

SPACE-IoT SOLUTION BOX FOR CLIMATE-SMART AGRICULTURE IN AFRICA

*“Empowering Climate-Smart Agriculture with Copernicus and IoT
Innovations for Smallholder Farmers in Africa”*

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CONTRIBUTORS TABLE

Author(s)	Reviewer(s)
Dr Kevin Obiero (KMFRI)	Corentin Dupont (IT21)
Dr Samuel Mnyoro (MNUAT)	Kevin Kinusu (APBL)
James Odede (LakeHub)	
Margaret Sandra (LakeHub)	

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EXECUTIVE SUMMARY

The KijaniSpace Ideation Workshops held in Kisumu, Kenya (29–31 October 2025), and Musoma, Tanzania (11–12 December 2025) represent an important milestone in translating technological innovation into user-driven solutions for the Lake Victoria Basin. The main objective of the ideation workshops was to gather user requirements, new challenges, and mutual learning on how Space-IoT technologies (e.g., KijaniBox) can be applied for climate-smart agriculture in the Lake Victoria Basin.

In both countries, the workshops involved potential technical users of the KijaniBox solution (researchers, engineers, developers, SMEs, and startups). Kenya convened 59 participants over three days, while Tanzania brought together researchers, students, government representatives, and innovators over two days. Collectively, the workshops engaged a broad spectrum of stakeholders—including government agencies, research and academic institutions, private sector enterprises, farmer cooperatives, Beach Management Units (BMUs), youth innovators, and civil society organizations—in a participatory process of problem identification and solution co-design.

Both workshops employed a human-centered, design-thinking methodology combining plenary presentations, stakeholder group ideation, structured co-design sessions, and prioritization exercises. The Kenya workshop focused mostly on institutional and systemic problems. It found six main areas of concern: fragmented data ecosystems, high costs and technical barriers to technology adoption, climate and environmental risk management, productivity and disease management, market access and value chain inefficiencies, and policy and governance gaps. The Tanzania workshop complemented these findings by centring on nine operational and field-level challenges affecting daily agricultural and aquaculture practice, including climate variability, limited access to information, soil health, water quality management, crop and fish diseases, farm and cage management, fish stock estimation, resource-use conflicts, and financial and market access constraints.

Despite these contextual differences, a strong consensus emerged across both settings on the need for integrated, affordable, and locally adapted digital systems that combine space technologies, Internet of Things (IoT) sensors, artificial intelligence (AI) analytics, and user-friendly mobile interfaces. Participants consistently emphasized the necessity of converting complex Earth observation and IoT data into accessible, actionable information tailored to the decision-making needs of end-users.

The synthesised findings yielded five converging priority use cases for pilot implementation: (i) climate and early-warning advisory services; (ii) smart aquaculture health and feeding management systems; (iii) digital soil, water, and crop health monitoring; (iv) disease detection and response tools; and (v) market intelligence and traceability platforms. Cross-cutting themes of technology integration, user-centred design, capacity building, inclusive engagement of youth and vulnerable groups, and multi-stakeholder collaboration were identified as essential enablers of adoption and sustainability. These results provide a

solid evidence base for transitioning from ideation to pilot implementation within the KijaniSpace framework.

1. INTRODUCTION

The Lake Victoria Basin is a strategically important socio-economic zone of East Africa, sustaining the livelihoods of millions through agriculture, fisheries, and aquaculture. These sectors form the foundation of food security, employment, and regional economic stability. In Kenya, the basin supports major aquaculture and capture fisheries activities across counties bordering the lake, while in Tanzania, the Mara and Mwanza regions depend heavily on lake resources for both subsistence and commercial production.

However, these sectors face intensifying pressures. Climate variability—manifesting as erratic rainfall, prolonged droughts, rising lake temperatures, and unpredictable wave patterns—has disrupted production cycles and threatened resource sustainability. Environmental degradation, including the proliferation of invasive species such as water hyacinth, declining fish stocks, and soil erosion, has compounded these challenges. Structural inefficiencies in governance, data management, and market access further constrain productivity and equitable growth.

