Space-IoT Solution Box for Climate-Smart Agriculture in Africa

"Empowering Climate-Smart Agriculture with Copernicus and IoT Innovations for Smallholder Farmers in Africa"

Report D2.1

Requirements for Space-IoT centric Regional Development Strategy

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EXECUTIVE SUMMARY

The Lake Victoria Basin (LVB) supports millions of smallholder farmers and fishers in Kenya, Uganda, and Tanzania, yet their livelihoods are increasingly threatened by climate variability and change. Erratic rainfall, prolonged droughts, soil degradation, and declining water quality continue to undermine food security and rural incomes. While Climate-Smart Agriculture (CSA) has been identified as a pathway to resilience and sustainability, adoption remains limited due to weak institutional coordination, inadequate financing, and low uptake of modern technologies. Although each Partner State has developed CSA strategies, implementation has been fragmented and poorly aligned with farmer realities. To address these gaps, the KijaniSpace Programme, through Work Package 2 (WP2), commissioned the needs assessment to consolidate evidence from inception, review, baseline studies and stakeholder consultation workshops in Kenya and Tanzania. The overall objective was to develop a comprehensive report that provides outputs for actionable recommendations, while highlighting opportunities for leveraging Space–Internet of Things (IoT) technologies to enhance the resilience and sustainability of agriculture and fisheries in the region. The needs assessment study employed a mixed-methods approach. A desktop review examined CSA-related policies, legal and institutional frameworks, and digital innovation strategies at national, regional, and global levels. A baseline survey, complemented by key informant interviews and focus group discussions across the three Partner States, generated farmer-level evidence. Quantitative data were analysed using descriptive and inferential statistics, while qualitative data were thematically reviewed. Triangulation of desk and field evidence ensured validity and robustness of the findings. The results revealed that CSA needs vary by value chain and geography, with drought-tolerant seeds prioritized by 42% of respondents in Kenya, irrigation cited by 38% in Uganda, soil fertility management emphasized by 45% in Tanzania, and aquaculture inputs consistently prioritized across all three countries (over 50% overall). Agroforestry and organic manure use are emerging in Kenya and Tanzania, while aquaculture expansion is evident across all three countries. Awareness of Earth Observation (EO) and IoT technologies was low (below 20% across all three countries), but demand for digital advisory services, tools, and training was strong, with over 70% of farmers indicating interest in mobile-based advisory platforms and more than 65% requesting training support. At the institutional level, CSA policies exist but remain underfunded, weakly disseminated, and poorly linked to farmer realities, the need for a multi stakeholder platform to enhance information sharing, policy influencing and alignment and cascading of solutions to farmers was highly recommended, though it was cognizant that there is need for proper structuring, resource mobilization and leadership at country and regional level for such MSPs to take off and thrive. The study concludes that farmers are aware of the climate related challenges, institutions have developed many enabling policies though fragmented , and therefore EO and IoT can offer solutions to bridge the gap between farmers and their climate related challenges, and the harmonization of fragmented regional policies. However, scaling CSA requires coordination, enabling policies, financing, and capacity-building. Recommendations include scaling access to CSA technologies, deploying EO and IoT solutions via the KijaniBox platform, strengthening extension and digital literacy, harmonizing national CSA frameworks under Lake Victoria Basin Commission (LVBC), and promoting inclusive adoption for women and youth.

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1. Introduction

The KijaniSpace project represents a collaborative, innovation-driven initiative supported under the Horizon Europe programme (Project No. 101180225), coordinated by INNOTEC21 GmbH, and involving a consortium of thirteen beneficiaries from seven countries, including significant participation from Africa and Europe. The project comes in as a collaborative initiative to harness Earth Observation (EO) and Internet of Things (IoT) technologies for climate smart agriculture, fisheries, and environmental management in LVB and possible replication in other Africa transboundary basins. By combining Copernicus EO data, IoT-based monitoring, and smart innovation ecosystems, the KijaniSpace Programme aims to deliver region-specific solutions that strengthen resilience and promote sustainable intensification in the Lake Victoria Basin.

The programme operates in a zone characterized by high population density, fertile soils, and diverse agricultural methodologies, and a context where awareness and adoption of digital tools such as EO and IoT are still very low among farmers, institutions face weak coordination and limited financing, and infrastructure gaps constrain technology deployment. These limitations highlight that, despite the existence of CSA policies and strategies, smallholders still lack access to actionable, real-time data and advisory services. Despite its potential, the region grapples with climate-induced vulnerabilities such as soil erosion, water scarcity, and dwindling fish populations. By piloting inventive solutions in this locale, KijaniSpace aims to showcase scalable models for climate-smart agriculture that can be replicated across Africa and contribute to enduring sustainable economic expansion and green employment creation in Africa and Europe through Copernicus and IoT.

KijaniSpace also underscores capacity enhancement and stakeholder involvement through its Space-IoT Talent and Innovation Programs. These endeavours strive to cultivate local expertise, nurture public-private partnerships, and boost the adoption of digital technologies in agriculture. By amalgamating technological advancement with community empowerment, KijaniSpace endeavours to pave the way for sustainable agricultural practices, economic progress, and enhanced livelihoods in Africa. To deliver on the mandate of the project, stakeholder perspectives, involvement and ownership of the project from the onset is critical. The project therefore planned as part of the initial interventions to undertake multi stakeholder workshops that would enable interactions that inform the project's interventions, and socialization of the project with all the key stakeholders that play a role in the crops and fisheries agriculture value chains in the region.

In Section 2, this deliverable provides an assessment of the region's agroclimatic conditions, identifying both challenges and opportunities, while also examining the agricultural practices prevalent in the LVB, their economic contributions, and the region's inherent strengths. Additionally, it identifies best practices, applications, and initiatives that utilize EO and IoT technologies to promote Climate-Smart Agriculture (CSA). Finally, the study is highlighting the region's CSA priorities to guide public investments, with a focus on shaping regional CSA policies and strategies. In Section 3, we provide the approach that will be taken by the project to engage local stakeholders, with the proposed Multi-Stakeholder Platform.

2. Regional development strategy for climate-smart agriculture

2.1. Overview

Agriculture remains a cornerstone of the economies and livelihoods across East Africa, employing approximately 65–80% of the rural population and contributing significantly to GDP in Kenya, Uganda, and Tanzania (World Bank, 2022). The sector underpins food security, rural incomes, and export revenues, with value chains such as maize, beans, rice, and fisheries forming the backbone of subsistence and trade in the Lake Victoria Basin (LVB). However, agricultural productivity in the region is increasingly threatened by the growing impacts of climate change and variability. Rising temperatures, erratic rainfall, prolonged droughts, and frequent flooding have led to declining crop yields, increased pest and disease outbreaks, and degradation of land and water resources (FAO, 2021).

Smallholder farmers—who dominate agricultural production in the LVB—face heightened vulnerability due to limited access to climate information, modern technologies, and financial services (AGRA, 2020). The implications are far-reaching: food and nutritional insecurity, reduced household incomes, and fragile value chains. In response to these challenges, Climate-Smart Agriculture (CSA) has emerged as a vital approach to transform and reorient agricultural systems to support resilience and food security under climate change. CSA, as defined by FAO (2013), seeks to: (i) sustainably increase agricultural productivity and incomes; (ii) adapt and build resilience to climate change; and (iii) reduce or remove greenhouse gas emissions where possible.

The needs assessment process focused on conducting a multi-country (Kenya, Uganda and Tanzania), evidence-driven assessment of CSA adoption, policy frameworks, and digital technology readiness in the Lake Victoria Basin. It is informed by a comprehensive analysis of primary data collected, detailed findings, and comparative analyses across Kenya, Uganda, and Tanzania, and presents actionable recommendations. Its findings are important for informing and providing contextual direction to subsequent work packages under the project, including the design of a regional CSA strategy, knowledge-sharing platforms, and pilot interventions that demonstrate the value of Space–IoT solutions.

CSA principles are already being integrated into the development agendas of the three targeted countries. Kenya's CSA Strategy (2017–2026), Uganda's CSA Programme (2015–2025), and Tanzania's CSA Guidelines (2017) provide frameworks for scaling up agroforestry, conservation agriculture, improved water management, and climate-resilient crop varieties. Despite these efforts, CSA implementation remains fragmented, underfunded, and constrained by weak institutional coordination, low awareness, and poor uptake of innovative digital solutions (NEPAD, 2014). Moreover, there is inadequate integration of emerging technologies such as satellite imagery, digital advisory platforms, and IoT-based sensors into farming and aquaculture practices. This has left farmers and fishers without the data and decision-support tools they need to cope with increasing climatic risks.

The assessment was guided by several hypotheses: first, that CSA adoption in the LVB is fragmented and varies significantly by geography and value chain; second, that while national and regional CSA policies exist, there is a gap between policy frameworks and farmer-level implementation; and third, that the integration of EO and IoT technologies, if embedded within extension, financing, and capacity-building systems, can accelerate adoption, enhance resilience, and increase productivity in both crop and fisheries systems. This has laid a clear foundation for a Regional CSA Strategy for the LVB, aligned with the mandates of the Lake Victoria Basin Commission (LVBC), national development priorities, and global frameworks such as the Sustainable Development Goals (SDGs) and the Paris Agreement.

2.2. Objectives

The objective is to conduct desk research, surveys to collect data on regional and national R&I, agriculture, food security, and climate policies and strategies in order to understand and analyse gaps in agriculture development strategy taking into account local strength, natural resources, and agro-climatic conditions. Second is to analyse how Space-IoT technologies have been used in agriculture so far and how this EO data from Copernicus can improve the development of the Lake Victoria Basin (LVB) by addressing climate risks and threats.

The specific objectives include:

i. Analysis of the region's agroclimatic conditions, threats and opportunities.

ii. Elaboration of LVB agricultural practices, their economic contribution, and the region's strengths.

iii. Identification of EO and/or IoT empowered CSA best practices, applications, services, projects, and initiatives in the region.

iv. Highlighting the region's CSA priorities for public investments (regional CSA policy and strategy focus).

2.3. Methodology

2.3.1. Literature review

A comprehensive desktop review was undertaken to establish the policy, institutional, and technological context of Climate-Smart Agriculture (CSA) in the Lake Victoria Basin. The review involved systematic analysis of existing literature, including national CSA strategies, climate change policies, agricultural development frameworks, and regional and global agreements such as the EAC Climate Change Policy, the Paris Agreement, and the SDGs. In addition, documents from international development partners (e.g., FAO, World Bank, IFAD, AGRA, and GIZ) were examined to capture best practices and lessons relevant to CSA adoption and digital agriculture. Special emphasis was placed on identifying gaps and opportunities for integrating Earth Observation (EO) and Internet of Things (IoT) technologies within ongoing CSA initiatives. The desktop review provided the analytical foundation for mapping institutional readiness, assessing policy coherence, and highlighting regulatory opportunities that could enable effective uptake of digital and space-based technologies across Kenya, Uganda, and Tanzania.

