GREEN CLIMATE FUND | Independent Evaluation Unit

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Learning-Oriented Real-Time Impact Assessment Programme (LORTA)

Impact evaluation baseline report for FP034: Building resilient communities, wetlands ecosystems and associated catchments in Uganda

Executive summary

The impacts of climate change will accelerate the pressures wetlands are experiencing in Uganda. FP034 “Building resilient communities, wetland ecosystems and associated catchments in Uganda”, managed by the United Nations Development Programme, is being implemented in 12 districts in southwestern Uganda and 12 in eastern Uganda. The project is designed sequentially so alternative livelihood activities build on the restoration of wetland systems. The Learning-Oriented Real-Time Impact Assessment (LORTA) Programme is assessing the project using a difference-in-differences design with matching at the levels of wetland system communities and households.

For this report, survey data was collected from 1,666 households in eight treatment and eight comparison wetland systems – four each in eastern and southwestern Uganda. At the time of the survey, selected treatment wetlands had all received some form of implementation, varying between 35 per cent to 100 per cent of all planned activities. The survey highlighted a range of socioeconomic, demographic and livelihood differences between treatment and comparison households. Survey data was supplemented with data on flora and fauna, water quality assessments, as well as Normalized Difference Vegetation Index (NDVI) comparisons through time. To account for implementation progress prior to the completion of this baseline report, at endline the evaluation team will match households using two different specifications: (i) retrospective information of community characteristics collected during a community leader survey; and (ii) satellite data (including but not limited to NDVI and nightlight trends) prior to project implementation.

Foreword

Uganda's wetlands, covering 11 per cent of our landmass, play a vital role in flood regulation, safeguarding water resources, and sustaining agricultural productivity. In response to the gaps in public awareness and the imperative to take concrete actions for wetland restoration and protection, the United Nations Development Programme (UNDP), in collaboration with the Government of Uganda (GoU) and other partners, is managing the project titled "Building Resilient Communities Wetland Ecosystems and Associated Catchment in Uganda." This initiative aims to restore and manage wetland hydrology and associated catchment, enhance agricultural practices through alternative livelihood options, and strengthen access to climate and early warning information for farmers and target communities.

Launched in 2018, this 8-year project is funded by the Green Climate Fund (GCF), UNDP and GoU. It is being implemented in 24 districts, with 12 each in the eastern and southwestern regions. The project is implemented by the Ministry of Water and Environment in partnership with the Ministry of Agricultural Animal Industry and Fisheries (MAAIF), Uganda National Meteorological Authority (UNMA), and other actors.

In 2018, the Independent Evaluation Unit (IEU) of the GCF initiated the Learning-Oriented Real-Time Impact Assessment (LORTA) programme. This programme, designed for GCF projects worldwide, focuses on embedding real-time impact evaluations to provide accurate data on project implementation quality and impact likelihood. The primary aim is to build project capacity for designing high-quality data sets to measure overall impact. I commend GCF for their commitment to utilizing impact evaluation methodologies for result measurement.

I am optimistic that LORTA will fulfil its purpose and call on policymakers, development partners, practitioners, and other stakeholders to leverage the generated information and knowledge for better and more informed decisions benefiting both people and the planet.

Alfred Okot Okidi

Permanent Secretary

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Abbreviations

ATT	Average treatment effect on the treated
C	Comparison
C4ED	Center for Evaluation and Development
CAPI	Computer-assisted personal interview
CEM	Coarsened exact matching
DiD	Difference-in-differences
FAO	Food and Agricultural Organization of the United Nations
FGD	Focus group discussion
FIES	Food insecurity experience scale
GCF	Green Climate Fund
GIS	Geographic information system
GoU	Government of Uganda
ha	Hectare
HDDS	Household dietary diversity score
HFIA	Household food insecurity access
ICC	Intra-cluster correlation
IEU	Independent Evaluation Unit
IPWRA	Inverse probability weighted regression adjustment
KMO	Kaiser-Meyer-Olkin
LORTA	Learning-Oriented Real-Time Impact Assessment
MAAIF	Ministry of Agricultural Animal Industry and Fisheries
MAHFP	Months of adequate household food provisioning
MDES	Minimum detectable effect size
MDM	Mahalanobis distance matching
MoWE	Ministry of Water and Environment
NAP	National adaptation plan
NAP-Ag	National adaptation plan for the agricultural sector

NAPA	National adaptation plan of action
NDVI	Normalized difference vegetation index
PCA	Principal components analysis
PSM	Propensity score matching
RCT	Randomized control trial
SLM	Sustainable land management
SMS	Short message service
T	Treatment
TLU	Tropical livestock unit
ToC	Theory of change
UGX	Ugandan Shilling
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNMA	Uganda National Meteorological Authority
WHO	World Health Organization
WMD	Wetland Management Department

Executive summary

Climate change poses considerable challenges for Uganda. Models estimate an increase in mean temperatures each decade and, in aggregate, predict an increase in rainfall accompanied by more extreme weather events. The impacts of climate change will accelerate the pressures that wetlands are experiencing in Uganda. Over four million people live close to wetlands in Uganda and derive many livelihood activities from these vital ecosystems as, in hydrological terms, they regulate and smooth out surplus and deficit rainfall events. As a result, the Government of Uganda (GoU) has prioritized wetlands in its adaptation planning for the agricultural sector.

The project FP034 “Building resilient communities, wetland ecosystems and associated catchments in Uganda” is managed by the United Nations Development Programme (UNDP) and implemented through executing entities. These include the Ministry of Water and Environment (MoWE), the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) and the Uganda National Meteorology Authority (UNMA). The project is being implemented for eight years between 2017 and 2025 in 12 districts in southwestern Uganda and 12 in eastern Uganda. It consists of three key components. The first focuses on restoring and managing wetland hydrology and associated catchments and conducting community engagement and sensitization. A second component targets improving agricultural practices and alternative livelihood options in wetland catchments. The third component strengthens access to climate and early warning information for farmers and other communities to support wetland management. The UNDP designed the project sequentially so that component two on alternative livelihood activities builds on the restoration of wetlands. In this respect, outcomes and impacts from the component two project are likely to be lagged and materialize later than those of the other components.

The Learning-Oriented Real-Time Impact Assessment (LORTA) Programme is assessing the project using a difference-in-differences design with matching at the levels of both wetland systems and households. Wetlands have been matched using expertise and local project stakeholder knowledge in a four-day workshop with representatives from UNDP Uganda, MoWE, wider government ministries and LORTA. Key criteria were the regional balance, where the selection had to involve an equal number of project sites from eastern and southwestern regions, the budget and sample size restrictions (ensuring representativeness of wetland systems), agroecological zones and the level of implementation for components one and two in treatment wetland systems. The selected treatment wetlands have all received some form of implementation, varying between 35 per cent and 100 per cent of all planned activities. To account for implementation progress prior to the completion of this baseline report, at endline, the evaluation team will match between treatment and control households based on (i) retrospective information of community characteristics collected during a community leader survey; and (ii) satellite data (including but not limited to NDVI and nightlight trends) prior to project implementation. The community leader survey will ask retrospective community information prior to 2019, including the main sets of livelihoods, use of wetlands and community programmes.

For this baseline report, focusing mainly on components 1 and 2, survey data was collected from 1,666 households in eight treatment and eight comparison wetland systems – four each in eastern and southwestern Uganda. The sampling of households within each wetland system was completed in two stages. First, a list of all the villages within the parishes covered by the wetland system was created and used as a sampling frame. Six villages were randomly selected from this sampling frame, and 17 participants were selected from each village.

The following descriptive statistics compare treatment and comparison households but differences cannot be attributed to the project. A greater proportion of treatment households reported observable improvements in nearby wetlands and greater efforts to restore or sustainably manage these areas. Furthermore, fewer treatment households see nearby wetlands as degraded compared to comparison households, and a much greater proportion of treatment households report efforts to restore and

sustainably manage wetlands in their area. Smaller projects such as small-scale irrigation facilities, farmer field schools, or pig and cattle distribution were observed more within treatment areas. A greater proportion of treatment households reported project activities such as pig and goat distribution than comparison households. Most households reported still using wetland areas, with households practising, on average, two activities in wetlands, especially grazing and collecting firewood.

Socioeconomic and demographic differences also exist between the treatment and comparison samples. The biggest differences between treatment and comparison households are in the demographic profiles Households in treatment areas are more likely to be headed by a woman and are less likely to be married. They have fewer members (reflected in a lower adult equivalence score) and have less education. The degree to which the livelihood options promoted by the project consider this profile could be reconfirmed to ensure alternative livelihood strategies are tailored for all demographic groups. These demographic differences may also influence current residence patterns and access to land, as households in treatment areas have lived in their houses for a shorter time. In some contexts, women-headed households can face challenges in accessing and owning land, which may be reflected to a limited extent in this baseline report.

On average, households reported growing 5.5 crops, where maize, millet and sorghum are the three most frequently reported. The application of inputs to crops is very low, with many more comparison households applying agrochemicals, using more improved varieties and applying more sustainable land management (SLM) practices. Overall, men are more likely to receive information on agricultural practices from extension services compared to women, highlighting some of the key challenges women-headed households face. In addition, men tend to control the income from agriculture and contribute substantially to applying agrochemicals, transporting crop produce and selling crop produce within the range of agricultural practices. In contrast, women tend to contribute to physical labour including planting, weeding, harvesting, and post-harvest handling.

Regarding livestock, comparison households own more cattle and chickens, practice more intensive livestock practices, including zero grazing, and receive more income from these sources. These findings suggest greater and more advanced livestock rearing systems within comparison households, hinting at greater access to agricultural extension and the different demographic profiles. Another difference worth noting is that households in treatment areas apply fewer SLM practices.

Overall, the differences in employment profiles of the treatment and comparison households suggests:

- There is still a large reliance on agriculture.
- Diversification of livelihoods remains broadly similar.

The LORTA team's endline survey may choose to focus on the type of broader national and institutional interventions in the comparison area to gain a clear understanding of interventions in these treatment and comparison areas to ensure these differences are controlled for in the project's impact estimates.

Turning to wider sources of data, we now describe ecological results using satellite data to compare the vegetation and water coverage in treatment and comparison wetland systems by comparing wetlands before and after the project commenced.

The regional satellite findings in southwestern Uganda cover the period between 2016 and 2022. The trends in satellite data show that treatment sites recorded a reduction in tree plantations and farmlands within wetlands. These areas were mainly replaced by grassland. In the comparison sites, grassland areas decreased in size at the expense of tree plantations, farmland and built-up areas. Wetland degradation levels were high in two treatment and two comparison wetland systems.

The regional satellite findings in eastern Uganda cover 2015 to 2022. Two treatment sites showed an increase in farmlands. Three of the four treatment sites also showed a reduction in grasslands. For the comparison sites, a reduction in grassland and tree plantations at the expense of farmlands and built-up areas is also visible.

Data on fauna and flora was collected to cover the physical and natural properties of wetland systems. Overall, wetland systems show few significant differences in phytoplankton, green algae, flagellates, zoo phytoplankton and crustaceans.

The physiochemical properties of the water were also tested in situ, such as temperature, conductivity, dissolved solids and salinity. Regarding chemical analysis, treatment sites in southwestern Uganda had higher temperatures, total dissolved solids and salinity than comparison sites. Water salinity levels were beyond the usual range, which is a threat to aquatic life. These findings suggest that the water quality has not recovered despite progress in restoration activities. In the sampled wetlands in eastern Uganda, treatment sites also had higher temperature levels, total dissolved solids and salinity levels than the comparison sites. Only salinity was beyond the permissible water quality limits of the World Health Organization (WHO).

The National Adaptation Plan for the Agricultural Sector (NAP-Ag) in Uganda focuses on resilient cropping and livestock, value chain development, alongside interventions in climate information systems and better natural resource management. The FP034 project aims to promote conservation agriculture, diversification and farm crop management. The findings from this baseline report will be used to generate impact estimates at endline. They may also potentially inform any ongoing adaptive management and implementation adjustments. Uganda is already experiencing climate change impacts. The degree of urgency is palpable as changing climatic conditions affect different sectors of the economy, including agriculture and water resources.

I. Context

1. Climate change presents Uganda with considerable challenges including an increase in mean temperatures each decade and, in the aggregate, an increase in rainfall accompanied by more extreme weather events. In 2019, the MoWE predicts that by 2050, temperatures are likely to rise by at least 1°C and rainfall patterns are expected to become less predictable and more extreme (Uganda, Ministry of Water and Environment, 2019). Similarly, models show a 10-20 per cent increase in rainfall by 2100 and a greater likelihood of extreme weather events. The temporal distribution of rainfall is also expected to change. Greater precipitation is expected between December and February and less between June and August. Nsubuga and others (2021) detail how the variability in rainfall is likely to lead to greater dryness in the west and limited dryness in the east.

2. It is important to recognize how climate change is already affecting Uganda, with increasing minimum and maximum temperatures and an increased duration of drought periods. The lack of moisture is especially pronounced in the drier portions of the country (Uganda, Ministry of Water and Environment, 2014). In addition, greater precipitation variability between years and decades is also being observed. The current changes to climatic conditions are already affecting different sectors of the economy, particularly agriculture, forestry, health and water resources.

3. Within agriculture, increased variability of precipitation patterns is leading to soil erosion, nutrient loss and water logging, limiting the ability to close the yield gap (that is, the difference between current and potential maximum yields) of major crops such as Arabica coffee, Robusta coffee, maize, bananas, beans, sorghum, and cassava, ordered in terms of sensitivity to climatic impacts (Uganda, Ministry of Water and Environment, 2014). The Ugandan Ministry of Water and Environment (2019) highlights how modelling work estimates the largest loss of value will be for food crops, corresponding to USD 1.5 billion per year. Regarding export crops, coffee, tea and cotton yields are predicted to decline by at least 50 per cent by 2050.[1]

4. Wichern and others (2019) identified four climate vulnerability hotspots. These include central areas of the southwest region, where households are vulnerable to extreme temperature increases and rainfall declines that can adversely impact crops such as highland banana, maize and sorghum. A further hotspot in central northern Uganda is particularly vulnerable due to climate change’s impact on beans. However, the impacts here varied by elevation. Lugoi and others (2023) also highlight a series of climate hotspots in one river basin, indicating how climate change’s effects on sorghum, groundnuts, beans, maize and sweet potatoes could start as early as 2030. Zizinga and others (2022) highlight how greater variability in rainfall is likely to cause critical shortages for crops such as maize, with projections indicating yield reductions of 7-10 per cent by 2050. Climate change will also profoundly affect livestock rearing, dairy and fisheries.

5. Climate change impacts will accelerate the pressures on forests and wetlands in Uganda. Over 4 million people live close to wetlands in Uganda with many deriving livelihood activities from these vital ecosystems. The impacts of climate change on the water sector highlight two key areas of concern. First, changes in the country’s bimodal rainfall patterns may adversely impact Lake Victoria’s role as the major source of the country’s hydropower. Second, with increasing demand for groundwater, large changes in the form and amount of precipitation can threaten aquifers and lower water tables beyond the reach of current borehole depths.

6. These changes in physical systems will predominantly affect the economy through the role wetlands play within the country, as they regulate and smooth out surplus and deficit rainfall events. As a

[1] Climate impacts will also influence the health of the population through increased outbreaks of vector and water borne diseases, with particular concern regarding the potential for increased prevalence of malaria across higher altitudes and through the direct impacts of extreme weather events (Uganda, Ministry of Water and Environment, 2019).

result, the GoU has prioritized wetlands in its adaptation planning, alongside planning for the agricultural sector.

1.1. National policy context

7. Uganda has been a signatory of the United Nations Framework Convention on Climate Change (UNFCCC) since 1992 and ratified the Kyoto Protocol in 2002. The GoU developed a policy framework for mitigation and adaptation, based on the utilization of external finance and domestic expenditures. Uganda has reported regularly to the UNFCCC. Two pieces of legislation, the National Climate Change Policy of 2015 and the National Climate Change Act of 2021, set the legislative framework for coordination between ministries, local government and implementing agencies.

8. At national level, the Climate Change Department, housed within the MoWE under the Permanent Secretary, leads on climate coordination, with the Commissioner acting as the main interlocuter with the UNFCCC. The Commissioner oversees national communications and biennial update reports. The Climate Change Department also monitors the implementation of climate interventions. It communicates its findings to national stakeholders and the UNFCCC.

9. The Climate Change Act of 2023 confirmed the coordination role of the Climate Change Department. Also, the Act maintained the role of the Ministry of Finance, Planning and Economic Development as the focal point for climate finance from external sources, such as acting as the National Designated Authority for the Green Climate Fund (GCF). Implementation remains with ministries, departments and agencies. The Climate Change Act of 2023 delineated clearer roles and responsibilities for these actors. A key actor is the Natural Resources Department, the focal point at the district level.

10. Since 2011, Uganda has participated in the national adaptation plan (NAP) process started at the Durban Conference of the Parties (COP 17) and has followed the guidance offered by the UNFCCC's Least Developed Countries Expert Group (Uganda, Ministry of Water and Environment, 2019). Implementation of the National Adaptation Plan of Action (NAPA) started in 2012 and continued for one year in four districts, focusing on agriculture, energy and water (Nyasimi and others, 2016).[2] The experiences gained from implementing NAPAs have assisted countries in completing reports for intended nationally determined contributions and developing policy initiatives, including non-climate policy frameworks such as Uganda's National Development Plan and the National Policy for Disaster Preparedness and Management (Nyasimi and others, 2016).

11. Uganda is taking a two-pronged approach to the development of its NAP. The first is individual sectoral NAPs, and the second is the aggregation of these into an overarching policy framework (United Nations Development Programme, 2020). Reflecting the institutional architecture outlined above, NAP implementation involves five-year local development plans focusing on strategic local priorities and the key sectors of agriculture, energy, and, most importantly, water.[3] The development of the NAP is inclusive and involves a wide range of stakeholders. As overall coordination is centralized, the national government provides finance for implementation via grants, with local revenue collection expected to play a minor role (United Nations Development Programme, 2020).

12. A notable input into the country's NAP is the NAP-Ag from November 2018. The NAP-Ag has been developed in consultation with a range of stakeholders, including the Food and Agricultural Organization of the United Nations and through participatory events (Uganda, Ministry of Agriculture, Animal Industry and Fisheries, 2018). Overall, the NAP-Ag prioritizes resilient cropping, livestock and fishery systems, value chain development, interventions in climate information systems

[2] The lessons learned from pilot implementation projects show the importance of community participation and that capacity-building of local-level stakeholders is necessary for implementation but often requires long-term engagement.
[3] The degree to which local five-year development plans will integrate adaptation concerns is unclear, as local officials do not have substantive experience in mainstreaming climate concerns into these policy frameworks.

and better natural resource management. For example, actions are proposed to promote conservation agriculture, improve irrigation and water harvesting techniques, enhance extension services and promote diversification and better on-farm management of crops, especially post-harvest losses.[4] The next section describes the UNDP project funded by GCF.

II. Project intervention description

13. The project FP034 "Building resilient communities, wetland ecosystems and associated catchments in Uganda" has a project cost of USD 44.26 million, comprising a GCF grant of USD 24.14 million, UNDP co-financing of USD 2 million and government co-financing of USD 18.12 million. UNDP is the international accredited entity in Uganda responsible for implementing the GCF Project. The project is implemented through executing entities, including MoWE, MAAIF and the UNMA. The project engages a technical working group, which steers technical implementation alongside downscaled project ownership through district officials, subcounty engagement and community participation.

14. The project aims to manage wetlands based on a clear understanding of meteorology and hydrology. The project stemmed from the observation that the poorest households entered the wetlands, drained them, dug trenches and planted rice and vegetables. By removing the trenches, the project increases the absorptive and storage capacity of the wetlands, reducing surface run-off and allowing the ecosystem to regain its ability to regulate hydrological flows. The aim of the project is to support local residents in diversifying livelihood activities by removing constraints to engaging in higher-value nodes of value chains, such as aquaculture, fish farms, livestock, and small and medium-sized enterprises.

15. The project is being implemented for eight years between 2017 and 2025. It targets two regions, focusing on 12 districts in southwestern Uganda and 12 in eastern Uganda. [5][6] The project consists of three key components: (i) wetland restoration, including a hydrology subcomponent, (ii) improved agricultural practices and alternative livelihoods, and (iii) strengthening farmer and target-community access to climate and early warning information to support wetland management.

16. For component 1, wetland restoration involves discouraging activities that may damage the land, depending on how badly wetlands have been degraded. A healthy wetland in Uganda is flooded with water and contains a range of natural flora and fauna. Accordingly, wetlands typically retain water through trees, natural dams and other environmental features. As outlined above, several elements within natural and human systems have limited wetland the water retention abilities of wetlands. Component 1 aims to examine the necessary actions to restore each wetland area and gain buy-in from local communities. This outreach is conducted by engaging with district leaders who mobilize community leaders through their own communication channels to inform people about wetland degradation and the options for restoring them. This engagement is also where the interplay between components 1 and 2 becomes crucial: to canvass the views of community members on feasible and profitable alternative livelihood strategies compatible with healthy wetlands. Restoration is also carried out in wetland associated catchment areas.

17. Component 2 aims at offering viable alternative livelihoods to community members. Training is conducted at the community level, prioritizing community members who voluntarily allow wetland restoration and those who use catchment areas. The project conducted an "Alternative Livelihood Study" in 2018 to identify alternative sustainable and profitable livelihoods for wetland communities.

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[4] Additionally, the NAP-Ag outlines a series of challenges for successful implementation. These are relevant as they highlight how the institutional landscape and its incentives limit early and effective implementation.

[5] These are Kabale, Kisoro, Kanungu, Ntungamo, Bushenyi, Buhweju, Mitooma, Rubirizi, Sheema, Rukungiri, Rubanda and Rukiga.

[6] These are Budaka, Pallisa, Ngora, Bukedea, Mbale, Kaliro, Namutumba, Kibuku, Butebo, Tororo, Butaleja and Kumi.

Project team members surveyed communities to identify attractive and profitable alternative livelihoods in 11 districts. Each community was offered training in the alternative livelihoods identified in the "Alternative Livelihood Study". The project modified training packages according to community members' demands. The training includes different combinations of livelihoods, such as fishing and small business ownership. It is contingent on communities' interests. The MAAIF is responsible for coordinating component 2.

18. Component 3 complements climate change adaptation for communities through improved climate information. This first involves installing improved weather stations, analysing data to produce meaningful weather forecasts and disseminating understandable climate information to community members. The UNMA is responsible for this component. After installing the weather stations, which allow higher quality data-collection, UNMA creates reliable forecasts for several days, using time series data and analysis. These forecasts are compiled into accessible and relevant products, translated into different local languages and distributed to specific community stakeholders, such as farmers, fishers, and citizens engaged in non-agricultural activities. The project envisions climate information reaching the relevant population through radio, SMS, newsletters, and other modes and via extension workers.

19. The three components are implemented in a sequence, starting with component one. Component 1 requires mapping and identifying wetlands, engaging with stakeholders, demarcating stakeholder areas, conducting a wetland user inventory and restoring the associated catchment area.

20. Component 2 uses the wetland user inventory to form enterprise groups, provide livelihood options, and build capacity in livelihood management, climate smart agriculture, and sustainable wetland management. Component 3 offers climate and early warning information to optimize farmers' livelihoods.

21. The evaluation focuses mainly on components 1 and 2. For these components, physical wetland restoration and alternative livelihood training were piloted in Pallisa in 2018, before full project implementation. Both components were expected to be phased in over a six-year period and restore around 10,000 hectares (ha) per year. In the first full implementation year in 2019, 10,000 ha of wetland area was selected in a non-random, needs-oriented political process. These first 10,000 ha locations were geographically mapped, and communities were informed about project implementation in 2019. For the remaining 54,000 ha, the vulnerability of the wetlands' key agroecological and hydrological systems and community dependencies were identified more methodically. At the start of the project, the project team conducted a rapid assessment to generate geographic information on targeted wetlands in the project districts to update or bridge existing GIS data gaps.[7]

2.1. Project implementation

22. Based on information provided by UNDP project staff, as of December 2022, the project had restored 38,317 ha of degraded wetlands out of an end-of-project target of 64,370 ha. See Appendix 5 below for district disaggregated data. The number of hectares increased from 4,040 ha in 2019 to 11,168 in 2020 and from 22,853 in 2021 to 38,317 in 2022.[8] More broadly, the project also restored 1,655 ha of

[7] These were mapped as intact (no impact), slightly degraded (small impact), moderately degraded (moderate impact), degraded (largely impacted), highly degraded (highly impacted) and completely degraded (critically degraded).

[8] Project staff believe this has helped to restore ecosystem services such as water availability, increased moisture retention and biomass production in previously degraded wetland areas. Moreover, project staff report increased diversity of birdlife in a number of sites, indicating an improvement in ecosystem functions and services, in addition to increased production of usable biomass for grazing, mulching and harvesting for handicrafts. Project staff also maintain that increased moisture levels and water availability have contributed to increased agricultural production and domestic uses of water, and improved habitat has resulted in improved catches from fishing.

degraded catchment from a target of 11,630. The degraded catchments have been restored by planting assorted tree seedlings and constructing trenches and gabions at water pour points.[9] [10]

23. Component 2 focuses on providing alternative livelihood options in the wetland catchment areas. As of December 2022, the project had benefited 17,422 of the targeted 50,500 households. Households benefited from receiving different livelihood alternatives. Regarding livestock, pigs, goats, heifers, chickens, turkeys, and beehives were provided to 3,427 beneficiaries, comprising 1,901 men and 1,526 women.[11] Up to 2,366 farmers, comprising 1,659 men and 707 women, received support in the form of assorted seeds such as Irish potatoes, maize, beans, and vegetables. An additional 1,722 farmers, consisting of 1,295 men and 427 women, gained access to solar-powered mini-irrigation schemes. Fish farming has been promoted to 1,519 men and 476 women. Furthermore, 2,642 men and 1,410 women farmers from enterprise-based groups received training in crop diversification and resilient agricultural practices to enhance adaptation. In addition, 2,232 men and 1,628 women farmers undertook training in the use of International Labour Organization (ILO) methodologies for enterprise development and management.[12] Project staff reported that former wetland users have more alternative options and entrepreneurial skills to diversify their incomes.[13]

24. Regarding the goal of component 3 in strengthening access to climate and early warning information, as of December 2022, project staff reported that at least 1.48 million of the targeted 3.9 million people in the project areas have access to improved climate information. In this respect, project staff state that percentage of the population with access to improved climate information and drought, flood and severe storm warnings has increased from 20 per cent in 2020 to 30 per cent in 2021 and reached 38 per cent in 2022. The data is collected from the 41 hydro-meteorological facilities installed by the GCF Project. Project staff outlined how farmers and other targeted community members have been categorized and receive tailored SMS-based weather alerts and early warning advisories. The project has translated weather and early warning information into local languages and trained practitioners in disseminating weather and early warning information. In addition, the project uses digital platforms such as Telegram, WhatsApp, Facebook, Twitter, and Instagram to share weather advisories and make presentations at the Uganda media centre.

[9] Here, communities received training in making trenches using an "A" frame. Such frames manage the speed of water and minimize soil erosion. According to project staff, restored catchment areas improved soil and water conservation, due primarily to reduced erosion and the use of soil and water conservation measures. Moreover, project staff report that agricultural productivity and farming resilience in the catchment area have increased. The staff report that adopting soil, water conservation and climate resilient farming practices has promoted upstream sustainable farming practices and reduced the pressure on wetlands through greater availability of more productive land.

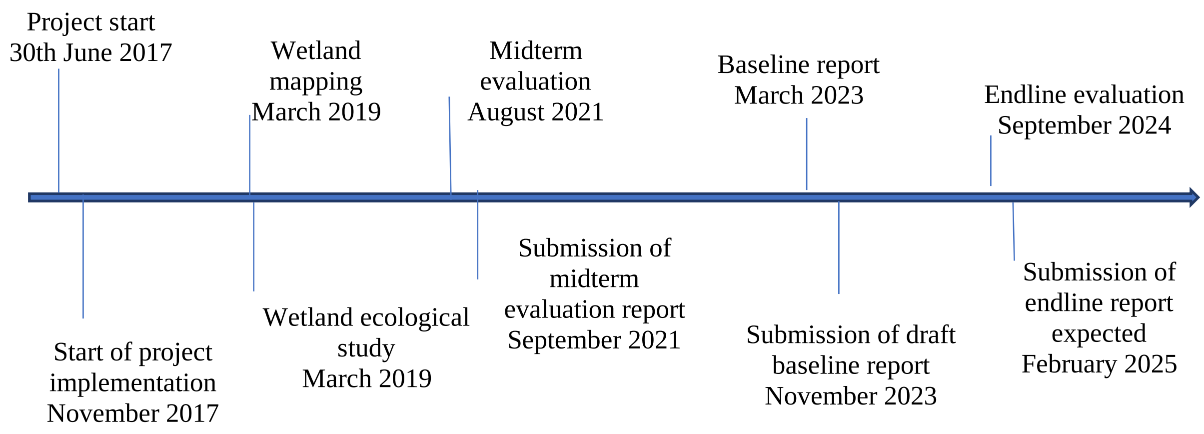
[10] Implementation in catchments has been limited with only 50 ha restored in 2020, 450 in 2021 and 1,655 in 2022.

[11] Component 2 indicators are the number of women involved in livelihoods and employability interventions in the project sites, as detailed above.

[12] These include Start and Improve your Business and Gender Entrepreneurship Together Ahead.

[13] Project staff state that component 2 activities have contributed to a 34 per cent increase in agricultural incomes and alternative livelihoods among the targeted beneficiaries. According to the project members, incomes increased by 0.47 per cent in 2019, 12.47 per cent in 2020, 27.47 per cent in 2021 and 34.47 per cent in 2022. It is unclear how these figures were derived.

Figure 1: Timeline for intervention activities



2.2. Theory of change

25. A simple description of the theory of change (ToC) for the impact evaluation of the FP034 is explained below for the two components this impact evaluation is mainly focusing on.[14] It should be noted that the ToC relies on several underlying assumptions extensively discussed during an inception workshop in Uganda in 2019. For example, that component 1 can only be successfully implemented if there is sufficient political will and support. Specifically, this refers to support from community leaders and their communities. An extensive and budgeted engagement plan is in place to deliver the needed support. A further assumption is that component 2 requires community members' willingness to adopt alternative livelihoods. At the same time, community members are expected to continue with existing agricultural livelihoods outside wetlands to ensure food security and benefit from the projects' additional activities for improving agricultural production. As highlighted above, the project was designed sequentially so that component 2 alternative livelihood activities build on wetland restoration. This sequential arrangement means the project's outcomes and impacts will lag.

26. Project staff reported that, once damaging practices are removed and retention facilities rebuilt, wetlands typically need saturation from four rainy seasons to recover their flora and fauna. This corresponds to a minimum of two years for harmful agricultural practices to be reduced and before the results of wetland restoration become visible. In addition, it takes at least one year before the positive impacts of the alternative livelihood component become apparent. Therefore, the effect of wetland restoration is likely to be observed three years after the start of component 1. The time between the programme's start in 2021 and the planned endline in 2024 may allow enough time for the LORTA to determine if project effects have materialized.

2.2.1. Component 1: Physical wetland restoration

Inputs

27. These refer to machinery and trained staff. The budget for these inputs comes from the GoU and UNDP Uganda through GCF funding.

[14] The overarching project ToC is described in Appendix 7.

Activities

28. The implementing agencies normally engage community members in wetland restoration. This activity includes encouraging community members to move out of wetland areas and to abandon harmful agricultural practices. In terms of restoration, community members build retention capacity in the wetland and catchment areas, for example, by planting trees. Additionally, small-scale water storage is built near the wetlands, serving the dual purpose of reducing flooding during heavy rains and providing water for irrigation systems, especially during dry seasons.

Outputs

29. After fully implementing component 1, 64,370 ha of wetland and 11,630 ha of catchment areas will be restored.

Outcomes

30. The community manages the wetland areas, preventing new degradation and sustaining the functioning water storage systems. They also move out of the wetland areas and reduce harmful agricultural practices.

Goals

31. The main goals behind physical wetland restoration are reduced food insecurity and enhanced resilience to climate shock.

2.2.2. **Component 2: Alternative livelihoods**

Inputs

32. These refer to experienced and skilled staff and seed funds.

Activities

33. The MAAIF takes the lead in training communities in economically viable, sustainable, agriculture-based and non-agricultural livelihoods with support from the district's local government and non-governmental organizations. The project introduces, promotes and supports income-generating interventions in the wetland and catchment areas, depending on the communities' demand and interest. Additionally, the project introduces saving schemes in the form of revolving funds. These ensure the availability of funds to purchase agricultural inputs when project funding expires.

Outputs

34. Farmers receive training in alternative livelihood options, such as vegetable farming in agriculture-based livelihoods or shop ownership in non-agricultural livelihoods. Sustainable agricultural practices, such as the wetland-based irrigation system, are implemented, allowing for multiple planting times each year and generating higher yields. Saving schemes in the form of revolving funds allow members to support their businesses by contributing and borrowing interest-free.

Outcomes

35. Farmers adopt alternative livelihood options and sustainable agricultural practices. The saving scheme is managed to ensure long-term viability.

Goals

36. The main goals behind alternative livelihood training are to contribute to higher agricultural yields, higher revenues, lower food insecurity, and enhanced resilience to climate shocks.

III. Evaluation questions and indicators

37. The main research questions to be answered by this impact evaluation, derived from the underlying hypotheses behind the ToC, are the following:

    1. What are the characteristics of respondent households?
    2. To what extent do respondents use wetlands, and how has this changed?
    3. How are households making a living?
    4. How are households spending money?
    5. How did shocks affect households?
    6. How prevalent is the use of early weather warning information?
    7. What are the perceived impacts and causes of climate change?
    8. What assets and entitlements do households possess and have access to?
    9. What is the state of wetland ecosystems in the selected sites in terms of level of degradation, presence of flora and fauna, and quality of water?

38. The following indicators provide answers to each of the evaluation questions. In terms of the characteristics of respondent households, variables have been generated on sociodemographic characteristics, household geographical characteristics, social connections and attitudes towards risk. This section included questions on what assets and entitlements households possess and have access to that led to the creation of indices on assets, physical capital, natural capital, human capital, and social capital (question 8).

39. Respondents have also offered self-reported information on the number of activities carried out in wetlands, perception of the state of the wetlands, perceived drivers and impact of wetland degradation, and wetland restoration and sustainable management activities. Furthermore, the survey questionnaire elicited data on community- and household-level resilience.

40. The third main research question focuses on how households are making a living. Here, the team has collected information on household income, livelihood activities, crop-related production, inputs, land-use, yield, practices, and challenges, as well as livestock-related production, inputs, land management practices, challenges and by-products. Households were also asked about fishing activities. Data on expenditure patterns was also included (question 4). The questionnaire elicited information on how shocks affected households (question 5), how prevalent the use of early weather warning information is (question 6), and data on sources of weather and climate early warning information (question 6). Furthermore, variables have been generated on climate change's perceived impacts and causes through understanding household experiences (question 7).

41. Turning to wider data sources, degradation levels are analysed through satellite data to compare the vegetation and water coverage in treated and comparison wetland systems by comparing wetlands before and after project implementation started (question 9). In addition, ecological indicators regarding fauna and flora check the physical and natural properties of treatment wetland systems alongside water quality monitoring (question 9).