Although the development of Earth Observation (EO) and Internet of Things (IoT) technologies presents significant opportunities to address these issues, their application in the region remains fragmented, project-specific, and often inaccessible to end-users such as smallholder farmers and fishers. This disconnect between technological innovation, and real-world application emphasizes the necessity of solutions that are contextual, affordable, and accessible.

The KijaniSpace project aims to close this gap by fostering the utilization of space-based technologies and IoT systems to support climate-sensitive and data-driven decision-making. A central element of this approach is user-centric design, ensuring that technologically sound solutions are grounded in local realities and aligned with national development priorities—including Kenya’s Bottom-Up Economic Transformation Agenda (BETA), Tanzania’s national development frameworks, and the Sustainable Development Goals (SDGs) for food security and climate action.

To operationalize this strategy, ideation workshops were conducted in Kenya (Kisumu, 29–31 October 2025) and Tanzania (Musoma, 11–12 December 2025). Building on prior multi-stakeholder workshops held in April 2025 in Kisumu and July 2025 in Mwanza, the sessions were structured as participatory engagements that enabled stakeholders to directly identify challenges, set priorities, and co-develop practical solutions. They served as the essential bridge between innovation development and user needs. This report synthesises the findings from both workshops, providing an evidence-based foundation for design of Space-IoT Talent and Innovation Programs as well as the development of Fish Farm and Crop Irrigation Applications.

2. IDEATION WORKSHOPS

The ideation workshops were structured as participatory, multi-stakeholder engagements designed to bridge the gap between technological potential and practical application. Through a design-thinking approach, the workshops systematically moved participants from problem identification to the co-creation of actionable digital solutions. The two complementary national workshops yielded distinct yet related insights, reflecting the specific institutional, environmental, and operational contexts of each country.

2.1 Workshop Design and Methodology

Both workshops employed a human-centered, design-thinking methodology to foster participatory solution development. The process was structured in sequential phases to progress from context understanding to concrete solution design:

- **Plenary Presentations:** Sessions introduced the KijaniSpace project and its technologies (including the KijaniBox solution), regional strategies, and stakeholder perspectives from academia, government, and industry.
- **Stakeholder Group Ideation:** Participants were divided into breakout groups by user category. In Kenya, three groups were formed: (i) Research and Academia, (ii) Government Agencies, and (iii) Private Sector, Farmer Groups, BMUs, and SMEs. The Tanzania workshop adopted a comparable structure with thematic groups focused on agricultural and aquaculture practitioners.
- **Co-Design Sessions:** Groups engaged in structured brainstorming using guided worksheets (the KijaniSpace Ideation Group Worksheet) to document current practices, challenges, opportunities, and “quick-win” ideas, progressively moving from stating challenges to sketching application concepts.
- **Prioritization and Road-mapping:** Collective voting and facilitated discussion were used to rank proposed solutions by feasibility and impact and to define immediate next steps with stakeholder commitments.

This structured approach ensured that the outputs reflect both policy-level dynamics and grassroots realities, consistent with EU principles of co-creation, inclusivity, and impact-oriented innovation.

The Kenya workshop was held over three days and convened 59 participants (Day 1: registration; Day 2: understanding context and user needs; Day 3: co-designing solutions and next steps).





Plates 1, 2, & 3: Participants during the ideation workshop in Kisumu, Kenya.

The Tanzania workshop was conducted over two days (Day 1: understanding context and challenges; Day 2: co-designing solutions and defining the way forward was launched by the Mara Region Administrative Secretary, Mr. Gerald Musabila, who emphasized the importance of involving vulnerable groups—youth, women, and people with special needs—in development and research projects.