2.3.2. Study area

This study was conducted in the Lake Victoria Basin (LVB) (Figure 1), the world's second-largest freshwater lake, shared by Kenya (6%), Uganda (43%), and Tanzania (51%), and serving as a critical ecological and socio-economic hub in East Africa (Aura et al, 2024). The basin supports over 40 million people, with livelihoods primarily dependent on smallholder crop farming, aquaculture, capture fisheries, and mixed farming systems (LVBC, 2017). The region is characterized by a tropical climate, with bimodal rainfall patterns that influence agricultural calendars but have become increasingly variable due to climate change, leading to challenges such as delayed rains, droughts, flooding, and rising temperatures (Tumbo et al., 2018). Soils are fertile but vulnerable to erosion and nutrient depletion, particularly under intensified land use. The LVB is also a hotspot for CSA innovations, with governments and regional bodies promoting digital technologies, agroforestry, irrigation, and aquaculture as adaptive strategies (FAO, 2020). However, structural barriers, including weak extension systems, gender inequalities, and inadequate infrastructure, continue to constrain technology adoption. Thus, the LVB provides a representative case for examining the opportunities and challenges of scaling CSA innovations in a climate-vulnerable yet agriculturally productive region.

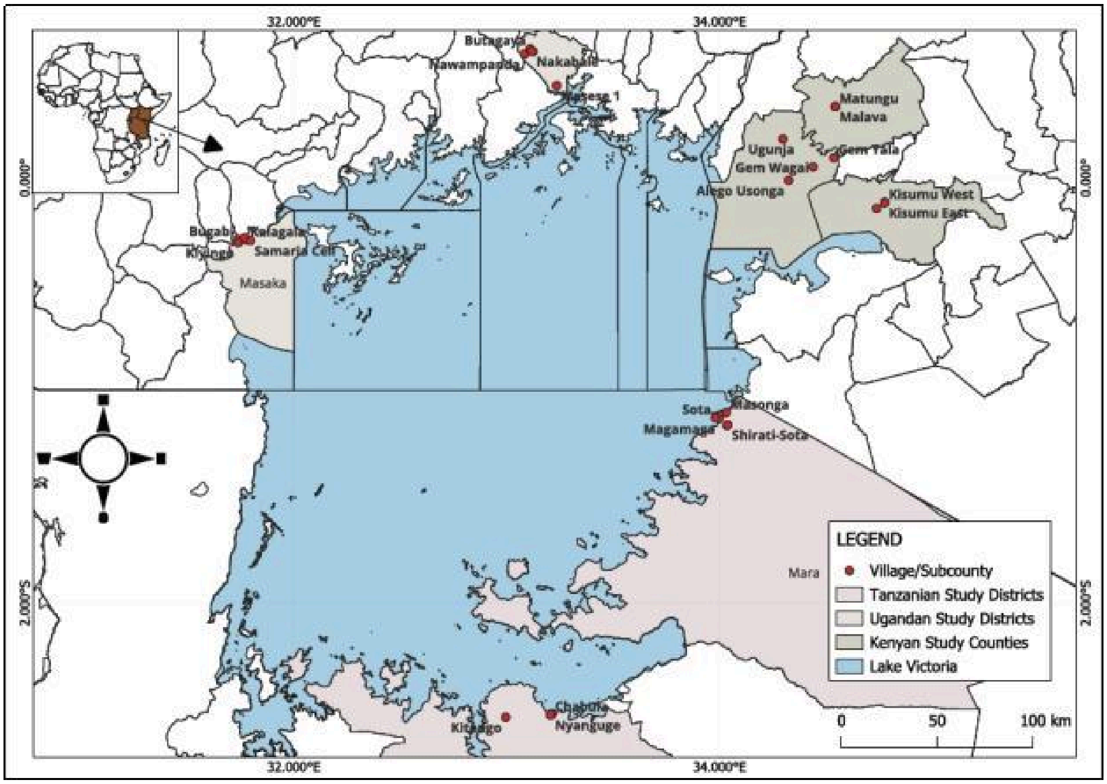

Figure 1. Study area within the Lake Victoria Basin (LVB) for the July – August 2025 Climate Smart Agriculture (CSA) needs assessment survey.

2.3.3. Study design and sampling

This study adopted a cross-sectional survey design focusing on fish farmers, crop farmers and mixed farmers in the LVB. A total of 69 respondents were sampled purposively from three riparian countries: Kenya (n = 29), Tanzania (n = 20), and Uganda (n = 20). The purposiveness was dependent on strata that were selected based on the presence of CSA solutions and technologies in crop farming and fisheries (Aura et al., 2023). Other solutions and technologies that occurred in active aquaculture and mixed farming activities that are highly vulnerable to climate variability were targeted and thus relevant for assessing CSA needs. Table 1 presents the distribution of samples across countries and the percentage achievement of the targeted sampling. From the below samples, and using the Kobo Collect tool, we generated a dataset of 69 valid survey entries corresponding to the number of respondents purposely selected from the three LVB countries. Each entry represents a complete farmer or fisher response across multiple modules structured around the study objectives. The survey covered key variables or strata in purposive sampling including socio-demographic characteristics, production systems, climate-related challenges, awareness and adoption of CSA technologies, use of digital and IoT tools, satisfaction with government support, and policy and governance gaps. These variables were directly aligned with the study's objectives, ensuring that every response contributed to at least one analytical dimension of the research.

Although the sample size (n = 69) may appear modest, it meets the analytical threshold for exploratory and comparative studies in transboundary basins, particularly where purposive sampling targets key information-rich respondents (Creswell, 2009; Etikan, 2016). Furthermore, the key informants were employed to moderate and validate the data and to inform on vital aspects of CSA that may have been considered as outliers. Importantly, the balanced distribution across the three Lake Victoria Basin countries enhanced country specific analysis (non-pooling of data) and representativeness of insights, while also facilitating cross-country comparisons (Aura et al., 2022). The data therefore provides sufficient breadth and depth to draw meaningful patterns and policy-relevant lessons for scaling Climate-Smart Agriculture (CSA) and digital innovations in the LVB.

Table 1. Sample distribution for Key Informant Interviews (KII) across the three countries in the Lake Victoria Basin (LVB) for Climate Smart Agriculture (CSA) based on the July - August 2025 needs assessment survey.

Country	County/ District	Village/ Sub-County	Proportion (No.)			Achieved	Target	Surplus / Deficit	% Achievement
			Crop farmers	Fish farmers	Mixed farmers				
Kenya (KII - 3)	Kisumu	Ahero town	0	1	0	1	2	-1	50
		Kasagam	2	0	1	3	2	1	150
		Kisumu Central	1	1	0	2	2	0	100
		Kisumu East	0	1	0	1	2	-1	50
		Kisumu West	1	0	0	1	1	0	100
		Nyalenda	1	0	0	1	1	0	100
	Siaya	Alego	4	0	0	4	2	2	200
		Gem	1	2	2	5	4	1	125
		Tatro	0	0	1	1	2	-1	50
		Usula	0	0	1	1	2	-1	50
	Kakamega	Ikolomani	0	1	0	1	1	0	100
		Malava	0	1	0	1	1	0	100
		Matungu	0	1	0	1	1	0	100
		Mumias East	0	3	0	3	1	2	300
		Mumias West	0	3	0	3	1	2	300
Tanzania (KII - 1)	Magu	Chabula	0	1	0	1	2	-1	50
		Kitongo	0	2	0	2	2	0	100
		Kongolo	1	1	1	3	2	1	150
		Lutale	0	1	1	2	2	0	100
		Nyambilo	0	1	0	1	1	0	100
		Nyanguge	1	0	0	1	1	0	100
	Rorya	Magamaga	0	1	1	2	2	0	100
		Masonga	0	0	2	2	2	0	100
		Mkoma	0	0	1	1	2	-1	50
		Shirati-Sota	0	1	0	1	2	-1	50

		Sota	0	3	1	4	2	2	200
Uganda (KII - 1)	Jinja	Butagaya	1	1	1	3	2	1	150
		Masese 1	0	2	0	2	2	0	100
		Nakabale	0	1	0	1	2	-1	50
		Nawampanda	0	2	0	1	2	-1	50
		Wansimba	0	2	0	2	1	1	200
		Wansimba-Nakabaale	1	0	0	1	1	0	100
	Masaka	Bugabi		2	0	2	2	0	100
		Kalagala	2	0	0	2	2	0	100
		Kiyingo	1	0	1	2	2	0	100
		Lwabilkele	2	0	0	2	2	0	100
		Samaria Cell	1	1	0	2	2	0	100
Totals			**20**	**36**	**14**	**69**	**65**	**4**	**106.2**

2.3.4. Conceptual framework of the study

Figure 2 illustrates the logical flow of activities from the inception stage to policy recommendation, demonstrating how each step contributes to generating empirical evidence on CSA adoption in the LVB. The process begins with the inception meeting, which serves to align stakeholder priorities, refine the research scope, and validate the study objectives to ensure relevance to the regional CSA context.

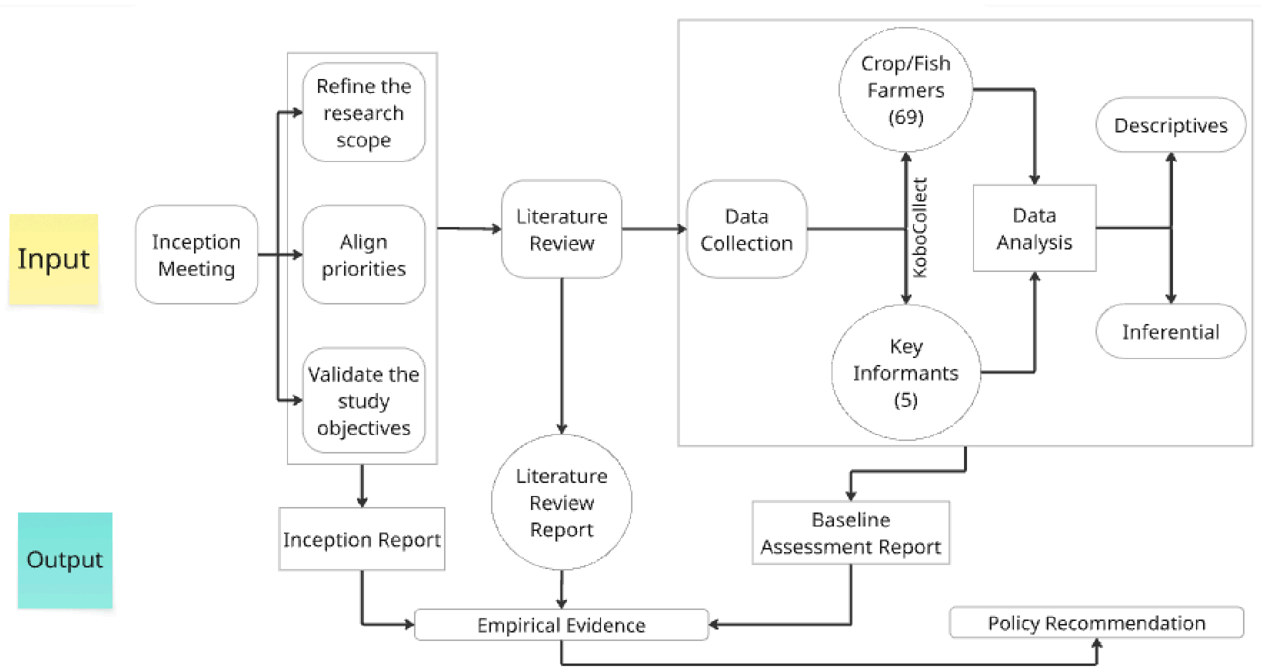

Figure 2. The conceptual framework of the Climate Smart Agriculture (CSA) needs assessment in the Lake Victoria Basin (LVB) for the July – August 2025 Survey.