IV. Evaluation strategy and design

42. Early in the evaluation process, it became clear that a randomized impact evaluation was not feasible. As outlined above, a difference-in-differences (DiD) combined with matching was the next best approach for measuring programme effects at the wetland and community level. However, due to delays in project implementation related partly to COVID-19 and challenges with coordinating data and information between the evaluation and project management teams, accessing timely data to inform the selection of control wetland systems was challenging. Due to this, the evaluation design evolved to a DiD design with matching at the levels of wetland systems (using Ministry and project staff expertise) and households (through statistical procedure).

43. Matching at the household level uses statistical techniques to construct an artificial comparison group that shares key observable characteristics with the treatment group. The idea is to select, for every treated unit, a comparison unit that has the most similar observable characteristics. When applied in this way, it is important to ensure that (i) treatment and comparison units are drawn from the same data source, (ii) both groups are exposed to similar economic incentives, and (iii) there are enough variables available to predict programme participation. Then we decided not to do this due to the long time lag (we need to ask about the situation prior to 2019 in 2024 which will suffer from recall bias).

44. The LORTA team held several meetings with the project management unit through 2022 to propose this specific approach for selecting the treatment and comparison wetland systems. The LORTA team received a data set on the ecological characteristics of wetland systems and alongside a consultant from UNDP completed a matching exercise at the wetland level. However, due to the limited quality and range of ecological variables included in that analysis, and the limited visibility by some project stakeholders (who viewed the matching exercise as a black box), this initial matching of treatment and control wetland systems was not endorsed by key stakeholders.

45. To increase the transparency of wetland-level matching, and to ensure full national stakeholder ownership of the process, the LORTA team participated in a four-day UNDP and MoWE workshop attended by over 30 government officials and stakeholders from wider ministries and agencies. During this workshop held in February 2023, stakeholders stated and reiterated the importance of working face-to-face with government stakeholders. Working remotely during the pandemic had created considerable challenges in ensuring agreement on specific evaluation design features. Through a four-day workshop, the project and LORTA teams clarified terms from different disciplines, engaged different departments, utilized the different teams' GIS expertise, and confirmed the approach for the matching of wetland systems. During the workshop, consultations with the implementing team revealed that most of the wetlands and their associated catchments have been restored to a certain level. In addition, stakeholders explained how the matching of wetlands using propensity score matching (outlined in Appendix 3) was not transparent and was widely seen as a black box. These factors rendered the wetland-level matching exercises (which used ecological indicators to match treatment and comparison wetland systems) obsolete.

46. Instead, the selection of wetland systems was conducted in a participatory manner involving all agencies involved in the evaluation. Key criteria were (i) the regional balance, where the selection had to involve an equal number of project sites from eastern and southwestern regions, (ii) the budget allocated for the evaluation, and (iii) the level of implementation for both components 1 and 2 for treatment wetland systems. With the help of GIS for each treatment wetland system, a comparison wetland system was identified and agreed upon by all stakeholders within the same district, although from a different catchment area. Table 1 indicates the list of selected project sites with their corresponding comparisons sites.

Table 1: Implementation levels of components 1 and 2 in the selected treatment and comparison sites in eastern and southwestern Uganda

Treatment sites			Comparison sites	
Wetland system	**Components 1, 2 implementation level (%)**	**Region**	**Wetland system**	**Region**
Namutumba – Mazuba mini-Mpologoma	100%, 80%	eastern	Namutumba – Nabinyonyi – Kimenyulo	eastern
Bushenyi – Nyaruzinga	95%, 90%	southwestern	Bunshenyi – Mbachi	southwestern
Rubirizi – Kidubule – Ibamba – Nyakagyera – Ngoro	85%, 50%	southwestern	Rubirizi – Chambura	southwestern
Kisoro – Chotsa Bay – Mulehe Mutanda	80%, 70%	southwestern	Kisoro – Mulindi – Echuya/Muchoya	southwestern
Ngora – Agu	80%, 40%	eastern	Ngora – Agwiki	eastern
Bukedea – Lwere/Komorototo	70%, 40%	eastern	Bukedea – Kapia/Okula	eastern
Mitooma – Nyamuhizi – Kagogo	60%, 80%	southwestern	Mitooma – Nchwera	southwestern
Kumi – Oladoti/Kakores	60%, 35%	eastern	Kumi – Obura	eastern

47. A key point that emerged from the workshop concerned the selection of wetland systems with varying degrees of implementation.

48. The project and evaluation team had to review the overall DiD design, recognizing that implementation had already proceeded for components 1 and 2. Due to the purposive selection of treatment wetland systems and the selection of comparable comparison wetland systems based on expert judgment from project stakeholders, the characteristics of the treatment and comparison wetland systems will vary systematically at baseline.[15] Therefore, to allow the estimates to capture project impacts from the inception of the baseline survey, the evaluation will use three different approaches to matching households: nearest neighbour matching (teffects), caliper matching (set at 0.5 teffects) and direct nearest neighbour matching (nnmatch), as detailed below.

[15] A DiD design accounts for initial observable and unobservable differences between the treatment and comparison groups, by assuming that these observations followed a similar trend over the intervention years, without the difference introduced due to one group receiving the treatment. Therefore, as long as the assumption of initial differences in the outcomes of interest evolves constantly over time, this method enables the causal identification of the program's impacts. This approach is also robust to external shocks, as long as these shocks affect both groups similarly. Nonetheless, time-varying differences are not controlled for within a difference-in-differences approach, and – if present – would undermine the estimation of the programme's effects. Examples of such uncontrolled time-varying differences are alternative infrastructural activities in the treatment or comparison wetlands or similar livelihoods training in the comparison wetlands from other projects.

4.1. Heterogenous effects

49. Wetlands differ in geographic location, population and biodiversity. The impacts of the FP034 will be analysed separately according to eastern and southwestern regions to examine if the effects differ by location. Regarding gender differences, impacts will be estimated separately by the gender of the household head. Finally, two other dimensions of heterogeneity will also be considered, that are (i) the initial wealth level of households, and (ii) the distance to urban areas. These variables will be interacted with the treatment dummy to assess if FP034 impacts differ by subgroup. It is important to note that the sample size was designed to detect impacts in the whole sample. Hence, every subgroup analysis will suffer from a reduction in statistical power.

4.2. Assumptions and limitations

50. Propensity Score Matching (PSM) is likely to be used for matching. PSM creates a comparison group by matching treatment households to one or several untreated households on their estimated probability of receiving project activities, called propensity scores. This probability will be estimated based on a range of observable characteristics, called matching variables, that can predict receiving project activities.

51. PSM is based on two assumptions. The first assumption, conditional mean independence, is that non-beneficiaries mean outcomes would be identical to those of beneficiaries if they had not received the programme. The matching exercise will ensure that the conditional independence assumption is met by including variables in the logit/probit model that cover the eligibility criteria for the programme but which cannot be directly affected by programme participation. If the evaluation team has any doubts about potential predictor variables due to the project having started already (for example, it may be the case that wetland restoration has influenced the location of households, or the number of individuals living within treatment households), the models will be run using different specifications both with and without these specific predictor variables. Moreover, to reflect certain district level characteristics that might affect project participation, such as access to markets, dummy variables are used in the logit/probit model.

52. The second assumption, "common support", ensures ample overlap in treatment and control propensity score distributions. Households that fall outside the zone of the common support area are dropped. Since the data set will include a broadly similar number of participants and non-participants, a Kolmogorov-Smirnov test for equality of distributions for both treatment and control groups will be implemented.[16] All specifications will need to pass balancing tests.

53. Moreover, a wrong specification of the propensity score model may lead to greater imbalances within the sample at hand (Iacus, King and Porro, 2012). King and Nielsen (2019) show that PSM can increase imbalance, inefficiency, model dependence and bias.[17] They recommend complementing it with Coarsened Exact Matching (CEM) or Mahalanobis Distance Matching (MDM). A further recent advance in this respect is Inverse Probability Weighted Regression Adjustment (IPWRA).

54. But that is not to say that CEM, MDM or IPWRA are without their own shortcomings. By directly matching on covariates, CEM and MDM may lead to greater sample losses due to a lack of common support between the treatment and comparison groups. As such, these approaches may be suboptimal when many matching variables are required to achieve balance (Ripollone and others, 2020).

[16] Performing matching only at the household level requires a dataset of potential comparison households, ideally at least two times larger than the treatment group, to enhance the quality of the matches and, thus, the comparability between the treatment and comparison groups. However, dedicated evaluation budget of FP034 does not allow the survey to cover such a large sample in the control wetland systems.

[17] Such criticisms and results are applied specifically to nearest neighbour matching, using calliper bandwidths, rather than all uses of PSM (Guo and others, 2020).

Furthermore, CEM and MDM also require precise knowledge of the source of selection bias and precise measurement of the matching variables. Guo and others (2020) show that CEM and MDM are not always better choices than various uses of PSM when considering reductions in imbalance and retention in sample size.

4.3. Identification strategy and empirical strategy

55. The impact evaluation is based on an ex-post matching design. The propensity scores will be estimated via a binary choice model (i.e., a probit or a logit model), as illustrated by equation (1).

$$T_i = \alpha + \delta M_{ji} + \mu_{ji} \quad (1)$$

56. In this equation, T_i represents the treatment dummy, which takes the value 1 if household j is located in a treatment wetland system and 0 otherwise, α is a constant representing the average probability of treatment in the comparison group, δ is a set of coefficients capturing the impact of matching variables M_{ji} on the probability of treatment and μ_{ji} is an error term. This equation will be used to predict the probability of receiving the project activities for each household in the sample based on their characteristics reflected by the selected set of matching variables. The predicted probability of treatment is illustrated by equation (2), where *p(m)* represents the propensity scores.

$$\Pr(T = 1 | M = m) = p(m) \quad (2)$$

57. Households from comparison wetland systems were not eligible to receive project activities solely because of their residence location. Hence, the matching variables will capture differences in characteristics between treatment and comparison households, resulting from their different residential locations, which are also correlated with the outcomes of interest. Differences in treatment and comparison households will be assessed by the means of balance tests from this baseline report and can guide specifications of matching variables.[18] This initial list of matching variables will be further informed by insights from the literature on the determinants of the key outcomes of interest and by directly exploring correlations between this indicative set of determinants and outcomes. At this stage, the evaluation team intends to match using three different specifications: retrospective variables based on sociodemographic characteristics and selected assets; a full suite of variables that cover as many characteristics of households as possible; and by matching solely on outcome indicators from this baseline report. Recent comparative work highlights how this final approach to matching provides the closest approximation of estimates derived from randomized evaluation designs.

58. As a second step of the propensity scores specification, the LORTA team will assess if these variables are balanced within two groups with estimated propensity scores. Rather than manually going back and forth between these two steps (i.e. 1. determining the list and forms of matching variables; 2. assessing balance), the study will follow the automated procedure developed by Imbens and Rubins (2015). This procedure tests the balancing properties of a pre-selected set of variables and their first and second-order interactions.

59. The estimated propensity scores will then be used to match treatment households with comparison households. Specifically, the study will estimate average treatment effects on the average treatment effect on the treated (ATT), as represented by equation (3).

$$ATT = E\left(y_{ji}{}^{1} - y_{ji}{}^{0} \middle| T_i = 1\right) = E\left(y_{ji}{}^{1} \middle| T_i = 1\right) - E\left(y_{ji}{}^{0} \middle| T_i = 1\right) \quad (3)$$

60. In this equation, y_{ji} represents each respective outcome of interest in household j located in wetland system i and T_i represents the treatment dummy, which takes the value 1 if household j is located in a treatment wetland system i and 0 otherwise. The ATT corresponds to the difference (E) between the

[18] A list of potential matching variables is presented in Appendix 1.

outcomes of the treatment group ($T_i = 1$) when this group receives the project intervention (${y_{ji}}^1$) with the outcomes of the same group when this group does not receive the programme (${y_{ji}}^0$). Both statuses cannot be observed simultaneously: a household either receives the programme or does not.

61. To lower the dependence of the results on the specification of the propensity scores, the team proposes using the doubly robust IPWRA. IPWRA assigns more weight to households less likely to have received the project, here the FP034 activities, and less weight to those more likely to have received the programme. More specifically, the ATT is retrieved by equation (4) below. A key advantage of this method is its requirement for only one of these two equations to be well specified for consistently estimating treatment effects (Wooldridge, 2010). Hence, this estimator allows for a more flexible and robust specification compared to other matching estimators.

$$ATT = \frac{1}{n_1}\sum_{j=1}^{n} y_{ji}\, T_i - y_{ji}\,(1 - T_i)\,\frac{\hat{p}(m_j)}{1-\hat{p}(m_j)} \qquad (4)$$

62. In this equation, n_1 represents the sample size of the treatment group (i.e., the number of households members in treatment wetland systems in the sample), y_{ji} each respective outcome of interest in household j located in wetland system i, T_i represents the treatment dummy, which takes the value 1 if household j is located in a treatment wetland system and 0 otherwise, and $\hat{p}(m_j)$ the estimated propensity score of household j based on its characteristics m. The ATT estimated using IPWRA corresponds to the average difference in outcomes between treatment households and the outcomes of the comparison group weighted by the inverse probability of being treated.

63. Within districts, each project site stretches across several parishes. As indicated above, sampling has included all parishes covered by the wetland system because projected benefits accrue to the beneficiaries and influence all citizens adjacent to the restored wetland system. The sampling of households within each wetland system will be completed in two stages.

First, a list of all the villages within the parishes covered by the wetland system was created and used as a sampling frame. Six villages were randomly selected from this sampling frame. A further sampling frame was completed for all households from the selected villages, and 17 participants were selected from each village. This approach would ideally have provided 1,632 respondents. However, some variations occurred during the data-collection. Some villages recorded higher than the planned sample, while others yielded slightly lower. In the end, the respondents numbered 1,666, higher than the sample size in

64. Table 5.

4.3.1. Ecological outcomes – satellite data

65. The conditions of wetlands before implementation started (2015, 2016) and close to the timing of the survey for this baseline report in February 2023 were assessed using high-resolution satellite imagery. Changes in wetland use or cover types in selected districts in eastern and southwestern Uganda were mapped using Google Earth Engine[19]. High-resolution Google Earth satellite images for 2015 (eastern) and 2016 (southwestern) which had a reduced cloud coverage were filtered for mapping purposes. 2015 and 2016 were considered baseline years for monitoring changes in wetlands in eastern and southwestern Uganda, respectively.[20] For this baseline report, 2022 was used to monitor the current wetland changes in eastern and southwestern Uganda. The satellite images for the selected wetland sites were masked using wetland boundaries from the Wetland Management Department (WMD), MoWE, Uganda. Appendix 12 shows the temporal and spatial attributes of the satellite images to be analysed in this baseline report.

66. Representative training areas for the different wetland use/cover types (built-up areas, farmlands, grasslands, open water, papyrus, tree plantations, and woodlands) were created to teach the classifier. The classified satellite images were then reclassified into the various wetland use/cover types (see Table 2). The classification and reclassification process were repeated for all the wetland sites. Change detection analysis was completed to assess the trends before implementation started and 2022.

Table 2: Description of wetland use/cover types that were mapped for 2015/2016

No	Wetland classes	Description
1	Built-up areas	Wetlands converted into settlements, industries, waste treatment plants, roads.
2	Farmlands	These are wetlands under cultivation for both subsistence and commercial purposes.
3	Grasslands	These are wetlands with tall and short grasses.
4	Papyrus	These are wetlands with rooted and floating vegetation that can grow up to 5–6m.
5	Open water	These are areas covered with natural water, dams, and ponds.
6	Tree plantations	These are wetlands converted into tree plantations, such as eucalypts and pine.
7	Woodlands	These are wetlands composed of scattered tall trees, shrubs, and palm trees with grasslands underneath.

67. Validation for the classified wetland use/cover types was completed in the selected sites of eastern and southwestern Uganda by picking coordinates of the various wetland use/cover types using a hand-held Garmin GPS device. The collected ground-truth points were used to assess the accuracy of the classified wetland use/cover types and wetland boundaries. The classified wetland use/cover types were also validated using the country-level classified wetlands layer for 2022. Areas with a small

[19] Google Earth Engine is a cloud-based geospatial analysis platform that supports planetary-scale environmental data analysis.
[20] The difference in year is due to the availability of cloud free satellite images.

cloud coverage on the satellite images were visited to confirm the ground wetland use/cover types. The accuracy of the classified wetland use/cover types was completed using the error matrix in the GIS environment. The team used the following classified wetland use/cover types to categorize the levels of degradation in wetlands of eastern and southwestern Uganda (Table 3).

Table 3: Levels of degradation based on the wetland use/cover types

Wetland use/cover type	Levels of degradation
Built-up areas	High
Farmlands	Moderate
Grasslands	Low
Papyrus	Low
Tree plantations	High
Open water	Low
Woodlands	Low

4.3.2. Ecological outcomes – flora and fauna

68. The evaluation also checked key ecological indicators for fauna, including the presence of macrophytes, zooplanktons and macroinvertebrates. For phytoplankton sampling, the samples were collected using plastic bottles, then fixed with 1 per cent Lugols iodine solution and wrapped in aluminium foil prior to laboratory analysis.[21] For zooplankton sampling, samples were collected and filtered through a 64mm plankton net to concentrate to 100ml and fixed with 70 per cent ethanol before laboratory analysis.[22] For macroinvertebrate sampling, aquatic invertebrates were collected using a mud grabber, and samples were washed in a benthic net.

69. The evaluation was completed with a water quality assessment in two parts. First, a physical water quality assessment involved the determination of temperature. Second, a chemical water quality assessment involved the assessment of various parameters, including electrolytic conductivity, salinity and total dissolved solids. These properties were determined on-site using portable metres. On each sampling occasion, water temperature, electrolytic conductivity and total dissolved solids were measured at 1-m depth from the water column surface using an EC/Sal and TDS EXTech 3200 probe.

4.3.3. Asset index

An asset index was created based on four asset capitals that allowed the project team to compare the project's impact on households' initial wealth. This was conducted using principal components analysis (PCA) (Filmer and Pritchett, 2001), a data reduction technique used to combine and reduce multiple variables into one or more underlying components which are orthogonal – meaning they are entirely uncorrelated and represent different underlying dimensions of, in this case, wealth.

[21] In the laboratory, 50ml samples were concentrated and 0.1ml sub-samples counted using Utermohl's inverted microscope methods. Phytoplankton were identified to genus level according and expressed as cells per litre.
[22] In the laboratory, samples were identified and counted under a light binocular microscope using 1ml Sedgwick counting chamber. Zooplanktons were identified to genus level.

70. Table 4 describes the variables used to represent four asset capitals.[23] Appendix 5 describes the weighting used to create the physical and social capital variables.

[23] 1 outlines the descriptive statistics for these variables, construction of the two indices including the weights applied.

Table 4: Description of variables used in PCA

Variable
Physical capital: Housing index based on the quality of the roof, walls, floor, latrine and number of rooms
Natural capital: Total land area for crop production in acres
Human capital: Highest educational level of the household head
Social capital: Index based on leadership positions in local churches and mosques or local authorities, membership of local groups of communities

A series of checks were performed to ensure variables were suitable for PCA. Correlation coefficients showed significance above 95 per cent for all variables in

71. Table 4.[24] In addition, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's sphericity test were applied to determine the adequacy of variables. The result of the KMO measure of sampling adequacy was 0.6, within the necessary range for PCA (0.5–1.0), and Bartlett's test of sphericity was significant (<0.001). The two tests underlined that the selected variables were appropriate for PCA. PCA created one component with an eigenvalue of 1.437, representing 35 per cent of the variance in the original variables.[25]

4.4. Description of the units used in decision-making, the intervention and analysis

72. The wetland project restores each wetland area by engaging with district and community leaders to inform people about the degradation of wetlands and the types of actions that can be undertaken for restoration. The views of community members are canvased in terms of alternative livelihood strategies that are compatible with healthy wetlands and are profitable. The project offers viable alternative livelihoods to community members through training at the community level. Most of the project activities were implemented at the community level. In this report, the survey data focuses on households, the unit of analysis for understanding socioeconomic characteristics and livelihood portfolios. This is the data used for the impact evaluation estimates. The study supplements this with descriptive data at the wetland level for ecological indicators from satellite data and biological and chemical assessments of flora and fauna.

4.5. Sample size and power calculations

73. The initial approach to sample size calculations is outlined in this section. The study used the following power formula that relates the sample size to the minimum detectable effect size (MDES) between the mean outcomes of the two groups:

$$MDES = (t_{1-\kappa} + t_{\alpha})\sqrt{\frac{1}{P(1-P)}}\sqrt{1+\rho(m-1)}\sqrt{\frac{\sigma^2}{N}}\sqrt{1-R^2} \qquad (5)$$

where $t_{1-\kappa}$ and t_{α} are t-statistics representing the required power and level of statistical significance (conventionally, the study aims for a power level of 80 per cent and a statistical significance of 95 per cent), P represents the proportion in one of the two compared groups (allocation ratio), ρ is the intra-cluster correlation, m is the number of individuals per cluster, σ^2 is the variance, N is the total sample size, and R^2 represents the extent to which characteristics predict the endline outcomes. Since the livelihood training is delivered on a group basis and wetland restoration affects all households located in the cluster around one restoration node, there will likely be some similarities in outcomes between the members of one cluster. It is important to consider this aspect in the power calculations, which is captured in the intra-cluster correlation (ICC).

74. Initial power calculations were conducted for a sample of 1,500 households, 150 communities, 10 households per community, an expected R-squared of 30 per cent, and an evaluation sample equally split into 750 comparison and 750 treatment households. The power calculations are based on a

[24] At this stage, the variable for geographical capital, an index based on distance to the health centre, market, town and tarmac was dropped as the Pearson's correlation coefficient with the social capital index and human capital index was low and insignificant.

[25] The study uses the first component for this impact evaluation. For the use of further components, it could use a scree plot to determine how many eigenvectors need including.

sample of 2,000 Ethiopian smallholders in 2019, and different potentially interesting outcome measures were selected (see Appendix 13).[26]

75. The outcome variables included for power calculations are the number of income sources, income itself and food security measured via the Household Dietary Diversity Score (HDDS), the Months of Adequate Household Food Provisioning (MAHFP) as well as the Household Food Insecurity Access Score (HFIA). Results show that the sample of 1,500 households is sufficient to detect minimum changes between 5 per cent for the HDDS and 32 per cent for income. An increase of 32 per cent in income seems high, and it may not be possible to capture increases in income with statistical significance. The calculations show that the sample size will be sufficient to capture increases in food security.

76. As the initial sample size calculations used Ethiopian data and not Ugandan data, the evaluation team referred to Nkonya and others (2020) to check for the ICC for agricultural income at the village level for Uganda. Using a statistical power of 80 per cent at a significance level of 95 per cent together with the above information, the LORTA team again estimated the MDES through the following equation using ICC values of 0.10 and 0.15 and R^2 of 0.30.[27]

$$MDE = (t_{1-k} + t_{\alpha})\sqrt{\frac{1}{P(1-P)}\sqrt{1} + \rho(m-1)\sqrt{\frac{\sigma^2}{N}\sqrt{1} - R^2}} \qquad (6)$$

where t_{1-k} and t_{α} are t-statistics representing the required power and level of statistical significance, P represents the proportion of treatment groups, which is 50 per cent for the study, ρ is the ICC, m is the number of individuals per cluster, comprising 20 for the study, δ^2 is the variance, N is the total sample size, R^2 is the extent to which the baseline characteristics predict the ending outcomes and is fixed at 30 per cent. The LORTA team estimated the MDES using Optimal Design Software for one of the study's outcome variables, agricultural income. This indicator captures both agricultural productivity and market linkages. The results of the revised MDES calculations are shown in

[26] Since there was no data available initially for the Ugandan villages, similar information from Ethiopian farmers was used as a reference.
[27] The LORTA team will review the power calculations considering the data collected at baseline.

Table 5.

Table 5: Indicator and sample size

	Sample size	ICC	MDES
Agricultural income	1,520	0.100	0.22
Agricultural income	1,600	0.100	0.22
Agricultural income	2,000	0.100	0.21
Agricultural income	1,520	0.150	0.25
Agricultural income	1,600	0.150	0.24
Agricultural income	2,000	0.150	0.24

77. The LORTA team chose a sample size of 1,600 as at this size, it would require a significant increase in sample size to reduce the MDES. The corresponding MDES for a sample size of 1,600 with an ICC of 0.1 and an R-squared of 0.3 is 0.22. This sample size builds in a buffer for attrition. Therefore, the project will have to improve the agricultural income of participating households by at least 22 per cent to leave a noticeable impact consistent with the Nkonya and others (2020) findings that agricultural programmes in Uganda increase agricultural income by 20–100 per cent.[28]

4.6. Challenges encountered with the research design and data-collection

78. During the survey data-collection for the baseline report, team members adhered to the evaluation strategy outlined above without major deviation. Comparison wetland systems were validated in the field with the guidance of the project district focal person before the data-collection process to ensure these areas would support the evaluation. The distance between the comparison and treatment wetlands ensured limited contamination between treatment and comparison wetland systems. For example, wetland systems were selected from different watersheds. [29] The data-collection for this report did reveal the following challenges in the design and data-collection processes:

- **Collection of spatial data:** The location of households is an important factor in the evaluation design, with high GPS errors >6m recorded in southwestern Uganda due to high cloud coverage. These errors undermined the exact location of some households. They were remedied by recording the names and administrative locations of survey respondents.
- **Accessibility challenges:** The mountainous terrain in the project areas, especially in Kisoro, hindered socioeconomic data-collection, with the lack of transport requiring walking to access households situated at the top of hills or the bottom of valleys. This difficulty delayed the completion of data-collection within the two-week allocation.
- **Limited engagement of district focal persons:** The limited availability of district focal persons in certain comparison sites delayed the data-collection. The scheduled data-collection time was extended, and the project team needed to mobilize local leaders.

[28] Power calculations were based on a randomized control trial design.

[29] Data on the distance between the control and treatment wetlands may be included in the endline survey's analysis.

- **Evaluation of the project's component 3:** While some aspects of component 3 were included in the survey, stakeholders emphasized the importance of component 3 and proposed that this should be fully incorporated for the endline survey.

4.7. Data and quality assurance

79. Survey data was collected using a computer-assisted personal interview tool, KoBo Toolbox. The open-source tool provided a robust and reliable way to conduct this type of interview. KoBo Toolbox has become standard in data-collection as it only needs a tablet to collect and upload data to the server, including photos, audio, and GPS location.

80. Before entering the field, the project team ensured the quality of the data-collection instrument and associated enumerator guide through a four-day workshop to allow all stakeholders to voice their opinions and ensure co-ownership and co-creation of the questionnaire. Broader data-collection tools, including the key informant guide and focus group discussion guide, were reviewed by technical personnel from the LORTA team, UNDP, the GCF Project management unit and MoWE WMD.

81. Data enumerators were hired and trained to understand the operation of smart tablets, the standard operating procedures for conducting social research, and the questions and responses highlighted in the survey tool. The household questionnaire was pre-tested and piloted outside the treatment and comparison wetlands. The survey was conducted in March and April 2023. Data quality checks were conducted daily during fieldwork to check the quality of data submitted by enumerators and advise them on improving data quality. For the ecological data, physical visits to wetland sites were organized with the district focal person alongside the natural resources officer, agriculture production officer and community development officers. As described above, the classification of satellite data was triangulated through a process of ground-truthing.

Table 6: Wetland systems per region and district covered

Region	District	Treatment wetland system	Comparison wetland system	No. of households
Eastern	Bukedea	Komuge	Akuolo	220
Eastern	Kumi	Oladoti/Kakores 1	Obura	214
Eastern	Ngora	Agu	Agwiki	212
Eastern	Namutumba	Mazuba mini-Mpologoma	Nabinyonyi–Kimenyulo	191
Southwestern	Mitooma	Nyamuhizi–Kagogo–Mushasha	Katenga	225
Southwestern	Rubirizi	Kidubule–Ibamba–Nyakagyera–Ngoro	Chambura	204
Southwestern	Bushenyi	Nyaruzinga/Kanyara–Nyampimbi	Mbachi	190
Southwestern	Kis–ro	Chotsa bay–Mulehe Mutanda	Mulindi/Echuya/Muchoya	210

82. For focus group discussions (FGD), one village was selected from the restored wetland system and another from the comparison wetland system with the assistance of the local Council Chair. For each focus group, seven respondents were selected, with a focus on households that utilized the wetlands. Data was collected using the focus group discussion guide. In total, 32 FGDs were held. One-on-one interviews were conducted using an interview guide. Those who could not physically be reached were approached for phone interviews.

83. The LORTA team provided technical assistance and quality assurance throughout the evaluation process. The LORTA team engaged with UNDP in developing the evaluation design and sampling strategy. The data set was reviewed and cleaned to allow data analysis by removing outliers, coding non-coded responses and correcting illogical or contradictory answers. Checking for unique IDs, consent, answer typos and completeness of questions was also part of this process. The final baseline data set was used for analysis. All quality issues that were encountered were immediately addressed.

4.8. Software and code

84. Table 7 lists the project evaluators' software.

Table 7: Software utilized by the project team

Software	Purpose	Project objects derived
KoBo toolbox	Coding questionnaire	Used to capture household responses
Stata	Socioeconomic data analysis	Analysis of livelihood options
ArcGIS 10.8	Spatial data analysis	State of wetlands
Google Earth Engine	Satellite image classification	State of wetlands

4.9. Ethics

85. The ethical standards guiding the evaluators in collecting data include voluntary participation, informed consent, anonymity, confidentiality, mitigating any potential for harm, and results communication. The LORTA team ensured that these principles were adhered to in the design of tools, training of enumerators, and engagement with stakeholders and that participants offered their informed consent before opting into the evaluation activities and data-collection. In addition, the evaluators considered and used the LORTA Uganda data-collection guide. It facilitated the implementation of standardized field protocol, data quality monitoring and data cleaning of socioeconomic data.

V. Presentation of results

86. This section covers findings from the household survey, reports on the findings from the satellite assessment of treatment and comparison wetlands and examines the ecological assessment of fauna and water quality. When reporting findings from the socioeconomic survey, we first cover the sociodemographic characteristics of the treatment and comparison households before moving on to assets, wetland benefits and restoration, livelihoods and income, crop production, post-harvest handling, the use of agricultural incomes, gender and agriculture and the livestock profile. Findings from the socioeconomic survey then cover food diversity, food security, shocks, weather, climate and connections of the household and the attitude to risk. Only the most relevant tables are shown in this section. Appendix 13 contains a full set of baseline results tables.

87. For the socioeconomic survey, this section includes statistical comparisons between (i) households in wetland areas that have received some project activities and are noted as a treatment group or treatment household and (ii) households in areas that have not received any implementation under Project FP034 (denoted as comparison households or the comparison group). It could be that these areas have received similar activities from other programmes, information that the evaluation team may choose to collect and analyse at endline. The differences between the two groups cannot be considered causal.

5.1. Socioeconomic survey

5.1.1. **Sociodemographic characteristics of the sample**

88. This section compares the household's main sociodemographic and geographic characteristics between the treatment and comparison groups. Table 8 depicts the sociodemographic characteristics of the household, many of which pertain to the head of the household. Regarding the main differences between the treatment and comparison households, treatment households are less likely to be male-headed by 9.7 percentage points and have one less member. The difference in household composition may be driven by the lower number of adults in treatment households, as shown by the higher adult equivalence score of comparison households. The household head is also more likely to be married in the comparison households, at around 6 percentage points higher, and less likely to be widowed, at around 4.8 percentage points higher. Finally, household heads in comparison areas are marginally more likely to have completed their O-level of education at around 7.6 percentage points. Other characteristics, such as the average age of the household head, the dependency ratio of the household, the share of single household heads, and other levels of education, show no significant difference between treatment and comparison households.

Table 8: Descriptive statistics on sociodemographic indicators

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Age of the household head	48.54	48.05	0.73	582	701
Male-headed household	0.67	0.76	0.07*	609	726
Number of household members	6.30	7.32	0.00***	730	771
Adult equivalence score	3.82	4.89	0.06*	698	796

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Dependency ratio (based on minors)	0.62	0.60	0.55	667	662
Household head is married	0.77	0.83	0.00***	761	905
Household head is widowed	0.16	0.11	0.01**	761	905
Household head is single	0.07	0.05	0.24	761	905
Education level of the household head	2.16	2.38	0.16	761	905
No formal education	0.25	0.16	0.16	761	905
Primary	0.53	0.53	0.95	761	905
O' Level	0.15	0.23	0.07*	761	905
A' Level	0.02	0.03	0.20	761	905
Certificate	0.01	0.02	0.67	761	905
Vocational training	0.02	0.02	0.96	761	905
Diploma	0.02	0.01	0.43	761	905
Bachelor's degree	0.00	0.01	0.36	761	905

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

What are the geographical characteristics of the household?

89. In terms of the residence of the households, as shown in Appendix 15, comparison households report living in their current house for 4.5 years longer (significant at the 1 per cent level), on average, and are more likely to own the land where they live (by around 4 percentage points, at the 10 per cent level). These results will be taken into account during the endline analysis. However, all households are at a similar distance from a paved road and facilities like health clinics, markets, nearby towns or trade centres. This similarity implies that households in both areas are equally connected to where they can acquire inputs and assets, trade or sell them, and acquire medical care.

5.1.2. **Indices**

90. Table 9 illustrates the comparison between treatment and comparison households in terms of the asset index and constituent asset capitals. Overall, one does not observe a statistically significant difference in the four components or the PCA. A higher value indicates greater asset wealth for each variable and the index overall. As is common practice, the PCA index has been standardized.

Table 9: Descriptive statistics on the asset index and variables used to create the index

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Asset index	-0.02	0.026	0.72	905	761
Physical capital – housing	98.16	88.92	0.17	905	761
Natural capital: Total land area for crop production	2.57	3.19	0.13	905	761
Human capital: Highest educational level of the household head	2.16	2.38	0.16	905	761
Social capital index on leadership and membership	1.72	1.54	0.49	905	761

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.1.3. Wetland benefits and restoration

To what extent do respondents use wetlands, and how has this changed?

Use and benefits from wetlands

91. Table 10 shows the overall use of wetlands. From the total sample, about 77 per cent of the population in both treatment and comparison areas benefit from the wetlands. Of these, around 80 per cent report an observed change in the benefits derived from the wetlands in the last five years. On average, households engage in about two wetland activities, with grazing and collecting firewood being reported most frequently.[30] No statistical difference exists between the treatment and comparison samples on these three indicators.

What is the current status of wetland degradation and restoration?

92. Table 49 illustrates how respondents view the state of nearby wetlands. It shows that a significantly higher proportion of treatment households consider their nearby wetlands as improved (at the 5% level), at 28 per cent, relative to the comparison households' 14 per cent. In addition, a significantly lower percentage of treatment households, 40 per cent, view nearby wetlands as degraded compared to comparison households with 70 per cent, which is significant at the 10% level.

