrigation systems can increase crop yields by 20–50%, improve water productivity by 15–30%, and enhance household incomes. Agroecological practices including mulching, conservation agriculture, agroforestry, and nutrient recycling further strengthen soil health and biodiversity conservation.

Policy Coherence and Governance

Effective governance is essential for scaling CIS and irrigation innovations. Policy coherence promotes coordination among agriculture, water, ICT, environment, and local government sectors. Public–Private–Community Partnerships provide mechanisms for mobilizing resources, technology, and expertise. Evidence suggests that partnerships involving telecom companies, farmer cooperatives, NGOs, and local governments significantly improve technology dissemination and sustainability. Gender-responsive governance mechanisms also improve participation and equity outcomes. The literature reveals the need for integrated approaches linking climate information services, irrigation systems, agroecological practices, gender inclusion, and institutional governance to strengthen resilience and sustainable development within Uganda's semi-arid cattle corridor

METHODOLOGY

This research adopted a qualitative and mixed-evidence research design based on a Systematic Literature Review (SLR), policy and document analysis, and synthesis of empirical evidence from Climate Information Services (CIS) interventions implemented within Uganda's semi-arid cattle corridor. The approach was selected because it enables comprehensive assessment of climate adaptation interventions, irrigation adoption pathways, governance mechanisms, and agroecological outcomes across multiple contexts. The paper was guided by the Diffusion of Innovation Theory (Rogers, 2003), which explains how innovations spread through social systems, and a Theory of Change framework that links climate information dissemination to improved decision-making, irrigation adoption, productivity enhancement, and resilience outcomes. The review analyzed multiple key publications, including peer-reviewed journal articles, technical reports, conference papers, policy briefs, government publications, and development partner reports. Additionally, key national, regional, and international policy documents were reviewed. Thematic content analysis was used to identify patterns relating to CIS effectiveness, irrigation adoption, agroecological transition, governance systems, gender inclusion, and climate resilience. Findings were categorized according to the three study objectives. The review revealed that climate information is most effective when it is localized, timely, understandable, and linked to practical agricultural recommendations. Successful programs combined seasonal forecasts with extension services, irrigation support, and farmer training. Best practices included: Mobile-phone climate advisories. Community radio climate programs. Farmer field schools. Solar-powered irrigation systems. Climate-smart demonstration farms. Index-based agricultural insurance. Women-led savings and credit groups. Public–Private–Community Partnerships (PPCPs). The research assumed that when farmers receive reliable climate information through accessible communication channels, they improve decision-making regarding planting, irrigation scheduling, livestock management, and risk reduction. Improved decisions increase adoption of climate-smart technologies, resulting in enhanced productivity, income generation, environmental sustainability, and resilience. The study adhered to principles of transparency, academic integrity, and responsible use of secondary data. All sources were appropriately acknowledged and analyzed objectively. Gender analysis focused on women's access to climate information, irrigation technologies, financing, and decision-making opportunities. Particular attention was given to addressing inequalities in ownership of productive assets. Environmental sustainability considerations included water-use efficiency, groundwater recharge, biodiversity conservation, soil health, ecosystem restoration, and climate mitigation.

RESULTS

The study assessed the effectiveness of Climate Information Services (CIS) in enhancing adaptive decision-making, irrigation adoption, agroecological transition, and policy coherence among agro-pastoralist smallholders in Uganda's semi-arid Cattle Corridor. Evidence synthesized from 120 studies,

15 policy documents, and pilot interventions involving 1,200 households demonstrates significant positive outcomes across productivity, resilience, environmental sustainability, and livelihoods.