2.3.5. Data collection

Data collection was carried out from purposely selected crop and fish farmers (n = 69) and key informants (n = 5), using KoboCollect for consistency and accuracy (Aura et al., 2023). The dual focus on farmers and key informants allowed for triangulation of perspectives, enhancing reliability and moderation of results. Subsequent data analysis integrated both descriptive statistics to profile socio-demographics (with assessment of significant variations at $p < 0.05$), practices, and challenges, and inferential statistics to model relationships such as the influence of farmer experience on CSA adoption. This mixed analytical approach provided both breadth and depth in understanding CSA dynamics. Finally, the iterative feedback loop between data analysis and policy recommendation ensures that findings are not only evidence-based but also directly linked to actionable insights, thereby supporting robust CSA strategies in the LVB.

Figure 3. Key Informant Interviews (KIIs) conducted during July - August 2025 Climate Smart Agriculture (CSA) needs assessment survey in the Lake Victoria region: Officer from KALRO, Kenya

2.3.6. Data processing and analyses

The data collected was exported from Kobo Collect into Microsoft Excel for cleaning, coding, and validation, to ensure that inconsistencies, missing values, and duplicates were addressed before running statistical procedures. The cleaned dataset was subsequently analyzed using IBM SPSS Statistics 20, which provided both descriptive and inferential outputs. This type of analysis aligns with established practice in CSA and aquaculture research, where mixed software use enhances accuracy and flexibility (Aura et al., 2023).

Using descriptive statistics, frequencies and percentages were generated for categorical variables such as gender, education level, and production system, while means and standard deviations were computed for continuous variables like years of farming experience. The lack of significant variations ($p > 0.05$) in sociodemographic between the three countries aided the comparison of key variables across the countries as social demographics were deemed not to affect the CSA priority areas. Cross-tabulations were further used to highlight cross-country comparisons, allowing the study to draw out differences and similarities across Kenya, Tanzania, and Uganda. Such descriptive summaries are critical in CSA-focused studies to provide a baseline for understanding the socio-demographic and institutional context of adoption (Rodino & Ifrim, 2022; Quarshie et al., 2025).

Figure 4. One on one farmer interviews conducted during the July-August 2025 CSA needs assessment survey in Kenya.

2.4. Sociodemographic characteristics of farmers in the Lake Victoria Basin

From the table below, we observe that the region's farming practices, both fisheries and crops, are dominated by male farmers across all countries. This is likely due to cultural norms and land ownership patterns that limit women's participation in farming and fisheries. Majority of the farmers are aged between 26–49 years, reflecting active working-age groups, potentially with energy and resources to engage in CSA. Kenya is leading in tertiary education, possibly due to stronger investment in higher learning, while Tanzania and Uganda show higher proportions at primary level due to limited rural education access. Uganda shows stronger cooperative membership, due to historical reliance on farmer groups for credit and extension services, unlike Kenya and Tanzania. There is dominance of private businesses in Tanzania due to commercialization of agriculture, while Uganda relies on cooperatives and Kenya on CBOs, reflecting country-level institutional structures. Kenya shows high smartphone penetration because of stronger digital infrastructure, whereas Uganda depends more on radio and Tanzania on multiple device mixes due to rural access constraints.

Table 2. Sociodemographic characteristics of farmers interviewed in the Lake Victoria Basin (LVB) for the Climate Smart Agriculture (CSA) July – August 2025 needs assessment survey.

Parameter	**Level**	**Kenya**		**Tanzania**		**Uganda**	
		n	**%**	**n**	**%**	**n**	**%**
Gender	Female	9	31.0	4	20.0	5	25.0
	Male	20	69.0	16	80.0	15	75.0
Age	18–25	3	10.3	1	5.0	1	5.0
	26–34	13	44.8	6	30.0	3	15.0
	35–49	7	24.1	9	45.0	10	50.0
	50–64	6	20.7	4	20.0	3	15.0
	65 And Above	0	0.0	0	0.0	3	15.0
Education level	None	0	0.0	3	15.0	2	10.0
	Primary	2	6.9	6	30.0	7	35.0
	Secondary	4	13.8	5	25.0	7	35.0
	Tertiary	23	79.3	6	30.0	4	20.0
Membership to a farmer or fisher group	No	17	58.6	14	70.0	9	45.0
	Yes	12	41.4	6	30.0	11	55.0
Type of entity	Association	0	0.0	0	0.0	5	41.7
	CBO	6	27.3	1	5.0	0	0.0
	Cooperative	0	0.0	1	5.0	6	50.0
	Institution	3	13.6	1	5.0	1	8.3
	NGO	1	4.5	0	0.0	0	0.0
	Private	12	54.5	17	85.0	0	0.0
Ownership or Access to devices	Internet	1	3.6	0	0.0	0	0.0
	None of these	0	0.0	0	0.0	2	10.0
	Radio	2	7.1	3	15.0	6	30.0
	Smartphone	25	89.3	9	45.0	4	20.0
	Smartphone & Internet	0	0.0	0	0.0	4	20.0
	Smartphone & Radio	0	0.0	0	0.0	1	5.0
	Smartphone, Radio & Internet	0	0.0	1	5.0	1	5.0
	Smartphone, Radio & Smart tv	0	0.0	1	5.0	0	0.0
	Smartphone, Radio, Internet & smart tv	0	0.0	6	30.0	2	10.0
Main livelihood	Crop farming	10	34.5	2	10.0	8	40.0
	Fish farming	14	48.3	11	55.0	10	50.0
	Mixed	5	17.2	7	35.0	2	10.0

Figure 5. One on one farmer interviews conducted during the July-August 2025 CSA needs assessment survey in KeTanzania , (left crop farmer; right fish farmer)

2.4.1. Pathways to improving gender equity in CSA technology access

Analysis from all the three countries on gender equity (figure 6) showed that targeted training for women farmers is the most prominent pathway to enhancing gender equity in CSA technology adoption across the LVB, with Kenya (53.6%), Tanzania (40.0%), and Uganda (55.0%) all prioritizing this intervention. This highlights the critical role of knowledge empowerment in bridging gender gaps, consistent with findings by Beuchelt & Badstue (2013) and Quisumbing et al. (2014), who emphasized that training improves women's confidence and ability to adopt new practices. Gender-sensitive financing and incentives emerged as the second key enabler, reported by 25.0% in Kenya, 26.7% in Tanzania, and 20.0% in Uganda, underscoring that equitable access to resources is vital for scaling women's participation in CSA. Additional strategies included digital literacy programs (notably 10.0% in Uganda) and women's cooperatives/groups (15.0% in Uganda, 13.3% in Tanzania), which strengthen collective action and digital inclusion. Land access and inclusive decision-making were mentioned but at lower rates, reflecting persistent structural barriers. Together, these findings suggest that addressing women's skills, finance, and collective empowerment is central to gender equity in CSA, aligning with literature that calls for multi-pronged interventions to reduce the gender gap in agricultural innovation (Doss et al., 2018; FAO, 2020).

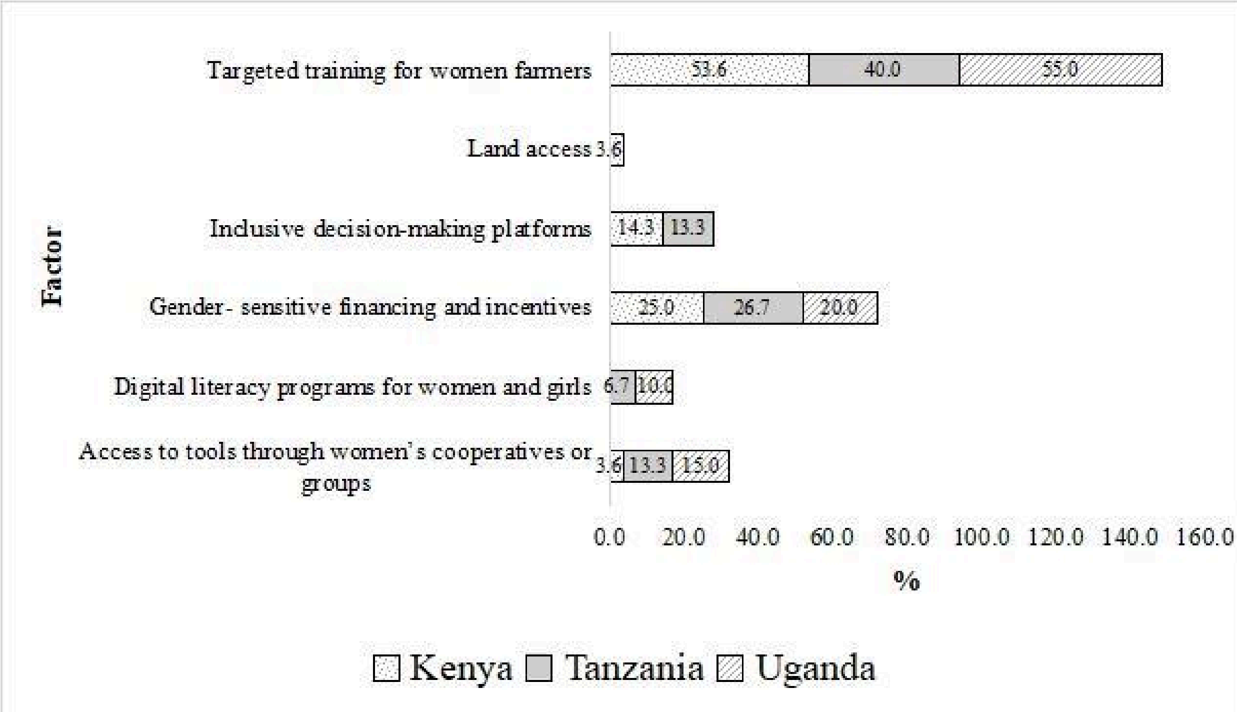

Figure 6. Pathways to improving gender equity in Climate Smart Agriculture (CSA) technology access in the Lake Victoria Basin (LVB) based on the July – August 2025 needs assessment survey.

2.5. Analysis of the region's agroclimatic conditions, threats and opportunities

2.5.1. The common needs for Climate Smart Agriculture (CSA) in crops and fisheries

The study findings (table 3) reveal that crop diversity varies across the basin, with maize dominating in Kenya, rice in Tanzania, and coffee in Uganda, reflecting agro-ecological suitability and market orientation. Kenya is leading in agroforestry adoption due to strong extension promotion, while Tanzania lags, highlighting policy and awareness gaps. In fisheries, Nile tilapia remains the most widely farmed species across all countries, driven by high consumer demand and established aquaculture systems. Fish farming is observed as the primary livelihood across the basin, though Uganda shows stronger crop dependence compared to Kenya and Tanzania. The fish production systems are highly country-specific, with Kenya focusing on ponds, Tanzania on cages, and Uganda showing mixed systems, reflecting resource and investment patterns. Small holder farmers across all three countries reported delayed rains and flooding as key issues, with higher temperatures most strongly noted in Uganda. In terms of current CSA adoption practices, Kenya leads in agroforestry and crop-fish integration, Tanzania in composting, while Uganda shows gradual uptake of soil mulching and water harvesting.

Table 3. High-level common needs for Climate Smart Agriculture (CSA) in crops and fisheries across the Lake Victoria Basin (LVB) based on July – August 2025 needs assessment survey.