93. Table 50 shows how households responded when asked about the main drivers of wetland degradation. The five most common reasons cited are (i) cultivation (61 per cent), (ii) grazing (47 per cent), (iii) channelling water from wetlands (27 per cent), (iv) overharvesting of resources from wetlands (26 per cent), and (v) soil erosion from nearly catchments and farms (18 per cent). The

[30] Of the 1248 households reporting on benefits/activities, the most commonly reported one is grazing (27 per cent of all households) and the next common ones (around 20 per cent of all households) are collection of firewood and acquiring grasses for thatching houses and for mulching.

observed differences in responses between treatment and comparison households were not statistically significant.[31]

94. As Table 10 indicates, several wetland management and restoration activities occurred in the treatment areas. Consequently, the treatment households' responses to partaking in wetland restoration and management activities are nearly 39 percentage points higher and statistically significant at the 1 per cent level relative to the comparison areas' 69 per cent and 30 per cent, respectively. In terms of the most commonly reported specific actions, there is no statistically significant difference between treatment and comparison households such as for the demarcation of the boundary of wetlands and the sensitization of people about the benefits of wetlands.[32]

Table 10: Wetland restoration and sustainable management activities

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Anything done to restore and sustainably manage wetlands in this area	0.69	0.31	0.01***	859	738
If yes, what has been done:					
- Demarcation of the boundary of wetlands	0.71	0.72	0.89	587	222
- Sensitization of people about the benefits of wetlands	0.53	0.55	0.77	587	222
- Blocking of channels	0.25	0.20	0.54	587	222
- Sensitization on the wetlands policy and environmental laws	0.20	0.28	0.48	587	222
- Development and implementation of a community wetland management plan	0.08	0.18	0.27	587	222

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

95. Respondents were also asked about their most frequent observations related to wetland restoration in the last three years. Table 52 shows how respondents were mostly aware of project activities for community restoration and wetland management, where 63 per cent of comparison households reported awareness compared to 52 per cent of treatment households.[33] Around 37 per cent of respondents reported multiple efforts by different stakeholders to protect wetlands, with a slightly

[31] Households also reported on the main impacts of wetland degradation they have observed. The most common responses are the decline/loss of wetland benefits (69 per cent), drought (56 per cent), flooding (42 per cent), reduction of water levels (42 per cent), and reduction in wetland size (24 per cent).
[32] Readers can note the much lower number of control households reporting any restoration activities in control areas (with only 222 households overall).
[33] Respondents were asked "Which of the following have you observed or participated in about wetland and catchment restoration in this community in the last three years?".

higher proportion of treatment households doing so than comparison households. Exactly 18 per cent of respondents reported that the protected and restored wetland areas have increased in size over the past few years. In comparison, 11 per cent and 9 per cent reported sensitization drives and demarcation activities, respectively. None of these variables is statistically significantly different between the treatment and comparison samples.

5.1.4. Livelihoods and income

96. Table 53 shows the livelihood activities reported by households. It shows that households reported a limited number of ways to make a living, corresponding to 1.5 activities per household on average. Livelihood activities consisted of (i) crop farming (81 per cent), (ii) livestock farming (19 per cent), (iii) casual labouring (17 per cent), (iv) small-scale business (11 per cent), and (v) brick-making (5 per cent). None of the differences between treatment and comparison groups are statistically significant.

Household expenditure

97. Table 54 shows the descriptive statistics for household expenditure. It shows that, on average, households reported spending 43 per cent of their income on food. Furthermore, it shows that when households reported expenditure in absolute values, using Ugandan shillings (UGX), most households spent the largest amount on education, followed by food and health care.[34] A very small proportion of households reported spending money on rent or insurance based on the number of observations.[35] Table 55 shows the descriptive statistics for a range of community-based resilience practices supported by the project. It shows that 34 per cent of treatment households are aware of a small-scale irrigation facility (sprinkler and drip irrigation system, water pump) in their community compared to only 16 per cent of comparison households (significant at the 10 per cent level). It was reported that 21 per cent and 20 per cent of treatment and comparison households, respectively, belong to a farmer's group or cooperative on crop diversification and resilient agricultural practices, respectively (this difference is not statistically significant). It was also reported that a slightly larger proportion of treatment households, 1.9 per cent, are aware of a community nursery garden for multiplying improved seeds, compared to 1.4 per cent of comparison households (again, this difference is not statistically significant). However, a significant difference was recorded in the proportion of respondents who stated they know of a farmer field school for demonstrating resilient agricultural practices, comprising 3.5 per cent of treatment households compared to 1.4 per cent of comparison households and significant at the 10 per cent level.

98. Table 56 shows the descriptive statistics for various household-level resilience practices. It shows that 29 per cent of households received training on crop diversification and resilient agricultural practices, 28 per cent received agricultural inputs, such as improved vegetable seeds, herbicides, hoes or pangas, and 18 per cent received training on alternative livelihoods in areas such as aquaculture, goat and pig farming, vegetable growing, poultry farming and beekeeping. Only 8 per cent and 5 per cent of households received pigs and goats, respectively. These averages include two significant differences between treatment and comparison households. Firstly, a greater proportion of comparison households reported receiving agricultural inputs, at 41 per cent, compared to only 13 per cent of treatment households, at the 10 per cent level. Secondly, in contrast, a greater proportion of treatment households reported receiving pigs at 12 per cent and goats at 8 per cent, relative to comparison households at 5 per cent and 2 per cent, respectively, which are significant at the 5 and 10 per cent levels.

[34] The difference in terms of the share of food in total expenditure compared to the reported figures in shillings is covered in the discussion. It is worth noting that fewer households report spending on education compared with those reporting expenditures on food.
[35] It is only this expenditure category that shows a significant difference between treatment and control households (at the 5 per cent level).

5.1.5. Agriculture – crop production

99. Table 57 shows the proportion of households carrying out crop farming, the number of crops grown by the household, the number of parcels for crop production, the size of land for crop production (in acres) and the frequency of the most common land tenure arrangements.

100. A similar proportion of treatment and comparison households carry out crop farming, 84 per cent and 87 per cent, respectively. Moreover, the number of crops households grow in both samples is almost identical at 5.5 per household. Neither of these differences is statistically significant. The LORTA team observed a meaningful difference between treatment and comparison households regarding the number of parcels for crop production, with treatment households only utilizing 2.4 parcels of land compared to 3.3 for comparison households, significant at the 99 per cent level. Results from the survey indicate a significant difference (at the 99 per cent level) in the size of land for crop production, with comparison households utilizing 3.9 acres compared to 2.7 acres in treatment households.

101. A patchwork of tenure types exists, the most widespread being customary tenure whereby households have usufruct rights over land accessed through traditional inheritance and marriage practices in each area. The study found that 69 per cent of comparison households reported using customary land compared to 52 per cent of treatment households, representing a significant difference at the 1 per cent level. The study did not observe significant differences for the next three most frequent tenure types: (i) privately owned (43 per cent), (ii) rented (11 per cent), and (iii) borrowed for free (2 per cent) (which showed a difference between treatment and control at the 10 per cent level).

Table 11: Descriptive statistics on crop farming and land

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Carrying out crop farming	0.84	0.87	0.70	859	755
Number of crops grown by the household	5.55	5.54	0.99	714	659
Number of parcels for crop production	2.37	3.33	0.01**	692	654
Size of land for crop production (acres)	2.75	3.93	0.02**	691	646
Customary ownership	0.52	0.69	0.00***	713	658
Privately owned	0.49	0.37	0.29	713	658
Rented	0.12	0.10	0.70	713	658
Borrowed for free	0.031	0.00	0.09*	713	658

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Cereals and rice

102. Table 58 presents the cereal and rice crops reportedly grown in the treatment and comparison areas. Regarding the cropping profile, both areas appear to be similar, with the most commonly produced crop being maize at approximately 56 per cent of households. However, the preference for cultivating other crops differs. Following maize, the next most commonly grown crops for treatment households are millet at 26 per cent and sorghum at 20 per cent. For comparison households, the most commonly grown crops are sorghum at 37 per cent and rice at 31 per cent. Overall, fewer households in the treatment sample, 17 per cent, reported producing rice, nearly half the 31 per cent of households in the comparison areas. This result is not statistically significant. Indeed, none of the crop production rates significantly differ between treatment and comparison households.

103. Comparing land allocation for key cereal crops, excluding rice, Table 59 shows that treatment households allocated most land to sorghum, maize, and millet. In contrast, comparison households allocate a similar amount of land to maize, sorghum, and millet. None of the differences in land allocation are statistically significant.

104. As shown in Table 60, crop production for the three crops shows broadly a similar amount of production for treatment and comparison households with, on average, about 236 kg of maize grown in treatment and comparison areas, and 189 kg and 153 kg of sorghum, respectively. Millet yields are around 8 kg higher in comparison households, compared to 61 kg in treatment households.

105. Finally, comparing the productivity of these three crops shows broadly similar values for treatment and comparison households. Table 12 (and Table 62) shows maize has the highest productivity in both areas, at a rate of 187 kg per acre and 209 kg per acre in treatment and comparison groups, respectively, followed by sorghum and millet. Yields for all three crops are surprisingly low, considering the average yields in Uganda for all three crops.

Table 12: Crop productivity (kg/acre) for three most frequent crops

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Area productivity of maize	187.37	208.62	0.64	340	245
Area productivity of sorghum	93.31	152.85	0.21	67	163
Area productivity of millet	58.63	72.65	0.38	138	95

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Rice

106. Table 13 describes the production of rice in the most recent agricultural season prior to March/April 2023. The characteristics of rice production are quite similar across both treatment (17 per cent of households) and comparison groups (31 per cent of households), with no statistically significant difference noted in any indicator. Most rice-producing households grow all their rice in wetland areas, approximately 94 per cent of rice-producing households in both areas. Treatment households appear to use a marginally smaller land area for rice production (statistically insignificant) compared to comparison households. This corresponds to 1.3 to 1.4 acres in the wetlands, as opposed to 1.4 to 1.67 acres, respectively, outside of wetlands. A very small proportion of households reported growing

upland rice. Rice production corresponds to 410 kg in the most recent agricultural season prior to March/April 2023 and is broadly similar across treatment and comparison groups.

Table 13: Descriptive statistics on rice production

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
All rice is grown in wetland	0.96	0.93	0.72	114	190
if yes, then the amount of land allocated for rice in wetlands (acre)	1.28	1.38	0.36	94	155
if no, then the amount of land allocated for rice in wetlands (acre)	1.40	1.67	0.44	5	9
if no, then the amount of land allocated for rice upland (acre)	0.75	0.90	0.26	4	10
Production of rice (kg)	407.48	413.01	0.94	103	168

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Other crops

107. Table 63 shows the proportion of households that grew vegetables and melon crops, oil seed crops, root/tuber crops, leguminous crops, fruits and nut crops, and beverage and spice crops. The three most frequently grown crops are reported for each crop type. Table 14 shows that besides cereals, the most frequently grown crops are cassava, beans, sweet potatoes, groundnuts, banana (food), eggplant and cabbages. Over 50 per cent of households produce the first four of these seven crops. The study team only observed significant differences between treatment and comparison households for cabbages and bananas, with a greater proportion of treatment households, 19 per cent and 44 per cent, respectively, producing these crops compared to comparison households at 11 per cent and 28 per cent. Both differences are significant at the 1 per cent level.

108. The final indicator in Table 63 shows the proportion of households who reported growing improved crop varieties. It shows that while 8 per cent of treatment households reported this practice, comparison households reported almost double, at 17 per cent. The difference is significant at the 10 per cent level.

109. Table 64 shows the average land allocated for the three most frequent crops grown within the six categories. It shows that households allocated large areas of land to a very wide variety of crops in the last season: roots and tubers, and leguminous crops have the highest land allocation, yet the amount of land allocated to vegetables and melons, oil seed crops, fruits, and nuts, as well as beverage and spice crops, is substantial and is often over one acre.

110. We can observe significant differences for five crops with comparison households allocating more land to soya beans (at the 1 per cent level), Irish potatoes (at the 1 per cent level), beans at the 10 per cent level and old varieties of Arabica coffee at the 5 per cent level. Treatment households only allocated more land to one crop: cowpeas at 10 per cent. The number of observations for linseed and peas is very low.

111. Table 65 shows the average production for the most frequently grown crops within seven categories. Overall, households produce the most root and tuber crops, fruits, nuts, and cereals. In addition, households also produce large amounts of coffee as a beverage, spice crops (sold mainly for cash), and oil seed crops for consumption and sale. The study observed significant differences for six crops. Comparison households show greater production amounts for groundnuts at the 10 per cent level, Irish potatoes with an almost four-fold increase over treatment households at the 99 per cent level, peas at the 95 per cent level, and old robusta coffee at the 99 per cent level. In contrast, treatment households show greater production amounts for soya beans at the 99 per cent level and clonal robusta coffee at the 99 per cent level. However, the percentage for the latter relies on a limited number of comparison observations.

112. Table 14 (and Table 66) shows the average yield for the most frequent crops grown across the six categories. When comparing across treatment and comparison groups, it is noted that comparison households have reported significantly greater yields for groundnuts at the 10 per cent level, Irish potatoes at the 1 per cent level, old robusta coffee varieties at the 1 per cent level, and peas at the 1 per cent level. However, treatment households show a very limited number of observations for peas and coffee. The only crop showing greater yields for treatment households is soya beans, at the 1 per cent level.

Table 14: Descriptive statistics on yields in most frequently grown vegetables, crops and other harvests

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Vegetables and melons					
Doodo (*amaranthus dubius*)	35.84	19.82	0.52	50	45
Eggplant	74.18	44.84	0.49	65	51
Cabbages	98.54	74.88	0.57	59	49
Oil seed crops					
Groundnuts	123.52	171.84	0.08*	206	257
Soya beans	177.42	95.60	0.02**	54	42
Sim sim	50.00	93.00	0.47	2	6
Root/tuber crops					
Cassava	269.52	355.64	0.43	292	252
Sweet potatoes	287.27	181.30	0.38	158	214
Irish potatoes	176.47	629.02	0.00***	16	88
Leguminous crops					
Beans	101.32	118.63	0.37	320	248
Cow peas	282.59	180.74	0.15	22	60

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Peas	28.60	95.34	0.02**	5	32
Fruits and nuts					
Banana (food)	179.61	216.33	0.69	171	96
Avocado	102.55	82.53	0.69	56	53
Mangoes	260.43	70.25	0.32	28	20
Beverage and spice crops					
Coffee Arabica (old)	180.43	313.89	0.26	108	56
Coffee Robusta (old)	146.55	223.33	0.00***	40	24
Coffee Robusta (clonal)	158.09	31.25	0.16	40	4

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

113. Table 67 shows the five most frequent challenges to crop production encountered by households. The most frequent challenge by far is pests and diseases, with 87 per cent of households reporting that they have encountered these problems. Price fluctuations were reported by 46 per cent of households. Between 36 per cent and 28 per cent of households also report they have encountered unreliable rainfall, low soil fertility or prolonged dry spells. None of the differences between treatment and comparison groups are statistically significant.

114. Table 68 describes the impacts of challenges in crop production. Overall, 91 per cent of households reported a reduction in yields, while 68 per cent of households reported a reduction in income. The next most frequently reported impact was food insecurity, 37 per cent, followed by malnutrition of household members, 16 per cent. Twelve per cent of households also reported that the challenges associated with crop production provide a disincentive to grow improved varieties. None of the differences between treatment and comparison groups are statistically significant.

115. Table 69 describes access to markets. It shows that 62 per cent of households have access to multiple selling points for selling farm produce, broadly similar proportions of treatment and comparison households reporting travel times ranging from less than one kilometre (44 per cent), to over 5 kilometres (10 per cent). None of the differences between treatment and comparison groups are statistically significant.

Sustainable land management

116. Table 15 (and Table 70) describes the SLM practices reported by households. Overall, 34 per cent of households reported using SLM practices, with the most frequent types being (i) inter-cropping (61 per cent), (ii) crop rotation (49 per cent), (iii) mulching (44 per cent), (iv) cover crops (23 per cent), and (iv) animal and green manure (22 per cent). A significantly greater proportion of comparison households reported practising inter-cropping at 5 per cent, crop rotation at 5 per cent and animal and green manure at 10 per cent. Conversely, a greater proportion of treatment households reported practising mulching, which is significant at the 5 per cent level. It should be noted that, on average, comparison households conduct 3.41 SLM practices compared to 2.1 in treatment households, again

significant at the 10 per cent level. The greater proportion of comparison households practising SLM highlights the potential for broader agricultural projects to be active in comparison areas.

Table 15: Descriptive statistics for sustainable land management

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Using sustainable land management practices in the garden	0.38	0.29	0.45	671	652
Number of sustainable land management practices conducted by household	2.12	3.41	0.07*	255	191
Sustainable land management practices: inter-cropping	0.49	0.77	0.04**	255	191
Sustainable land management practices: crop rotation	0.36	0.65	0.01**	255	191
Sustainable land management practices: mulching	0.56	0.29	0.04**	255	191
Sustainable land management practices: cover crops	0.18	0.30	0.35	255	191
Sustainable land management practices: use of animal and green manure	0.13	0.34	0.09*	255	191
Who mainly decides on the SLM practices to be applied: adult male	0.69	0.83	0.20	249	183
Who mainly decides on the SLM practices to be applied: adult female	0.27	0.15	0.16	249	183
Who mainly decides on the SLM practices to be applied: female youth	0.02	0.00	0.29	249	183
Who mainly decides on the SLM practices to be applied: male youth	0.02	0.02	0.65	249	183

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Post-harvest handling

117. Table 71 in the appendix illustrates key aspects of post-harvest handling activities. Three activities are described, including post-harvest handling, the transportation of crop produce, and the selling of crop produce. Overall, around 25 per cent of households reported being engaged in post-harvest handling, 28 per cent in the selling of crop produce, and 21 per cent in the transportation of crop produce. A greater proportion of comparison group households reported engagement with these post-harvest crop production activities. The transportation of crop produce showed a significant difference at the 5 per cent level with 28 per cent of comparison households, and only 14 per cent of treatment households reported they engaged in that activity.

Use of agricultural incomes

118. Table 72 illustrates how households utilize agricultural incomes. It shows that the main use of agricultural income reported by households is to purchase household essentials such as soap and sugar, at 71 per cent of respondents. This is followed by payment for health and medical services at 60 per cent, buying assets such as land and bicycles at 20 per cent, buying agricultural inputs such as pesticides at 18 per cent, and repaying loans at 15 per cent. None of the differences between treatment and comparison groups is statistically significant.

Gender and agriculture

119. Table 16 (and Table 73) below focuses on gendered differences in terms of receiving information regarding good agricultural practices and who benefits from agricultural income. It shows that, across both treatment and comparison groups, in 68 per cent of households adult men mainly receive information about good agricultural practices compared to 27 per cent of households where adult women receive this information. A small number of young men, 4 per cent, and young women, 1 per cent, are the main recipients of information on good agricultural practices. The latter variable shows a statistically significant difference between treatment and comparison households at 2 per cent and zero per cent, respectively. Regarding who benefits from agricultural produce income across the whole sample, 68 per cent of interviewees responded that adult men were the main beneficiaries, followed by adult women at 25 per cent, young men at 4 per cent, and young women at 3 per cent. None of the differences between treatment and comparison households are statistically significant.

Table 16: Descriptive statistics on gender and agriculture

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Who mainly receives information about good agricultural practices?					
Adult male	0.65	0.72	0.55	249	181
Adult female	0.29	0.25	0.76	249	181
Young women	0.02	0.00	0.06*	249	181
Young men	0.04	0.02	0.45	249	181
Who mainly benefits from the income from agricultural produce?					
Adult male	0.69	0.66	0.64	623	594
Adult female	0.27	0.22	0.15	623	594
Female youth	0.02	0.05	0.28	623	594
Male youth	0.02	0.07	0.20	623	594

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The household questionnaire also included a section on the gendered division of labour within agricultural activities. This section asked about the degree to which adult men and women, young men and women, as well as hired labourers contributed to the labour required (in terms of the percentage of labour applied) for key agricultural activities.[36]

[36] These include clearing the garden, applying crop inputs like pesticides, planting, weeding, scaring pests, harvesting, post-harvesting handling, transport of crop produce, and selling crop produce.

Table 17 (and

120. Table 74) only shows the variables which are statistically significant from all 40 variables on this topic.[37]

121. Across the whole sample, adult men contributed the greatest proportion of the labour for (i) applying crop inputs such as pesticides (49 per cent), (ii) transporting crop produce (48 per cent), and (iii) selling crop produce (56 per cent). Adult women contributed the most labour in terms of (i) planting (46 per cent), (ii) weeding (49 per cent), (iii) harvesting (46 per cent), and (iv) post-harvest activities (53 per cent). The one further activity, clearing the garden, shows a close balance between the labour contributions of adult men at 39 per cent and adult women at 38 per cent.

[37] In contrast to the observations for the livestock profile, the number of observations for many of agricultural questions was sufficient for all 40 variables.

Table 17, however, indicates that this activity shows a significant difference between treatment and comparison households. Specifically, it was noted that women contribute most labour to clearing the garden in treatment households, 47 per cent, versus 32 per cent in comparison households, which is significant at the 99 per cent level. Men contribute the most labour to clearing the garden in comparison households, 43 per cent, versus 32 per cent of labour in comparison households (again significant at the 95 per cent level). In addition,

122. Table 17 shows a significant difference between treatment and comparison households for the proportion of labour contributed by adult women to harvesting, which is greater in treatment households, at 95 per cent.

Table 17: Descriptive statistics for labour by demographic categories

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Participation of adult males in clearing the garden (%)	32.28	43.18	0.04**	333	522
Participation of adult females in clearing the garden (%)	47.10	31.52	0.01***	333	522
Participation of adult females in harvesting (%)	52.16	40.72	0.02**	333	344

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Agricultural inputs

123. Table 75 illustrates how a broadly similar percentage of treatment and comparison households reported using fertilizer, seeds, machinery and hired labour. Across the whole sample, 42 per cent of households reported using seeds, 17 per cent reported the use of hired labour, 11 per cent reported the use of fertilizer, and 2 per cent reported the use of machinery (another surprisingly low figure). The only statistically significant result is the use of agrochemicals in the form of pesticides, herbicides, and insecticides. While 48 per cent of comparison households reported using these inputs, only 14 per cent of treatment households did so, contributing to a difference which is significant at the 95 per cent level.[38] A limited number of respondents offered information in terms of the cost of these agricultural inputs, reducing the number of observations considerably.[39]

5.1.6. Livestock profile

What is the livestock profile of the household?

[38] The LORTA endline evaluation may examine this topic.
[39] Due partly to the limited sample size for treatment and control households, none of the differences in terms of the costs of agricultural inputs are statistically significant.

Table 18 (and

124. Table 76) illustrates the livestock holding of households using the Tropical Livestock Unit (TLU) score and the ownership of improved breeds. It illustrates that 39 per cent of households have reported owning livestock, including 33 per cent of treatment households and 46 per cent of comparison households. The difference is not statistically significant. Not only in terms of ownership but also units of livestock, treatment households fare worse. Treatment households own 1.82 TLUs compared to 1.94 TLUs in comparison households. Of the households that own livestock, the most frequent livestock types owned by households are goats, cattle, chickens, pigs and sheep. Comparison households own significantly more cattle, at 99 per cent, and chickens, at 90 per cent. A slightly greater proportion of treatment households reported ownership of improved livestock breeds at the 10 per cent level, compared to 6 per cent of comparison households. Neither of these last two differences were statistically significant.

Table 18: Descriptive statistics for livestock profile

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Having livestock	0.33	0.46	0.23	854	753
Goat	0.74	0.64	0.27	280	347
Cattle	0.47	0.69	0.00***	280	347
Chicken	0.36	0.49	0.07*	280	347
Pig	0.21	0.29	0.24	280	347
Sheep	0.13	0.30	0.11	280	347
Tropical livestock score for household	1.82	1.94	0.70	279	345
Having improved livestock breeds	0.10	0.06	0.28	274	347

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

125. Table 77 shows the sources of pasture used by households who own livestock. It shows that wetlands are the main source of pasture, with 68 per cent of households utilizing wetland areas. It should be noted that fewer treatment households reported using wetlands compared to the comparison household. However, this difference is not statistically significant. The next most frequent sources of pasture used by households are (i) land used for crop farming (43 per cent), (ii) rangelands (16 per cent), (iii) forests (9 per cent), and (iv) processed feeds (around 1.5 per cent). Two of these sources show significant differences between treatment and comparison households at the 10 per cent level, with treatment households using rangelands and forests much more.

Table 19 (and

126. Table 78) illustrate the land management practices performed by households in relation to livestock. The most prevalent practices reported in order of frequency are (i) pest, parasites, and disease comparison (66 per cent), (ii) rotational grazing or paddocking (18 per cent), (iii) manure management (12 per cent), (iv) afforestation within the farm (8 per cent), and (v) pasture management such as making silage and hay (7 per cent). Differences between treatment and comparison households are not statistically significant.

Table 19: Descriptive statistics for land management practices performed by households in relation to livestock

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Livestock management practices					
Pest, parasites and disease control	0.61	0.71	0.58	264	330
Rotational grazing or paddocking	0.20	0.17	0.77	264	330
Manure management	0.08	0.16	0.27	264	330
Practising afforestation within the farm	0.05	0.11	0.25	264	330
Pasture management	0.07	0.07	0.95	264	330

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

127. Table 20 outlines the main livestock production systems reported by households. The two most frequent systems are the communal/pastoral system and the tethering system, with 44 per cent and 43 per cent of respondents reporting using these two systems, respectively. The next most frequent production systems are mixed agropastoral systems at 19 per cent, zero grazing at 17 per cent and the extensive system at 7 per cent. Only one of these systems showed a significant difference between treatment and comparison groups with a significantly greater proportion of comparison households utilizing zero grazing compared to treatment households (at the 10 per cent level).

Table 20: Descriptive statistics for main livestock production systems reported by households

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Livestock production systems					
Communal/pastoral system	0.52	0.37	0.29	261	333
Tethering system	0.38	0.47	0.29	261	333
Mixed farming system (agropastoral system)	0.23	0.17	0.59	261	333

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Zero grazing	0.12	0.20	0.06*	261	333
Extensive system (mixed herds of cattle, sheep, goats)	0.09	0.06	0.49	261	333

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

128. The analysis of livestock products indicated a number of significant differences between treatment and comparison households (Table 79). The most frequent livestock products reported by households are milk at 41 per cent of respondents, horns at 35 per cent, cow manure at 28 per cent, meat at 17 per cent, and yoghurt at 4 per cent. The last three products showed significant differences between treatment and comparison households. Forty-one per cent of comparison households reported selling cow manure compared to only 10 per cent of treatment households, significant at the 1 per cent level and possibly reflecting the greater proportion of treatment households that use zero grazing. In addition, more comparison households than treatment households reported selling yoghurt at 6 per cent, which is significant at the 5 per cent level. Once again, this points to one of the possible benefits from zero grazing. Conversely, a greater proportion of treatment households reported selling meat, 27 per cent, versus 8 per cent of comparison households, which is also significant at the 95 per cent level.

129. Table 80 shows that a similar proportion of both treatment and comparison households participate in different stages of the livestock value chain, with the most frequent activities being the transportation of livestock, application (spraying) of inputs, the grazing of animals, the purchase of livestock, and the making of livestock products. None of these activities displayed significant differences between treatment and comparison households. Twenty-one per cent of households reported selling livestock. The total cost of livestock inputs reported by households was just over UGX 150,000. Neither of these last two variables showed significant differences between treatment and comparison groups.

130. Households also reported challenges that they encountered in managing livestock. Table 81 shows that the most frequent challenge reported by households were (i) pests, parasites and diseases (88 per cent of respondents), (ii) inadequate pastures (38 per cent), (iii) price fluctuations (37 per cent), (iv) prolonged dry spells (31 per cent), and (v) limited land for livestock (25 per cent). A significantly greater proportion of comparison respondents, 93 per cent, indicated they encountered pests, parasites and disease challenges compared to 82 per cent of treatment households, which is significant at the 1 per cent level and may again reflect the higher proportion of zero grazing).[40]

The household questionnaire included a section on the gendered division of participation within livestock production activities (see

[40] It may also be the case that through the project they were taught how to manage pests, parasites and disease.

Table 82). Respondents reported the degree to which adult men and women, young men and women, and hired labourers contributed to the labour required for key livestock activities, expressed in percentage participation terms.[41] The number of observations for many of these questions is very low.

[41] Purchasing livestock, animal grazing, input application, the milking of animals, making livestock products, livestock transportation, selling livestock product and selling livestock.

131. Table 82 only shows the variables which illustrated significant differences and were reported by 30 or more treatment and comparison households.[42]

[42] Both participation of female youth in making livestock products (in per cent) and participation of male youth in making livestock products (in per cent) showed significant differences between treatment and control households yet the number of observations was very low for both variables. In addition, the participation of adult men in livestock transportation (in per cent) also showed a significant difference, but the number of observations for both treatment and control groups was under 30.

Table 82 illustrates that adult women in treatment households participated more in applying inputs to livestock, at 29 per cent of total labour participation, compared to 16 per cent in comparison households. This difference is significant at the 10 per cent level. In contrast, hired labour contributed more labour for this task in comparison households at 29 per cent of total labour participation, compared to 10 per cent by the treatment households, which is significant at the 10 per cent level.

132. Table 82 also illustrates that adult men contributed more labour to milking animals in treatment households at 63 per cent of total labour participation compared to 53 per cent in comparison households. The study also noted that adult women in treatment households contributed less total labour when selling animals at 14 per cent of total labour participation compared to 32 per cent in comparison households.

133. Table 83 shows significant differences in where livestock are sold, and the income generated from selling livestock and livestock products. The most frequent locations for the sale of livestock, in order of importance, are (i) local/community markets (80 per cent of respondents), (ii) selling from home (30 per cent), (iii) regional markets (9 per cent), (iv) kiosks/shops (3 per cent), and (v) selling to a trader (3 per cent). A significantly greater proportion of comparison households reported using local or community markets to sell livestock, 91 per cent, against 66 per cent of treatment households, which is significant at the 99 per cent level. Conversely, more treatment households reported selling livestock from home, totalling 42 per cent compared with 22 per cent of comparison households, again significant at the 99 per cent level. Additionally, while total earnings from selling livestock (in UGX) was broadly comparable across treatment (UGX 504,740) and comparison (UGX 596,794) households (and was not significant), treatment households reported significantly more total earnings from selling livestock products (at UGX 367,867) compared to comparison households (UGX 132,201), significant at the 99 per cent level.[43]

5.1.7. Food diversity

134. The study estimated the diversity in food consumption by asking each household about their consumption of 12 food groups, in line with the HDDS.[44] The HDDS sums up the score for each food group consumed, which increases by one for each additional food group the household reports having consumed. Therefore, the HDDS score ranges from 0 to 12, with a higher score implying more diversity in food consumption. As shown in Table 84, the households in treatment and comparison areas are similar in the food diversity score, lying between six and seven food groups, on average.

135. Within the 12 food groups, the consumption profile appears to be similar in the treatment and comparison areas. Comparing the various food groups, the most commonly consumed food categories (all being consumed by more than 80 per cent of the households in the treatment and comparison areas) are cereals, roots and tubers, pulses, legumes and nuts, and vegetables and leaves. The least commonly consumed food items, i.e. consumed by less than 20 per cent of the households, are oils, fats and butter. Meat, poultry, offal, fruit and fish categories are consumed by between 60 per cent and 70 per cent of the households in both treatment and comparison areas. None of these food groups are statistically significantly different between the comparison and treatment groups.

5.1.8. Food security

136. The survey also captured the food insecurity experienced by households in the treatment and comparison areas. Respondents were asked seven questions related to their household's experience with respect to the quantity and quality of food in the last month. These questions are in line with the

[43] Earning income from livestock products is a regular albeit smaller source of income compared to the sale of livestock.

[44] The HDDS is usually asked for the past 24 hours. In this case, the survey team asked the questions for the past seven days, as is usual for the Food Consumption Score (FCS). The FCS was not constructed for this report, as the categories differed from the ones asked within the survey and were more in line with those for the HDDS.

Food Insecurity Experience Scale (FIES), which sums the number of insecurities that households faced to indicate increased food insecurity with a higher score.[45] [46]

[45] Other indicators such as the Household Hunger Scale (HHS) or the Coping Strategies Index (CSI) were also considered. The FIES usually ranges between zero and eight. In this case, the project team adjusted the questions to the country context and removed one questions. Hence, a high score of only seven is possible.

[46] Five out of eight insecurities were asked for a 12-month period with which the reduced FIES was calculated with a maximum score of five. Three questions were not asked in the survey: during the last 12 months "your household ran out of food?", "You were hungry but did not eat?" and "were you worried you would not have enough food to eat?".

Table 21: Food insecurity experience of households

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
FIES – last 12 months	0.82	0.98	0.27	781	735
FIES – last 30 days	1.49	1.49	1.00	430	470
Unable to eat healthy and nutritious food	0.40	0.47	0.47	430	470
Ate only a few kinds of food	0.23	0.46	0.04**	430	470
Skipped a meal	0.36	0.28	0.38	430	470
Ate less than you thought you should	0.25	0.14	0.19	430	470
Household ran out of food	0.14	0.09	0.42	430	470
Were hungry but did not eat	0.08	0.03	0.21	430	470
Went without eating for a whole day	0.03	0.02	0.84	430	470
None of the above	0.05	0.04	0.94	430	470

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

138. As shown in Table 21 and Table 85, the FIES is not different between the two groups, where households faced 1.49 insecure experiences in the past 30 days and 0.9 in the past year. However, breaking down the types of insecurity experiences reveals that a greater proportion of comparison households ate a limited range of food types in the past month, 46 per cent, compared to the treatment households with 23 per cent (significant at the 5 per cent level). Another noteworthy but not statistically significant difference is that treatment households are more likely to report that they ate less than they thought they should have, at 10 percentage points higher. Overall, the most frequently reported insecurity of being unable to eat healthy and nutritious food was reported by 43 per cent of households. Two per cent of households reported going a whole day without eating. Less than five per cent of households reported no types of food insecurity.

5.1.9. **Shocks**

139. Within the survey, respondents were asked whether households had been affected by shocks such as droughts and floods in the last 12 months (see Table 86). Almost 84 per cent of respondents stated they had experienced droughts, 43 per cent had experienced floods, and 39 per cent reported strong winds. In comparison, 32 per cent and 13 per cent reported experiencing hailstorms and landslides, respectively.

140. Households were also asked to outline the steps the household took in response to the shock(s) in the past 12 months to try to regain their welfare level (see Table 86). The most frequent responses by households included 59 per cent relying on their savings, 39 per cent changing their eating patterns, 33 per cent receiving unconditional help from relatives or friends, and 16 per cent receiving unconditional government help. Almost 14 per cent of respondents stated they had sold stored crops.

Of these steps, the reliance on savings and sale of stored crops was significantly greater within comparison households compared to treatment households at the 5 per cent level. For example, only 49 per cent of treatment households relied on savings compared to 66 per cent of comparison households. In addition, only 4 per cent of treatment households reported the sale of stored crops compared to 21 per cent of comparison households. These findings could suggest greater savings and stored crops within comparison households.

Table 22: Descriptive statistics for shocks in the last 12 months

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Was your household affected by shocks such as droughts and floods in the last 12 months?					
- Drought	0.85	0.83	0.83	340	415
- Flood	0.40	0.47	0.58	340	415
- Strong winds	0.30	0.47	0.14	340	415
- Hail storms	0.31	0.33	0.75	340	415
- Landslide	0.06	0.19	0.27	340	415
Response to shock					
- Relied on own savings	0.49	0.66	0.05**	323	403
- Changed eating patterns	0.38	0.40	0.92	323	403
- Received unconditional help from relatives/friends	0.37	0.30	0.56	323	403
- Received unconditional government help	0.21	0.12	0.31	323	403
- Sold crop stock	0.04	0.21	0.03**	323	403

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.1.10. **Weather and climate**

141. This section discusses the degree to which treatment and comparison households differ in terms of their experience of weather information and climate impacts (see Table 23 and Table 87). In terms of the receipt of meteorological information, 80 per cent of respondents used radios, 20 per cent relied on community announcements, and 15 per cent used village meetings, with the same proportion relying on places of worship. Only 9 per cent relied on mobile phones for weather and climatic forecasts. The only channel that differed significantly between treatment and comparison respondents was the use of village meetings, with 23 per cent of treatment households reporting this source of

weather information compared to 8 per cent of comparison households, significant at the 10 per cent level.