Plate 4, 5, & 6: Participants during the ideation workshop in Mwanza, Tanzania

Across both workshops, participants represented a broad spectrum of stakeholders, including national and county government agencies, research and academic institutions, private sector enterprises, farmer cooperatives, Beach Management Units (BMUs), youth innovators, and civil society organizations. In Kenya, these included the State Department for Blue Economy and Fisheries, Kenya Fisheries Service, Kisumu County Government, Maseno University, KALRO, KMFRI, and aquaculture enterprises such as Aquarech, Hydro-Victoria, and DalaAqua. In Tanzania, key participants included representatives from Mwalimu Nyerere University of Agriculture and Technology (MNUAT), the Small Industries Development Organisation (SIDO), and regional government authorities.

2.2 Kisumu, Kenya Workshop: Institutional and Systemic Findings

The Kenya workshop, held from 29 to 31 October 2025 at Kisumu Hotel, Kisumu, was oriented towards identifying institutional and systemic constraints that limit the scalability and sustainability of digital innovation in the region. The thematic analysis of group discussions revealed six core challenge areas and their corresponding digital solution pathways:

Data Accessibility and Management Fragmentation

Challenge: Siloed databases, restrictive data policies, and lack of interoperability across systems such as Kenya Integrated Agricultural Management Information System (KIAMIS) and E-Fish hinder evidence-based decision-making at both national and county levels.

Proposed Solutions: Develop an integrated, open-data platform for harmonized EO, IoT, and socio-economic datasets; promote standardized data protocols and APIs; deploy

cloud-based digital record-keeping tools for farmers and BMUs; establish common data pooling and sharing policies.

High Costs and Technical Barriers to Technology Adoption

Challenge: Prohibitive costs of EO data, IoT sensors, and equipment maintenance; digital illiteracy among end-users; and poor connectivity in rural areas.

Proposed Solutions: Pilot affordable, locally assembled IoT kits with low-energy LoRaWAN networks; advocate for pay-as-you-go models and public-private partnerships; implement phased capacity building from basic digital literacy to advanced data interpretation; subsidize high-resolution data access and promote open-source platforms such as Copernicus; use Bluetooth/IR for offline data collection in low-connectivity areas.

Climate and Environmental Risk Management

Challenge: Unpredictable weather patterns, absence of localized early warning systems, and environmental hazards including invasive species and lake-level fluctuations.

Proposed Solutions: Integrate Sentinel-2 and MODIS satellite data with IoT ground sensors for hyper-local early warnings; develop AI-driven SMS and voice alerts in local languages; create participatory GIS mapping for vulnerable zones; and deploy IoT data loggers as backup during cloudy weather using multi-satellite image fusion.

Productivity and Disease Management

Challenge: Late disease detection in both crops and fish, inefficient feeding regimes, and poor stock and biomass management.

Proposed Solutions: AI-based smartphone tools for early disease detection; IoT-enabled automated feeding systems with real-time biomass estimation; digital dashboards for cage farmers providing health and harvest insights; sensor-equipped aerators to monitor and regulate dissolved oxygen levels.

Market Access and Value Chain Inefficiencies

Challenge: Lack of price transparency, exploitation by middlemen, and poor product traceability from producer to consumer.

Proposed Solutions: Blockchain-enabled traceability platforms linked to IoT and EO-verified data; mobile market intelligence platforms with real-time pricing; digital platforms connecting sustainable producers directly with buyers; clear communication of cost-benefit analyses to farmers.

Policy, Governance, and Infrastructure Gaps

Challenge: Bureaucratic delays, outdated government systems, poor rural internet infrastructure, and low technological awareness among farmers and administrators.

Proposed Solutions: Develop policy dashboards for county governments using EO data; establish a multi-agency KijaniSpace steering committee; organize policy-technology

dialogue forums; improve internet infrastructure and explore satellite internet solutions (e.g., Starlink); implement ERP/IFMIS tracking to prevent fund misappropriation; simplify technical language using media and visual dashboards for farmer sensitization.