Parameter	Level	Kenya		Tanzania		Uganda	
		n	%	n	%	n	%

Crops grown	Coffee	0	0.0	0	0.0	3	42.9
	Maize	10	100.0	0	0.0	3	42.9
	Rice	0	0.0	2	100.0	0	0.0
	Sugarcane	0	0.0	0	0.0	1	14.3
Practice of agroforestry	No	7	24.1	19	95.0	14	70.0
	Yes	22	75.9	1	5.0	6	30.0
Fish species cultured	African catfish	2	16.7	0	0.0	2	22.2
	Nile Tilapia	5	41.7	11	100.0	7	77.8
	Tilapia and Catfish	5	41.7	0	0.0	0	0.0
Main livelihood	Crop farming	10	34.5	2	10.0	8	40.0
	Fish farming	14	48.3	11	55.0	10	50.0
	Mixed	5	17.2	7	35.0	2	10.0
Production system used	Cage aquaculture	0	0.0	7	36.8	2	10.5
	Cage aquaculture Pond aquaculture	1	3.6	1	5.3	0	0.0
	Fish tank	0	0.0	0	0.0	1	5.3
	Irrigated farming	2	7.1	3	15.8	4	21.1
	Irrigated farming Cage aquaculture	0	0.0	1	5.3	0	0.0
	Irrigated farming Rainfed farming	2	7.1	0	0.0	0	0.0
	Pond aquaculture	11	39.3	0	0.0	3	15.8
	Rainfed farming	8	28.6	3	15.8	5	26.3
	Rainfed farming, Cage aquaculture & Pond aquaculture	1	3.6	0	0.0	0	0.0
	Rainfed farming & Irrigated farming	1	3.6	1	5.3	1	5.3
	Rainfed farming, Irrigated farming & Cage aquaculture	0	0.0	3	15.8	0	0.0
	Rainfed farming, Irrigated farming & Pond aquaculture	1	3.6	0	0.0	0	0.0
	Rainfed farming & Pond aquaculture	1	3.6	0	0.0	3	15.8
Weather/climate change patterns observed in recent years	Delayed rains	11	39.3	10	50.0	5	25.0
	Drought	2	7.1	1	5.0	3	15.0
	Flooding	7	25.0	5	25.0	3	15.0
	Higher temperatures	5	17.9	4	20.0	9	45.0
	Water scarcity	3	10.7	0	0.0	0	0.0
CSA practices used	Agroforestry	13	48.1	1	6.7	5	35.7
	Compost/organic manure	5	18.5	10	66.7	2	14.3
	Crop-fish integration	7	25.9	1	6.7	2	14.3
	Drought-resilient seed/fingerlings	2	7.4	3	20.0	2	14.3
	Soil mulching	0	0.0	0	0.0	2	14.3
	Water harvesting	0	0.0	0	0.0	1	7.1

2.5.2. Climate-related challenges faced across value chains in the Lake Victoria Basin (LVB)

Drought is the most severe constraint in Uganda, likely due to high reliance on rainfed systems, while Kenya shows a mix of drought, flooding, and pest/disease incidences, indicating exposure to multiple climate stressors on legumes in poorly adapted systems, limited access to quality inputs and weak pest control measures. Tanzania is most affected by drought compared to Kenya, as irrigation systems remain underdeveloped and highly dependent on seasonal rainfall. In fisheries, Input shortages are equally dominant across all countries, especially in Kenya and Tanzania, due to high costs and limited hatchery/feed supply, while Uganda also reports drought, reflecting vulnerability of aquaculture to water scarcity. Market failures are most pronounced in Tanzania and Uganda due to unstable value chains and poor infrastructure, whereas pest/disease is the leading challenge in Kenya, linked to weak extension services and limited access to pest/disease resistant varieties.

Table 4. Climate-related challenges faced across value chains in the Lake Victoria Basin (LVB) based on the July – August 2025 Climate Smart Agriculture (CSA) needs assessment survey.

Parameter	Level	Kenya		Tanzania		Uganda	
		n	%	n	%	n	%
Maize	Drought	5	23.8	3	30.0	4	100.0
	Flooding	2	9.5	1	10.0	0	0.0
	Input Shortage	8	38.1	1	10.0	0	0.0
	Market Failure	1	4.8	0	0.0	0	0.0
	Pest/Disease	5	23.8	5	50.0	0	0.0
Rice	Drought	6	40.0	8	80.0	0	0.0
	Flooding	2	13.3	0	0.0	0	0.0
	Heatwave	2	13.3	0	0.0	0	0.0
	Input Shortage	2	13.3	2	20.0	0	0.0
	Market Failure	1	6.7	0	0.0	0	0.0
	Pest/Disease	2	13.3	0	0.0	0	0.0
Beans	Drought	3	20.0	0	0.0	1	100.0
	Flooding	3	20.0	1	11.1	0	0.0
	Heatwave	2	13.3	0	0.0	0	0.0
	Input Shortage	3	20.0	4	44.4	0	0.0
	Market Failure	0	0.0	1	11.1	0	0.0
	Pest/Disease	4	26.7	3	33.3	0	0.0
Fish/ Aquaculture	Drought	1	5.3	0	0.0	3	30.0
	Flooding	0	0.0	0	0.0	1	10.0
	Input Shortage	14	73.7	9	60.0	4	40.0
	Market Failure	3	15.8	0	0.0	1	10.0
	Pest/Disease	1	5.3	6	40.0	1	10.0
Horticulture/Agroforestry	Drought	3	21.4	0	0.0	1	33.3
	Heatwave	1	7.1	0	0.0	0	0.0
	Input Shortage	3	21.4	1	7.7	0	0.0
	Market Failure	2	14.3	10	76.9	2	66.7

	Pest/Disease	5	35.7	2	15.4	0	0.0

2.6. LVB's agricultural practices, their economic contribution, and the region's strengths

2.6.1. Climate Smart Agriculture practice in relation to farming experience in the Lake Victoria Basin

Table 6 shows the regression model, explaining about half of the variation in farmers' years of experience (R^2 = 0.50). Results indicate that familiarity with Copernicus EO tools (Estimate = 4.391, p = 0.05) and awareness of CSA-related policies (Estimate = 6.14, p = 0.01) were positively associated with farming experience. This suggests that more experienced farmers are not only more aware of government and institutional policies but are also more likely to adopt structured digital tools such as EO platforms. In contrast, CSA information obtained via social media (Estimate = -3.23, p = 0.04) and the use of trial/pilot CSA technologies (Estimate = -5.01, p = 0.07) were negatively associated with farming experience, showing that less experienced (younger) farmers are more inclined to experiment with digital innovations and rely on informal, peer-to-peer digital channels. This reflects broader evidence that youth often drive experimentation and early adoption of agricultural innovations, while experienced farmers tend to adopt through institutionalized pathways (Makate et al., 2019; Kansiime et al., 2021). The standard error (SE) is critical to demonstrate across the regression estimates the extent of deviation from the regression line on average as a measure of prediction accuracy. The t-test was carried out to indicate how many standard errors the coefficient is from zero, and p is the probability of observing the data if the null hypothesis (no effect) were true. A smaller SE indicates more precise estimates, and larget t value suggests greater significance and a small p value (less than 0.05) indicates significant statistical relationship.

Positive baseline indicates that even without predictors, farmers have moderate experience, reflecting general engagement in agriculture across the LVB. EO and IoT exposure has a significant positive effect; It is observed that farmers that are familiar with EO tools tend to have longer farming experience, possibly due to better planning and adaptation strategies. Trial/pilot tools are more attractive to younger or less experienced farmers who are open to experimentation but have fewer years in farming and less access to land. There is a strong positive effect with increased awareness; policy awareness supports continuity and resilience in farming, likely enabling experienced farmers to align with institutional programs. On the other hand, high reliance on social media is more common among less experienced farmers who end up using these platforms for quick information as opposed to institutional support, exposing them to unverified and unchecked advisories.

Table 5. Regression analysis predicting Climate Smart Agriculture (CSA) practice in relation to farming experience in the Lake Victoria Basin (LVB) July – August 2025 needs assessment survey.

Predictor	**Estimate**	**SE**	**t**	**p**
Intercept [a]	4.65	2.13	2.19	0.04**
Familiarity with satellite-based tools like Copernicus Earth Observation (EO) for farming or aquaculture	4.39	2.12	2.07	0.05**
Use of trial or pilot CSA technologies (e.g. mobile apps, dashboards)	-5.01	2.69	-1.87	0.07***

Awareness of any CSA policy or government program	6.14	2.2	2.80	0.01*
Receipt of CSA information via social media	-3.23	1.53	-2.11	0.04**
Model Fit Measures	R	0.71		
	R^2	0.50		
Level of Significance	*0.01, **0.05, ***0.1			

2.6.2. LVB's youthful population strength and role in the promotion and adoption of CSA

In Kenya, youth were most engaged in labour and practical farming (34.6%), alongside contributing to awareness creation and advocacy (19.2%), and entrepreneurship within value chains (11.5%), underscoring their central role in both physical production and knowledge transfer. Tanzania, on the other hand, revealed a strong emphasis on capacity building, training, and extension (50.0%), suggesting that youth are seen as critical actors in disseminating knowledge and improving farmer skills, although a notable 25% indicated no involvement, reflecting gaps in inclusion. In Uganda, the dominant role of youth was in awareness creation and advocacy (71.4%) and labour contributions (28.6%), pointing to their importance in mobilization and sustaining farming activities. However, technological innovation and adoption, while reported in Kenya (7.7%) and Tanzania (6.3%), remained low across the region, indicating untapped potential.

These findings are consistent with studies that have shown youth often contribute to CSA adoption through labour provision, knowledge dissemination, and innovation potential but remain constrained by systemic barriers such as lack of capital and limited access to decision-making spaces (Yami et al., 2019; FAO, 2020). Kristjanson et al. (2017) emphasize that youth engagement in CSA can be catalytic when supported with training, credit, and digital tools, while Mukembo & Edwards (2016) highlights that those entrepreneurial initiatives by rural youth significantly influence technology adoption. The low representation of youth in innovation roles observed in the region aligns with Njenga et al. (2021), who stress that policy frameworks in East Africa often overlook the role of young people in agricultural technology scaling. Overall, while youth in the LVB are already playing visible roles in labour and advocacy, unlocking their potential in innovation, entrepreneurship, and governance, which is critical for accelerating CSA transformation.