142. Regarding local climate impacts, 52 per cent of respondents reported having experienced climate change or variability in their area. Respondents were also asked about the specific impacts of climate change. Almost 59 per cent of respondents reported prolonged dry spells, 49 per cent reported higher temperatures, 45 per cent noted more frequent extreme events such as droughts or floods, 40 per cent reported differences in the planting dates and planting seasons, and 31 per cent reported unpredictable and erratic rainfall patterns. None of these variables showed significant differences between treatment and comparison respondents.

143. Regarding climate impacts on agriculture, exactly 89 per cent of respondents stated they had experienced reduced crop yields and productivity, 46 per cent reported reduced livestock productivity, 42 per cent reported increased food prices, and 33 per cent noted limited availability and quality of pastures. One of these variables showed significant differences between treatment and comparison households: reduced livestock productivity. Specifically, only 28 per cent of treatment households reported this climate impact compared to over double 60 per cent of comparison households (at the 1 per cent level).

144. Respondents were also asked about the degree to which they had seen the impacts of climate change on wetlands. Almost 76 per cent of respondents reported a decline or loss of benefits from wetlands. Specifically, 63 per cent reported the impact of drought, 41 per cent reported dryer wetland vegetation, 30 per cent reported reduced water levels in wetlands, and 26 per cent reported increased flooding. There were no significant differences between the treatment and comparison groups.

Table 23: Descriptive statistics for weather and climate

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Weather and climate early warning information					
Receiving early weather and climate warning information	0.20	0.22	0.7624	818	743
Is the weather and climate early warning information (forecasts) accurate?	0.46	0.53	0.6300	161	157
Sources of the early warning information: FM radios	0.71	0.89	0.1160	159	159
Sources of the early warning information: community announcements	0.26	0.15	0.1650	159	159
Sources of the early warning information: community village meetings	0.23	0.08	0.0583*	159	159
Sources of the early warning information: places of worship (churches/mosques)	0.20	0.10	0.5049	159	159

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Sources of the early warning information: mobile phones (SMS messages)	0.11	0.07	0.2281	159	159
Climate impacts in the area					
Experienced climate change or variability in this area	0.43	0.62	0.2081	821	748
Climate change impact: prolonged dry spells	0.59	0.58	0.9816	352	464
Climate change impact: increased temperatures	0.39	0.57	0.2351	352	464
Climate change impact: increased extreme events (i.e. drought/floods)	0.3977	0.49	0.5627	352	464
Climate change impact: change of planting seasons	0.3580	0.44	0.2581	352	464
Climate change impact: unpredictable and erratic rainfall patterns	0.2528	0.35	0.4211	352	464
Climate impacts on agriculture					
Reduced crop yields and productivity	0.9083	0.88	0.6833	349	461
Reduced livestock productivity	0.2779	0.60	0.0037***	349	461
Increased food prices	0.3410	0.49	0.2078	349	461
Limited availability of pastures	0.2751	0.38	0.4136	349	461
Reduced quality of pastures	0.2579	0.39	0.0744*	349	461
Climate impacts on wetlands					
Impact of climate change on wetland: decline/loss of wetland benefits	0.7265	0.78	0.5684	351	459
Impact of climate change on wetland: drought	0.6011	0.66	0.7551	351	459
Impact of climate change on wetland: drying of wetland vegetation	0.3191	0.48	0.3740	351	459
Impact of climate change on wetland: reduced water levels in wetlands	0.2450	0.33	0.5261	351	459

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Impact of climate change on wetland: flooding	0.1624	0.33	0.1877	351	459

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

5.1.11. What are the connections between households and their attitude to risk?

145. The final set of results in Table 88 shows the proportion of households that reported having insurance and reported having members that are leaders in local religious institutions or part of the local government (which can be understood as a form of social capital). The overall insurance coverage lies between 0.4 per cent and 1.25 per cent, implying a low pervasiveness of insurance as a risk coping mechanism. A broadly similar proportion of treatment (18 per cent) and comparison (15 per cent) households reported having a member who acted as a leader in a local church or mosque, or had a position in local government (12 per cent and 11 per cent, respectively). None of these differences were statistically significant.

5.1.12. Baseline results by gender of household head

146. Tables in Appendix 15 display baseline results categorized by the gender of the household head, revealing significant disparities in demographic characteristics between the two subgroups.

147. Specifically, marital status, duration of residence at the current address, and educational attainment emerge as the most notable distinctions. Male-headed households predominantly consist of married individuals, at 92.53 per cent. In contrast, more than half of female household heads are either widowed at 45.31 per cent or single at 12 per cent. Moreover, male-headed households tend to have resided at their current address for a significantly longer duration, averaging six years more. Educational attainment among female household heads generally appears lower, evidenced by a notably higher proportion lacking formal education and lower proportions possessing qualifications.

148. In contrast, there are no major significant differences between male- and female-headed households concerning SLM practices, other practices affecting climate change, or wetland restoration and management activities, except for the so-called sensitization on wetlands policy and environmental laws, as well as encroachment of wetlands. In these cases, the differences are relatively minor, with roughly 6 and 9 percentage points more of male-headed households engaging in the two activities, respectively.

149. Regarding challenges in crop production, male-headed households appear to encounter more significant issues with price fluctuations and unreliable rainfall compared to their female counterparts, with differences of approximately 8 percentage points in both cases. However, clear disparities in other types of challenges are not observed.

150. Conversely, the two subgroups notably differ in the number and scope of livelihood activities. Male-headed households show higher values in terms of the average number of livelihood activities and participation in crop farming, livestock farming, and brick-making activities. For example, the proportion of male-headed households engaged in livestock farming and crop farming is around 9 and 6 percentage points higher, respectively. However, the differences in livelihood activities does not translate into major differences in food poverty indicators. Both groups exhibit similar levels of HDDS and FIES.

5.2. State of wetland ecosystems

151. As outlined in the previous section, the condition of wetlands has been assessed using high-resolution satellite imagery comparing imagery before implementation and in 2022. This has been through using Google Earth Engine using cloud free satellite images and wetland boundaries from WMD of the MoWE. Table 2 and Table 3 above detail the specific wetland use/cover types mapped in the assessment.[47] The study now describes the findings from the water quality assessment. It is important to note that due to the purposive sampling of wetlands, any trends through time and comparisons between treatment and comparison wetlands cannot be extrapolated beyond the specific sample discussed below. Specifically, findings cannot be extrapolated to the full number of project wetlands. In addition, the change cannot be solely attributed to the project FP034 due to the sampling approach utilized.

5.2.1. **State of wetland ecosystems in western Uganda**

District level findings

152. For southwestern Uganda, the study covers the districts in the following order: Bushenyi, Kisoro, Mitooma and Rubirizi, as seen in Table 24. Bushenyi experienced an increase in built-up areas in both the comparison and treatment sites between 2016 and 2022. Table 24 illustrates that during this period, the area of farmland increased in the comparison wetland by 29.1 per cent and decreased in the treatment wetland by 6.9 per cent. Similarly, tree plantations increased by 4.6 per cent in the comparison wetland but decreased in the treatment wetland by 0.5 per cent. Grasslands were observed to have increased in the treatment sites by 9 per cent but declined in the comparison site by 33.9 per cent. Between 2016 and 2022, open water increased in the treatment site by 0.2 per cent while papyrus decreased by 2 per cent. No open water and papyrus were observed in the comparison site (see Appendix 9). For the levels of wetland degradation, between 2016 and 2022, the low degradation class in the Bushenyi decreased by 33.9 per cent in the comparison wetland. It increased in the treatment wetland by 7.2 per cent. The moderate level of degradation increased by 29.1 per cent in the comparison wetland and decreased by 6.9 per cent in the treatment wetland. Between 2016 and 2022, the high degradation class in Bushenyi increased by 4.8 per cent in the comparison site. However, it decreased by 0.3 per cent in the treatment wetland, as indicated in Table 25 and Appendix 9. Overall, there was a shift from low degradation to moderate degradation in the comparison wetlands alongside a shift from moderate degradation to low degradation in the treatment wetland.

153. Table 24 also shows Kisoro experiencing a shift from moderate to low degradation in the treatment wetland compared to an increase of high degradation in the comparison wetland. In the comparison site grasslands decreased by 4.9 per cent during the study period, while they increased in the treatment site by 11.6 per cent. Open water dropped by 1.3 per cent in the treatment wetland but increased by 0.36 per cent in the comparison wetland. Papyrus in the treatment site increased by 2.5 per cent between 2016 and 2022. No papyrus was detected in the comparison site. During the study period, tree plantations decreased in the treatment wetland by 1.2 per cent but increased in the comparison wetland by 6.2 per cent. For the levels of wetland degradation, between 2016 and 2022, the low degradation class in Kisoro decreased by 4.5 per cent in the comparison site and increased by 12.7 per cent in the treatment wetland. Table 25 provides further details. The moderate class of degradation decreased in both the comparison and treatment wetland sites at 1.4 per cent and 12.1 per cent, respectively. In the comparison wetland, the high degradation class of degradation increased by 5.9 per cent but decreased by 0.6 per cent in the treatment wetland. Figure 2 and Figure 3 show the trend

[47] These cover built-up areas (high), farmlands (moderate), grasslands (low), papyrus (low), open water (low), tree plantations (high), and woodlands (low). These have been mapped onto high, moderate and low levels of degradation.

through time in Kisoro across treatment and comparison wetland sites. Appendix 12 provides a full set of figures for comparison and treatment wetlands in all eight districts.

Figure 2: Wetland use/cover changes in Kisoro – treatment wetland

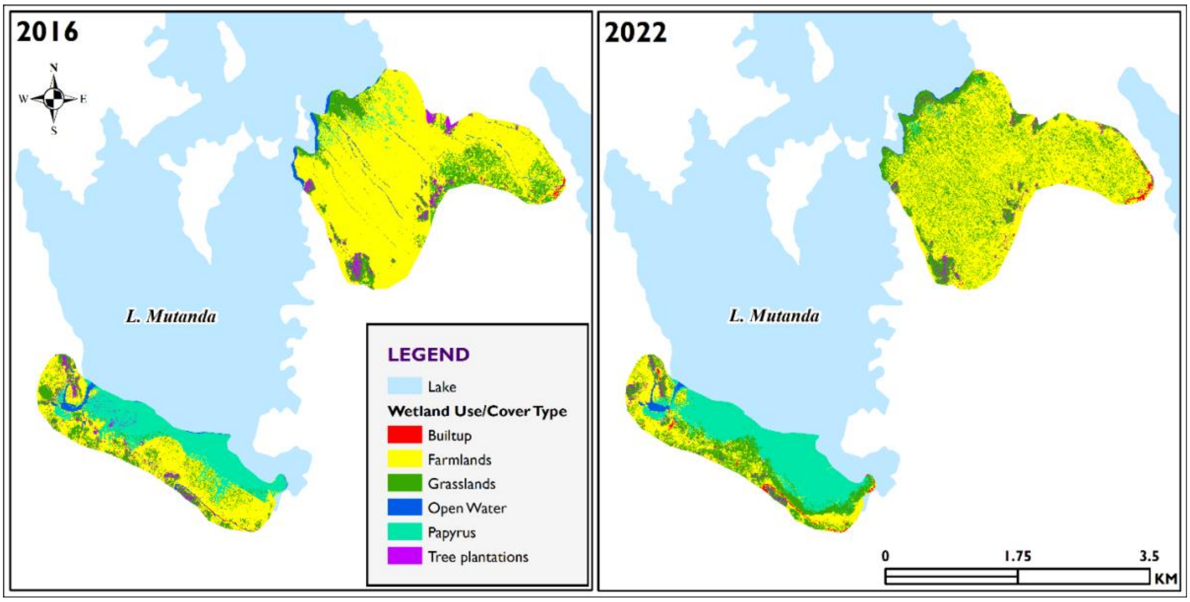
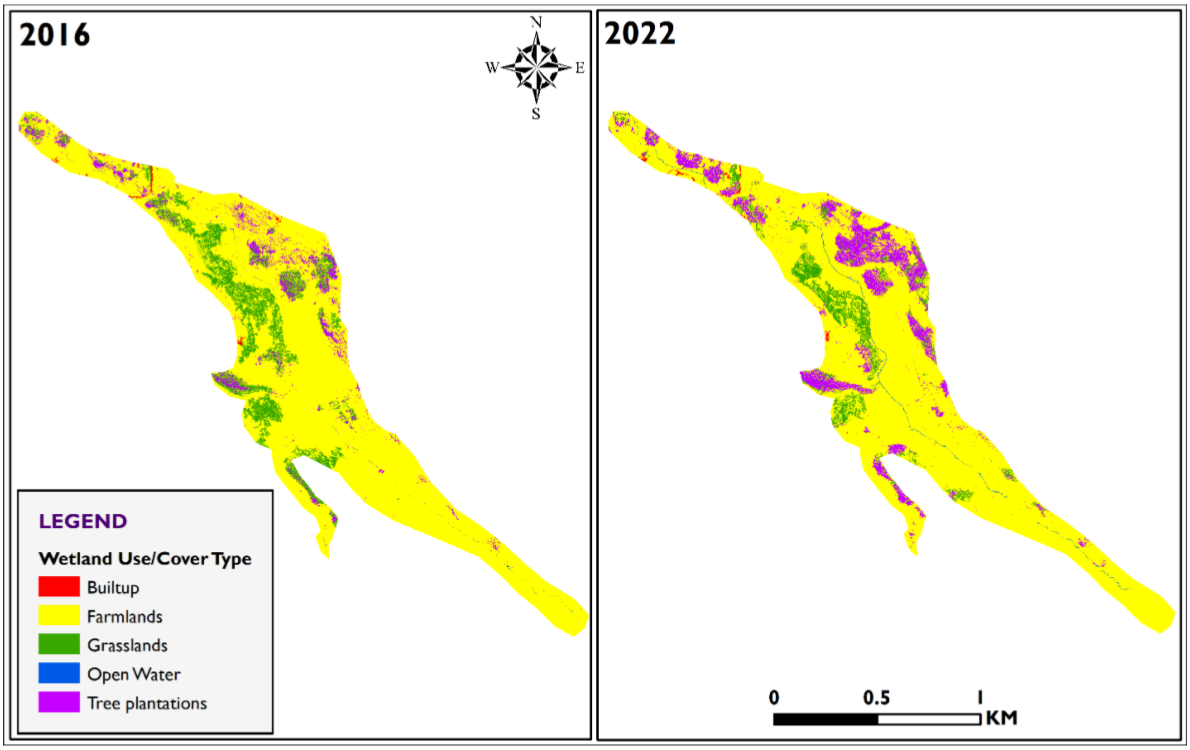


Figure 3: Wetland use/cover changes in Kisoro – comparison wetland



154. An assessment of Mitooma indicated a shift from moderate to low degradation in the treatment wetlands mainly due to a decrease in farmlands. Between 2016 and 2022, the built-up areas in

Mitooma increased in both the comparison and treatment wetland sites (see Table 24). During the same period, the farmlands in the treatment wetland decreased by 25.4 per cent, whereas the farmlands in the comparison site increased by 0.9 per cent. Grasslands increased in both sites, although a higher increment was observed in the treatment wetland. Between 2016 and 2022, the open water increased in the treatment wetland by 0.21 per cent. No open water was detected in the comparison wetland site. During the study period, the papyrus in the comparison wetland decreased by 7.1 per cent, while in the treatment wetland papyrus increased by 10.4 per cent. Tree plantations in both study sites decreased between 2016 and 2022, although a greater reduction was noticed in the comparison wetland site. In terms of the level of degradation in Mitooma (see Table 25), between 2016 and 2022, the low degradation class decreased by 0.13 per cent in the comparison wetland and increased in the treatment wetland by 25.2 per cent. The moderate level of degradation increased by 0.9 per cent in the comparison wetland and decreased by 25.4 per cent in the treatment wetland. Between 2016 and 2022, the high degradation class in the Mitooma increased by 0.12 per cent in the treatment site. However, it decreased by 0.8 per cent in the comparison wetland.

155. In the Rubirizi, a shift was observed from moderate to low degradation in the treatment wetland (see Table 24). The built-up areas in the comparison wetland site decreased by 0.02 per cent. No built-up areas were noticed in the treatment wetland site. Between 2016 and 2022, the farmlands in the comparison wetland increased by 0.6 per cent, whereas those in the treatment wetland decreased by 7.8 per cent. Grasslands in both sites increased during the assessment period, although a higher increment was observed in the comparison wetland. Open water in both sites reduced during the study period, although a greater reduction was noticed in the comparison wetland. Between 2016 and 2022, papyrus in the treatment wetland increased by 6.6 per cent, while that in the comparison wetland decreased by 11.4 per cent. The tree plantations in the treatment wetland site decreased by 0.8 per cent between 2016 and 2022. No tree plantations were observed in the comparison wetland. The woodlands in the comparison wetland decreased by 0.6 per cent during the assessment period. No woodlands were detected at the treatment site. In terms of the levels of degradation, between 2016 and 2022, the low degradation class decreased by 0.6 per cent in the comparison wetland and increased by 8.6 per cent in the treatment wetland, as elaborated in Table 25). The moderate category of degradation increased by 0.6 per cent in the comparison wetland and then decreased by 7.8 per cent in the treatment wetland. Between 2016 and 2022, the high degradation class decreased in both the comparison and treatment wetland sites at 0.02 per cent and 0.8 per cent, respectively.

Table 24: State wetland use/cover changes between 2016 and 2022 in western Uganda

	Wetland use/ cover type	**2015–2022 net change – Area (ha, %)**	
		Comparison	**Treatment**
Bushenyi	Built-up	0.1 (0.2)	1.2 (0.2)
	Farmlands	14.5 (29.1)	-33.4 (-6.9)
	Grasslands	-16.9 (-33.9)	43.2 (9)
	Open water	0 (0)	1.1 (0.2)
	Papyrus	0 (0)	-9.5 (-2)
	Tree plantations	2.3 (4.6)	-2.6 (-0.5)
Kisoro	Built-up	0.005 (0.004)	4.5 (0.6)

	Wetland use/ cover type	2015–2022 net change – Area (ha, %)	
		Comparison	Treatment
	Farmlands	-2 (-4.9)	-98.5 (-12.1)
	Grasslands	-5.9 (-4.9)	94.3 (11.6)
	Open water	0.43 (0.36)	-10.9 (-1.3)
	Papyrus	0 (0)	20.2 (2.5)
	Tree plantations	7.5 (6.2)	-9.6 (-1.2)
Mitooma	Built-up	0.07 (0.2)	0.6 (0.12)
	Farmlands	0.39 (0.9)	-115.3 (-25.4)
	Grasslands	2.9 (7)	66.4 (14.6)
	Open water	0 (0)	0.96 (0.21)
	Papyrus	-2.9 (-7.1)	47.3 (10.4)
	Tree plantations	-0.41 (-1)	-0.01 (-0.003)
Rubirizi	Built-up	-0.01 (-0.02)	0 (0)
	Farmlands	3.3 (0.6)	-2.8 (-7.8)
	Grasslands	92 (16)	0.7 (2.1)
	Open water	-26.3 (-4.6)	-0.02 (-0.1)
	Papyrus	-65.6 (-11.4)	2.3 (6.6)
	Tree plantations	0 (0)	-0.3 (-0.8)
	Woodlands	-3.3 (-0.6)	0 (0)

Note: Land-use includes built-up areas (high), farmlands (moderate), grasslands (low), papyrus (low), open water (low), tree plantations (high), and woodlands (low). These have been mapped onto high, moderate and low levels of degradation.

Table 25: Levels of wetland degradation in western Uganda

	Level of degradation	2016–2022 net change	
		Comparison	Treatment
Bushenyi	Low	-16.9 (-33.9)	34.8 (7.2)
	Moderate	14.5 (29.1)	-33.4 (-6.9)

	Level of degradation	2016–2022 net change	
		Comparison	Treatment
	High	2.4 (4.8)	-1.4 (-0.3)
Kisoro	Low	-5.5 (-4.5)	103.6 (12.7)
	Moderate	-1.7 (-1.4)	-98.5 (-12.1)
	High	7.2 (5.9)	-5.1 (-0.6)
Mitooma	Low	-0.06 (-0.13)	114.7 (25.2)
	Moderate	0.39 (0.9)	-115.3 (-25.4)
	High	-0.34 (-0.8)	0.6 (0.12)
Rubirizi	Low	-3.2 (-0.6)	3 (8.6)
	Moderate	3.3 (0.6)	-2.8 (-7.8)
	High	-0.09 (-0.02)	-0.3 (-0.8)

Note: Land-use includes built-up areas (high), farmlands (moderate), grasslands (low), papyrus (low), open water (low), tree plantations (high), and woodlands (low). These have been mapped onto high, moderate and low levels of degradation.

Regional level summary

156. This assessment shows that between the comparison and treatment sites in southwestern Uganda, the treatment sites recorded a reduction in tree plantations and farmlands. These land areas were mainly replaced by grassland. In the comparison sites, the grassland wetland cover type was the most vulnerable class to encroachment. The decrease was at the expense of tree plantations, farmland and built-up wetland classes that gained more land. It is worth noting that the wetland degradation levels in the treatment wetlands are high in Bushenyi and Kisoro, while in the comparison sites, the levels are high in Rubirizi and Mitooma.

5.2.2. State of wetland ecosystems in eastern Uganda

District level findings

157. Built-up areas in Bukedea's comparison and treatment sites increased between 2015 and 2022, as demonstrated in Table 26. During the same period, farmlands increased in the comparison wetland by 35.55 per cent compared to a 6.24 per cent decrease in the treatment wetland. A 37.02 per cent reduction in grasslands was observed in the comparison site and 2.63 per cent in the treatment site during the study period. Tree plantations increased by 0.09 per cent in the comparison wetland and increased in the treatment site by 0.12 per cent. Papyrus increased in the treatment wetland by 6.68 per cent. No papyrus was observed in the comparison site. Open water was not observed in both comparison and treatment. Table 26 provides additional details. Overall, low-level degradation in the treatment wetland increased slightly relative to the comparison site, which showed a large increase in moderate degradation (see Table 27).

158. Table 27 indicates that Kumi experienced a slight increase in low degradation land-use in the treatment site compared to the comparison site.[48] In the comparison site, grasslands and farmlands decreased by 20.53 per cent and 19.06 per cent respectively during the study period. Farmlands declined 14.33 per cent and grasslands increased by 9.76 per cent in the treatment site. Papyrus in the treatment site increased by 3.68 per cent between 2015 and 2022. No papyrus was detected in the comparison site. No open water was observed in the comparison and treatment sites. Built-up areas and tree plantations increased between 2015 and 2022 in both the comparison and treatment wetland sites but from a very low base.

159. As Table 27 shows, Namutumba saw an increase in moderate degradation at the treatment site compared to the comparison site driven by farmlands, which increased 23.51 per cent in the treatment wetland and 3.84 per cent in the comparison site. The area of grasslands declined in both sites, with the reduction in the treatment wetland much greater than in the comparison wetland, at -26.14 per cent and 2.08 per cent, respectively. Between 2015 and 2022, tree plantations in both study sites decreased slightly. Treatment sites showed an increase in papyrus and open water. Built-up areas increased in the comparison by 0.63 per cent and reduced in the treatment wetland by -0.78 per cent.

160. Table 27 shows a greater increase of moderate degradation in Ngora’s treatment site in moderate degradation compared to the comparison wetland. The area of farmlands increased in both comparison and treatment sites by 11.36 per cent and 14.54 per cent, respectively. The area of grasslands in both sites declined during the assessment period, with a greater decline observed in the treatment wetland at -19.78 per cent compared to -9.16 per cent in the comparison wetland. The area of open water increased in the comparison site by 1.21 per cent but fell in the treatment by -0.79 per cent during the study period. The area of papyrus in the treatment wetland increased by 3.39 per cent while that in the comparison wetland decreased by 2.34 per cent. Tree plantations in the treatment wetland site increased by 3.46 per cent between 2015 and 2022 and fell by -1.18 per cent in the comparison site in the same study period. The built-up areas in the comparison wetland site increased by 0.11 per cent between 2015 and 2022 and reduced in the treatment wetland site by -0.81 per cent.

Table 26: State wetland use/cover changes between 2015 and 2022 in eastern Uganda

	Wetland use/ cover type	2015–2022 net change – Area (ha, %)	
		Comparison	Treatment
Bukedea	Built-up	1.6 (1.38)	2.93 (2.08)
	Farmlands	41.32 (35.55)	-8.80 (-6.24)
	Grasslands	-43.02 (-37.02)	-3.71 (-2.63)
	Open water	0 (0)	0 (0)
	Papyrus	0 (0)	9.41 (6.68)
	Tree plantations	0.10 (0.09)	0.16 (0.12)
Kumi	Built-up	0.04 (0.98)	0.26 (0.18)
	Farmlands	-7.8 (-19.06)	-20.11 (-14.33)

[48] One of these should be positive.

	Wetland use/ cover type	2015–2022 net change – Area (ha, %)	
		Comparison	Treatment
	Grasslands	-8.4 (-20.53)	13.70 (9.76)
	Open water	0 (0)	-0 (0)
	Papyrus	0 (0)	5.09 (3.68)
	Tree plantations	0.2 (0.49)	1.06 (0.75)
Namutumba	Built-up	1.03 (0.63)	-3.87 (-0.78)
	Farmlands	6.33 (3.84)	117.05 (23.51)
	Grasslands	-3.43 (-2.08)	130.15 (-26.14)
	Open water	0 (0)	1.54 (0.31)
	Papyrus	0 (0)	20.50 (4.12)
	Tree plantations	-3.93 (-2.39)	-5.06 (-1.02)
Ngora	Built-up	0.63 (0.11)	-1.03 (-0.81)
	Farmlands	65.76 (11.36)	18.37 (14.54)
	Grasslands	-53.01 (-9.16)	-24.98 (-19.78)
	Open water	7.00 (1.21)	-1.00 (-0.79)
	Papyrus	-13.56 (-2.34)	4.28 (3.39)
	Tree plantations	-6.81 (-1.18)	4.37 (3.46)

Note: Land-use includes built-up areas (high), farmlands (moderate), grasslands (low), papyrus (low), open water (low), tree plantations (high), and woodlands (low). These have been mapped onto high, moderate and low levels of degradation.

Table 27: Levels of wetland degradation in eastern Uganda

	Level of degradation	2015–2022 net change	
		Comparison	Treatment
Bukedea	Low	-43.02 (-37.02)	5.71 (4.05)
	Moderate	41.32 (35.55)	-8.8 (-6.25)
	High	1.7 (1.47)	3.09 (2.5)
Kumi	Low	-8.42 (-20.53)	18.8 (13.39)

	Level of degradation	2015–2022 net change	
		Comparison	Treatment
	Moderate	7.8(19.06)	-20.11 (-14.33)
	High	0.6(1.47)	1.31 (0.94)
Namutumba	Low	-3.43 (-2.09)	-108.11 (-21.72)
	Moderate	6.32 (3.84)	117.05 (23.5)
	High	-2.89 (-1.76)	-8.94 (-1.8)
Ngora	Low	-59.58 (-10.29)	-66.31 (-6.1)
	Moderate	65.76 (11.36)	66.14 (6.09)
	High	-6.18 (-1.07)	0.17 (0.02)

Note: Land-use includes built-up areas (high), farmlands (moderate), grasslands (low), papyrus (low), open water (low), tree plantations (high), and woodlands (low). These have been mapped onto high, moderate and low levels of degradation.

161. Regional level findings

162. In the wetland treatment sites in eastern Uganda, we can see an increase in farmlands in Namutumba and Ngora. We can also see a reduction of grasslands across three of the four treatment sites. The classes that gained land between 2015 and 2022 are grasslands and tree plantations. For the comparison sites, we can see a reduction in grassland and tree plantations at the expense of farmlands and built-up areas. Levels of wetland degradation in the treatment sites were high in Ngora and low in Kumi (Figure 4 and Figure 5). In comparison sites, high levels of wetland degradation were experienced in Namutumba and Bukedea but not in Kumi. Appendix 12 provides a full set of figures for comparison and treatment wetlands in all eight districts.

Figure 4: Wetland use/cover changes in Ngora – treatment wetland

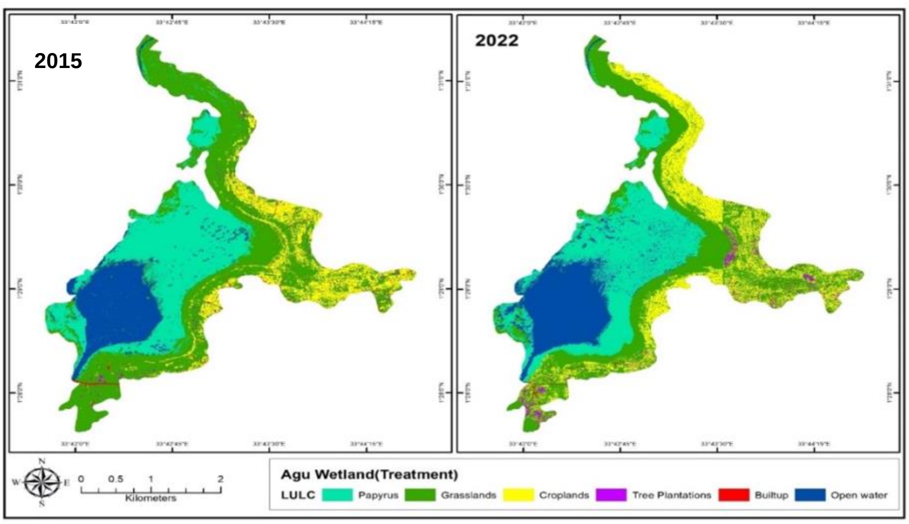
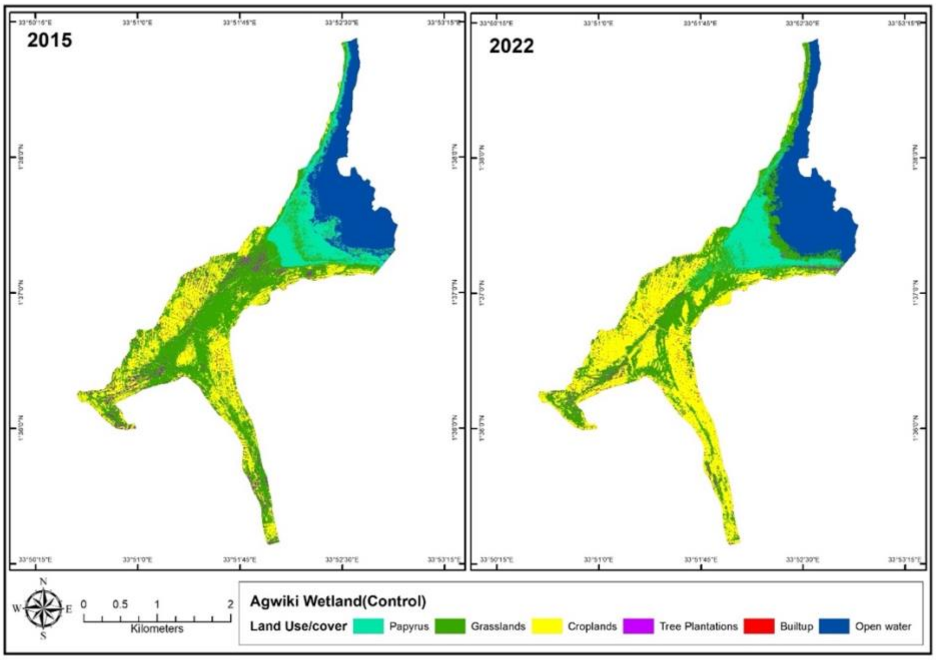


Figure 5: Wetland use/cover changes in Ngora – comparison wetland



5.2.3. Fauna – Presence of macrophytes, zooplanktons and macroinvertebrates

163. This section describes findings from the ecological variables as presented in full. It first discusses fauna and then overviews the findings from the water quality assessments.[49]

164. **Fauna – phytoplankton:** in western Uganda, the presence of phytoplankton in the form of blue algae was found to be moderately high across the restored wetland sites. Wetland sites with the greatest frequency of phytoplankton were in Kisoro's Nyumba wetland, Rubirizi's Kidubure wetland, Mitooma's Nyamihiza wetland and Bushenyi's Nyaruzinga wetland. None of the differences between treatment and comparison sites were statistically significant.

165. The frequency of phytoplankton in the form of green algae and flagellates was not significantly different across the treatment and comparison wetland sites. For example, flagellate frequency was high in the treatment sites in Bushenyi and Kisoro and the comparison sites in Mitooma and Rubirizi.

166. **Fauna – zooplanktons:** in western Uganda, the highest number of rotifers was recorded in Mitooma and Rubirizi, followed by Kisoro and Bushenyi. In the latter, the frequency of zooplankton was significantly higher (at the 5 per cent level) in the comparison site compared to the treatment wetland. For crustaceans, the greatest numbers were recorded in Rubirizi and Mitooma, followed by Kisoro for the wetland sites under treatment. Whereas in the comparison wetlands, the highest number was observed in Bushenyi. None of these differences were statistically significant.

167. **Fauna – macrophytes:** in eastern Uganda, the presence of macrophytes in restored wetland sites was higher in the Agu wetlands of Ngora, and Oladot in Kumi, in contrast to Bukedea and Namutumba. In Bukedea and Namutumba, wetland management interventions had lower impacts on the reappearance of macrophytes. Disparities in the abundance of species between treatment and comparison sites can be observed in Kumi and Namutumba (at the 5 per cent level), with significantly more macrophytes (at the 5 per cent level) in the treatment wetlands in Kumi and significantly less in the treatment wetland in Namutumba.

[49] See Appendix 10 and Appendix 11, respectively.

168. **Fauna – zooplankton:** wetlands in the treatment sites in Bukedea, Kumi, and Namutumba recorded the highest number of zooplankton. The differences between treatment and comparison wetlands were not statistically significant. The study found limited numbers of macroinvertebrates across comparison and treatment areas. Most were found in wetland sites in Namutumba and Kumi, followed by Bukedea.

5.2.4. **Water quality assessment**

169. The physiochemical properties of water were tested in *situ*, including temperature, conductivity, dissolved solids and salinity. For the sampled wetlands in eastern Uganda, treatment sites had higher levels of temperature, total dissolved solids and salinity than the comparison sites. This assessment shows that it is only salinity which was beyond the WHO's permissible water quality limit. In southwestern Uganda, the treatment sites had relatively higher levels of temperature, total dissolved solids and salinity than the comparison sites. Water salinity levels were also still out of range and present a threat to aquatic life.

VI. Discussion

170. The survey has highlighted a range of significant differences between households surrounding treatment and comparison wetland systems in the eight districts. Some of the most important differences are in the demographic profiles between comparison and treatment households. Treatment households are more likely to be headed by a woman, have smaller households, are less likely to be married and more likely to be widowed. These characteristics are reflected in a statistically significant difference in adult equivalent scores, with treatment households containing fewer adult equivalent units. Treatment households also have lower educational levels. Overall, these findings point to a very different demographic basis of treatment households with considerable implications for livelihood strategies, mobility, and the types of alternative livelihoods preferred.

171. Comparison households reported living in their current house for an average of 4.5 years longer and are more likely to own the land where they live. The endline survey may choose to examine this further. Equal access of all households to a tarmac road and local facilities, implies that households in both areas are equally connected.