2.3 Musoma, Tanzania Workshop: Operational and Field-Level Findings

The Tanzania workshop, conducted on 11–12 December 2025 at Mwembeni Complex in Musoma, Mara Region, complemented the Kenyan findings by centring on operational and field-level challenges that directly affect the daily activities of smallholder farmers and aquaculture practitioners. Organized by MNUAT in collaboration with SIDO, KMFRI, LakeHub, and consortium partners, the workshop adopted a comparable design-thinking methodology. The thematic analysis of group discussions identified nine core challenge areas:

Climate Variability and Weather Uncertainty

Challenge: Unpredictable rainfall, droughts, waves, and temperature changes were identified as major constraints affecting crop production, fish farming, and fishing safety.

Proposed Solutions: Satellite-based monitoring of weather and surface water conditions; GIS and remote sensing analysis of climate trends; IoT sensors for real-time environmental monitoring; mobile and SMS-based advisories providing early warnings and operational guidance.

Limited Access to Reliable Agricultural and Aquaculture Information

Challenge: Farmers, fishers, and fish farmers lack timely, accurate, and understandable information on production practices, disease control, and management.

Proposed Solutions: Digital training platforms using videos, images, and audio content; AI- and digital box-driven advisory systems; SMS and WhatsApp-based information dissemination.

Soil Health and Land Productivity

Challenge: Poor understanding of soil nutrients and moisture leads to inefficient fertilizer use and reduced crop yields.

Proposed Solutions: Satellite imagery, GIS, and remote sensing for soil mapping; IoT soil and moisture sensors measuring nutrients and moisture levels; and digital analytics generating site-specific fertilizer recommendations.

Water Quality Management in Aquaculture

Challenge: Inadequate information on water quality contributes to fish stress, disease outbreaks, and mortality.

Proposed Solutions: Satellite-based surface water assessment; IoT sensors monitoring temperature, dissolved oxygen, and other parameters; digital dashboards and early-warning alerts.

Crop and Fish Diseases

Challenge: Delayed disease detection causes major losses in both crops and fish populations.

Proposed Solutions: Satellite-derived indicators for detecting abnormal crop and water conditions; AI-based image analysis for disease detection; digital advisory alerts recommending timely interventions.

Farm, Cage, and Production Management

Challenge: Weak record-keeping and inefficient feeding reduce productivity and profitability across both crop and aquaculture operations.

Proposed Solutions: Digital farm and aquaculture management systems; IoT-enabled smart feeding systems; real-time performance monitoring dashboards.

Fish Stock, Biomass, and Broodstock Identification

Challenge: Limited ability to estimate stock size and identify quality broodstock affects aquaculture outcomes and planning.

Proposed Solutions: Satellite-based remote sensing of water bodies; sonar and sensor technologies for stock estimation; digital profiling of broodstock performance.

Conflicts, Cage Security, and Resource Use

Challenge: Conflicts arise due to unclear spatial boundaries between fishing and cage farming areas, compounded by theft and cage damage.

Proposed Solutions: GIS- and satellite-based spatial mapping of designated zones; IoT-enabled geofencing systems; automated alerts for cage intrusion or damage.

Financial Management and Market Access

Challenge: Lack of financial records and market information limits access to credit and fair market prices.

Proposed Solutions: Digital financial record-keeping tools; market intelligence platforms using production and climate data; digital marketplaces and traceability systems.

2.4 Consolidated Findings

The combined outcomes of the Kenya and Tanzania workshops reveal a set of deeply interconnected challenges spanning environmental, technological, and institutional dimensions. Despite the contextual differences between the two countries, the following convergent themes emerged consistently:

- **Climate Variability and Environmental Risk:** Instability in weather patterns and the absence of localised early warning systems were identified as the single most significant threat to agricultural output and fishing activities in both countries. Participants articulated a clear need for integrated climate advisory solutions that

translate satellite and sensor data into actionable alerts delivered through accessible channels such as SMS and voice messages in local languages.