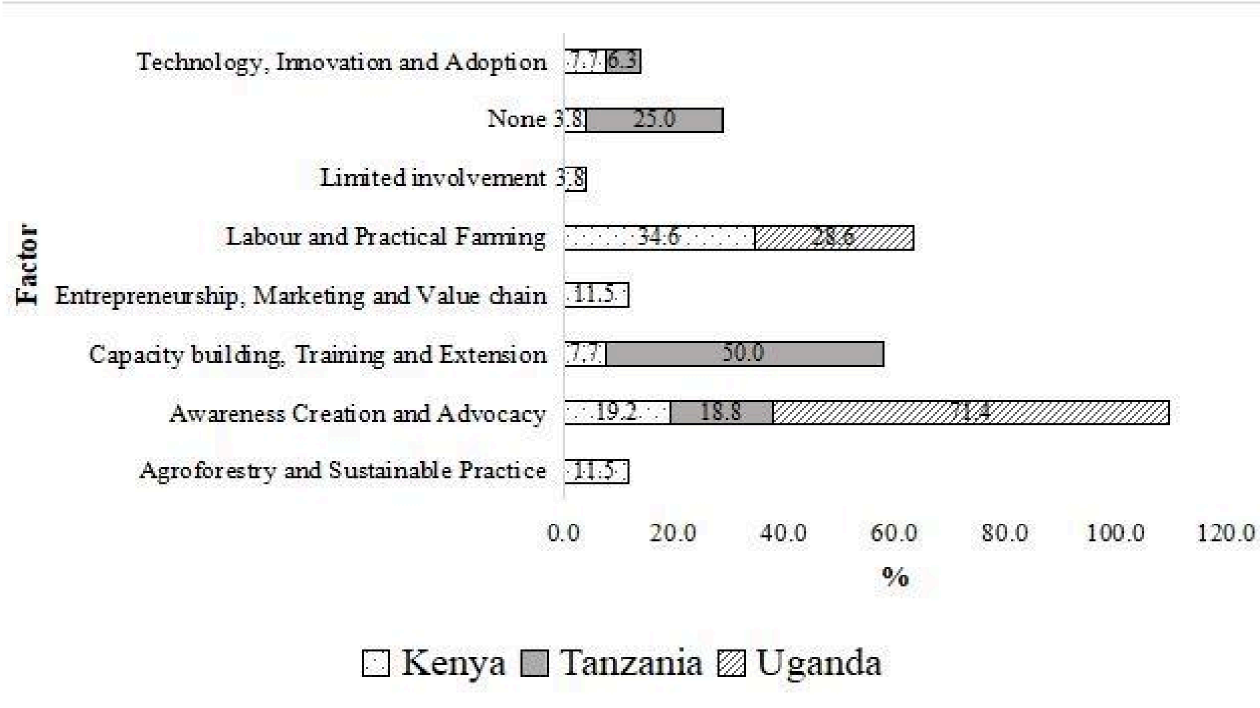

Figure 7. Role of youth in promoting Climate Smart Agriculture (CSA) in the Lake Victoria Basin (LVB) based on the July – August 2025 needs assessment survey.

The youth in the LVB can be more effectively engaged in CSA through a combination of; training and capacity building, access to finance, agribusiness incubation, and inclusion in decision-making processes (Figure 4). Importantly, involvement in policy and decision-making appeared across all three countries (14.3 – 25.0%), signalling that youth not only seek economic empowerment but also a stronger voice in shaping CSA strategies.

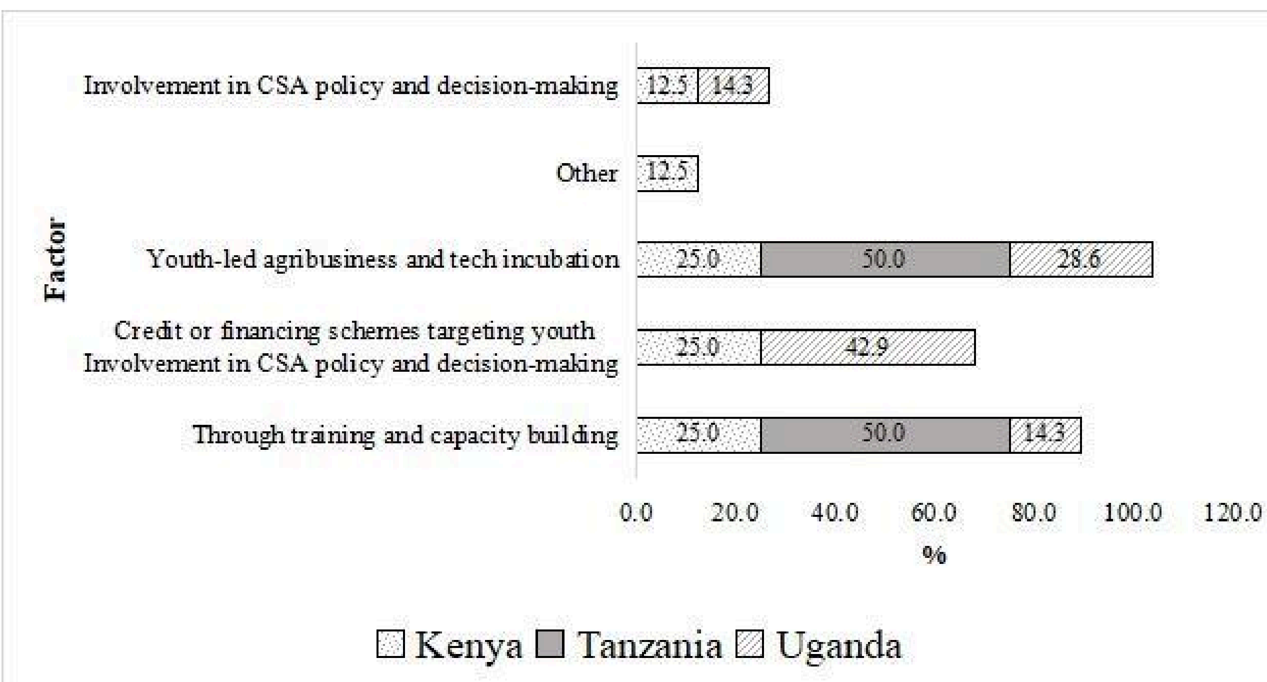

Figure 8. Pathways for youth involvement in Climate Smart Agriculture in the Lake Victoria Basin

Literature reinforces these findings, with FAO (2020) and Yami et al. (2019) noting that youth participation in agriculture is enhanced when financial inclusion, targeted training, and policy engagement are prioritized, while Njenga et al. (2021) stressed the importance of youth-led agritech innovations in transforming food systems.

"We see youth and women participating in BMUs (Beach Management Units) where they cover initial costs of fingerlings and are later supported with feeds. Access to collateral-free loans through partnerships like ALIP and Equity Bank has also opened opportunities, but the outreach is still limited to a few clusters" (Metrine, Aquarech, Kenya).

"In Uganda, women and youth need more than training; they need mobilization, access to credit, and support systems to actively participate in CSA. Without structured outreach, they remain on the margins" (Research Scientist, NaFIRRI, Uganda).

2.7. Digitally empowered CSA adoption level, best practices and initiatives in the LVB

2.7.1. Users of EO and IoT CSA technologies across the LVB

Kenya is leading in access to EO data for CSA, this is likely due to stronger investment in digital advisory services and farmer sensitization through programs like ABDP, while Uganda lags because of low awareness and weak digital extension systems. Tanzania leads when it comes to drone or satellite imagery, possibly because of donor-supported pilot projects in agriculture and aquaculture, while Kenya lags due to high costs and limited private sector uptake of the same. The dominance of "No" responses highlight the digital divide, consistent with earlier studies that found limited awareness and accessibility of EO technologies among smallholder farmers in Sub-Saharan Africa (Klerkx et al., 2019; Smidt & Jokonya, 2022). Kenya is equally leading in the usage of EO data for plant production, as most farmers are exposed to mobile weather apps and training, whereas Uganda lags because EO data services are not widely localized or accessible. The survey revealed that farmers who accessed EO data did so mainly through SMS-based weather and market advisory services and AgriApps such as M-Farm and localized agro-weather apps. These provided basic but practical information such as rainfall forecasts, drought alerts, and market price updates.

"CSA in Uganda is still very low because of multiple barriers: lack of training, high costs, weak policies, and farmers' literacy levels. Even where tools exist, most farmers do not know how to use them effectively, which reinforces the gap between innovation and practice." (Research Scientist, NaFIRRI, Uganda).

For IoT technologies, adoption was more limited and concentrated among project-supported farmers. Reported tools included soil moisture sensors and smart irrigation kits in horticultural systems, GPS-enabled farm mapping devices, and automated fish-feeding devices and pond water quality sensors in aquaculture enterprises. Institutions and extension projects managed more advanced IoT-linked weather stations and data loggers, though farmers had limited direct interaction with these. None of the three countries recorded the IoT or EO powered tech to land rehabilitation as technologies are still costly and not mainstreamed. Kenya is leading in medium-scale farmer adoption because of higher smartphone ownership and ICT literacy, while Uganda lags as most farmers operate at smallholder level with minimal digital penetration. Current users are primarily smallholders with limited capacity for scaling, while future users are expected to emerge from the same group provided enabling conditions such as training, affordable access, and awareness are strengthened. These findings reinforce the view that successful adoption of digital CSA innovations in Sub-Saharan Africa requires not only technological availability but also strong institutional support, farmer training, and inclusive infrastructure (Manzvera & Anaman, 2023; World Bank, 2021).

“At Aquarech, we have piloted IoT sensors to monitor oxygen and temperature levels in aquaculture systems. These tools have improved feed conversion ratios and reduced costs, but the challenge remains in maintaining them after pilot’s end. Farmers appreciate their value, but sustainability is an issue” (Metrine, Aquarech, Kenya).

Table 6. Users of Climate Smart Agriculture (CSA) technologies in the Lake Victoria Basin (LVB) July – August 2025 needs assessment survey.

Parameter	Level	Kenya		Tanzania		Uganda	
		n	%	n	%	n	%
Receipt or access to EO data	No	14	48.3	12	60.0	20	100.0
	Yes	15	51.7	8	40.0	0	0.0
Access to drone or satellite imagery of the farm or pond	No	27	93.1	13	65.0	18	90.0
	Yes	2	6.9	7	35.0	2	10.0
Use of EO data to plan production	No	16	55.2	16	80.0	17	100.0
	Yes	13	44.8	4	20.0	3	16.7
Use of IoT or EO technologies to rehabilitate or convert non-arable land	No	27	100.0	17	100.0	15	83.3
Level of digital technology	Medium scale	7	24.1	4	20.0	0	0.0
	Small scale	22	75.9	16	80.0	17	100.0

2.7.2. Existing CSA technology innovations in the LVB region

The results reveal that familiarity with CSA – related digital innovations such as EO tools remains uneven across the three countries (Table 8). In Kenya, 46.4% (n = 13) of farmers reported familiarity with Copernicus EO tools, compared to 30% (n = 6) in Tanzania, while none in Uganda were aware of such technologies (100%, n = 20, No). Kenya leads in awareness due to stronger extension and digital projects, while Uganda lags because of limited outreach and sensitization. Among those familiar, mobile apps emerged as the dominant delivery mechanism, especially in Kenya. This aligns with findings by Ndukhu et al. (2023), who emphasized that mobile-based applications are the most common entry point for CSA innovations in East Africa due to their relatively low cost and wide accessibility. Kenya relies on mobile apps owing to higher smartphone penetration, whereas Tanzania uses hybrid channels due to diverse extension strategies, and Uganda shows no structured delivery because of weak digital infrastructure. In terms of trials/piloting programs on EO and IoT CSA solutions, Kenya and Tanzania have some more exposure thanks to donor-driven CSA initiatives, while Uganda has none due to low investment and weak piloting programs, while on familiarity to AI tolls for decision making, Uganda shows relative leadership from donor-backed ICT-in-agriculture pilots, Kenya follows with emerging tech exposure, while Tanzania remains slow due to low innovation penetration. Future scaling of CSA innovations in the LVB will require targeted investments in awareness campaigns, training, and affordable digital platforms to bridge the existing knowledge and adoption gap (Klerkx et al., 2019; World Bank, 2021).

Table 7. Existing CSA technology innovations across the Lake Victoria Basin (LVB) July – August 2025 needs assessment survey.