172. Turning to the use of wetlands by the whole sample, around 77 per cent of respondents are benefiting from wetland areas, with households practising on average, two activities in wetlands, especially grazing and collecting firewood. Respondents reported that activities in wetlands are leading to a range of impacts, including changes in water levels and wetland size. A greater proportion of treatment households view nearby wetlands as being improved compared to comparison households, at 28 per cent and 14 per cent, respectively. Forty per cent of treatment households consider nearby wetlands as degraded compared to 70 per cent of comparison households. A much greater proportion of treatment households reported efforts to restore and sustainably manage wetlands in their area, at 69 per cent, compared to 31 per cent among comparison households.

173. In terms of community-based resilience practices supported by the project, 34 per cent of treatment households are aware of a small-scale irrigation facility in their community compared to only 16 per cent of comparison households. A significant difference is also observed regarding community farmer field schools, with the proportion of households aware of these initiatives being very low, at 3 per cent and 1 per cent, respectively. Overall, around one-fifth of households in treatment and comparison groups belong to a farmer group.

174. Regarding the receipt of support for enhancing resilience, treatment households reported receiving more pigs and goats compared to comparison households. In contrast, more comparison households reported receiving agricultural inputs, at 41 per cent, compared to only 13 per cent of treatment households. This data suggests that different projects may be operating in the comparison areas, and their effect will need to be carefully captured in the endline survey.

175. Households reported a very high proportion (43 per cent) of total expenditure on food, suggesting a higher susceptibility to food insecurity, with losses in household income. However, when households reported expenditure in Ugandan shillings, the greatest amount of spending was on education, followed by food and health care. This discrepancy between perceived and actual food expenditure deserves greater attention in the LORTA team’s endline research, with a more detailed assessment of expenditure patterns. Respondents reported how agricultural income is mainly used to pay for household essentials such as soap and sugar, followed by paying for health and medical services.

176. Overall, households reported a surprisingly limited number of ways of making a living (1.5 activities per household), with most combining crop farming with one or more of livestock rearing, casual labouring, small-scale business or brick-making. Households in both samples grow around 5.5 crops. Treatment households use significantly fewer land parcels, numbering 2.4, and less overall land area, at 2.7 acres, relative to comparison households’ reported number of parcels at 3.3 and land area of four acres for crop production. In addition, more comparison households reported that access to land was through customary tenure compared to treatment households. A greater proportion of treatment

households have gained access to land through borrowing, at 3 per cent compared to 0.3 per cent in comparison households. The differential access to land and tenure security suggests two possibilities – either demographic factors are playing a role, as women-headed households can struggle to access land, or, a greater number of treatment households are recent arrivals. These possibilities need further investigation in the endline survey.

177. The cropping profile in treatment and comparison areas appears broadly similar, with very low production and yields. Households are realizing the highest yields on a kg/acre basis for root and tuber crops and fruits and nut crops. The low yields for cereals, oil seed crops and leguminous crops are particularly surprising. Reported rice production at 410 kg is considerably more than for other cereals. Outside of cereals, a greater proportion of treatment households produced cabbages and bananas. Project staff suggested the higher production of bananas could be related to the higher proportion of women-headed households in treatment areas, as these households often distil and ferment bananas into alcoholic beverages, along with sorghum and millet. The allocation of land to further crop types is broadly similar. However, the LORTA team observed differences in the production and yield of groundnuts and soya, with comparison households growing significantly more groundnuts and treatment households growing significantly more soya.[50] The endline survey may choose to explore the reasons for the differential crop production.

178. Overall, data on land allocation reported by households highlights a rich mosaic of cropping patterns across a wide diversity of crops. Considering the average land sizes reported by households of around 3.3 acres per household and an average number of crops grown at 5.5 per household, it suggests a considerable degree of inter-cropping.

179. Interestingly, the team noted a divergence of SLM practices across treatment and comparison households. On average, comparison households conduct 3.4 SLM practices compared to 2.1 in treatment households. In addition, a significantly greater proportion of comparison households practice inter-cropping, crop rotation, and use animal and green manure. Treatment households reported practising more mulching. Once again, this suggests wider agricultural project activities in comparison sites, leading to the uptake of different agricultural best practices there.

180. Regarding agricultural inputs, a similar and low percentage of treatment and comparison households reported using seeds at 42 per cent, hired labour at 17 per cent, and fertilizer at 11 per cent. Only 2 per cent reported using machinery. Interestingly, 48 per cent of comparison households reported using agrochemicals and pesticides relative to 14 per cent of treatment households. This disparity may indicate that comparison households receive more extension advice than the demographically different treatment group.

181. Across the sample, 68 per cent of households reports that adult men mainly receive information about good agricultural practices compared to 27 per cent of adult women. Four per cent of young men and 1 per cent of young women also receive this information.

182. Over the whole sample, households reported widespread challenges in terms of pests and diseases, price fluctuations, unreliable rainfall, low soil fertility or prolonged dry spells, leading to a reduction in yields, income, food insecurity and malnutrition. Twelve per cent of households reported how challenges associated with crop production provide a disincentive to grow improved varieties. This finding is reflected in the survey data, which shows that 8 per cent of treatment households reported growing improved varieties, less than half of the 17 per cent that comparison households reported.

183. In terms of who benefits from the income from agricultural produce, across the whole sample, 68 per cent of respondents stated adult men are the main beneficiaries, followed by 25 per cent of adult women, young men at 4 per cent and young women at 3 per cent. The gendered patterns of

[50] The team observed that control households are also yielding more Irish potatoes, peas and old robusta coffee yet the number of observations for these crops is very low.

agricultural extension and accrual of agricultural income deserve careful consideration in the endline survey.

184. In terms of the gendered division of labour within agricultural activities, adult men contributed the greatest proportion of the labour to (i) applying crop inputs like pesticides (49 per cent), (ii) transporting crop produce (48 per cent), and (iii) selling crop produce (56 per cent). Adult women contributed the most labour to (i) planting (46 per cent), (ii) weeding (49 per cent), (iii) harvesting (46 per cent), and (iv) post-harvesting handling (53 per cent).

185. However, in treatment households, women contribute much more labour to clearing the garden than in comparison households. This difference aligns with the earlier finding that treatment households are more likely to have a female head, fewer members overall and are less likely to be married. Findings on livestock indicated that comparison households own significantly more cattle and chickens, and a greater proportion practice zero grazing, sell cow manure and yoghurt as products, and report greater problems with pests, parasites and diseases. It was also observed that a greater proportion of comparison households used hired labour to apply inputs and that adult women provided a greater proportion of labour when selling livestock products.

186. These findings suggest greater and more advanced livestock rearing systems within comparison households, hinting at greater access to agricultural extension and the different demographic profiles. In contrast, the survey found that a greater proportion of treatment households used rangeland grazing, sold meat products, and relied more on adult women for input application and livestock milking. These findings point towards a more extensive livestock production system and selling livestock as meat instead of livestock products.

187. An interesting difference was noticed regarding the location of markets. Ninety-one per cent of comparison households reported using local or community markets, compared to 66 per cent of treatment households. In contrast, 42 per cent of treatment households reported selling from home compared to 22 per cent of comparison households, suggesting limited mobility among treatment households and underscoring that they are more likely to be headed by women who typically have less mobility than men.

188. LORTA analysis of the pasture used by households when raising livestock found that 68 per cent of households reported using wetland areas. The next most frequent source of pasture used by households was land used for crop farming, accounting for 43 per cent of respondents, rangelands 16 per cent, and forests 9 per cent. Treatment households utilized rangelands and forests to a significantly greater extent.[51]

189. Similar findings apply to zero grazing and the extensive systems. As suggested earlier, a significantly greater proportion of comparison households, 41 per cent, reported selling cow manure compared to only 10 per cent of treatment households, reflecting a greater prevalence of zero grazing systems among these households. In addition, more comparison households than treatment households reported selling yoghurt at 6 per cent, which is significant at the 95 per cent level. Conversely, 27 per cent of treatment households reported selling meat as against 8 per cent of comparison households, which is significant at the 95 per cent level.[52]

190. The household questionnaire included a section on the gendered division of labour within livestock production. Again, these findings reflect the very different demographic composition of treatment households. A larger share of adult women reported participation in applying inputs to livestock in treatment households, amounting to 29 per cent of total labour, compared to 16 per cent in comparison households. This is significant at the 10 per cent level. In comparison households, used

[51] A similar proportion of treatment and control households use communal/pastoral, tethering and mixed livestock systems.
[52] Considering the distribution of pigs and goats as part of the project FP032, endline data should assess the degree to which these have been kept for breeding or sold.

more hired labour contributed for this task at 29 per cent of total labour, compared to 10 per cent in treatment households.

191. Total earnings from selling livestock were broadly comparable, with UGX 504,740 in treatment households and UGX 596,794 in comparison households. However, treatment households reported significantly more total earnings from selling livestock products at UGX 367,867 compared to UGX 132,201 by the comparison households, highlighting the importance of the sale of meat to treatment households.

192. In terms of diversity in food consumption, within the 12 food groups, the consumption profile appears to be similar in both treatment and comparison households. The survey also captured FIES by households in the treatment and comparison areas. This score is not different between the two groups, where, on average, households faced less than two insecure experiences in the past 30 days and less than one in the past year. However, comparison households are significantly more likely to have eaten fewer kinds of food in the past month.

193. Households were asked to outline the steps the household took in response to shock(s) in the past 12 months to try to regain their previous welfare level. Reliance on savings and sale of stored crops was significantly greater within comparison households compared to treatment households. For example, only 49 per cent of treatment households relied on savings compared to 66 per cent of comparison households. In addition, only 4 per cent of treatment households reported the sale of stored crops compared to 21 per cent of comparison households, suggesting greater savings and crop storage within comparison households. There are no differences for households purchasing insurance. The overall insurance coverage lies between 0.4 per cent and 1.25 per cent, implying a low pervasiveness of insurance as a risk coping mechanism.

194. Finally, respondents were asked about the degree to which they had seen the impacts of climate change on wetlands. Almost 76 per cent of respondents reported a decline or fewer benefits from wetlands. There were no significant differences between the treatment and comparison groups. In terms of weather information and climate impacts, 80 per cent of respondents used radios, and only 9 per cent relied on mobile phones for weather and climatic forecasts. The only channel which differed significantly between treatment and comparison respondents was the use of village meetings which was significantly greater in treatment households. The reasons for this could be examined in the endline data.

195. Survey data are supplemented with data on flora and fauna, water quality assessments, as well as Normalized Difference Vegetation Index comparisons through time. Overall, wetlands systems show very few significant differences in terms of phytoplankton, green algae, flagellates, zooplankton and crustaceans.

196. For western Uganda, the presence of phytoplankton (blue algae) was found to be moderately high across the restored wetland sites. However, the differences between treatment and comparison sites were statistically insignificant. In addition, the green algae and flagellates were not significantly different across the treatment and comparison wetland sites. Turning to zooplanktons, one district in western Uganda (Bushenyi) showed significantly higher zooplankton in the comparison site, compared to the treatment wetland. For crustaceans, none of these differences were statistically significant.

197. Disparities in the abundance of species between treatment and comparison sites can be observed in Kumi and Namutumba in eastern Uganda at the 5 per cent level, with more macrophytes in the treatment wetlands in Kumi and significantly less in the treatment wetland in Namutumba. In terms of zooplankton, none of the differences between treatment and comparison wetlands were statistically significant. This study found limited numbers of macroinvertebrates across comparison and treatment areas. The low numbers of macroinvertebrates precluded comparisons between treatment and comparison sites.

198. In terms of the chemical analysis of water, in western Uganda, the treatment sites had relatively higher levels of temperature, total dissolved solids and salinity than the comparison sites. Water salinity levels were out of the usual range, which is a threat to aquatic life. This suggests that despite progress in terms of restoration activities, the water quality has not recovered fully as of now.

199. In the sampled wetlands in eastern Uganda, treatment sites had higher levels of temperature, total dissolved solids and salinity than the comparison sites. The assessment shows that only salinity was beyond the WHO's permissible water quality limit, which suggests that the salinity level has not yet dropped sufficiently in these locations despite restoration activities.

200. In terms of the satellite data, in western Uganda, the treatment sites showed a reduction in tree plantations and farmlands. These land areas were mainly replaced by grassland, suggesting that restoration activities have contributed to regenerating the wetland ecosystem. In the comparison sites, the grassland wetland cover type was the class most vulnerable to encroachment from tree plantations, farmland and built-up land-use. Wetland degradation levels in the treatment wetlands are high in Bushenyi and Kisoro, while in the comparison sites, the levels are high in Rubirizi and Mitooma. These findings suggest that project restoration activities could be rechecked for Bushenyi and Kisoro as component 1 implementation is almost completed in both wetland systems.

201. In eastern Uganda, an increase in farmlands in Namutumba and Ngora and a reduction of grasslands across three of the four treatment sites were recorded. In the treatment wetlands, land-use activities that gained land between 2015 and 2022 are grasslands and tree plantations. For the comparison sites, the team noted a reduction in grassland and tree plantations and an increase in farmlands and built-up areas. Levels of wetland degradation in the treatment sites were high in Ngora and low in Kumi. In the comparison sites, high degradation levels of wetlands were experienced in Namutumba and Bukedea and were low in Kumi. This suggests that project restoration activities could be rechecked for Ngora as component 1 implementation is close to completion here. Lessons could be learned from Kumi as the wetland system here is exhibiting limited degradation relative to other wetlands systems presented in this report.

VII. Challenges and shortcomings

202. As indicated above, the evaluation has encountered several challenges. These have included delays during the COVID-19 pandemic, as well as pivoting away from the use of ecological data collected in 2018 to match wetland systems (due to concerns about the quality of this ecological data) towards a reliance on local expertise and experience.

203. The LORTA team adhered to the evaluation strategy throughout its data-collection, which included a survey, key informant interviews, FGD, and collecting ecological indicators in wetland systems. Early in the process, the team refined the number of ecological indicators to be collected and tested in laboratories in Kampala so it could complete this section of the fieldwork in a timely manner. There was no major deviation from the quantitative and qualitative methods which were conducted, and comparison wetland systems were validated in the field with the guidance of the project's district focal person before the data-collection process, thus ensuring these areas support the evaluation. As highlighted above, the team encountered several challenges collecting data for the report, including difficulties regarding (i) compiling spatial data on household location due to high cloud coverage, which was remedied by recording respondents' names and administrative locations, (ii) accessing households due to the mountainous terrain, and (iii) meeting district focal persons due to their limited availability, which required extending the data-collection time.

VIII. Conclusion

204. The GCF project FP034 “Building resilient communities, wetland ecosystems and associated catchments in Uganda” was commenced in 2017 and will conclude in 2025. The project targets 12 districts in southwestern Uganda and 12 in eastern Uganda and consists of three key components. Component 1 focuses on restoring and managing wetland hydrology and associated catchments. Component 2 aims at improving agricultural practices and alternative livelihood options in the wetland catchments. Component 3 targets strengthening access to climate and early warning information for farmers and other communities to support wetland management.

205. The results described in this report cannot be attributed to the project as such impacts can only be estimated after the endline data-collection. For the evaluation, survey data was collected from 1,666 households in eight treatment and eight comparison wetland systems, four each in the eastern and western regions of Uganda. The results show a wide range of differences between the comparison and treatment areas. This is not entirely surprising, given that the degree of implementation in treatment wetland areas is between 100 per cent and 35 per cent of components 1 and 2. Comparison wetlands have not received any interventions from this project although they may have received support from a range of other projects, an issue which could be included in the endline data-collection.

206. The biggest differences between treatment and comparison areas are the notable differences in the demographic profiles between the comparison and treatment areas, as treatment households are more likely to be headed by a woman (and are less likely to be married), have fewer members (reflected in a lower adult equivalence score), less education, are more likely to be widowed. The degree to which the project’s livelihood options consider this profile needs revisiting to ensure alternative livelihood strategies are tailored for all demographic groups, including their mobility and preferences. These demographic differences may also be influencing current residence patterns (as treatment households have lived in their houses for a shorter time) and access to land.

207. On average, households reported growing 5.5 crops. The application of inputs to crops is very low, with many more comparison households applying agrochemicals, using improved varieties and applying more SLM practices. Overall, men tend to receive information on good agricultural practices from extension services compared to women (highlighting key challenges women-headed households face). In addition, men tend to control income from agriculture and tend to apply agrichemicals, transport crop produce, and sell crop produce. Women tend to contribute labour in terms of planting, weeding, harvesting, and post-harvesting handling.

208. Regarding livestock, comparison households own more cattle and chickens, practice more intensive proportion practices, including zero grazing, and receive more income from these sources. These findings suggest greater and more advanced systems of livestock rearing within comparison households, hinting at greater access to agricultural extension and the different demographic profile.

209. Overall, the differences in employment profiles of the two areas suggests there is still a large reliance on agriculture. An investigation by the endline survey into the type of broader national and institutional interventions in the comparison area may provide a better understanding of what is occurring in these areas and ensure these differences are accounted for in the project’s impact estimates.

210. The NAP-Ag has placed a focus on resilient cropping and livestock, as well as value chain development, alongside interventions in climate information systems and better natural resource management. FP034 directly addresses these focus areas by promoting conservation agriculture, diversification and better on-farm management of crops. The findings from this baseline report can be used to inform any ongoing adaptive management and implementation adjustments. The institutional landscape in Uganda needs to ensure entities and implementing organizations incentivize actors to enhance coordination between mechanisms with clear challenges for solving coordination challenges,

ensure effective district level technical skills and policy literacy on climate implementation and issues, and ensure sincere engagement with local communities.

Appendix 1. Shortcomings of the UNDP's ecological data set

Sampling methods

The key problem with the data set is the apparent lack of structured sampling and methodological approaches in its collection. If there are specific methods/tools used, these need to be explicitly stated. For example, how were vegetation samples or observations of wildlife collected? It appears that no standard ecological methods for sampling species and richness were used, as there is no evidence of transects or point counts having been conducted. The sampling strategy appears opportunistic, perhaps based on accessibility. This may bias the samples. Finally, the taxonomic detail is limited for the observations pertaining to biota. Many observations use common and not scientific nomenclature.

Parameters are not comparable

The biophysical data covers a range of parameters which are not comparable. For example, different species of plants cannot be used to score a site unless they are compared with a reference site considered pristine.

Covariates and dependency

Some variables may be related, e.g. water depth and type of vegetation or soil humus content and land-use.

Repetition

Some variables are very similar or even identical. This may be due to a lack of clarity in their definition.

Missing parameters

No explicit hydrologic or landscape-based parameters were used.

Missing data sources

Data extracted from remotely sensed products and from available global geospatial data sets could have supplemented the available data and potentially provided a more robust framework for the matching exercise, such as land-use and land cover change maps. Hydrometeorological data from UNMA could also have been considered.

Issues with data organization

- Data is not complete across the variables (many blank cells).
- About 546 of 11,681 rows have coordinates.
- Many of the variables have multiple values in the same columns, which were re-organized.

Appendix 2. Ecological data set provided by UNDP

UNDP categorized the available ecological data down into nine groups. Specific proxy variables were then selected for each group (which in some cases was one single variable and in others a number of variables). Each proxy variable was scored and weighted by experienced staff within the UNDP team. They were then rescaled from 1–10. The table below illustrates the variable/s that constitute each group.

Table 28: Ecological data set provided by UNDP

Group ID	Group	Variable	Suggested weight	Variable scoring
1	Bioclim	Water regime [wtr_regime.rst]	1.0	Permanent 8 Always flooded along the stream 6 Seasonal 4 Sporadic 2
2a	Physiochem	Dissolved oxygen [do.rst]	1.0	Rescaled from 1 to 10, the higher DO, the higher the score
2b	Physiochem	Water colour [wtr_col.rst]	0.6	Clear 10 – good water penetration Milky 5 – some sediment/pollution Brown 2 – sediment
2c	Physiochem	pH [ph.rst]	0.3	The acidity or alkalinity of water
2d	Physiochem	Water temperature [wtr_temp.rst]	0.2	Ranges from 19 to 35
3	Hydrologic	Flow alteration [flw_alt.rst]	1.0	Obstructions were ranked lower while structures facilitating drainage were ranked higher. Dams 2 – obstructs flow Dykes 2 – obstructs flow Roads 4 – obstructs flow, but not as much as dams or dykes Culverts 6 – facilitates drainage Ditches 6 – facilitates drainage Drainage channels 8 – facilitates drainage
4a	Soil	Organic content [org_cnt.rst]	0.3	The more organic content, the better the soil. Little 2 Moderate 4 Substantial 8

Group ID	Group	Variable	Suggested weight	Variable scoring
4b	Soil	Soil disturbance [soil_dist.org]	0.8	The higher the disturbance, the lower the score, as it will contribute to the sedimentation of the wetland or the diversion of water from it. Tillage 1 Tillage and drainage 1 Tillage for rice 1 Trenches and damming 1 Channels 1 Crop plantations 1 Cultivation 1 Damming 1 Bush burning 2 Gullies 3 Grazing 5 Sediment deposit 6 None 10
5a	Vegetation	Vegetation type [veg_type.rst]	0.6	Emergent 1 Emergent rice 1 Rice 1 Crop 3 Cropland 3 None 5 Shrubs thickets palm 6 Floating 8 Grass 8 Grassland 8
5b	Vegetation	Invasive species [inv_sps.rst]	0.8	Eucalyptus 1 Mimosa 1 MimosaPigra 1 Polygonum 1 PolygonumSp 1 Aeschynomen elaphroxylon 10 None 10
6	Threat	Threat [threat.rst]	1.0	Artifdrainage 1

Group ID	Group	Variable	Suggested weight	Variable scoring
				Channelization 1 Cropland 2 AlienVeg 3 BushBurning 4 CommPlantations 6
7	Ecosystem services	Ecosystem services uses [es_uses.rst]	1.0	Agriculture 1 Rice growing 1 Irish growing 2 Cattle grazing 3 Water agric 3 Fish farming 3 Fodder 5 Fishing and grazing 7 Grass for mulching 7 Grazing 7 Grazing and tree planting 7 Papyrus reeds 8 Riverbank protection 10
8	Activities	Activities in wetland [activities.rst]	1.0	Crop production 1 Excavation 1 Hunting 3 Plantation trees 3 Fishing 6 Fodder harvesting 6 Grazing 6 Harvesting fibre 6 Harvesting herbs 6 Water collection 6 Tourism 8
9a	Wildlife	Birds	1.0	Pigeons 2 Ibis 4 Kingfisher 4 Egrets 5 Commorants 6

Group ID	Group	Variable	Suggested weight	Variable scoring
				Pelicans 10 Fish eagles 10 Cranes 10
9b	Wildlife	Fish	1.0	Catfish 7 Mudfish 7 Tilapia 7 Lungfish 10
9c	Wildlife	Mammals	1.0	RatusRatus 2 Hedgehog 5 MonitorLizard 5 MudFishBirds 5 Tortoise 5 Sitatunga 10 Hippos 10 Otters 10

Note: Bioclim stands for bioclimatic; physiochem stands for physiochemical.

Appendix 3. Original design and matching approach to wetland systems

3.1. Original evaluation design

Based on the staggered nature of implementation and the assured eventual coverage of the entire population within the intervention area, a phase-in randomized control trial was initially proposed. As the first 10,000 ha to implement the project in 2019 were already non-randomly selected, the design proposed to randomly select the next 10,000 ha for project implementation in 2020. From the total 64,000 ha envisioned for project implementation, the study would only focus on the 54,000 ha to draw a random sample. The unit of randomization was the wetland system that would not be affected by restoration efforts in other parts of the same district. This design aimed to randomly select systems covering 10,000 ha for treatment early in implementation, which would serve as the treatment group for the impact evaluation. Likewise, the aim was to simultaneously randomly select wetland systems covering 10,000 ha for the control group, which would receive the treatment only in 2024 after midline data-collection. It was noted from early discussions with the implementation staff that there are systematic differences in the two implementation regions; therefore, a stratified randomization sample was proposed where the eastern and southwestern regions would be the two different strata. In case of differences in population density and size in each cluster, the team proposed a further level of stratification at the population size/density level. Due to the stratified random assignment of the wetland systems into treatment or control groups, within this initial design, all observable and unobservable characteristics of the two groups would be balanced, with observable characteristics checked from the baseline data-collection. Consequently, the analysis at midline would provide an unbiased impact of the intervention between the control and treatment ha.

The sampling for scenario 1 consisted of, at the first level, the wetland systems. The aim was for a mapping exercise to provide an adequate sampling frame for the selection of the wetland systems/subsystems into control or treatment groups. A random sample of households living within each wetland system would then be drawn.

As discussions with the project team raised concerns about the practical feasibility of not starting any project activities in the pre-determined control areas before 2024 and ensuring the evaluation team could adapt to unannounced or unintended changes in implementation plans in the assigned control group (which would threaten the internal validity of the design), the evaluation team also proposed an alternative DiD with matching design.

To account for the difference in characteristics between the regions, different wetland system sizes, in terms of population density and size and the difference in community characteristics, this design would match the comparison and treatment wetland systems on a set of observable data that would already be available after the mapping in all 54,000 ha. This approach aimed to confirm the establishment of the first 10,000 ha to be assigned as the treatment group, which would cover wetland systems of differing sizes in population and area covered and then balance these observable characteristics in the comparison group. Hence, the selection of the first 10,000 ha for the treatment group would not be random. However, the evaluation design would ensure that observable characteristics would be used to match the treatment wetland with a control group within the remaining 44,000 ha.

Relevant criteria for the matching of wetland systems included region, population size, average population density, vulnerability level of the wetland areas and the community within, and community demand for training components.[53]

[53] This approach assumed that at the start of each year's restoration activity project staff provided information on the matching of the observable characteristics of the first 10,000 ha with the remaining ha of wetland in 2021 and in 2022.

At that stage, it was envisioned that the LORTA team would remain in close consultation with the project implementation team to develop the implementation plan so that the control group area balanced with the treatment 10,000 ha. Due to the project's flexible implementation needs regarding selecting the exact wetland systems or the exact 10,000 ha to be the control group, this method would allow the evaluation team to maintain a balance between the two groups. Accordingly, a matching based DiD estimation was applied to establish a causal impact of the intervention, removing any confounding time invariant differences between the treatment and control group.

Since the matching would occur on a number of different covariates mentioned above and would be stratified, a sufficient number of matched wetland systems would need to be correctly identified to create and maintain the control group. This approach aimed for a stratified random sampling of households from the control and treatment areas around wetland systems, with an oversampling of households within the comparable control group.[54]

3.2. Original matching approach

The data set consisted of 59 wetland systems. The data showed that 15 of these wetland systems received implementation in some or all wetlands between 2018 and 2021. Of these, nine wetland systems had received implementation during and since 2021. These 15 and 9 wetland systems are used as the treatment units in two different sets of matching, and the remaining 44 and 50 wetland systems, respectively, act as the comparison units. The study uses PSM to highlight the most similar wetland systems to the 15 or nine treatment units. Typically, PSM is used to explain the outcomes of households participating in a programme. When applied in this way, the study needs to make sure that treatment and comparison households are drawn from the same data source, both household groups are exposed to similar economic incentives, and there are enough independent variables that can be used to identify programme participation by households.

In this study, the selection of the 15 or nine wetland systems that have received implementation thus far has been conducted in a non-random political process. While the study cannot identify the political factors that led to the inclusion of some wetland systems and not others, it nevertheless aims to select wetland systems that share the most similar ecological characteristics to those that have received implementation to date.

Instead of including (socioeconomic) variables that cover eligibility criteria for a programme, which is usually the case for PSM, the study uses the ecological groups/variables listed in Appendix 2. However, to ensure wetlands match as accurately as possible, the study must avoid including any independent variables possibly affected by the project. As already seen, 15 wetlands have received implementation since 2018 and 9 during and since 2021. The project includes physical wetland restoration (component 1) and alternative livelihood training events (component 2). Project activities in the selected wetland areas may have affected the following variables.

- Hydrologic – Flow alteration, for example, removing obstruction)
- Soil – Soil disturbance, for example, reducing the frequency of tillage and drainage, tillage for rice, trenches and constructing dams, digging channels, crop plantations, cultivation, bush burning and grazing
- Threat – Threats, for example, removing artificial drainage, channels
- Ecosystem services – Ecosystem services use, for example, reducing growing rice or potatoes

[54] For the sampling frame, this approach intended to rely on available census data household lists prepared during agricultural surveys, data on the beneficiaries of the livelihood training from the implementing non-governmental organizations, and other available administrative lists.

- Activities – Activities in wetland, for example, reducing activities in wetlands such as crop production, excavation, grazing and harvesting

Due to this uncertainty and a lack of clarity when each of the constituent variables was collected, the PSM is conducted with and without this set of five variables. A further consideration with PSM is the assumption of common support, which essentially dictates that treatment and comparison units be discarded if their propensity score lies outside the range of values of the other group.

A further issue to discuss is what to use as an outcome variable. The best indicator for the health of each restoration group and their wetlands is the wildlife indicator. In this respect, an abundance of birds, fish and mammals is an ideal outcome indicator. The other eight ecological groups remain as inputs that increase or decrease the likelihood of achieving this ecological state. They comprise bioclim, physiochem, hydrologic, soil, vegetation, threat, and ecosystem services.

The final issue to highlight is the inclusion of the hectarage of each restoration group as a comparison variable. Further iterations of this PSM could also include a dummy variable to signify if the wetland systems are in the eastern or western zones.

To summarize, the study uses the two sets of data. The first is a truncated data set where hydrologic, soil, threat, ecosystem services and activities are not included in generating the propensity score, as project implementation might have influenced these. The second is a full set that includes all eight ecological variables.

The study applies models to the 15 wetland systems that have received implementation since 2018 and the nine that have received implementation during and after 2021. In both cases, the study uses the wildlife variable as the outcome variable, expecting that the PSM will narrow the difference in the wildlife score compared to a without PSM scenario. In each case, the results first display the naive comparison in the wildlife score before displaying the model findings. The direction, size, and significance of each of the ecological variables within probit and logit models are not shown, and they are not the primary concern. For both data sets, the study will use the 15 wetland systems from 2018-2021 and the nine wetland systems during and since 2021) to generate the propensity score for matching to comparison.

3.3. Matching methods

Three different matching methods are used for each of the two data sets in terms of checking the outcome variable of wildlife: nearest neighbour matching (teffects), caliper matching (set at 0.5 teffects) and direct nearest neighbour matching (nnmatch). Nearest neighbour matching links each treatment unit to a comparison unit with the closest propensity score. Caliper matching links each treatment unit with a number of comparison units within a pre-defined radius of the treatment unit and uses the mean figure of these comparison units. The bandwidth of the caliper can be varied. Direct nearest neighbour matching imputes the potential outcomes for each subject by using an average of the outcomes of similar subjects that receive the other treatment level. Every matching method calculates ATT.

3.4. Results

The results are presented according to the data and the number of independent variables utilized (leading to four approaches). Each part starts with the naive comparison between treatment (T) and comparison (C) wetland systems, after which the results from the PSM are displayed. A summary is then offered.

Approach 1: Implementation during 2021 (nine wetland systems), with a full range of eight independent variables. The outcome variable is the wildlife score. Here, the naive comparison has a smaller difference between the T and C groups for the wildlife score than the probit and logit estimates. The logit performs better but is still worse than the naive comparison. The team could not alter the bandwidth of the calliper below 0.5 due to a lack of matches. Increasing the calliper above 0.5 made no changes to the estimates. The direct nearest neighbour matching did not make a large difference.

Approach 2: Implementation from 2018 - 2021 (15 wetland systems), with a full range of nine independent variables. The outcome variable is the wildlife score. Studying the full 15 wetland systems with the full range of eight independent variables (keeping the outcome variable as wildlife score) reveals that the matching methods of all flavours have a larger discrepancy between the T and C groups regarding the outcome variable compared to the naive comparison. However, the discrepancy size is smaller than when only utilizing the nine wetland systems from 2021 onwards. This raises doubts about using the full set of ecological variables, as indicated above.

Approach 3: Implementation from 2021 (nine wetland systems), a limited number of independent variables. The outcome variable is the wildlife score. Considering the nine wetland systems from 2021 with the limited range of independent variables (keeping the outcome variable as wildlife score), all matching methods have a larger discrepancy between the T and C groups in the outcome variable relative to the naive comparison.

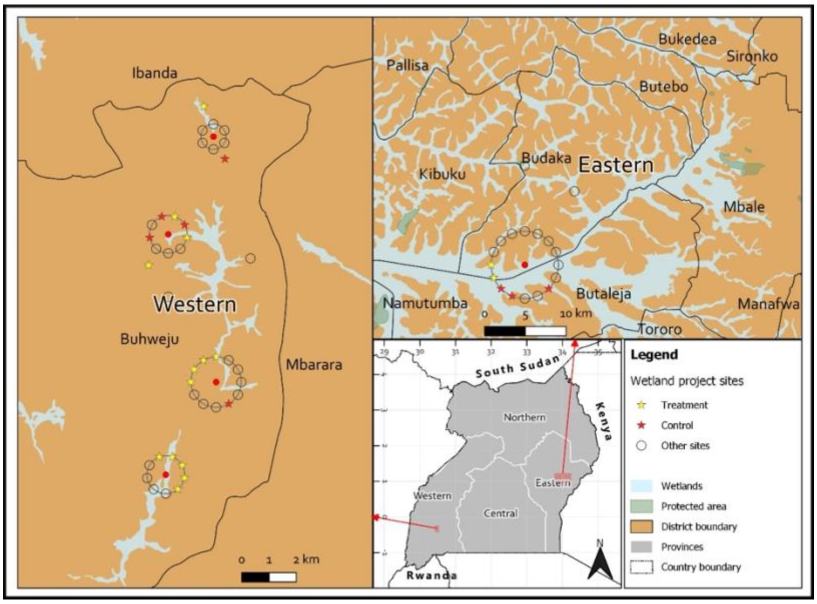
Approach 4: Implementation from 2018 - 2021 (15 wetland systems), a limited number of independent variables. The outcome variable is the wildlife score. Compared to the naive comparison of 0.61, all five matching methods for the data from 2018-2021 (15 wetland systems) and a limited number of independent variables (as outlined above) show a smaller discrepancy in terms of the wildlife score compared to the naive comparison. For example, both logit models show a difference of only 0.21 in the wildlife score compared to 0.61 in the naive comparison. The infographics on the degree of common support, combined with overlap checks in the data set, showed that all observations are on common support. This was also confirmed in the data set by checking if any cases were off sample). Of the four approaches detailed here, this approach to selecting comparison wetland systems offers the most promise.

To assess which of the wetland systems were matched with the 15 implementation groups, additional variables were appended to the data set using appropriate commands in Stata which illustrated the case numbers of the cases that were matched with each case. The variable illustrates the case number (observation number) from which the restoration group number can be checked. Eight cases were returned, as illustrated in

Figure 6.[55]

[55] The reason for the limited number of control wetland systems is that within the teffects function, treatment units can be matched with a single control unit. In other words, unlike pscore and psmatch2, there is no 'no replacement' option which would allow for a full fifteen unit to be drawn.

Figure 6: Matching approach to wetland systems



3.5. Challenges and shortcomings

This analysis is the first step in leveraging the existing UNDP Kampala ecological data. Many issues with the above analysis can be improved, and many further aspects need consideration.

First, instead of using a simple average to create the scores for each restoration group, consider a weighted average using the hectares of each wetland to refine the scores for each ecological indicator before matching. The size of the wetland varies from 1 acre to over 3,500 acres. These all carry the same weight when restoration group scores have been created.

Second, consider the inclusion of a dummy variable corresponding to whether each restoration group is in the east or west of the country.

Third, consider conducting similar matching on the last of our four approaches using pscore and psmatch2, as these allow for a "no replacement" term within psmatch2, allowing the study to match 15 comparison wetland systems for the 15 treatment wetland systems. This would be 1-1 matching without replacement using psmatch2 in Stata or even manually with Excel so the project team sees and understands what is happening.