- **Data Fragmentation and Information Inaccessibility:** The lack of interoperable systems and user-friendly platforms severely hinders evidence-based decision-making. In Kenya, this manifests as siloed institutional databases and restrictive data policies; in Tanzania, it takes the form of limited access to reliable and timely extension information. Both contexts highlight the necessity of developing embedded digital systems that convert complex datasets into actionable, context-specific information.
- **Technology Adoption Barriers:** High costs of equipment and data access, insufficient technical capacity, and connectivity limitations were common barriers across both countries. Overcoming these hurdles requires cost-effective technology solutions, phased capacity building, and innovative delivery models such as pay-as-you-go financing and offline-capable data collection tools.
- **Productivity, Disease, and Value Chain Constraints:** Issues of declining productivity, late disease detection, inefficient input management, and limited market access recurred across both settings. These challenges signal systemic value chain inefficiencies and underscore the need for digital tools that enhance efficiency, transparency, traceability, and resilience from production through to market.
- **Governance and Policy Coordination Gaps:** In Kenya, participants identified bureaucratic delays and misalignment between national and county-level policy frameworks as significant barriers. In Tanzania, the emphasis was on the need for inclusive governance that actively engages vulnerable groups. Both settings demand institutional alignment and supportive policy environments for technology adoption.

2.5 Cross-Cutting Themes

Several recurring themes unified the discussions across all stakeholder groups in both countries:

- **Integration is Non-Negotiable:** Stakeholders consistently called for seamless integration of EO data, IoT ground sensors, AI analytics, and user-friendly mobile interfaces into unified, coherent platforms. Piecemeal solutions were universally rejected in favour of holistic systems.
- **User-centered design is critical:** solutions must prioritize simplicity, affordability, and relevance to the daily operations of fishers and farmers. Complex data portals are insufficient; information must be translated into actionable guidance delivered through accessible channels.
- **Capacity Building as a Foundation:** Sustainable adoption requires continuous investment in skills development at all levels—from youth innovators and farmer

groups to government technicians and extension workers. Phased training from basic digital literacy to advanced data interpretation is essential.

- **Inclusive Engagement:** Both workshops emphasized the need to actively involve youth, women, and vulnerable groups. Youth and SME engagement through innovation challenges, hackathons, and incubators was identified as a growth engine for developing context-appropriate solutions and ensuring long-term sustainability.
- **Multi-Stakeholder Collaboration:** Effective implementation requires structured collaboration between government, research institutions, private sector actors, and local communities. No single entity can succeed alone.
- **Early Warning Systems:** The demand for real-time climate and disease early warning systems was a unifying priority across both countries, with participants emphasizing the importance of translating complex satellite and sensor data into simple, actionable information for end-users.
- **Market Access and Financial Inclusion:** Both workshops identified market intelligence, product traceability, and digital financial tools as essential for linking smallholders to fair markets and improving their economic resilience.

Additionally, the Kenya workshop identified specific implementation barriers and mitigation strategies, including conducting feasibility baseline surveys to address financial constraints, targeted training and mentorship to close human capacity gaps, leveraging low-bandwidth technologies for connectivity issues, and using localised sensitisation campaigns and pilot demonstrations to overcome farmer adoption resistance; and advocate for electronic approvals to streamline bureaucratic processes.

2.6 Priority Use Cases

Based on the group voting, feasibility analysis, and prioritization exercises conducted across both workshops, the following converging use cases were identified for immediate development and piloting within the KijaniSpace framework:

#	Use Case	Description
1	Climate and Early-Warning Advisory Services	Combining satellite weather forecasts (Sentinel, MODIS) with lake-based IoT sensors to deliver precise, actionable SMS and voice alerts to fishers and farmers. Includes GIS and remote sensing analysis of climate trends and satellite-based surface water monitoring.
2	Smart Aquaculture Management Systems	An integrated platform using underwater sensors, sonar, and AI for real-time monitoring of fish health, biomass, water quality parameters, and automated feeding optimisation. Includes digital dashboards, performance monitoring, and broodstock profiling.
3	Digital Soil-Crop-Water Monitoring	Mobile-linked tool suites combining satellite-derived soil maps, IoT moisture and nutrient probes, and image-based disease diagnosis for smallholder crop farmers. Generates site-specific fertiliser recommendations and water quality alerts.