Parameter	Level	Kenya		Tanzania		Uganda	
		n	%	n	%	n	%
Familiarity with satellite-based tools like Copernicus Earth Observation (EO) for farming or aquaculture	No	15	53.6	14	70.0	20	100.0
	Yes	13	46.4	6	30.0	0	0.0
Delivery method of the digital tools	Extension officer	0	0.0	1	12.5	0	0.0
	Mobile apps	13	86.7	2	25.0	0	0.0
	Mobile apps & Extension officer	0	0.0	2	25.0	0	0.0
	Mobile apps & SMS/USSD alerts	1	6.7	0	0.0	0	0.0
	Mobile apps, SMS/USSD alerts & Extension officer	0	0.0	2	25.0	0	0.0
	Mobile apps, SMS/USSD alerts, IoT sensors, Satellite imagery / EO platforms, GPS tools or geo-tagged maps, Drones AI tools, Extension officer &Community training	1	6.7	0	0.0	0	0.0
	SMS/USSD alerts	0	0.0	1	12.5	0	0.0
Use of trial or pilot CSA technologies	No	22	75.9	14	70.0	18	100.0
	Yes	7	24.1	6	30.0	0	0.0
Familiarity with AI tools for decision-making in agriculture	No	23	79.3	18	90.0	13	72.2
	Yes	6	20.7	2	10.0	5	27.8

2.8. Socioeconomic and environmental factors affecting digital CSA usage in crop and fish farming

2.8.1. Main socioeconomic factors affecting users of CSA technologies in the LVB

The findings indicate that cost and low awareness are the most significant barriers limiting CSA technology adoption across the three countries (Figure 6). Uganda reported the highest constraint from cost (30%) compared to Kenya (26.1%) and Tanzania (23.2%), underscoring financial barriers as a key impediment to scaling technologies.

“CSA adoption in aquaculture here in Tanzania is still at a formative stage. While farmers are interested, the biggest challenge is capital and access to the right technologies. As a university, we have tried to demonstrate through model farms, but without financing most small-scale farmers cannot implement what they see” (Dr. Mang’era Munyoro, Head Department of Aquaculture, Mwalimu Nyerere University of Agriculture and Technology, Tanzania).

Other challenges were more country-specific. For example, policy gaps were relatively higher in Uganda (18.3%) than in Kenya (9.1%) or Tanzania (14.3%), suggesting governance limitations in aligning CSA promotion with farmer needs. Infrastructure gaps were notable across all countries, with Tanzania leading at 17.9%. Interestingly, cultural barriers were reported only in Kenya (3.4%), albeit at a low level, indicating localized social factors affecting technology adoption.

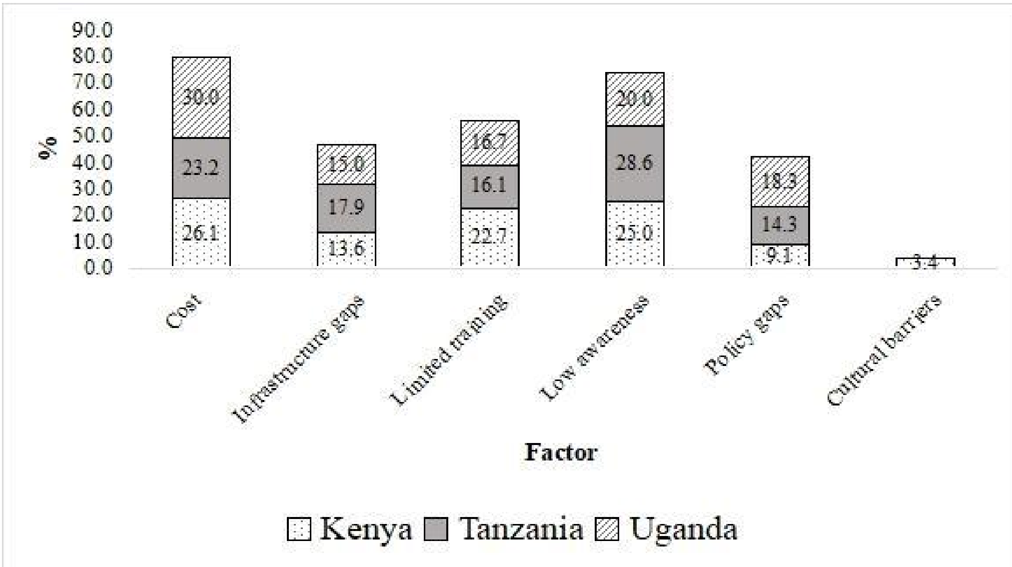

Figure 9. Factors limiting Climate-Smart Agriculture (CSA) technology adoption in the Lake Victoria Basin (LVB) July – August 2025 needs assessment survey

Kenya shows the highest openness due to better digital literacy and infrastructure, Tanzania reflects mixed attitudes from affordability concerns, while Uganda's hesitation stems from low awareness and trust in digital solutions. High cost and lack of training dominate in Tanzania and Uganda, reflecting financial constraints and insufficient extension services that limit technology adoption. While Kenya leads in readiness, Tanzania and Uganda will require capacity building, awareness creation, and affordability measures to strengthen their pipeline of future CSA technology users in the LVB (Makate et al., 2019; World Bank, 2021).

Table 8. Barriers to usage of Climate Smart Agriculture (CSA) technologies in the Lake Victoria Basin (LVB) based on the July – August 2025 needs assessment survey.

Parameter	Level	Kenya		Tanzania		Uganda	
		n	%	n	%	n	%
Openness to using new digital tools	Maybe	0	0.0	1	5.0	11	55.0
	No	0	0.0	4	20.0	2	10.0
	Yes	29	100.0	15	75.0	7	35.0
Main reason for not willing	High Cost	0	0.0	1	25.0	0	0.0
	No training	0	0.0	3	75.0	2	100.0

"In Kenya, CSA digital platforms like KAOB exist, but there is resistance and financial challenges in scaling them up. Only farmers with more than five acres have been included, which leaves out the majority of smallholders who actually need the support" (Tommy Atkins, KALRO, Kenya).

Overall, the results point to a combination of structural (cost, infrastructure), institutional (policy, training), and informational (awareness) constraints that must be addressed simultaneously to improve CSA adoption in the LVB, echoing findings from Totin et al. (2018) and Partey et al. (2020) that emphasize multi-dimensional interventions.

2.8.2. Main application of digital CSA technologies across crop and fish value chains the LVB region

The analysis reveals that CSA technologies in the LVB are primarily being used to enhance production planning and efficiency (Table 10). In Kenya, the dominant use case was production planning (60.0%, n = 9), followed by aquaculture management such as water quality monitoring and feeding (26.7%, n = 4). Weather and stocking prediction also featured prominently (50.0%, n = 3), underscoring the role of digital tools in reducing uncertainty and improving yield outcomes. Similarly, in Tanzania, the strongest applications were in climate awareness and risk preparedness (57.1%, n = 4) and production planning (42.9%, n = 3), with operational efficiency (50.0%, n = 2) and water-based IoT applications (20.0%, n = 3) pointing to a growing recognition of smart water management. Uganda, however, shows minimal adoption, with digital applications primarily supporting climate adaptation through AI and EO rainfall forecast apps (100%, n = 5), but with no evidence of production- or aquaculture-focused uses, reflecting the country's nascent stage of CSA technology integration.

Across the LVB, the findings suggest a country-differentiated adoption trajectory. Kenya is leveraging digital tools most diversely—from production planning and aquaculture management to weather prediction—while Tanzania emphasizes risk preparedness and operational efficiency. Uganda remains limited, with usage largely tied to AI-supported planning and EO forecasts. These patterns highlight a dual role of CSA technologies: (1) short-term adaptation to climate risks (through EO/rainfall apps, climate awareness, and risk preparedness) and (2) long-term productivity improvements (through aquaculture, soil/water IoT sensors, and yield optimization). The uneven uptake across countries was consistent with earlier findings that adoption depends heavily on access to infrastructure, training, and policy support (Makate et al., 2019; Aryal et al., 2021). This points to a need for targeted interventions in Uganda and Tanzania to expand CSA use cases beyond climate awareness into production and value chain efficiency.

Table 9. Use of CSA technologies and their rationale in the Lake Victoria Basin (LVB) July – August 2025 needs assessment survey.

Parameter	Level	Kenya		Tanzania		Uganda	
		n	%	n	%	n	%
Use of digital tools	Aquaculture Management (Water quality, Feeding, Stocking)	4	26.7	0	0.0	0	0.0
	Climate Awareness & Risk Preparedness	2	13.3	4	57.1	0	0.0
	Production Planning (Land Preparation, Planting, Irrigation)	9	60.0	3	42.9	0	0.0
Main rationale/objective for using IoT system	Market and Value Chain use	1	16.7	0	0.0	0	0.0
	Not aware	0	0.0	1	25.0	0	0.0
	Operational Efficiency	1	16.7	2	50.0	0	0.0
	Production and Yield improvement	1	16.7	1	25.0	0	0.0
	Weather and Stocking prediction	3	50.0	0	0.0	0	0.0
Digital tools or technologies	AI for planning	4	26.7	2	13.3	2	40.0

that support adaptation or mitigation	AI for planning & EO/rainfall forecast apps	0	0.0	0	0.0	3	60.0
	AI for planning	1	6.7	0	0.0	0	0.0
	EO/rainfall forecast apps	7	46.7	7	46.7	0	0.0
	IoT soil sensors	1	6.7	0	0.0	0	0.0
	IoT soil sensors & AI for planning	1	6.7	0	0.0	0	0.0
	IoT soil sensors & EO/rainfall forecast apps	1	6.7	3	20.0	0	0.0
	IoT water sensors	0	0.0	3	20.0	0	0.0

2.9. LVB region's CSA priorities for public investments (regional CSA policy and strategy focus)

2.9.1. Overview of CSA in the East African Community

The East African Community (EAC) recognizes Climate-Smart Agriculture (CSA) as an essential approach for enhancing agricultural resilience, improving food security, and reducing emissions. Through regional integration mechanisms and coordinated agricultural development strategies, EAC has embedded CSA into its broader sustainable development agenda (EAC, 2011). The EAC, in collaboration with COMESA and SADC, launched the Tripartite Climate-Smart Agriculture Programme aimed at supporting over 1.2 million smallholder households with climate-resilient practices and technologies (FAO, 2016).

Member states are encouraged to align national CSA strategies with regional priorities to facilitate knowledge exchange, cross-border collaboration, and harmonized implementation. This alignment supports the reduction of climate vulnerability across shared agroecological zones and improves consistency in agricultural extension and financing programs. It also enables the adoption of shared tools, such as early warning systems and agro-climatic advisories that benefit multiple countries within the region.

Technical and scientific bodies like the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), the Lake Victoria Basin Commission (LVBC), and the Lake Victoria Fisheries Organization (LVFO) play key roles in promoting regional CSA adoption. These institutions facilitate capacity building, regional research coordination, and the development of regional standards that support agroecological resilience and climate-informed decision-making (ASARECA, 2023; LVBC, 2023).