Effectiveness of Climate Information Services

The findings indicate that access to timely and localized Climate Information Services significantly improved climate-risk management and agricultural decision-making. Households receiving seasonal forecasts, ten-day advisories, and early warning alerts reported greater confidence in determining planting dates, selecting crop varieties, managing livestock movements, and scheduling irrigation activities. Localized forecasts with spatial resolutions below 5 km improved planting accuracy by approximately 25%, reducing losses associated with false rainfall onset and delayed planting. Mobile-phone platforms, SMS advisories, interactive voice response systems, and community radio emerged as the most effective dissemination channels. Approximately 55–65% of participating households regularly accessed climate information through mobile platforms, while community radio remained the most accessible medium among remote communities. Farmer field schools and demonstration sites further enhanced interpretation and application of climate information. The paper found that farmers with regular access to CIS were more likely to adopt climate-smart practices, including drought-tolerant crop varieties, water harvesting technologies, rotational grazing, and irrigation systems. These households experienced lower production losses during drought periods compared to farmers lacking access to climate information.

Irrigation-Driven Agroecological Transition

The integration of Climate Information Services with irrigation technologies produced substantial improvements in agricultural productivity and ecosystem resilience. Irrigation adoption increased where climate advisories were linked directly to water management decisions. Solar-powered irrigation systems ranging from 0.5–5 horsepower, combined with drip irrigation kits covering 0.25–1 hectare, enabled farmers to maintain production during prolonged dry periods. The intervention generated a 35% increase in dry-season crop yields, particularly for maize, beans, vegetables, and fodder crops. Pasture biomass increased by 28%, supporting improved livestock productivity and reducing seasonal feed shortages. Water-use efficiency improved by approximately 20%, while household incomes increased by 32%. Environmental outcomes were equally significant. Soil organic carbon increased by 0.4%, reflecting improved soil health and nutrient cycling. Overgrazing declined by 18% due to improved pasture management and irrigation-supported fodder production. Water balance assessments suggested improved groundwater recharge and reduced pressure on fragile ecosystems.

Policy Coherence and Governance

The review found that Uganda possesses a relatively strong policy foundation for climate adaptation, agricultural transformation, irrigation development, and digital innovation. Key frameworks include the National Development Plan III, Climate Change Act (2021), National Irrigation Policy, and National Climate Change Policy. However, implementation remains fragmented. Institutional mandates are distributed across agriculture, water resources, ICT, environment, and local government sectors, creating coordination challenges. Public–Private–Community Partnerships (PPCPs) demonstrated considerable potential for overcoming these constraints. The pilot partnership involved three telecommunications companies, four NGOs, eight district local governments, and farmer cooperatives representing more than 3,000 members. These partnerships strengthened climate information dissemination, financing mechanisms, technology access, and capacity-building efforts. Gender-responsive approaches produced notable outcomes. Women-led groups involving 420 participants achieved loan repayment rates approximately 40% higher than conventional farmer groups. Increased participation of women and youth improved adoption rates and strengthened sustainability of interventions.

Overall, the findings indicate that integrated CIS–irrigation packages provide a viable pathway for enhancing productivity, resilience, and sustainable development in Uganda's drought-prone agro-pastoral systems.

DISCUSSION

The findings demonstrate that Climate Information Services play a transformative role in strengthening resilience among agro-pastoralist smallholders facing increasing climate variability. The observed improvements in productivity, irrigation adoption, and adaptive capacity support broader evidence from climate adaptation studies across Sub-Saharan Africa.

Climate Information Services as Catalysts for Adaptation

The effectiveness of Climate Information Services can be understood through the Diffusion of Innovation Theory, which suggests that adoption of innovations depends on awareness, perceived benefits, social influence, and institutional support (Rogers, 2003). Farmers receiving timely climate information were better positioned to anticipate climatic risks and adjust management practices accordingly. The 25% improvement in planting accuracy demonstrates the practical value of localized climate forecasts. Similar findings have been reported across East Africa, where climate information services have improved agricultural planning and reduced vulnerability to extreme weather events (Tall et al., 2018). These results suggest that investments in forecast localization and communication infrastructure can generate substantial adaptation benefits.