Fourth, consider whether any of the nine comparison wetland systems highlighted within approach 4 above correspond to any of the 23 wetland systems slated not to receive any implementation by the end of the project, as described in the pre-analysis plan. If they do, this note's approach is validated, and these nine comparison wetland systems could be ideal locations for the DiD design.

Fifth, consider and double-check that the direction of each ecological variable is consistent, especially for "threat", which appears to show that a lower value is preferable to other variables that show a higher value as being better.

Sixth, conduct manual matching as a cross-check to assess the degree to which the "Stata teffects" tally with this approach.

Seventh, distance to density and infrastructure are key considerations. Consider socioeconomic or geographical characteristics, such as distance to the capital, road or infrastructural development, and population density. This is especially the case for household matching.

Appendix 4. Temporal and spatial attributes of satellite imagery

Table 29 shows the temporal and spatial attributes of satellite images that were used in the baseline report.[56]

Table 29: Temporal and spatial attributes of satellite images that were used in the baseline report

Region	District	Type	Name of the wetland	Imagery date (before)	Imagery date (after)	Spatial resolution (m)	Satellite
Eastern	Bukedea	T	Komuge	13 Dec 2015	7 Jan 2022	0.306	WorldView-4
		C	Akuolo	13 Dec 2015	26 Feb 2022	0.324	WorldView-3
	Kumi	T	Oladoti	2 Mar 2015	6 Jan 2022	0.259	WorldView-4
		C	Obura	1 Mar 2015	14 Jul 2022	0.153	WorldView-4
	Namutumba	T	Mazuba mini-Mpologoma	22 Jan 2015	27 Feb 2022	0.579	Pleiades-1B
		C	Nabinyonyi-Kimenyulo	12 Mar 2015	28 Feb 2022	0.173	WorldView-4
	Ngora	T	Agu	1 Mar 2015	9 Feb 2022	0.562	Pleiades-1B
		C	Agwiki	6 Feb 2015	20 Feb 2022	0.605	KOMPSAT-3
Southwestern	Bushenyi	T	Nyaruzinga/Kanyara-Nyampimbi	29 Jan 2016	20 July 2022	1.777	WorldView-2
		C	Mbachi	18 July 2016	11 Feb 2022	0.555	Pleiades-1B

[56] The satellite images were classified using supervised maximum likelihood classification technique. Wetland classification refers to the process of assigning wetlands to categories based on their origin, structure, flooding frequency, dominant flora, or some other combination of physical and/or biological attributes (Omute, 2019). In this assessment, wetlands were classified based on their physical attributes (wetland use/ cover types).

Region	District	Type	Name of the wetland	Imagery date (before)	Imagery date (after)	Spatial resolution (m)	Satellite
	Kisoro	T	Chotsa Bay - Mulehe Mutanda	18 Jan 2016	25 Feb 2022	3.225	Gaofen-2
		C	Mulindi/ Echuya/ Muchoya	15 Jul 2016	26 Feb 2022	1.000	WorldView-3
	Mitooma	T	Nyamuhizi-Kagogo-Mushasha	20 Dec 2016	11 Mar 2022	1.557	SPOT-7
		C	Katenga	20 Dec 2016	11 Mar 2022	0.333	WorldView-4
	Rubirizi	T	Kidubule-Ibamba-Nyakagyera-Ngoro	27 Jul 2016	11 Mar 2022	0.333	WorldView-4
		C	Chambura	24 Mar 2016	11 Mar 2022	2.443	KOMPSAT-3

Note: "Before" and "after" refer to a period before and after project implementation. The project started implementation in 2017.

Appendix 5. Asset index

This appendix describes the construction of the two indices included within the asset index constructed using PCA. In total, four variables were included:

- Physical capital: Housing index based on
- Natural capital: Total land area for crop production in acres
- Human capital: Highest educational level of the household head
- Social capital: Index based on leadership positions in local churches and mosques or local authorities, membership of local groups of committees

Both the physical and social capital variables were based on indices.

For physical capital, weights were constructed using key informant interviews to ascertain the relative cost of the materials in Uganda. The following weights were applied to the quality of the roof, walls, floor and latrine facilities. Any missing values, including other categories, were imputed with median values.

Variable	**Indices**
What is the main material in your roof?	1. Iron sheets – 18 2. Tiles – 27 3. Asbestos – 12 4. Concrete – 27 5. Tin – 6 6. Tarpaulin/Polythene – 3 7. Thatch (grass, reeds and papyrus) – 1
What is the main material of your wall?	1. Concrete or stones – 14.50 2. Cement blocks – 21.75 3. Burnt or stabilized bricks – 6.75 4. Unburnt bricks with cement – 4.5 5. Unburnt bricks with mud – 3 6. Wood – 2 7. Mud, wattle, poles and reeds – 1 8. Mud, wattle, poles, reeds and cement – 1.5 9. Tin or iron sheets – 4.5
What is the main material of your floor?	1. Earth – 1 2. Concrete – 10 3. Brick – 6.75 4. Stone – 4.5 5. Cement screed – 15

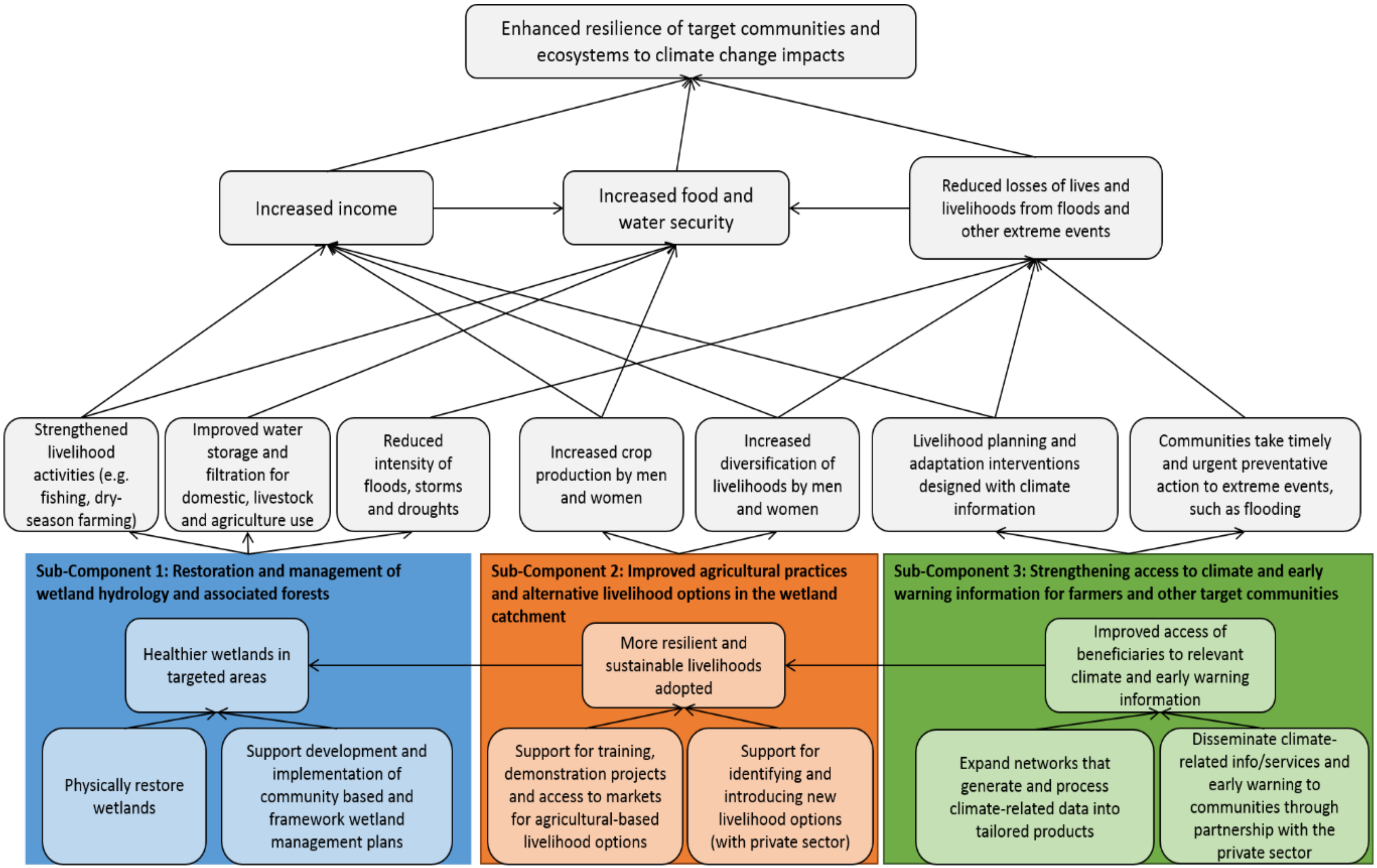
Variable	Indices
	6. Rammed earth – 1.5 7. Wood – 2.25 8. Tiles – 22.5
What is the type of latrine facility that this household mainly uses?	1. Flush toilet – 18 2. VIP latrine – 9 3. Pit latrine with a slab – 6 4. Pit latrine without a slab – 3 5. Ecosan – 13.5 6. No facility – 1 7. I use for the neighbour – 1 8. Bush or polythene bags – 1
What is the type of kitchen facility that this household mainly uses?	1. Inside – 8 2. Outside built – 4 3. Outside makeshift – 2 4. None – 1

Appendix 6. Restoration data disaggregated by district

SN	District	Hectares restored	Description
1	Ntungamo	700	Rufuha wetland
2	Kanungu	1,231	Mpangango wetland 1,231 ha (2021)
3	Sheema	600	Kandekye–Ruhorobero wetland
4	Bushenyi	3,007	Nyamirembe wetland 3,007 ha (2022)
5	Kisoro	1,010	Rwabara–Nyumba wetland 1,010 ha (2022)
6	Rukungiri	5,467	Ihimbo–Mashaku and Kyabahango wetlands 2,946 ha (2021). Rulindo wetland system 2,521 ha (2022)
7	Mitoma	1,500	1,500 ha of Nyamuhizi–Kagogo wetland in Mitooma subcounty; Mitooma (2020)
8	Buhweju	1,361	1,361 ha of Kyenjogyera wetland in Buhunga subcounty, Buhweju (2020)
9	Rubirizi	2,708	Kidubule, Mwongera and Kengeya wetlands 2,708ha (2021)
10	Pallisa	497	40 ha Limoto wetland (2017), 457 ha along the inlet streams of Papaya wetland in Pallisa (2020)
11	Kibuku	5,905	1,528 ha at Tirinyi wetland in Tirinyi subcounty, Kibuku (2020), Ssala-Kirika Wetland, Kibuku 4,377ha (2022)
12	Namutumba	4,482	1,982 ha of Mazuba – Mpologoma wetland in Mazuba subcounty, Namutumba (2020), Namakoke wetland 2500ha (2021)
13	Kumi	1,400	Oladot wetland 1,400 ha (2022)
14	Butaleja	1,200	Leresi wetland 1,200 ha (2022)
15	Kaliro	600	Budomero Wetland 600 ha (2021)
16	Tororo	726	Posuna wetland 726 ha (2022)
17	Bukedea	1,764	Lwere wetland
18	Ngora	936	Agu wetland
19	Mbale	300	300 ha along the inlet streams of Namakula wetland in Mbale (2020)
20	Butebo	2,923	Komorototo wetland 1700ha (2021), Kamenyamugongo wetland 1,223 ha (2022)
	Total	**38,317**	

Appendix 7. Project level theory of change

The following ToC describes the interrelationship between the project's three components. The three outputs are interrelated by addressing the identified barriers and climate related drivers of wetlands degradation. Output 1 aims to restore and strengthen the resilience of the physical attributes of the target wetlands by improving reforestation, water flow and storage, and the restoration of indigenous species. This restoration effort can only effectively address climate vulnerabilities if the people living in and around the wetlands have alternative and resilient livelihoods that do not rely on the wetlands. Thus, Output 2 provides alternative livelihoods by delivering high-quality training to improve beneficiaries' skills in implementing sustainable livelihoods, including employment and strengthening the resilience of their agricultural practices (including crop diversification) in the face of climatic changes. Output 3 provides reliable and accurate climate information and early warning to improve the resilient management of wetland dependent communities to ensure that beneficiaries have the necessary information for early detection and response to climate-induced risks and disasters. Below is the figure to illustrate the sequence.


Enhanced resilience of target communities and ecosystems to climate change impacts
Increased income
Increased food and water security
Reduced losses of lives and livelihoods from floods and other extreme events
Strengthened livelihood activities (e.g. fishing, dry-season farming)
Improved water storage and filtration for domestic, livestock and agriculture use
Reduced intensity of floods, storms and droughts
Increased crop production by men and women
Increased diversification of livelihoods by men and women
Livelihood planning and adaptation interventions designed with climate information
Communities take timely and urgent preventative action to extreme events, such as flooding
Sub-Component 1: Restoration and management of wetland hydrology and associated forests
Healthier wetlands in targeted areas
Physically restore wetlands
Support development and implementation of community based and framework wetland management plans
Sub-Component 2: Improved agricultural practices and alternative livelihood options in the wetland catchment
More resilient and sustainable livelihoods adopted
Support for training, demonstration projects and access to markets for agricultural-based livelihood options
Support for identifying and introducing new livelihood options (with private sector)
Sub-Component 3: Strengthening access to climate and early warning information for farmers and other target communities
Improved access of beneficiaries to relevant climate and early warning information
Expand networks that generate and process climate-related data into tailored products
Disseminate climate-related info/services and early warning to communities through partnership with the private sector

Appendix 8. Significant differences between treatment and comparison households – survey

Variable	Treatment mean	Comparison mean	Mean difference	No. of obs. treatment	No. of obs. comparison
Male-headed household	0.6680	0.7652	-0.0971*	609	726
Number of household members	6.3035	7.3192	-1.0157***	730	771
Adult equivalence score	3.8230	4.8934	-1.0704*	698	796
Household head is married	0.7724	0.8318	-0.0594***	761	905
Household head is widowed	0.1624	0.1143	0.0481**	761	905
O' Level	0.1536	0.2300	-0.0764*	761	905
Years living in current house	29.9465	34.4589	4.5124**	730	860
Owning the land where household lives	0.8967	0.9348	0.0382*	752	900
State of nearby wetlands: improved	0.2793	0.1371	-0.1422**	852	744
State of nearby wetlands: degraded	0.3955	0.7030	0.3074*	852	744
Anything done to restore and sustainably manage wetlands in this area	0.693	0.305	0.388***	859	738
Expenditure (UGX): insurance	175,000.00	54,166.67	0.0183**	10	6

Variable	Treatment mean	Comparison mean	Mean difference	No. of obs. treatment	No. of obs. comparison
I am aware of small-scale irrigation facilities (sprinkler and drip irrigation system, water pump) in this community	0.3359	0.1634	0.0955*	521	563
In my community, there is a farmer field school for demonstrating to farmers resilient agricultural practices.	0.0345	0.0142	0.0501*	521	563
I received agricultural inputs (improved vegetable seeds, herbicides, hoes, pangas).	0.1286	0.4139	0.0763*	521	563
I received pigs.	0.1190	0.0515	0.0289**	521	563
I received goats.	0.0806	0.0195	0.0882*	521	563
Number of parcels for crop production	2.3714	3.3287	0.0108**	692	654
Size of land for crop production (acres)	2.7478	3.9331	0.0152**	691	646
Customary ownership	0.5203	0.6854	0.0027***	713	658
Borrowed for free	0.0309	0.0030	0.0905*	713	658
Cabbages	0.1902	0.1090	0.0400**	631	587
Banana (food)	0.4406	0.2828	0.0280**	547	541
Groundnuts	124.0924	176.3674	0.0862*	249	313
Soya beans	174.5806	85.0862	0.0093***	62	58

Variable	Treatment mean	Comparison mean	Mean difference	No. of obs. treatment	No. of obs. comparison
Groundnuts	123.5243	171.8392	0.0831*	206	257
Soya beans	177.4167	95.6032	0.0210**	54	42
Irish potatoes	176.4688	629.0204	0.0018***	16	88
Peas	28.6000	95.3438	0.0246**	5	32
Coffee Robusta (old)	146.5500	223.3333	0.0013***	40	24
Number of sustainable land management practices conducted	2.1176	3.4084	0.0714*	255	191
Sustainable land management practices: inter-cropping	0.4863	0.7696	0.0398**	255	191
Sustainable land management practices: use of animal and green manure	0.1333	0.3403	0.0915*	255	191
Transport of crop produce	0.1365	0.2821	0.0448**	586	585
Participation of adult males in clearing the garden (%)	32.2823	43.1839	0.0426**	333	522
Participation of adult females in clearing the garden (%)	47.0961	31.5172	0.0085***	333	522
Pesticide/herbicide/insecticide	0.1442	0.4764	0.0128**	638	636
Cattle	0.4679	0.6888	0.0044***	280	347
Chicken	0.3571	0.4870	0.0683*	280	347

Variable	Treatment mean	Comparison mean	Mean difference	No. of obs. treatment	No. of obs. comparison
Rangelands	0.2655	0.0781	0.0980*	275	333
Zero grazing	0.1226	0.2042	0.0644*	261	333
Cow manure	0.1043	0.4056	0.0011***	211	286
Meat	0.2749	0.0839	0.0457**	211	286
Yoghurt	0.0142	0.0559	0.0429**	211	286
Pests, parasites and diseases	0.8242	0.9302	0.0091***	273	344
Participation of adult females in inputs application (%)	29.34	16.00	0.07*	46	90
Participation of hired labour in inputs application (%)	10.26	29.11	0.09*	46	90
Participation of adult males in milking of animals (%)	63.90	53.65	0.05*	55	82
Participation of adult females in selling livestock products (%)	14.08	31.55	0.04**	45	29
Local/community markets	0.6617	0.9099	0.0045***	269	344
Home	0.4164	0.2180	0.0079***	269	344
Ate only a few kinds of food	0.2279	0.4553	0.0421**	430	470
Relied on own savings	0.4892	0.6625	0.0491**	323	403

Variable	Treatment mean	Comparison mean	Mean difference	No. of obs. treatment	No. of obs. comparison
Sources of the early warning information: community village meetings	0.2264	0.0818	0.0583*	159	159
Reduced livestock productivity	0.2779	0.5987	0.0037***	349	461
Reduced quality of pastures	0.2579	0.3861	0.0744*	349	461

Appendix 9. Ecological outcomes – Satellite data

Table 30: State wetland use/cover changes between 2016 and 2022 in western Uganda

District	Wetland group / Wetland use/ cover type	Comparison: Area (ha, %)			Treatment: Area (ha, %)		
		2016	2022	Net change	2016	2022	Net change
Bushenyi		Mbachi wetland			Nyaruzinga wetland		
	Built-up	0.09 (0.2)	0.19 (0.4)	0.1 (0.2)	2.5 (0.5)	3.7 (0.8)	1.2 (0.2)
	Farmlands	12.9 (26.1)	27.5 (55.1)	14.5 (29.1)	140.1 (29.1)	106.7 (22.2)	-33.4 (-6.9)
	Grasslands	35.2 (70.6)	18.3 (36.7)	-16.9 (-33.9)	49.5 (10.3)	92.7 (19.3)	43.2 (9)
	Open water	0 (0)	0 (0)	0 (0)	0.18 (0.04)	1.3 (0.3)	1.1 (0.2)
	Papyrus	0 (0)	0 (0)	0 (0)	261.8 (54.4)	252.4 (52.4)	-9.5 (-2)
	Tree plantations	1.6 (3.1)	3.9 (7.8)	2.3 (4.6)	27.1 (5.6)	24.5 (5.1)	-2.6 (-0.5)
Kisoro		Echuya/Muchoya wetland			Chotsa bay wetland		
	Built-up	0.3 (0.26)	0.32 (0.26)	0.005 (0.004)	1.5 (0.19)	6.0 (0.74)	4.5 (0.6)
	Farmlands	100.9 (83.2)	98.9 (81.5)	-2 (-4.9)	542.4 (66.6)	443.9 (54.5)	-98.5 (-12.1)
	Grasslands	13.8 (11.4)	7.8 (6.5)	-5.9 (-4.9)	111.2 (13.7)	205.6 (25.2)	94.3 (11.6)
	Open water	0.13 (0.11)	0.56 (0.46)	0.43 (0.36)	19.2 (2.4)	8.2 (1)	-10.9 (-1.3)

District	Wetland group / Wetland use/ cover type	Comparison: Area (ha, %)			Treatment: Area (ha, %)		
		2016	2022	Net change	2016	2022	Net change
	Papyrus	0 (0)	0 (0)	0 (0)	115.7 (14.2)	135.9 (16.7)	20.2 (2.5)
	Tree plantations	6.1 (5.1)	13.7 (11.3)	7.5 (6.2)	24.2 (3)	14.6 (1.8)	-9.6 (-1.2)
Mitooma		Katenga wetland			Nyamuhizi wetland		
	Built-up	0.16 (0.4)	0.23 (0.6)	0.07 (0.2)	0.4 (0.1)	0.95 (0.21)	0.6 (0.12)
	Farmlands	18.6 (44.1)	18.9 (45)	0.39 (0.9)	178.1 (39.2)	62.8 (13.8)	-115.3 (-25.4)
	Grasslands	8 (19)	10.9 (25.9)	2.9 (7)	95.4 (21)	161.8 (35.6)	66.4 (14.6)
	Open water	0 (0)	0 (0)	0 (0)	0.18 (0.04)	1.15 (0.25)	0.96 (0.21)
	Papyrus	13.8 (32.7)	10.8 (25.6)	-2.9 (-7.1)	172 (37.8)	219.4 (48.3)	47.3 (10.4)
	Tree plantations	1.6 (3.8)	1.2 (2.9)	-0.41 (-1)	8.5 (1.9)	8.5 (1.9)	-0.01 (-0.003)
Rubirizi		Chambura wetland			Kidubule wetland		
	Built-up	0.68 (0.12)	0.58 (0.1)	-0.01 (-0.02)	0 (0)	0 (0)	0 (0)
	Farmlands	2.2 (0.4)	5.5 (1)	3.3 (0.6)	5.2 (14.8)	2.5 (7)	-2.8 (-7.8)
	Grasslands	168.8 (29.3)	260.8 (45.3)	92 (16)	1.5 (4.4)	2.3 (6.5)	0.7 (2.1)
	Open water	40.3 (7)	13.9 (2.4)	-26.3 (-4.6)	0.8 (2.2)	0.7 (2.1)	-0.02 (-0.1)

District	Wetland group / Wetland use/ cover type	Comparison: Area (ha, %)			Treatment: Area (ha, %)		
		2016	2022	Net change	2016	2022	Net change
	Papyrus	151.9 (26.4)	86.3 (15)	-65.6 (-11.4)	27.2 (76.9)	29.5 (83.5)	2.3 (6.6)
	Tree plantations	0 (0)	0 (0)	0 (0)	0.6 (1.8)	0.3 (0.9)	-0.3 (-0.8)
	Woodlands	211.7 (36.8)	208.5 (36.2)	-3.3 (-0.6)	0 (0)	0 (0)	0 (0)

Table 31: Levels of wetland degradation in western Uganda

District	Wetland group / Levels of degradation	Comparison: Area (ha, %)			Treatment: Area (ha, %)		
		2016	2022	Net change	2016	2022	Net change
Bushenyi		Mbachi wetland			Nyaruzinga wetland		
	Low	35.2 (70.6)	18.3 (36.7)	-16.9 (-33.9)	311.5 (64.7)	346.3 (72)	34.8 (7.2)
	Moderate	13 (26.1)	27.5 (55.1)	14.5 (29.1)	140.1 (29.1)	106.7 (22.2)	-33.4 (-6.9)
	High	1.7 (3.3)	4.1 (8.1)	2.4 (4.8)	29.6 (6.2)	28.2 (5.9)	-1.4 (-0.3)
Kisoro		Echuya/Muchoya wetland			Chotsa bay wetland		
	Low	13.9 (11.5)	8.4 (6.9)	-5.5 (-4.5)	246.1 (30.2)	349.7 (42.9)	103.6 (12.7)
	Moderate	100.9 (83.2)	99.2 (81.8)	-1.7 (-1.4)	542.4 (66.6)	443.9 (54.5)	-98.5 (-12.1)

District	Wetland group / Levels of degradation	Comparison: Area (ha, %)			Treatment: Area (ha, %)		
		2016	2022	Net change	2016	2022	Net change
	High	6.5 (5.3)	13.7 (11.3)	7.2 (5.9)	25.7 (3.2)	20.6 (2.5)	-5.1 (-0.6)
Mitooma		Katenga wetland			Nyamuhizi wetland		
	Low	21.8 (51.7)	21.7 (51.6)	-0.06 (-0.13)	267.6 (58.9)	382.3 (84.1)	114.7 (25.2)
	Moderate	18.6 (44.1)	18.9 (45)	0.39 (0.9)	178.1 (39.2)	62.8 (13.8)	-115.3 (-25.4)
	High	1.8 (4.2)	1.4 (3.4)	-0.34 (-0.8)	8.9 (1.9)	9.4 (2.1)	0.6 (0.12)
Rubirizi		Chambura wetland			Kidubule wetland		
	Low	572.7 (99.5)	569.5 (98.9)	-3.2 (-0.6)	29.5 (83.4)	32.6 (92)	3 (8.6)
	Moderate	2.2 (0.4)	5.5 (0.96)	3.3 (0.6)	5.2 (14.8)	2.5 (7)	-2.8 (-7.8)
	High	0.7 (0.1)	0.6 (0.1)	-0.09 (-0.02)	0.6 (1.8)	0.3 (0.9)	-0.3 (-0.8)

Table 32: Wetland use/cover changes between 2016 and 2022 in eastern Uganda

District	Wetland group / Wetland use/ cover type	Comparison: Area (ha, %)			Treatment: Area (ha, %)		
		2015	2022	Net change	2015	2022	Net change
Bukedea	Built-up	0.76 (0.65)	2.36 (2.03)	1.6 (1.38)	0.25 (0.18)	3.18 (2.26)	2.93 (2.08)
	Farmlands	38.36 (33.01)	79.68 (68.56)	41.32 (35.55)	55.19 (39.15)	46.39 (32.91)	-8.80 (-6.24)
	Grasslands	73.24 (63.02)	30.22 (26.00)	-43.02 (-37.02)	63.43 (44.99)	59.72 (42.36)	-3.71 (-2.63)
	Open water	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	Papyrus	0 (0)	0 (0)	0 (0)	15.56(11.04)	24.97 (17.71)	9.41 (6.68)
	Tree plantations	3.86 (3.32)	3.96 (3.41)	0.10 (0.09)	6.55 (4.65)	6.71 (4.76)	0.16 (0.12)
Kumi	Built-up	0.29 (0.71)	0.69 (1.69)	0.04 (0.98)	0.84 (0.60)	1.1 (0.78)	0.26 (0.18)
	Farmlands	15.73 (38.44)	23.53 (57.5)	-7.8 (-19.06)	58.38 (41.60)	38.27 (27.27)	-20.11 (-14.33)
	Grasslands	23.51 (57.45)	15.11 (36.93)	-8.4 (-20.53)	69.19 (49.30)	82.89 (59.06)	13.70 (9.76)
	Open water	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-0 (0)
	Papyrus	0 (0)	0 (0)	0 (0)	10.75 (7.66)	15.84 (11.29)	5.09 (3.68)
	Tree plantations	1.39 (3.4)	1.59 (3.89)	0.2 (0.49)	1.19 (0.85)	2.25 (1.6)	1.06 (0.75)
Namutumba	Built-up	2.49 (1.51)	3.52 (2.14)	1.03 (0.63)	5.91 (1.19)	2.04 (0.41)	-3.87 (-0.78)
	Farmlands	90.07 (54.69)	96.39 (58.53)	6.33 (3.84)	88.99 (17.88)	206.04 (41.38)	117.05 (23.51)

District	Wetland group / Wetland use/ cover type	Comparison: Area (ha, %)			Treatment: Area (ha, %)		
		2015	2022	Net change	2015	2022	Net change
	Grasslands	65.49 (39.77)	62.06 (37.68)	-3.43 (-2.08)	274.18 (55.07)	144.03 (28.93)	130.15 (-26.14)
	Open water	0 (0)	0 (0)	0 (0)	0 (0)	1.54 (0.31)	1.54 (0.31)
	Papyrus	0 (0)	0 (0)	0 (0)	121.41 (24.39)	141.9 (28.50)	20.50 (4.12)
	Tree plantations	6.65 (4.04)	2.72 (1.65)	-3.93 (-2.39)	7.38 (1.48)	2.31 (0.46)	-5.06 (-1.02)
Ngora	Built-up	1.50 (0.26)	2.13 (0.37)	0.63 (0.11)	1.97 (1.56)	0.94 (0.75)	-1.03 (-0.81)
	Farmlands	134.16 (23.18)	199.92 (34.54)	65.76 (11.36)	5.32 (4.21)	23.69 (18.75)	18.37 (14.54)
	Grasslands	221.23 (38.22)	168.22 (29.06)	-53.01 (-9.16)	87.20 (69.02)	62.22 (49.26)	-24.98 (-19.78)
	Open water	125.61 (21.7)	132.61 (22.91)	7.00 (1.21)	3.82 (3.03)	2.82 (2.23)	-1.00 (-0.79)
	Papyrus	77.82 (13.45)	64.26 (11.10)	-13.56 (-2.34)	26.57 (21.04)	30.84 (24.42)	4.28 (3.39)
	Tree plantations	18.45 (3.19)	11.64 (2.01)	-6.81 (-1.18)	1.43 (1.13)	5.59 (4.59)	4.37 (3.46)

Table 33: Levels of wetland degradation in eastern Uganda

District	Levels of degradation / Wetland use/ cover type	Comparison: Area (ha, %)			Treatment: Area (ha, %)		
		2015	2022	Net change	2015	2022	Net change
Bukedea	Low	73.24 (63.02)	30.22 (26)	-43.02 (-37.02)	78.99 (56.03)	84.7 (60.08)	5.71 (4.05)
	Moderate	38.36 (33.01)	79.68 (68.56)	41.32 (35.55)	55.19 (39.15)	46.39 (32.90)	-8.8 (-6.25)
	High	4.62 (3.97)	6.32 (5.44)	1.7 (1.47)	6.8 (4.82)	9.89 (7.02)	3.09 (2.5)
Kumi	Low	23.51 (57.45)	15.11 (36.92)	-8.42 (-20.53)	79.94 (56.96)	98.74 (70.35)	18.8 (13.39)
	Moderate	15.73 (38.44)	23.53 (57.5)	7.8 (19.06)	58.38 (41.60)	38.27 (27.27)	-20.11 (-14.33)
	High	1.68 (4.11)	2.28 (5.58)	0.6 (1.47)	2.03 (1.44)	3.34 (2.38)	1.31 (0.94)
Namutumba	Low	65.49 (39.77)	62.06 (37.68)	-3.43 (-2.09)	395.58 (79.46)	287.47 (57.74)	-108.11 (-21.72)
	Moderate	90.07 (54.69)	96.39 (58.53)	6.32 (3.84)	88.99 (17.88)	206.04 (41.38)	117.0 5(23.5)
	High	9.13 (5.55)	6.24 (3.79)	-2.89 (-1.76)	13.29 (2.67)	4.35 (0.87)	-8.94 (-1.8)
Ngora	Low	424.66 (73.37)	365.08 (63.08)	-59.58 (-10.29)	940.57 (86.57)	874.26 (80.47)	-66.31 (-6.1)
	Moderate	134.16 (23.18)	199.92 (34.54)	65.76 (11.36)	124.78 (11.48)	190.92 (17.57)	66.14 (6.09)
	High	19.95 (3.45)	13.77 (2.38)	-6.18 (-1.07)	21.10 (1.94)	21.27 (1.96)	0.17 (0.02)

Appendix 10. Fauna and flora indicators

Table 34: Presence of phytoplanktons in eastern Uganda

DISTRICT	Bukedea		Kumi		Namutumba		Ngora	
WETLAND type	Komuge (T)	Akuoro (C)	Oladot (T)	Obura (C)	Kimenyuro (T)	Mazuba (C)	L. Bisina (T)	Agu (C)
TAXON								
BLUE GREEN ALGAE								
Microcystis (sp)	52	46	75	66	88	54	62	40
Desmidium (sp)	45	-	60	48	-	35	54	38
Calothrix (sp)	19	28	-	22	34	-	36	22
Lyngbya (sp)	28	45	42	-	46	-	30	10
Oscillatoria (sp)	-	20	-	37	40	28	-	-
Zygnema (sp)	42	-	28	23	-	20	16	34
GREEN ALGAE								
Spirogyra (sp)	45	34	84	52	92	48	65	-
Cladophora (sp)	-	28	-	44	56	36	50	19
Hildenbradia (sp)	32	25	58	35	42	23	26	36

DISTRICT	Bukedea		Kumi		Namutumba		Ngora	
Urothrix (sp)	-	48	52	-	-	30	-	42
Chlorella (sp)	48	-	37	40	42	48	45	54
Pediastrus (sp)	25	36	48	52	-	-	34	58
Micrasterials (sp)	52	54	54	46	30	18	42	62
Oedogonium (sp)	-	56	62	38	38	27	-	-
Westella	34	68	-	24	16	20	40	46
Flagellates								
Phacus (sp)	-	58	45	38	46	32	26	40
Uroglena (sp)	54	35	32	-	65	46	-	32

Table 35: Presence of macrophytes in Eastern Uganda

DISTRICT	Bukedea		Kumi		Namutumba		Ngora	
WETLAND type	Komuge (T)	Akuoro (C)	Oladot (T)	Obura (C)	Mazuba (T)	Kimenyuro (C)	Agu (T)	L.Bisina (C)
Total abundance	476	581	677	565	465	635	533	526
mean±SD	39.67±11.72	41.50±14.26	52.08±16.13	40.36±12.37	33.21±11.79	48.85±21.73	38.07±14.62	40.46±14.58
df	24		22		18		25	

DISTRICT	Bukedea	Kumi	Namutumba	Ngora
t	-0.36	2.11	-2.29	-0.43
p	0.72	0.04	0.03	0.67

Table 36: Richness of macrophytes in eastern Uganda

DISTRICT	Bukedea		Kumi		Namutumba		Ngora	
WETLAND type	Komuge (T)	Akuoro (C)	Oladot (T)	Obura (C)	Mazuba (T)	Kimenyuro (C)	Angu (T)	L.Bisina (C)
New species in restored sites	Chlorella (48)		Lyngbya (28)		Desmidium (35)		Urothrix (42)	
	Zygnema (42)		Urothrix (52)		Zygnema (20)		Uroglena (32)	
	Desmidium (45)		Uroglena (32)		Urothrix (30)			
Species richness	12	14	13	14	14	13	14	13

Table 37: Presence of zooplanktons in eastern Uganda

DISTRICT	Bukedea		Kumi		Namutumba		Ngora	
WETLAND type	Komuge (T)	Akuoro (C)	Oladot (T)	Obura (C)	Mazuba (T)	Kimenyuro (C)	Angu (T)	L.Bisina (C)
Total abundance	321	254	309	302	339	327	294	296
mean±SD	40.13±14.59	31.75±6.98	38.63±14.13	33.56±12.72	48.43±9.50	46.71±9.45	42±10.39	37±12.33

DISTRICT	Bukedea		Kumi		Namutumba		Ngora	
df	10		14		12		13	
t	1.46		0.77		0.33		0.85	
p	0.17		0.45		0.75		0.41	
New species in restored sites	Proales (45) Trichocera (28)		Keratera (46)		Proales (65) Brachionus (48)		Euclanis (48)	
Species richness	8	8	8	9	7	7	7	8