2.9.2. Regional strategies and protocols on Climate Change, Agriculture and Food Security

The regional strategies and protocols outlined in Table 10 demonstrate a progressive, multi-stakeholder approach toward operationalizing CSA in the EAC and adjacent regions. The EAC Climate Change Policy (2011) and the EAC Agriculture and Rural Development Strategy (2016–2020) form the policy backbone, guiding member states toward climate-resilient agriculture through digital extension pilots and policy harmonization. These instruments offer region-wide frameworks for adaptation and mitigation, yet their effectiveness is constrained by enforcement gaps and limited fiscal backing (EAC, 2011; EAC, 2016). The COMESA Seed Harmonization Implementation Plan (COMSHIP) further addresses transboundary barriers to accessing climate-resilient crop varieties by introducing online seed tracking systems—a strategy that has improved certification flow but suffers from weak enforcement at national levels (COMESA, 2014).

The integration of digital and Earth Observation (EO) tools is most apparent in strategies like the LVBC Integrated Water Resources Management (IWRM) Strategy (2023–2050) and the HIGHWAY Project. These initiatives deploy Copernicus satellites, GIS platforms, and weather early warning systems to support real-time data access for basin management and agricultural planning across Kenya, Uganda, and Tanzania (LVBC, 2023; WMO, 2021). Such innovations have led to measurable improvements in resource coordination and resilience planning, especially in the Lake Victoria Basin, where water stress and climatic variability are prominent threats. However, localized uptake remains a challenge due to digital literacy gaps and weak subnational institutional capacities.

Meanwhile, the EASTECO Digital Innovation Program emphasizes research and technology transfer by promoting IoT platforms and EO-informed agricultural research and development. It seeks to bridge the divide between innovation and on-farm adoption by nurturing tech hubs and regional partnerships (EASTECO, 2022). Despite its moderate ranking, this program reveals critical lessons about the importance of linking research with policy implementation pathways. Across all strategies, common weaknesses include fragmented governance, low institutional sustainability, and insufficient domestic funding—underscoring the need for a more robust, integrated CSA policy ecosystem that is gender-responsive, innovation-driven, and regionally coordinated (ASARECA, 2023; AUDA-NEPAD, 2021).

Table 10. Regional strategies and protocols on Climate Change, Agriculture and Food Security.

No.	Strategies and Protocols	Region / Countries	IoT / Digital Tool	EO Used	Problem Addressed	Scale or Impact
1	EAC Climate Change Policy (2011)	EAC Partner States	Policy support tools	N/A	Lack of unified climate response across member states	Region-wide guidance
2	EAC Agriculture and Rural Development Strategy (2016–2020)	EAC Partner States	Digital extension pilots	N/A	Unsustainable farming practices and low rural incomes	Agriculture sector support across EAC
3	COMESA Seed Harmonization Plan (COMSHIP) - 2014	COMESA States	Online seed tracking systems	N/A	Fragmented seed regulation and market barriers	Cross-border seed certification growth
4	LVBC IWRM Strategy (2023–2050)	Kenya, Uganda, Tanzania	Water data platforms, GIS	Copernicus, satellite	Inefficient water use and land degradation in Lake Victoria Basin	Water use coordination in shared basin
5	EASTECO Digital Innovation Program (2024)	EAC Region	IoT platforms for agriculture R&D	Various EO sources	Low innovation uptake in climate-smart practices	Regional tech hubs and innovation labs
6	HIGHWAY Project (WMO, 2021)	Kenya, Uganda, Tanzania	Weather early warning systems	Satellite, radar	Lack of timely weather data for farmers and fishers	Enhanced forecasts in LVB and EAC zone

3. KijaniSpace multi-actor approach

3.1. The Multi-Stakeholders Platform

The KijaniSpace project is committed to fostering a multi-actor approach, recognizing the importance of diverse perspectives in addressing the challenges of climate-smart agriculture and aquaculture within the Lake Victoria Basin (LVB) region. This inclusive strategy was exemplified through a series of multi-stakeholder workshops, beginning with the first held on April 8, 2025, in Kisumu, Kenya, hosted by the Lake Hub Foundation, which brought together 47 participants primarily from Kenya. To broaden its reach, the project extended its engagement to Tanzania, culminating in a second workshop on July 10-11, 2025, hosted by the Small Industries Development Organization (SIDO) and Mwalimu Nyerere University of Agriculture and Technology (MJNUAT) in Mwanza, which gathered 33 stakeholders. Participants included farmers, farmer organizations, national agriculture and fisheries research institutions, government representatives, agrovets, private sector actors, digital solutions enterprises, universities, and students, all united by a shared interest in advancing sustainable practices in the LVB. The project's core aim is to leverage Copernicus Earth observation data and IoT innovations to enhance the resilience of smallholder farmers. Through structured discussions, stakeholders outlined a comprehensive framework for a Multi-Stakeholder Platform (MSP) designed to influence policy, drive research and innovation, and ensure practical application, underscoring the project's commitment to collaborative, multi-actor solutions.

3.1.1. MSP Objectives and Purpose

The project MSPs have five core focus areas essential for the project's successful development and implementation. The purpose of these focus areas is to ensure a holistic, inclusive, and innovative approach that drives sustainable development and maximizes the project's impact. These include:

- fostering effective knowledge sharing among stakeholders,
- creating accessible, localized data repositories that are user-friendly and easily searchable,
- leveraging AI and metadata to enhance data searchability,
- integrating traditional and indigenous knowledge with modern innovations, and
- promoting collaboration among start-ups, SMEs, researchers, and institutions to generate diverse and creative solutions.

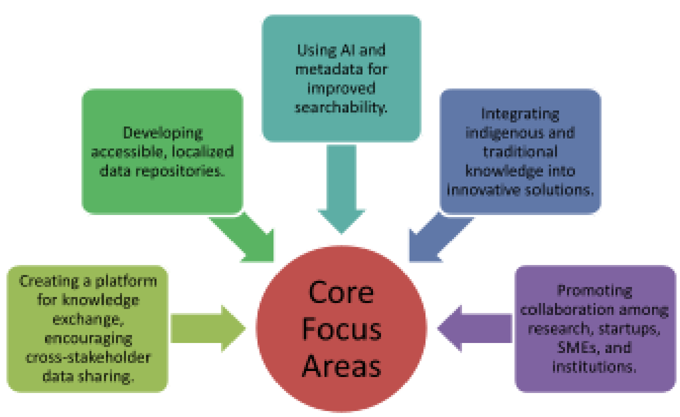

Figure 10. Summary of the core focus areas for the KijaniSpace Multi-Stakeholder Platforms in the LVB countries.

3.1.2. MSP Approach and Methodology

Designing an effective Multi-Stakeholder Platform requires a flexible and context-sensitive approach. The platform is adopting a problem-driven framework that focuses on specific challenges identified through community engagement rather than promoting predefined solutions A hybrid structure, combining predictive planning with adaptive, real-time feedback mechanisms, is being considered crucial to ensure the platform remains responsive to evolving needs. The MSP structure emphasizes stakeholder representation, ensuring the inclusion of all relevant sectors farmers, government agencies, researchers, private sector players, and community organizations—at every stage.

Farmer participation is being prioritized, actively engaging them at three key stages: ideation, adoption, and transition, to foster ownership and trust. Continuous feedback and peer learning are being encouraged, with mechanisms for ongoing stakeholder input and peer-to-peer learning among farmers being promoted to build confidence and leverage shared experiences in applying solutions. Additionally, needs are being categorized into knowledge-based, technical barriers, and farming challenges to address issues comprehensively through knowledge segmentation. The MSP is being designed to ensure inclusivity, adaptability, and responsiveness, with a strong focus on farmer engagement and continuous stakeholder collaboration to drive sustainable and impactful outcomes.

The following is a summary of the approach and methodology defining the MSP.

1. **Problem-Driven Framework:** Focus is on addressing specific challenges identified through community engagement rather than promoting predefined products.
2. **Hybrid Structure:** Combine predictive planning with adaptive, real-time feedback mechanisms to remain responsive to evolving needs.
3. **Stakeholder Representation:** Ensure inclusion of all relevant sectors—including farmers, government agencies, researchers, private sector players, and community organizations—at every stage
4. **Farmer Participation:** Engage farmers actively at three key stages: ideation, adoption, and transition, fostering ownership and trust.
5. **Continuous Feedback & Peer Learning:** Promote mechanisms for ongoing stakeholder input and peer-to-peer learning among farmers to build confidence and shared experience.
6. **Knowledge Segmentation:** Categorize needs into knowledge-based, technical barriers, and farming challenges to address issues comprehensively.

The MSPs relevance is based on the importance of translating innovative ideas into farmer-friendly solutions that directly respond to local needs. This involves conducting context-specific research to identify farmers' needs and translating research findings into simple, accessible language to avoid misunderstandings. Community feedback and data shall remain the basis to recognize recurring issues and interventions through hands-on training and gamification to boost farmer engagement. Additionally, it facilitates co-creation among policymakers, researchers, and farmers to develop shared solutions.

To address barriers such as technology costs, ease of use, and adaptability. The project through the MSPs will ensure inclusive outreach, reaching farmers across different capacities and sectors, and assess current adoption levels of climate-smart technologies in the region to tailor interventions effectively. The Application Group stakeholders highlight community-led capacity building as a way to empower farmers by partnering with cooperatives and local institutions to build their skills, improve access to quality inputs, and establish clear communication channels. The project, in supporting MSPs, will prioritize farmer-centric approaches, co-creation, and inclusive outreach to ensure that innovative solutions are practical, accessible, and effectively address the challenges faced by farmers in the region.

3.1.3. MSP Governance and Tools

To establish a functional and effective Multi-Stakeholder Platform, the following approach is adopted across the three project countries. First, appointment of a lead organization or organizations to coordinate MSP activities, essential for ensuring cohesive and streamlined operations. Additionally, the creation of regional Technical Working Groups (TWGs) covering Policy, Research and Innovation and Application to facilitate focused and collaborative efforts covering the 5 objectives of the MSP. Broad and inclusive representation from diverse stakeholders—including policymakers, researchers, farmers, and NGOs is considered critical to ensure a well-rounded and representative platform. Transparency in decision-making processes, particularly those that prioritize the interests of farmers, is highlighted as a cornerstone of the platform’s success. Finally, fostering capacity-building through targeted training programs is considered a core intervention to empower stakeholders and strengthen the overall functionality of the MSP. This comprehensive approach aims to create a collaborative, inclusive, and impactful platform that addresses the diverse needs of all stakeholders involvement throughout the life of the project to ensure the project is informed by the realities of the countries.

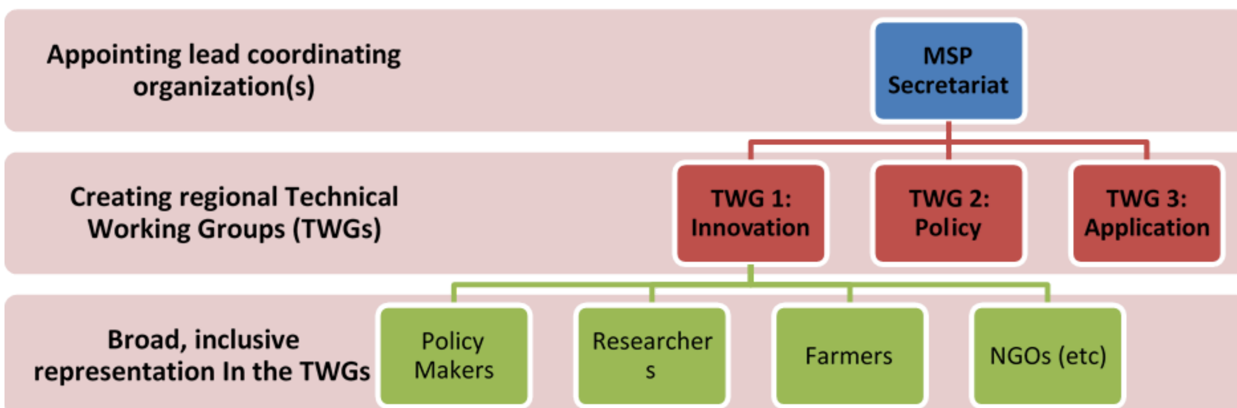

Figure 11. Governance structure for the KijaniSpace Multi-Stakeholder Platforms in the LVB countries.