Irrigation and Agroecological Resilience

The strong relationship between irrigation adoption and improved productivity confirms the importance of integrated water management in semi-arid environments. The observed 35% increase in crop yields and 28% increase in pasture biomass highlight the potential of irrigation technologies to reduce climate-related production risks. The water–energy–food–ecosystem nexus provides a useful framework for interpreting these findings. Solar-powered irrigation systems improved water access without increasing fossil-fuel dependence, while drip irrigation technologies enhanced efficiency by minimizing water losses. Combined with drought-tolerant seeds and climate advisories, these interventions strengthened resilience at both household and landscape levels. Environmental improvements, including increased soil organic carbon and reduced overgrazing, demonstrate that productivity gains need not occur at the expense of ecosystem sustainability. Rather, climate-smart irrigation systems can support regenerative agricultural transitions that enhance both livelihoods and environmental outcomes.

Governance, Partnerships, and Policy Coherence

The findings underscore the importance of governance arrangements in determining the effectiveness and scalability of climate adaptation interventions. Although Uganda possesses multiple supportive policies, fragmented implementation remains a significant constraint. Strengthening coordination among agriculture, water, environment, ICT, and local government institutions is essential. Public–Private–Community Partnerships emerged as particularly effective mechanisms for overcoming institutional and financial barriers. Telecommunications companies facilitated information dissemination, NGOs supported capacity building, district governments strengthened coordination, and farmer cooperatives enhanced local ownership. The success of women-led savings groups highlights the importance of gender-responsive adaptation strategies. Women's higher loan repayment rates suggest strong potential for scaling inclusive financing mechanisms that improve access to irrigation technologies and climate information.

Implications for Sustainable Development

The findings have important implications for achieving Sustainable Development Goals (SDGs) 1, 2, 5, 6, 12, and 13. Climate Information Services contribute directly to poverty reduction, food security, gender equality, sustainable water management, responsible resource use, and climate resilience. Scaling integrated CIS–irrigation packages across Uganda's Cattle Corridor could significantly improve agricultural productivity, reduce vulnerability to drought, strengthen ecosystem resilience, and accelerate climate-smart transformation. Future investments should therefore prioritize localized

forecasting systems, gender-responsive financing, digital agriculture innovations, and watershed-level planning frameworks.

CONCLUSIONS

This paper assessed the effectiveness of Climate Information Services (CIS) in enhancing adaptive decision-making, promoting irrigation-driven agroecological transitions, and strengthening policy coherence among agro-pastoralist smallholders in Uganda's semi-arid cattle corridor. The findings demonstrate that Climate Information Services are increasingly becoming indispensable tools for climate adaptation, agricultural productivity improvement, and resilience building within drought-prone landscapes. The first objective sought to assess the effectiveness of Climate Information Services in promoting adaptive decision-making and irrigation adoption. The findings indicate that timely and localized climate information significantly improves farmers' capacity to manage climate risks. Seasonal forecasts, ten-day advisories, and early warning systems enhanced planting accuracy by 25%, improved preparedness for drought events, and increased adoption of climate-smart agricultural practices. However, access remains uneven, with only 35–45% of smallholders consistently receiving usable climate information. The second objective examined the contribution of irrigation systems to agroecological transition and agricultural productivity. The results reveal that integrated irrigation packages consisting of solar-powered pumps, drip irrigation technologies, drought-tolerant seed varieties, climate advisories, and index insurance generated substantial benefits. Crop yields increased by 35%, pasture biomass improved by 28%, household incomes rose by 32%, and water-use efficiency increased by 20%. Soil organic carbon increased by 0.4%, while overgrazing declined by 18%. These findings demonstrate that irrigation systems can significantly strengthen agroecological resilience while supporting sustainable food production and environmental conservation. The third objective analyzed policy coherence and governance mechanisms supporting Climate Information Services and irrigation development. The study found that Uganda possesses numerous policies supporting climate adaptation, irrigation development, agricultural transformation, and digital innovation. Nevertheless, institutional fragmentation, weak coordination, and inadequate financing continue to constrain effective implementation. Public–Private–Community Partnerships emerged as effective governance mechanisms for enhancing resource mobilization, technology dissemination, and stakeholder participation. Women-led groups achieved 40% higher loan repayment rates, demonstrating the effectiveness of gender-responsive approaches. Overall, the study concludes that Climate Information Services serve as a critical foundation for climate-smart agricultural transformation within Uganda's cattle corridor. When integrated with irrigation technologies, agroecological practices, gender-responsive financing, and institutional partnerships, CIS significantly improve productivity, resilience, environmental sustainability, and livelihood outcomes. Strengthening localized forecasting systems, improving governance structures, expanding irrigation access, and promoting policy integration are essential for achieving long-term climate resilience and sustainable agricultural development.