Table 38: Abundance of zooplanktons in eastern Uganda

DISTRICT	Bukedea		Kumi		Namutumba		Ngora	
WETLAND type	Komuge (T)	Akuoro (C)	Oladot (T)	Obura (C)	Mazuba (T)	Kimenyuro (C)	Agu (T)	L.Bisina (C)
Total abundance	321	254	309	302	339	327	294	296
mean±SD	40.13±14.59	31.75±6.98	38.63±14.13	33.56±12.72	48.43±9.50	46.71±9.45	42±10.39	37±12.33
df	10		14		12		13	
t	1.46		0.77		0.33		0.85	
p	0.17		0.45		0.75		0.41	
New species in restored sites	Proales (45) Trichocera (28)		Keratera (46)		Proales (65) Brachionus (48)		Euclanis (48)	

DISTRICT	Bukedea		Kumi		Namutumba		Ngora	
Species richness	8	8	8	9	7	7	7	8

Table 39: Presence of macroinvertebrates in eastern Uganda

DISTRICT	Bukedea		Kumi		Namutumba		Ngora	
WETLAND type	Komuge (T)	Akuoro (C)	Oladot (T)	Obura (C)	Mazuba (T)	Kimenyuro (C)	Agu (T)	L. Bisina (C)
TAXON								
BLUE GREEN ALGAE								
Coleoptera	-	3	-	5	5	4	-	-
Hirudinae	-	-	-	-	-	-	-	-
Oligochaete	-	-	-	-	1	-	-	-
Mollusca	-	-	-	-	-	1	-	-
Odonata	-	-	1	-	-	-	-	-
Anneludae	-	-	-	-	-	-	-	-
Hirudinae	-	-	-	-	1	-	-	-
Bivalvia	-	-	-	-	-	-	-	-

Table 40: Presence of macroinvertebrates in eastern Uganda

DISTRICT	Bukedea		Kumi		Namutumba		Ngora	
WETLAND type	Komuge (T)	Akuoro (C)	Oladot (T)	Obura (C)	Mazuba (T)	Kimenyuro (C)	Angu (T)	L.Bisina (C)
Total abundance		3	1	5	7	5		
mean±SD					2.33±2.31	2.5±2.12		
df					2			
t					-0.08			
p					0.94			
New species in restored sites			Odonata (1)		Coleoptera (5) Oligochaete (1) Hirudinae (1)			
Species richness		1	1	1	3	2		

Table 41: Presence of phytoplanktons in western Uganda

DISTRICT	Mitooma		Kisoro		Rubirizi		Bushenyi	
WETLAND type	Nyamihizi (T)	Katereza (C)	Nyumba (T)	Mulindi (C)	Kidubure (T)	L. Kyamuyiga (C)	Nyaruzinga (T)	Nyamirembe (C)
TAXON								
BLUE – GREEN ALGAE								
Calothrix (sp)	64	48	64	52	50	-	42	55
Microcystis (sp)	94	112	135	140	82	56	74	65
Anabeana (sp)	42	25	-	-	34	24	46	50
Tolypothri (sp)	-	38	74	56	25	40	-	32
Oscillatoria (sp)	28	-	35	52	40	-	54	-
T-test value	0.435		0.250		0.587		-0.418	
p-value	0.706		0.818		0.617		0.717	
GREEN ALGAE								
Spirogyra (sp)	68	56	72	96	64	-	44	-
Desmidium (sp)	45	-	50	64	46	50	32	58
Clodophora (sp)	28	67	-	52	50	42	63	24
Zygnema sp	54	-	36	25	-	35	40	46

DISTRICT	Mitooma		Kisoro		Rubirizi		Bushenyi	
Urothrix (sp)	32	46	-	-	42	38	-	-
Micrasteria (sp)	-	-	30	58	-	-	26	45
Hilderbrandra	25	34	-	-	28	52	64	23
Microspora (sp)	-	-	65	46	22	18	-	-
T-test value	-1.193		-0.763		-0.418		0.405	
p-value	0.319		0.488		0.697		0.706	
FLAGELLATES								
Uroglena (sp)	10	-	42	18	-	12	16	-
Phacus (sp)	-	22	-	-	5	-	34	8

Table 42: Presence of zooplanktons in western Uganda

DISTRICT	Mitooma		Kisoro		Rubirizi		Bushenyi	
WETLAND type	Nyamihizi (T)	Katereza (C)	Nyumba (T)	Mulindi (C)	Kidubure (T)	L. Kyamuyiga (C)	Nyaruzinga (T)	Nyamirembe (C)
TAXON ROTIFERS								
Euclanis (sp)	24	-	46	62	-	-	54	68
Porlyayhra (sp)	56	64	-	-	38	82	46	-

DISTRICT	**Mitooma**		**Kisoro**		**Rubirizi**		**Bushenyi**	
Brachionus (sp)	-	78	44	35	92	43	-	55
Hydracarian (sp)	45	27	36	-	-	-	18	42
Ascomopha (sp)	28	64	-	47	-	56	32	48
Trichocerca (sp)	-	-	42	78	56	40	-	-
Lecane (sp)	84	58	-	22	20	45	36	-
T-test value	0.000		-1.101		-0.048		-5.892	
p-value	1.00		0.386		0.965		0.028	
CRUSTACEANS								
Bosmina (sp)	46	-	16	24	-	26	10	-
Cyclops (sp)	-	-	28	8	33	-	-	24
Ostracods (sp)	12	38	-	-	25	-	-	8
T-test value	-		0.429		-		-	
p-value	-		0.742		-		-	

Table 43: Presence of macroinvertebrates in western Uganda

DISTRICT	**Mitooma**	**Kisoro**	**Bushenyi**	**Rubirizi**
WETLAND type	Nyamihizi (T)	Katereza (C)	Nyaruzinga (T)	Kidubure (C)
TAXON ROTIFERS				
Arthropoda	2			
Mollusca			3	
Coleoptera		1		
Trichoptera (sp)				1

Appendix 11. Wetland water quality status

Table 44: Mean water quality values in western Uganda

Site ID	Temperature (^{0}C)	Electro-conductivity (µs/cm)	Total dissolved solids (ppm)	Salinity (mg/L)
MITOOMA				
Nyamuhizi (T)	23.3	23.7	16.5	11.5
Katereza (C)	20.5	23.4	16.5	11.8
BUSHENYI				
Nyaruzinga (T)	22.1	28.7	20.4	20.3
Nyamirembe (C)	20	21.9	15.2	10.9
RUBIRIZI				
Kidubure (T)	36.9	117.5	82.1	58.3
L. Kyamuyiga (C)	28.4	37	26.4	18.8
KISORO				
Mulindi (T)	18.3	109.8	75.1	54.5
Nyumba-Rwamba (C)	22.5	53.7	37	26.5
WHO 2009	15-35	71.5-985.5	50-600	0.00-0.04

Table 45: Mean water quality values in eastern Uganda

Site ID	Temperature (oC)	Electro-conductivity (µs/cm)	Total dissolved solids (ppm)	Salinity (mg/L)
NGORA				
Agu (T)	29.9	30.2	21.2	15.3
Lake Bisina (C)	28.3	33.8	23.5	17.1
KUMI				
Oladot (T)	31.4	153.7	105.1	76.1
Obura (C)	28.7	125.1	88.2	63.1
BUKEDEA				
Komuge (T)	33.4	153.5	107.7	75.3
Akuoro (C)	27	245	189	13.1
NAMUTUMBA				
Mazuba (T)	27	264	182.1	13.1
Kimenyuro (C)	32.3	187.6	131.2	93.7
WHO 2009	15-35	71.5-300	50-600	0.00-0.04

Appendix 12. Wetlands satellite assessment 2015/2016 to 2022

12.1. Levels of wetland use in Uganda

12.1.1. **Treatment sites in western Uganda**

Figure 7: Wetland use/cover changes in Bushenyi

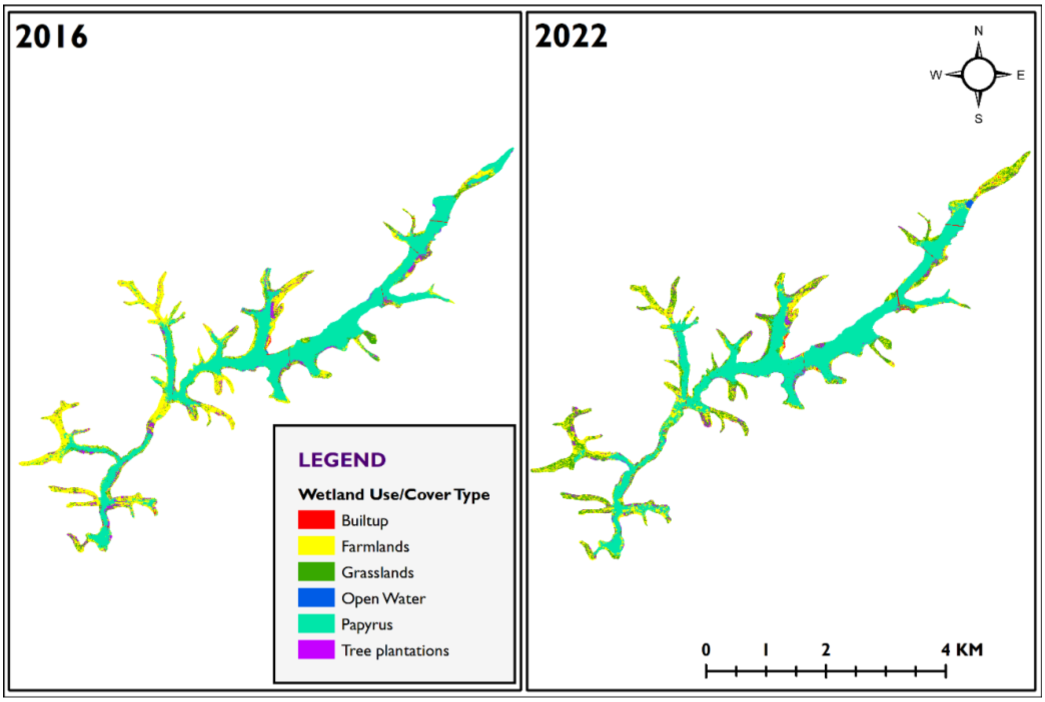


Figure 8: Wetland use/cover changes in Kisoro

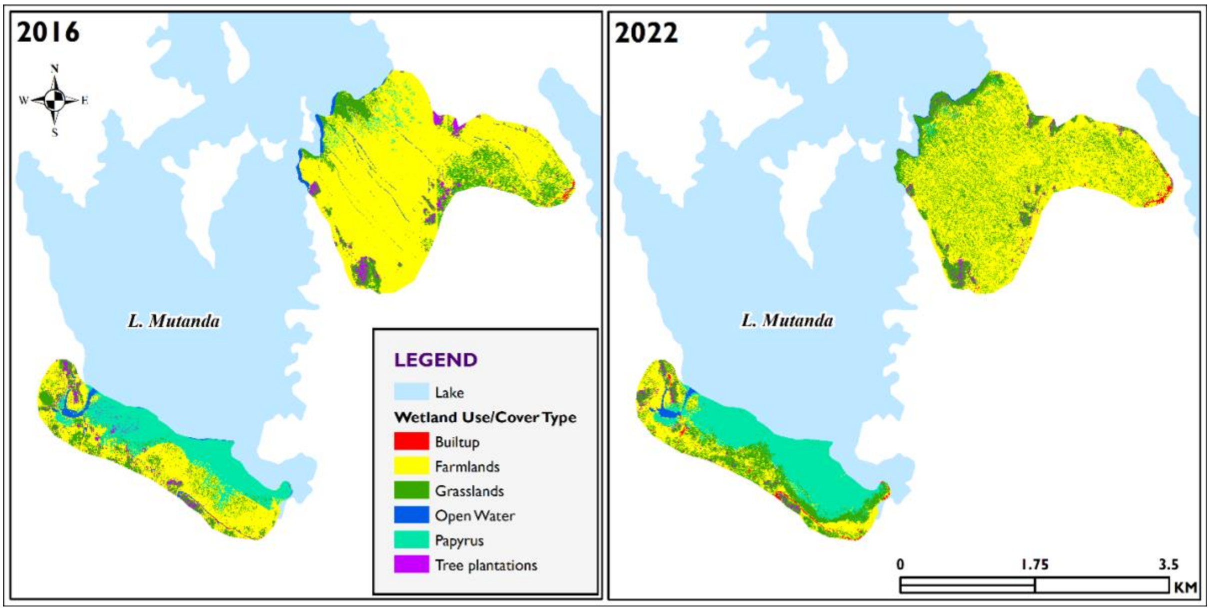


Figure 9: Wetland use/cover changes in Mitooma

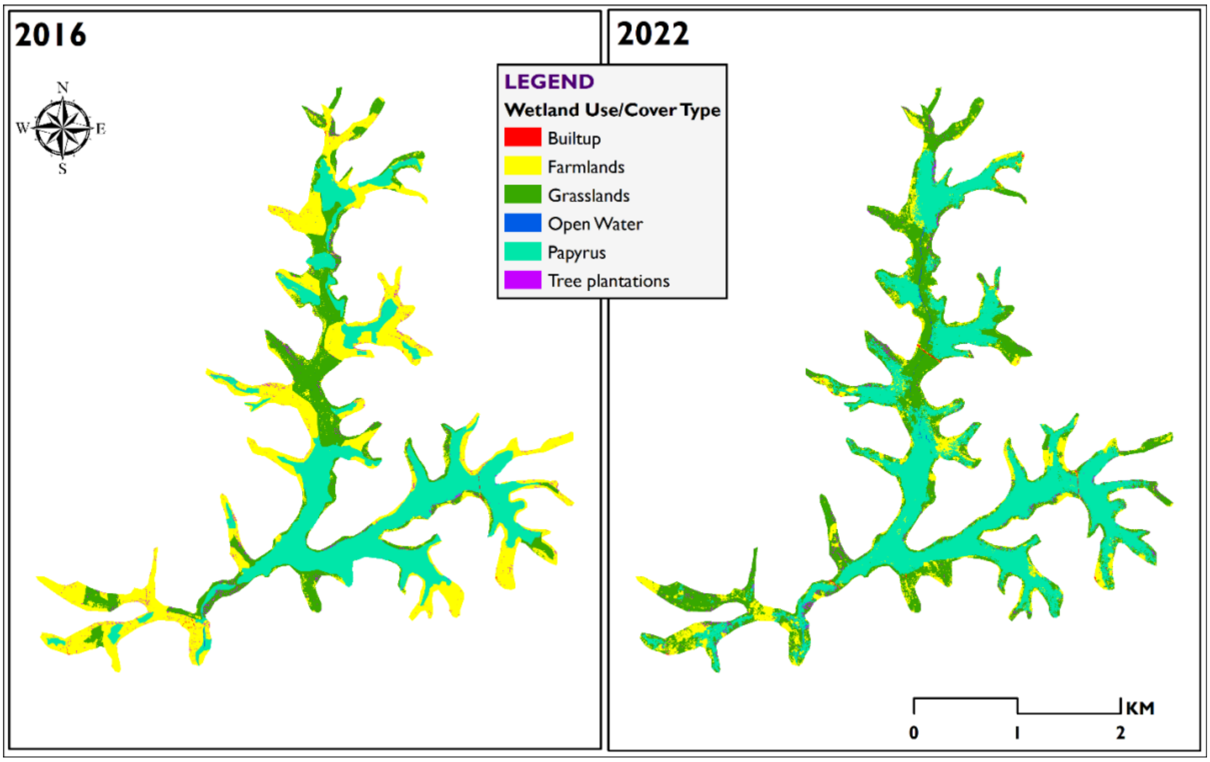
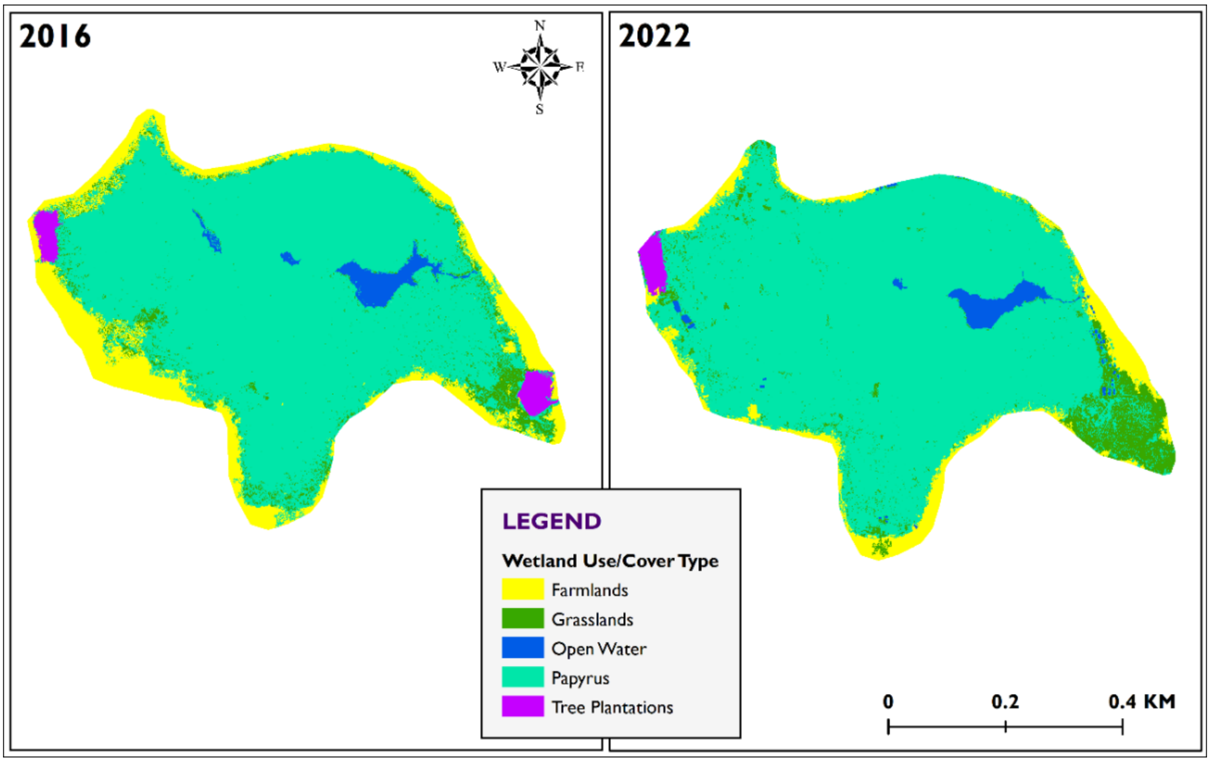


Figure 10: Wetland use/cover changes in Rubirizi



12.1.2. Treatment sites in eastern Uganda

Figure 11: Wetland use/cover changes in Bukedea

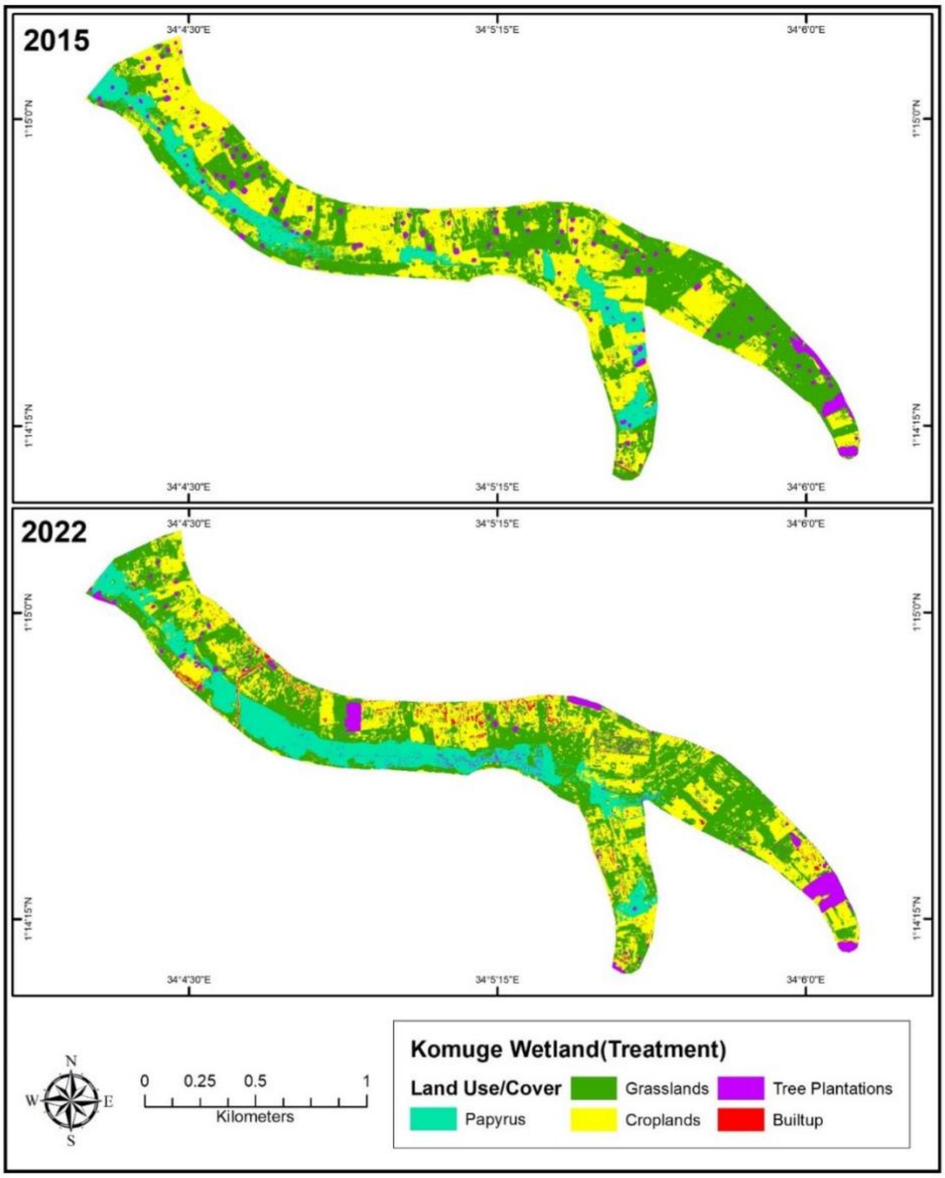


Figure 12: Wetland use/cover changes in Kumi

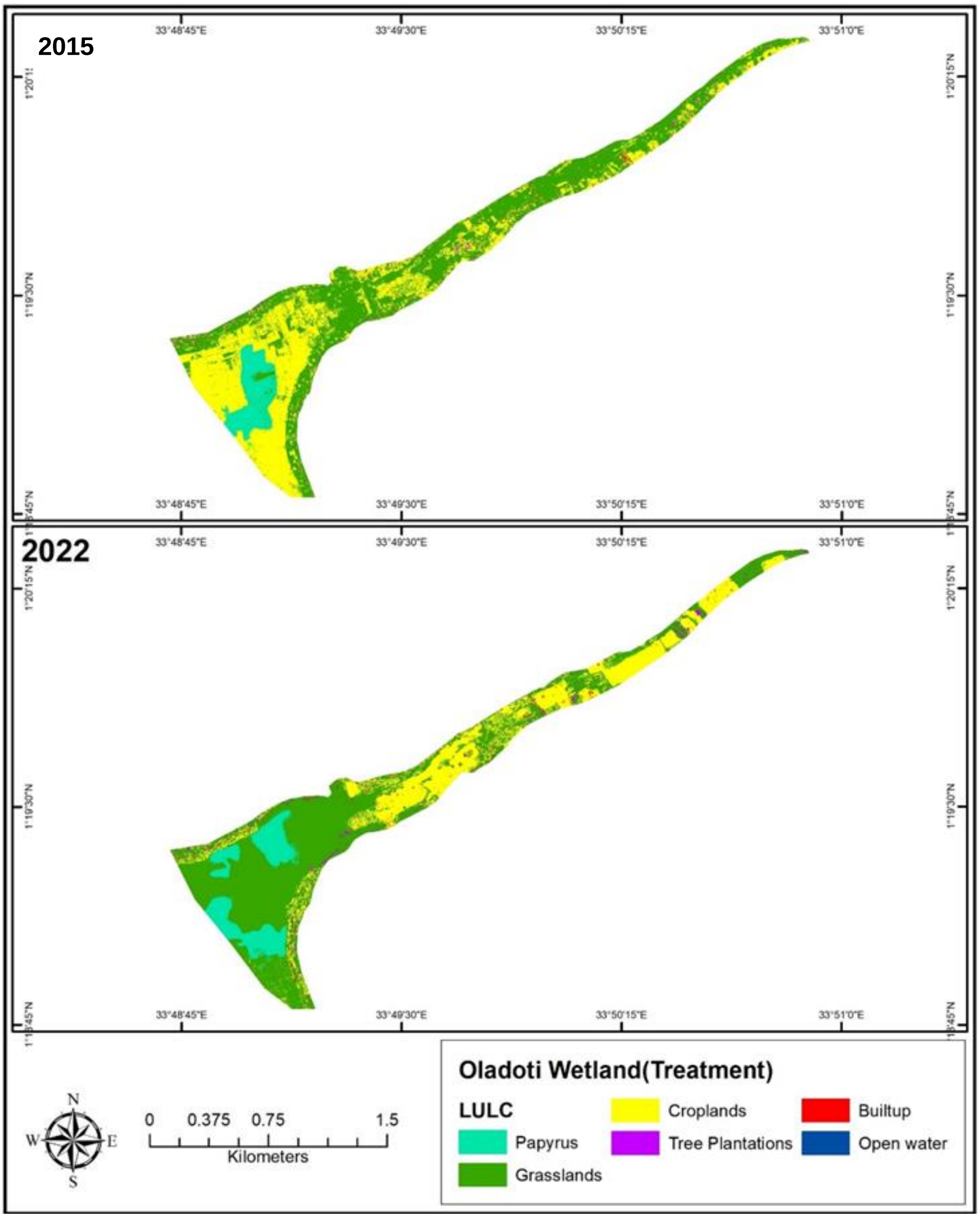


Figure 13: Wetland use/cover changes in Namutumba

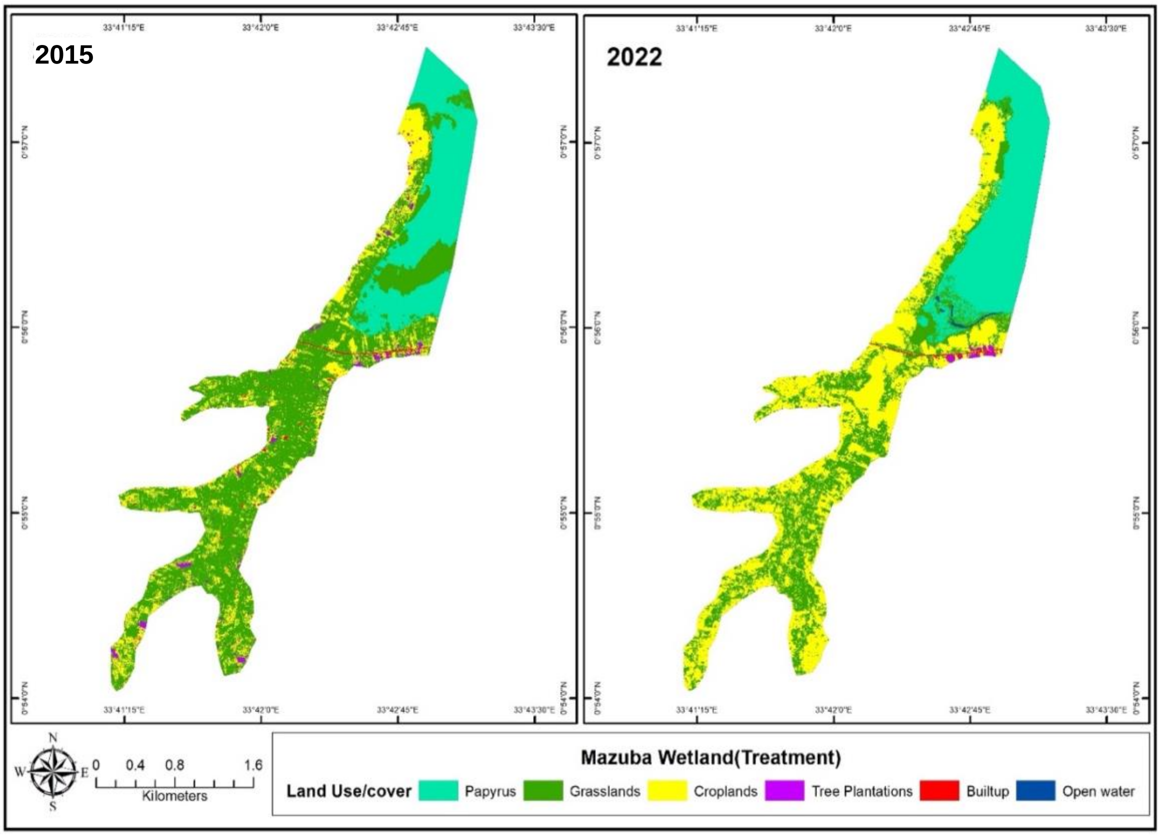
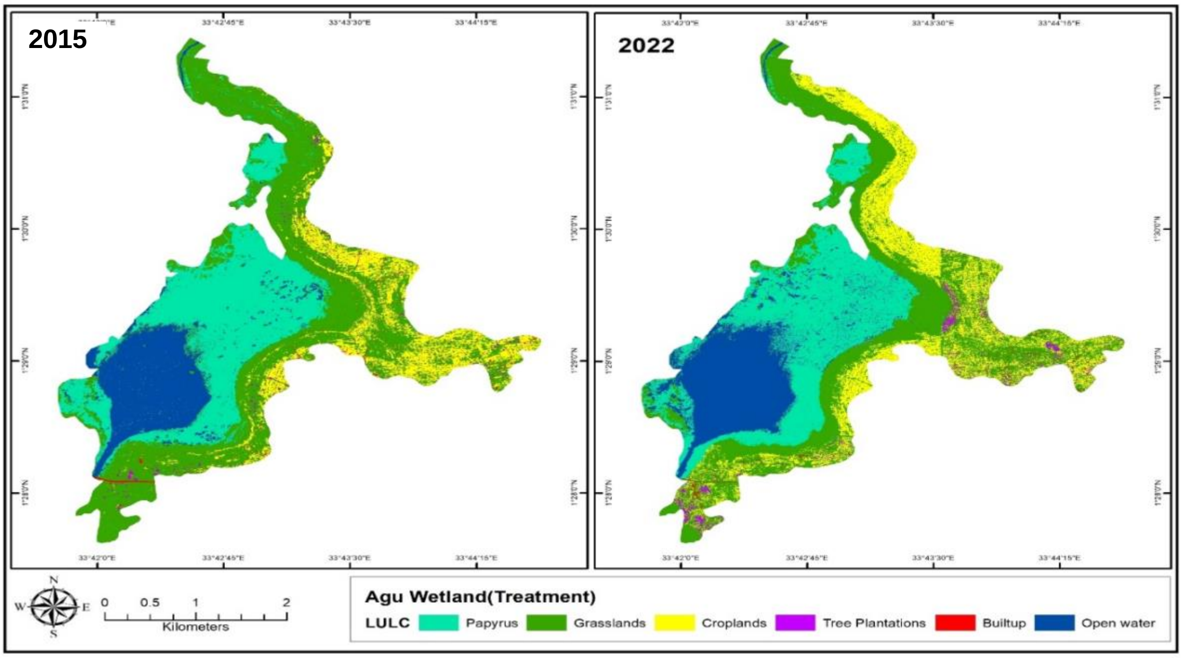