The MSPs will be made vibrant through multiple communication platforms and engagement forums, including; Slack for coordination, WhatsApp for quick updates, Teams and Zoom for meetings, and LinkedIn for professional networking. A dedicated website will be developed, with LakeHub serving as the secretariat, acting as a central hub for the project. A Lake Basin Innovation Network will also be established, connecting creators, users, data managers, and regulators to enhance collaboration.

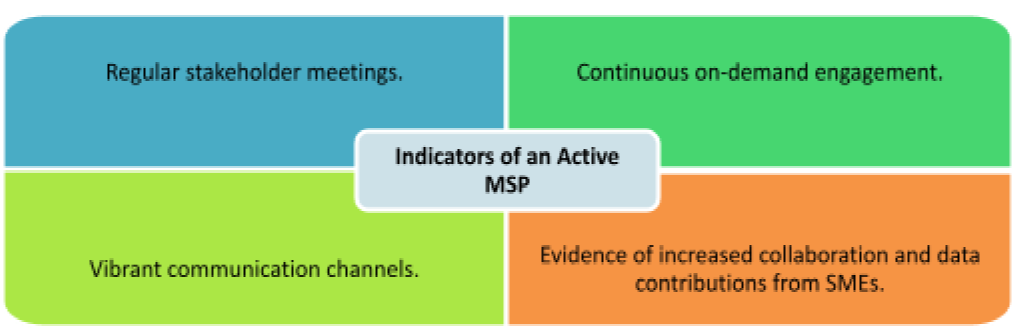

Figure 12. Indicators of a vibrant KijaniSpace Multi-Stakeholder Platforms in the LVB countries.

The sustainability of the MSPs will require diversification of funding streams, including government support, private sector investments, grants, and crowdfunding where possible, this will safeguard its financial viability. Integrating the MSP within existing regional governance structures will provide institutional stability. Implementing continuous monitoring, evaluation, and feedback systems will allow for regular adjustments and improvements. Finally, fostering stakeholder ownership through engagement and capacity development will ensure continued commitment and participation.

3.1.4. Sustainability of the MSPs

The MSP must be embedded within the local and regional systems to have lasting impact. Policy and institutional integration remain critical, requiring the development and institutionalization of policies and guidelines that remain relevant once the project concludes. Policymakers should be engaged from inception to ensure long-term commitment.

Community ownership should be fostered by promoting farmer ownership of tools, practices, and outcomes to build motivation and ensure continued adoption. Multifaceted funding, establishing diverse revenue streams, including government support, private sector investments, grants, and crowdfunding campaigns, is also necessary. Furthermore, capacity building and knowledge transfer should be provided, offering ongoing training and workshops to reinforce skills among farmers and stakeholders, embedding innovations locally.

Government and regional partnerships should be established, promoting collaboration with existing government institutions (e.g., regional agencies, environmental authorities, agricultural bodies) to sustain program activities. Monitoring and evaluation systems should be implemented, creating adaptive M&E systems to track progress, learn from challenges, and refine approaches regularly. Knowledge repositories and best practices should also be created by compiling accessible atlases of best practices tailored to different areas, serving as references for ongoing learning and consistency. Finally, robust customer care and engagement programs should be developed, offering responsive support systems to address user concerns, foster trust, and sustain community participation.

3.2. Multi-Stakeholder Workshops

3.2.1. Objective and Approach

Two “multi-stakeholder workshops” were held in Kenya and Tanzania in order to kick-off the MSP, and to address key questions about the MSP’s focus, structure, and sustainability. Each workshop was structured in three sessions:

- The first session involved the project team presenting an overview of the project’s design, goals, objectives, delivery model, and expected outputs, followed by interactive Q&A to align understanding.
- The second session featured country stakeholders sharing insights on local needs, challenges, and opportunities related to Earth Observation (EO) and Internet of Things (IoT) in climate-smart agriculture for both fisheries and crops.
- The third session engaged stakeholders in themed group discussions, divided into the Policy Group, Research & Innovation Group, and Application Group (Farmer-Centric Solutions), to identify critical focus areas, define stakeholder roles, and structure continuous engagement.

The output of these workshops has guided the structuring of the MSP presented in the previous section.

Figure 13. Participants of the second MSW meeting held in Mwanza Tanzania, led by SIDO.

3.2.2. Observed Challenges and Opportunities

Data quality and access needs: There is a need for accurate and accessible data to inform CSA in the Lake Victoria Basin region, including precise information on cage locations, water quality parameters such as lake levels and depths, locations of active farms, and details on soil fertility. Also crucial is the need for technological support, specifically leveraging Copernicus satellite data and IoT solutions to benefit farmers. Data accessibility and capacity building were highlighted as essential, ensuring that stakeholders have access to timely data and are trained to effectively utilize it. Finally, there is a need for a policy focus that actively encourages resource efficiency and environmental sustainability.

Underrepresented farmers voice: Across the region there is a notable absence of farmer representation in policymaking processes, and a lack of frameworks that would effectively integrate IoT and satellite data into farming decisions. Additionally, outdated policies need to be reviewed to adequately address climate change and aquaculture-specific challenges.

Scale barriers: There is limited funding and infrastructure for scaled EO/IoT enabled CSA, and a resistance from community leaders and farmers due to conflicting interests that need redress. Logistical hurdles affecting communication and transportation can also pose a significant barrier to scale.

Mobile phone and internet access: Increasing mobile phone access and internet connectivity, provides a platform for the utilization of mobile applications for real-time environmental monitoring, strengthening cross-sector partnerships involving bodies such as LVBC, LVFO, KMFRI, and KEFRI, scaling successful pilot projects across the region, and collaborating with non-governmental organizations to mobilize communities and advocate for impactful policies.

Figure 14. Mr.Paul Kariuki, Senior Manager at Lake Victoria Basin Commission, presenting the regional climate smart agriculture context for participants at the Kenya MSW held in Kisumu, at lake Hub.

3.2.3. Strategies to Overcome the Challenges

The project must put emphasis on the importance of translating innovative ideas into farmer-friendly solutions that respond directly to local needs. This involves conducting context-specific research to identify farmers' needs and translating research findings into simple language to avoid misunderstandings. Using community feedback and data to recognize recurring issues, and employing hands-on training and gamification to boost farmer engagement. Furthermore, the project should consider facilitating co-creation among policymakers, researchers, and farmers to develop shared solutions.

The project in collaboration with the stakeholders should address barriers such as technology costs, ease of use, and adaptability. KijaniSpace should ensure inclusive outreach, reaching farmers across different capacities and sectors, and assess current adoption levels of climate-smart technologies in the region to tailor interventions effectively. The project can leverage community-led capacity building as a way to empower farmers by partnering with cooperatives and local institutions to build their skills, improve access to quality inputs, and establish clear communication channels.

4. Recommendations

The findings from the study and the multi-stakeholder workshops reveal significant gaps in policy awareness, institutional support, and governance structures that limit the adoption of CSA technologies in the LVB. To address these challenges and unlock the potential of digital and climate-smart innovations, the following policy recommendations are proposed:

1. **Strengthen Farmer Access to CSA Technologies**

- Scale up access to drought- and pest-resistant seed varieties, water-saving irrigation technologies, and improved aquaculture inputs.
- Establish financing schemes (credit facilities, subsidies, public–private partnerships) to reduce cost barriers for smallholders adopting digital and CSA tools.

2. **Leverage Space–IoT Innovations through KijaniBox**

- Deploy EO for drought and flood monitoring, crop health mapping, and shoreline monitoring of fisheries.
- Introduce IoT sensors for soil moisture, water quality, and weather tracking to support precision farming and aquaculture management.
- Develop AI-driven advisory platforms that translate digital data into actionable, farmer-friendly recommendations.

3. **Promote Inclusive and Equitable CSA Adoption**

- Design interventions that specifically address gender and youth barriers to technology adoption, ensuring equitable access to training, finance, and market opportunities.
- Support women and youth-led agritech enterprises to drive localized innovation.

4. **Enhance Capacity Building and Digital Literacy through MSPs**

- Train farmers, extension officers, and youth on the use and maintenance of EO/IoT tools.
- Integrate digital literacy into farmer field schools and community-based organizations to ensure inclusive adoption.

5. **Align Policies and Strengthen Institutional Support through MSPs**

- Harmonize national CSA strategies across Kenya, Uganda, and Tanzania under a regional framework coordinated by LVBC.
- Mainstream EO and IoT into agricultural extension systems, research agendas, and climate adaptation programs.
- Strengthen policy awareness campaigns to ensure that farmers and local institutions understand existing CSA policies and opportunities.

6. **Establish Monitoring, Evaluation, and Learning Systems championed by LVBC**

- Integrate Space–IoT data streams into regional M&E systems for agriculture and fisheries.
- Use KijaniBox to generate evidence that can inform adaptive management, policy adjustments, and regional knowledge sharing.

5. Conclusions

This Needs Assessment confirms that CSA is both a pressing necessity and an emerging reality in the LVB. Farmers across Kenya, Uganda, and Tanzania are already adopting practices such as agroforestry, organic manure application, and aquaculture expansion, yet these remain fragmented and under-supported. Farmers are fully aware of their challenges—erratic rainfall, soil fertility decline, high input costs, and water quality degradation—but lack access to the digital tools, finance, and policy support needed to scale CSA effectively. On the institutional side, all three Partner States have developed CSA strategies and policies, but weak dissemination, limited farmer engagement, and insufficient financing have undermined their impact. At the same time, global and regional innovations in Earth Observation (EO) and Internet of Things (IoT) technologies present a clear opportunity to transform agriculture and fisheries in the Basin. The KijaniBox platform, under the KijaniSpace Programme, can serve as a bridge between these innovations and farmer needs by providing real-time monitoring, early warning systems, and digital advisory services. However, the success of such tools will depend on enabling frameworks, capacity-building, and investment in supportive infrastructure. CSA adoption in the LVB is at a crossroads: farmers know what they need, institutions have policies, and technology offers solutions. What is missing is a coordinated effort to align these elements into a coherent regional strategy. To operationalize a progressive regional strategy, there is need for coordinated stakeholder participation in advancing EO and IoT powered CSA. The collective insights and strategic recommendations from well-structured multi stakeholder platforms (MSPs) are first critical for realization of the KijaniSpace project goals and most importantly for sustainability of the work beyond the project period. Addressing policy gaps, fostering an inclusive research environment, and translating innovations into farmer-centric solutions, form the foundation for a resilient, sustainable multi-stakeholder platform. There is a need to cooperatively empower climate-smart agri-aquaculture through advanced data and IoT innovations to build ownership. Such a platform will catalyse regional transformation—improving livelihoods, enhancing environmental sustainability, and reinforcing the capacity of smallholder farmers in the Lake Victoria Basin to adapt to the challenges posed by climate change.

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