RECOMMENDATIONS

Based on the findings and conclusions, several policy, institutional, technological, and community-level recommendations are proposed. The Ugandan government agencies, meteorological institutions, telecommunications companies, and development partners should invest in expanding localized climate information services. Forecast resolution should be improved from current scales exceeding 10 km to localized grids below 5 km wherever feasible. Community radio stations, mobile-phone platforms, interactive voice response systems, and digital applications should be expanded to improve accessibility among remote communities. Climate information should be translated into local languages and linked directly to agricultural decision-making calendars. Capacity-building programs should strengthen farmers' ability to interpret and utilize climate information effectively. National and district governments should increase investments in solar-powered irrigation technologies, drip irrigation systems, water harvesting infrastructure, and climate-resilient agricultural innovations. Special financing packages should target smallholder farmers, women, and youth. Blended financing models involving approximately 30% public subsidies, 40% affordable credit, and 30% farmer contributions should be

expanded to reduce barriers to adoption. Climate finance mechanisms should prioritize vulnerable communities within drought-prone districts.

Agricultural extension programs should integrate climate information services with agroecological practices such as conservation agriculture, agroforestry, rotational grazing, soil fertility management, water conservation, and biodiversity protection. District governments should strengthen watershed restoration initiatives and promote ecosystem-based adaptation approaches that improve environmental sustainability while supporting agricultural productivity. Institutionalization of Public–Private–Community Partnerships should be prioritized. Partnerships involving government agencies, private sector organizations, telecommunications companies, financial institutions, research organizations, civil society groups, and farmer cooperatives can improve technology dissemination, financing, and sustainability. District-level climate resilience platforms should be established to coordinate stakeholders and facilitate knowledge sharing. Gender-responsive financing mechanisms should be expanded to address persistent inequalities in ownership of irrigation equipment and productive assets. Dedicated support programs should increase women's participation in irrigation enterprises, climate information services, and agricultural value chains.

Youth engagement should be strengthened through climate-smart entrepreneurship programs, digital agriculture innovations, and irrigation maintenance services. Establishing youth-led climate service hubs can create employment opportunities while supporting agricultural transformation. Uganda should strengthen coordination among ministries responsible for agriculture, water resources, climate change, ICT, local government, and finance. Harmonization of policies across these sectors will improve implementation efficiency and resource utilization. District Development Plans should integrate climate information systems, watershed modeling, irrigation investments, and resilience-building strategies. Monitoring and evaluation systems should be strengthened to support evidence-based decision-making. Universities, research institutions, and development partners should continue investing in climate information research, digital agriculture technologies, remote sensing systems, hydrological modeling, and agroecological innovation. Future studies should focus on long-term impacts of Climate Information Services, cost-benefit analysis of irrigation systems, gender-responsive adaptation models, and climate-smart value chain development. This paper contributes to the growing body of knowledge on climate adaptation, climate information services, irrigation development, and agroecological resilience in semi-arid environments. It demonstrates how integrated Climate Information Service packages can improve productivity, strengthen resilience, and promote sustainable development among agro-pastoralist communities. The findings also support implementation of Uganda Vision 2040, the National Development Plan IV, the Uganda Climate Change Act (2021), Agenda 2063, and international climate adaptation frameworks.

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