4	Disease Detection and Response Tools	AI-based smartphone and satellite-derived tools for early detection of crop and fish diseases. Includes digital advisory alerts recommending timely interventions and sensor-based monitoring of abnormal environmental conditions.
5	Market Intelligence and Traceability Platforms	Blockchain-enabled traceability systems linked to IoT/EO-verified data, mobile market intelligence platforms with real-time pricing, digital financial record-keeping tools, and digital marketplaces connecting sustainable producers with buyers.

In Kenya, an additional priority use case was identified: a lake-based spatial planning and conflict resolution tool—a public GIS platform using satellite imagery to map designated fishing zones, aquaculture cages, and navigation routes to reduce resource-use conflicts. This complements the Tanzania finding on the need for GIS- and IoT-based geofencing systems to address conflicts between fishing and cage farming areas.

3. CONCLUSIONS AND WAY FORWARD

The KijaniSpace ideation workshops in Kenya and Tanzania provide solid evidence confirming the relevance and applicability of Space-IoT-enabled solutions to the principal challenges facing the agriculture, fisheries, and aquaculture sectors in the Lake Victoria Basin.

The findings reveal a significant alignment between stakeholder needs and the technological capabilities of the KijaniSpace project. The Kenya workshop illuminated the systemic and institutional barriers—fragmented data ecosystems, policy coordination gaps, high adoption costs, and infrastructure deficits—that must be addressed to enable scalable innovation. The Tanzania workshop complemented these insights by grounding the analysis in the operational realities of smallholder practitioners, demonstrating the acute demand for practical, real-time, and accessible digital tools for day-to-day decision-making. Together, the two workshops confirm that effective implementation depends not only on technological soundness but equally on addressing systemic constraints, including affordability, accessibility, capacity, and policy alignment.

Consistent with these results, the workshops affirm the need for a holistic, user-centered strategy that integrates with WP4 on design of Space IoT Talent and Innovation Programs over an 18-month period and enabling policy frameworks. Specific emphasis is placed on the necessity of converting complex Earth Observation and IoT-based data into accessible, usable information tailored to the end-user context. The prioritization of five converging use cases—climate advisory services, smart aquaculture management systems, soil-water-crop monitoring, disease detection tools, and market traceability platforms—provides a clear roadmap for the design and developing of predictive irrigation and water quality and aquaculture management software web applications.

Piloting these use cases will yield essential evidence on their technical feasibility, usability, and scalability. Successful operationalization will require intensified multi-stakeholder cooperation among public institutions, research organizations, private sector actors, and local communities. Parallel to this, targeted capacity-building interventions—spanning basic digital literacy through advanced data interpretation—will be required to promote effective adoption and sustained use of the proposed technologies. The active engagement of youth, women, and vulnerable groups, as emphasized in both workshops, must be embedded throughout implementation to ensure equitable impact.

To facilitate evidence-based decision-making and continuous improvement, a structured monitoring and evaluation framework should be established to track implementation progress, measure impact, and enable iterative refinement of solutions.

Overall, the results of the ideation workshops position the KijaniSpace project to explore innovative solutions, co-create concepts, and agree on practical next steps. The ideas generated provide a foundation for subsequent development and will be proposed for implementation through the WP4 on design of the talent Program and WP5 for selection of

pilot demonstration sites and development of web applications. This transition from ideation to implementation marks an important step toward advancing the project's objectives within the Horizon Europe framework, with the potential to contribute—where feasible—to climate resilience, sustainable resource management, and inclusive economic development in the Lake Victoria Basin.

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