Figure 14: Wetland use/cover changes in Ngora



12.1.3. Comparison sites in western Uganda

Figure 15: Wetland use/cover changes in Bushenyi

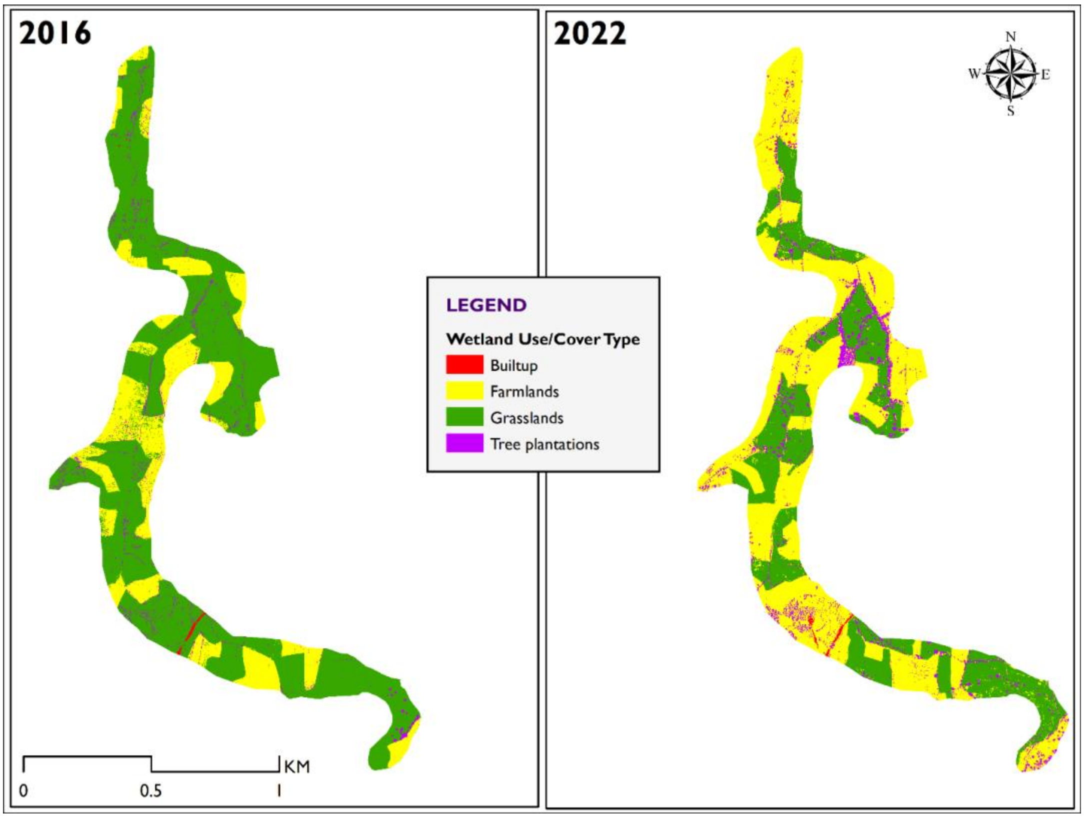


Figure 16: Wetland use/cover changes in Kisoro

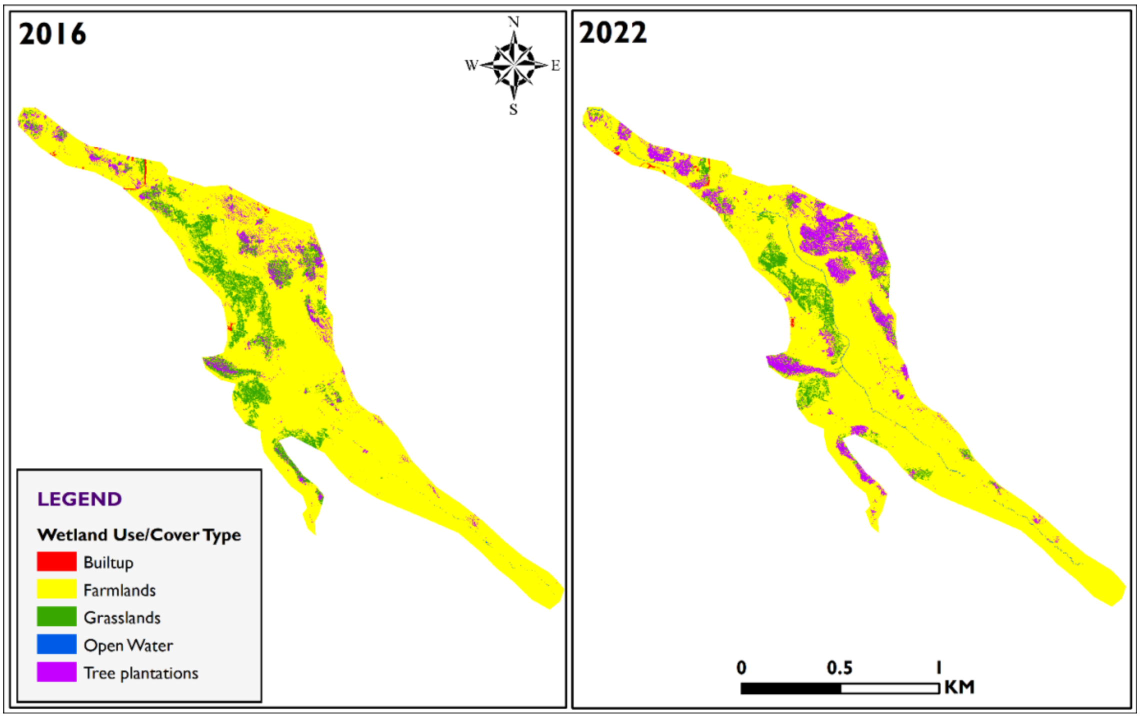


Figure 17: Wetland use/cover changes in Mitooma

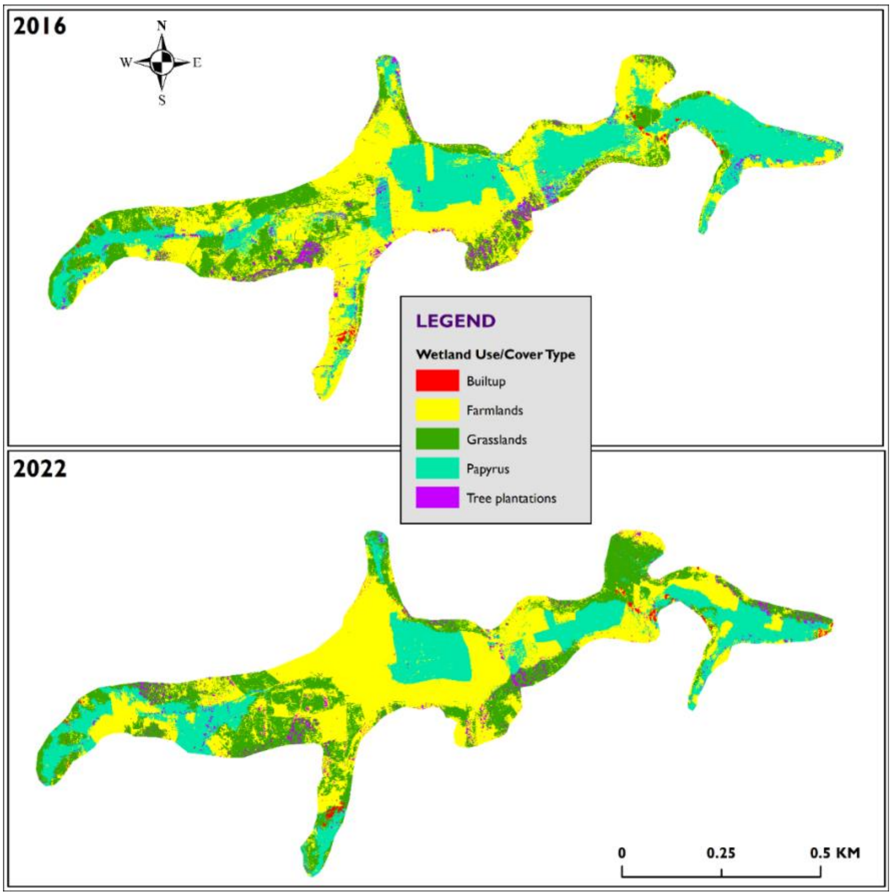
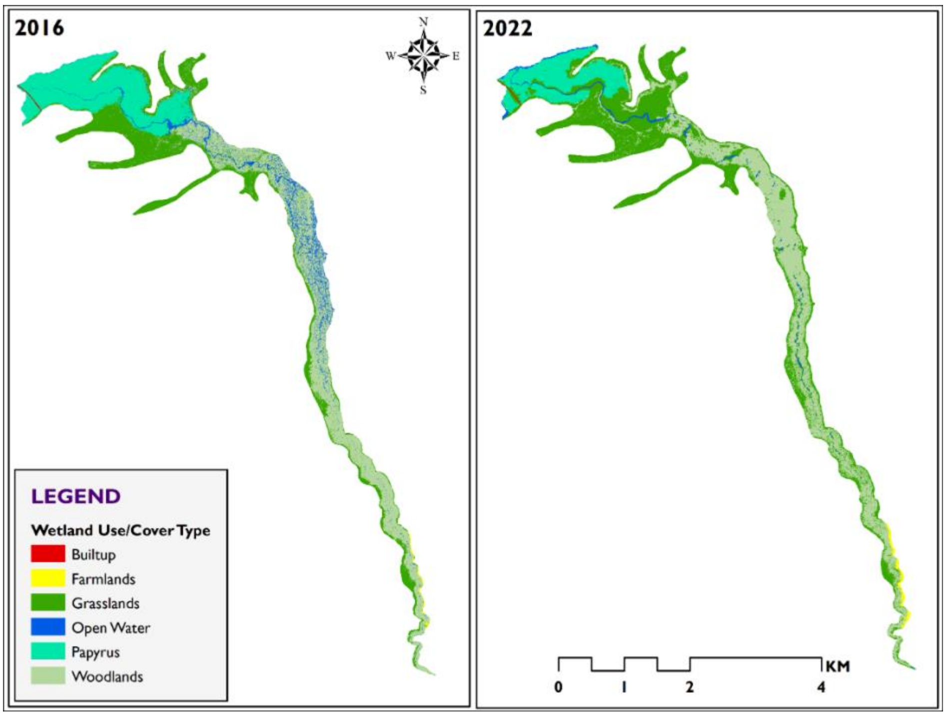


Figure 18: Wetland use/cover changes in Rubirizi



12.1.4. Comparison sites in eastern Uganda

Figure 19: Wetland use/cover changes in Bukedea

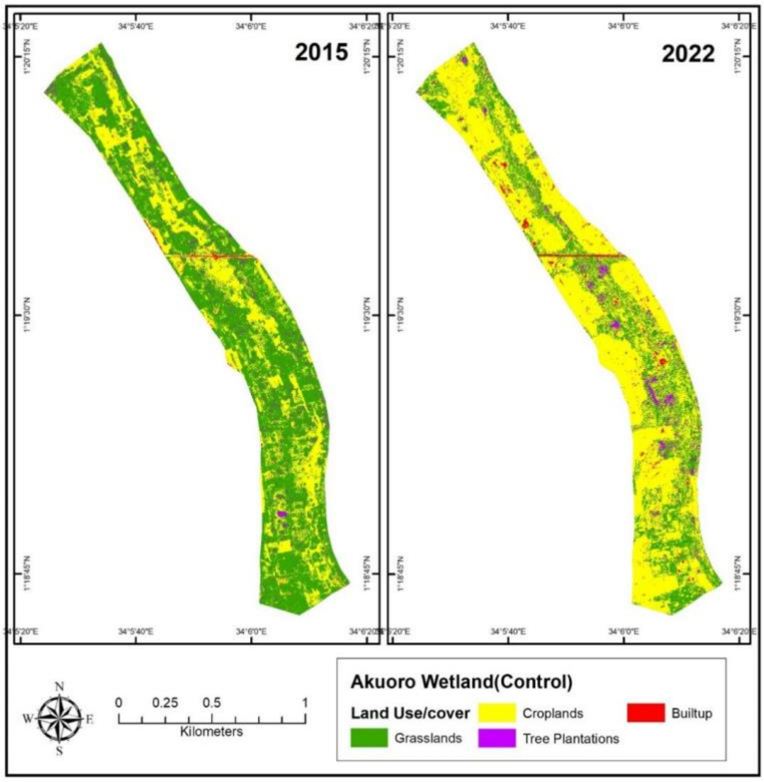


Figure 20: Wetland use/cover changes in Kumi

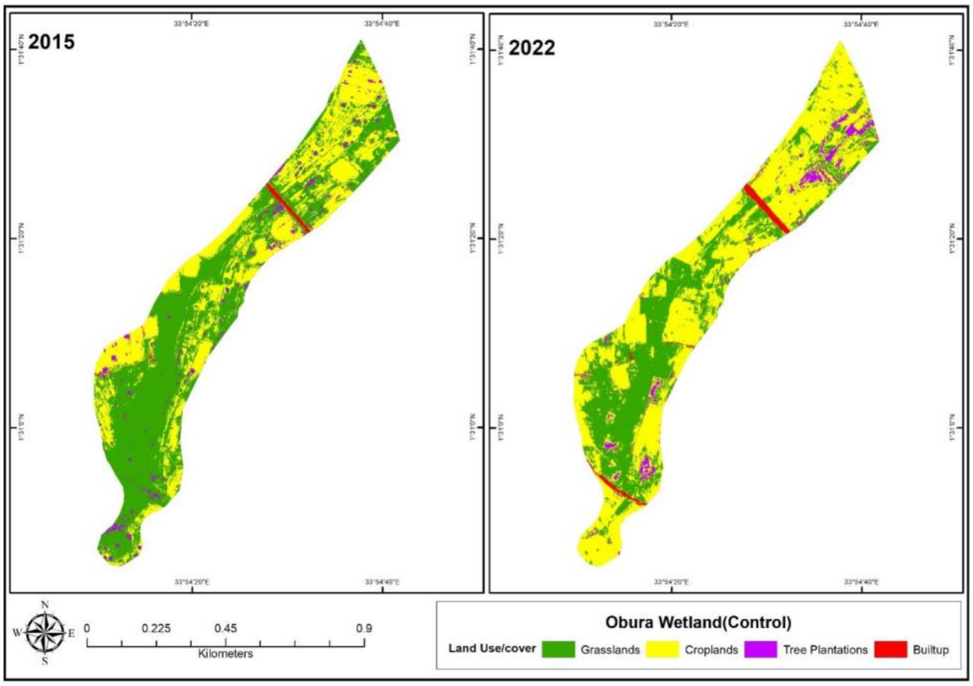


Figure 21: Wetland use/cover changes in Namutumba

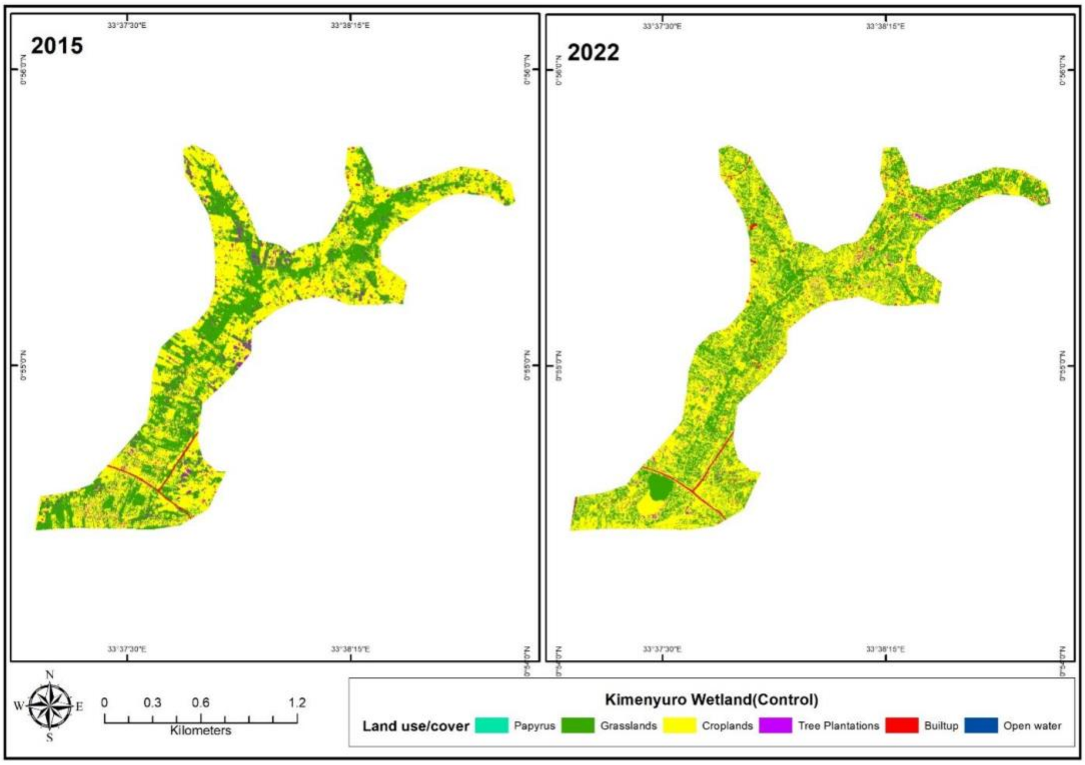
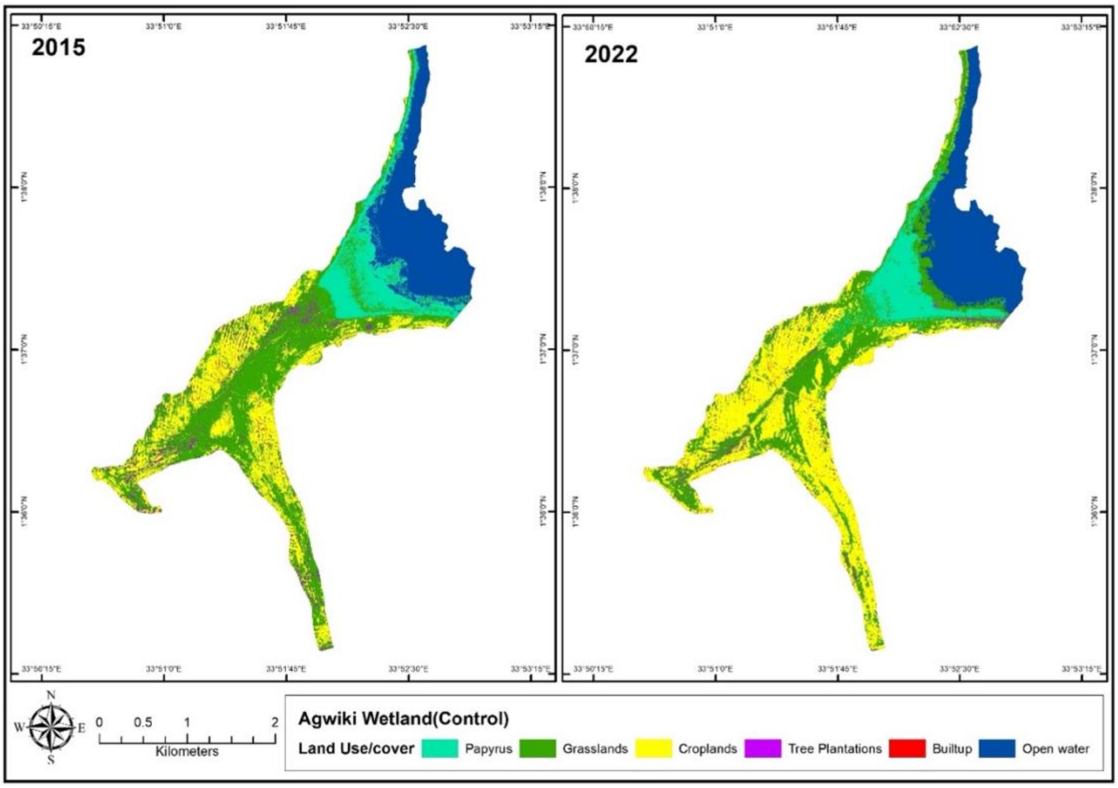


Figure 22: Wetland use/cover changes in Ngora



12.2. Levels of wetland use in Uganda

12.2.1. **Treatment sites in western Uganda**

Figure 23: Wetland degradation levels in Bushenyi

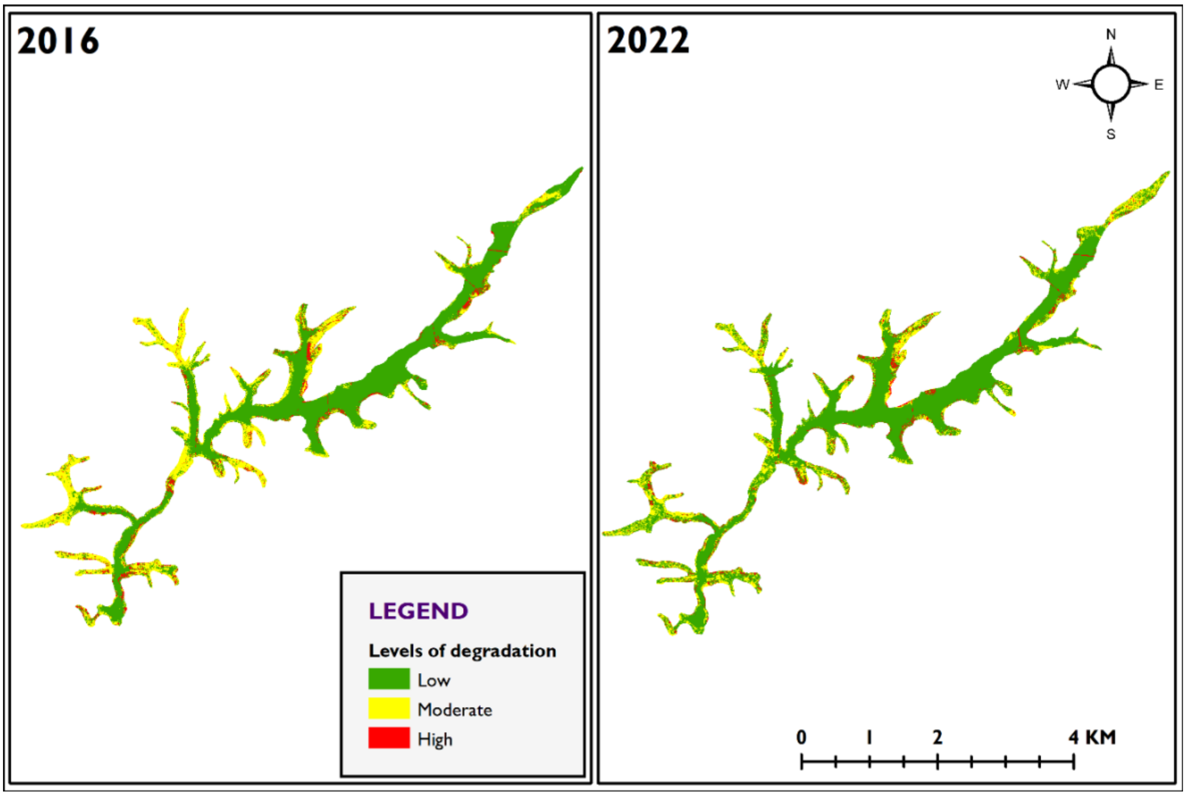


Figure 24: Wetland degradation levels in Kisoro

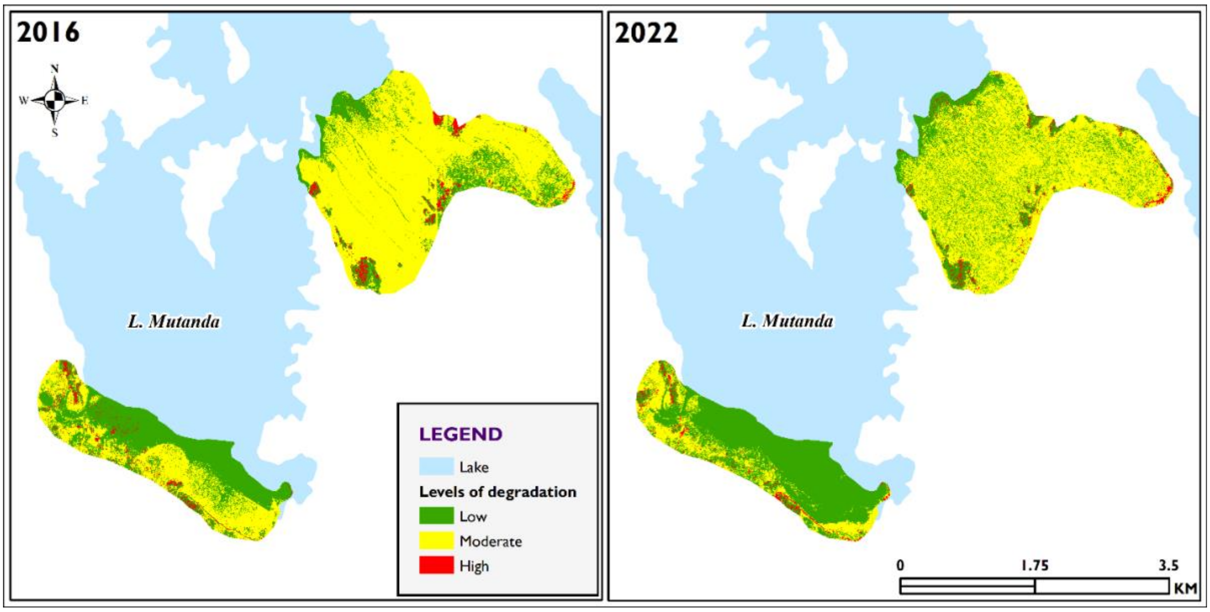


Figure 25: Wetland degradation levels in Mitooma

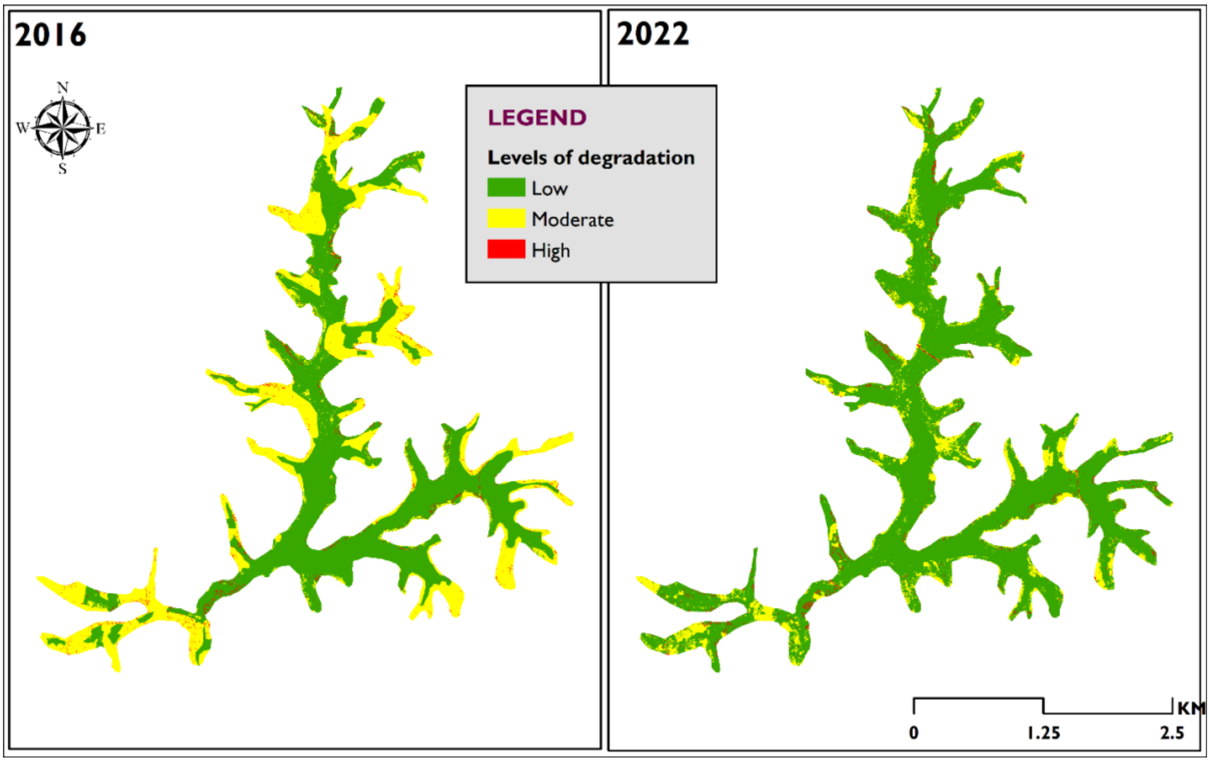
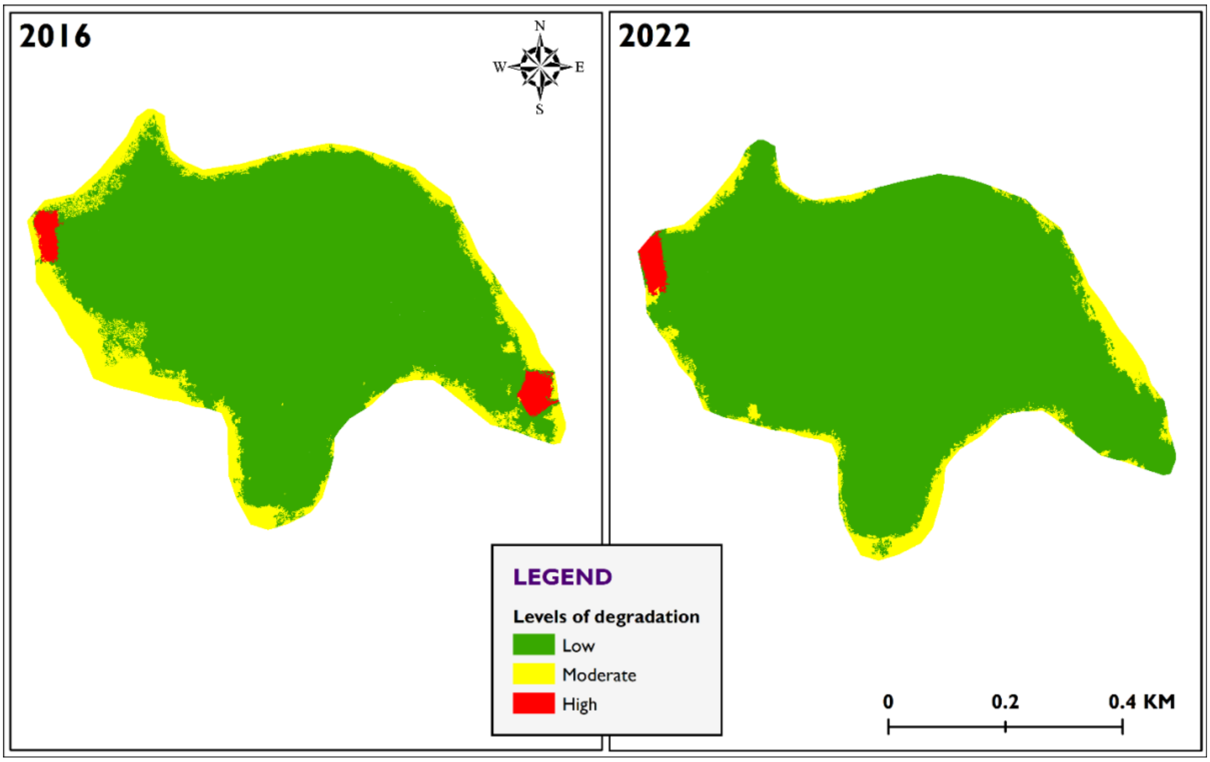


Figure 26: Wetland degradation levels in Rubirizi



12.2.2. Treatment sites in eastern Uganda

Figure 27: Wetland degradation levels in Bukedea

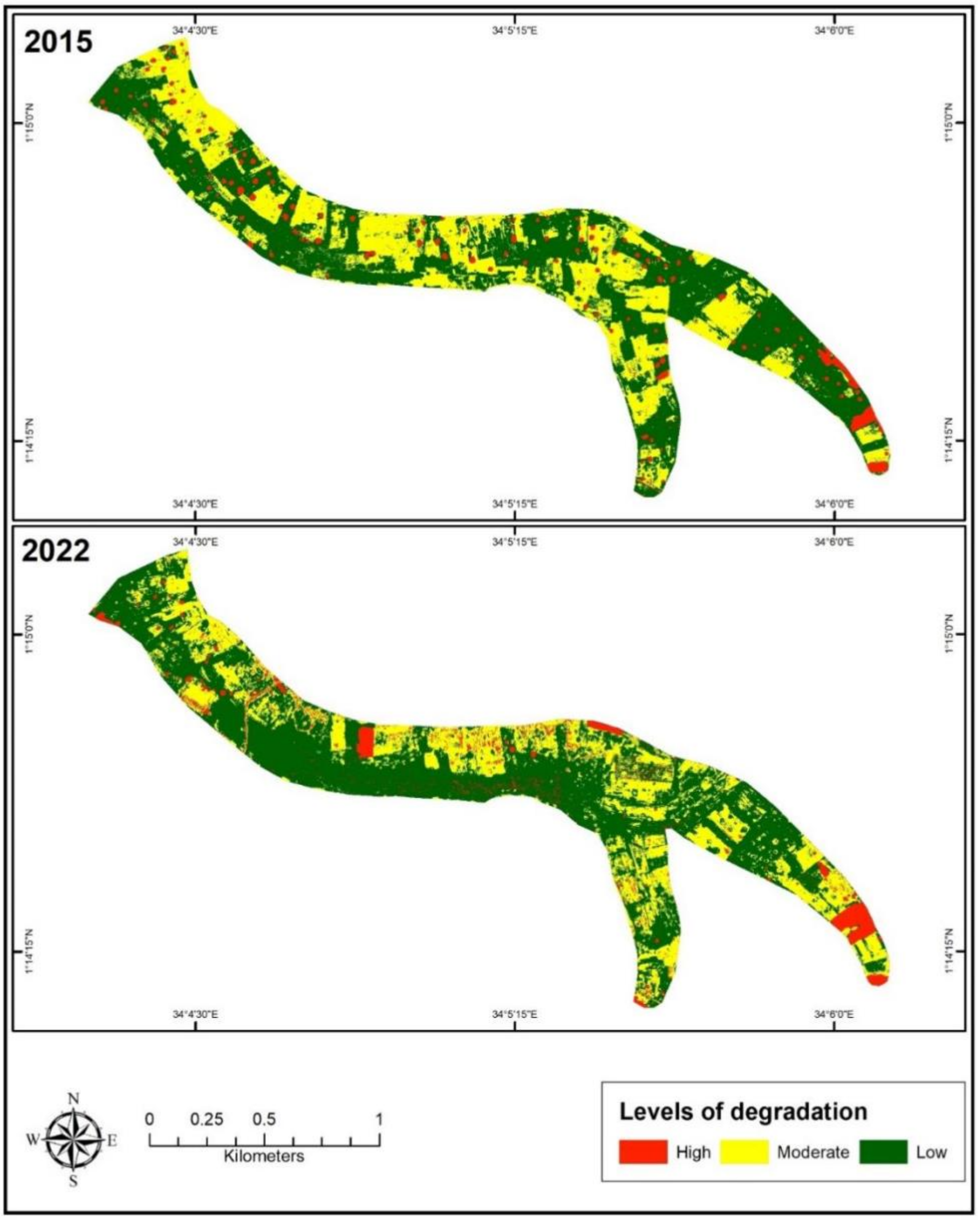


Figure 28: Wetland degradation levels in Kumi

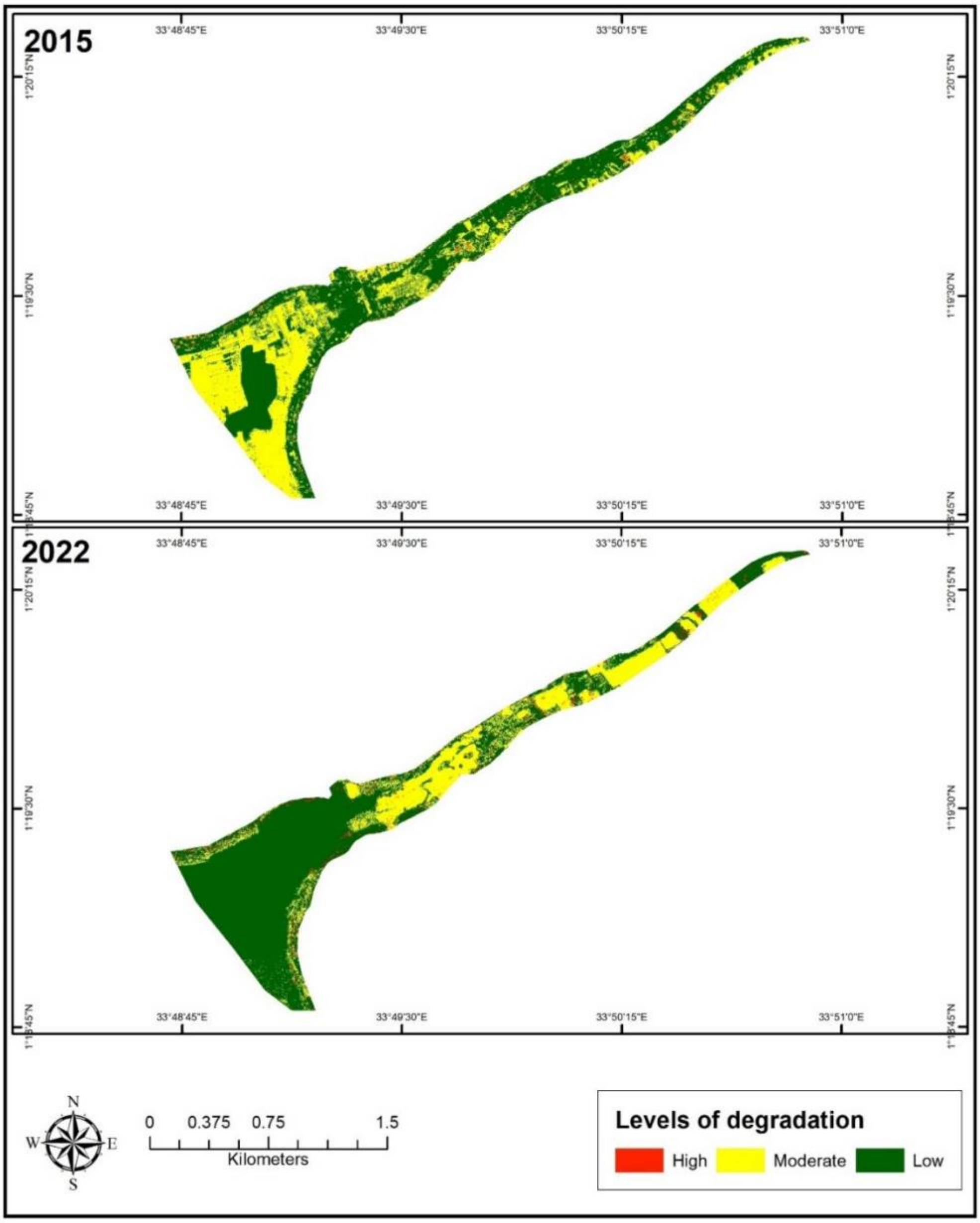
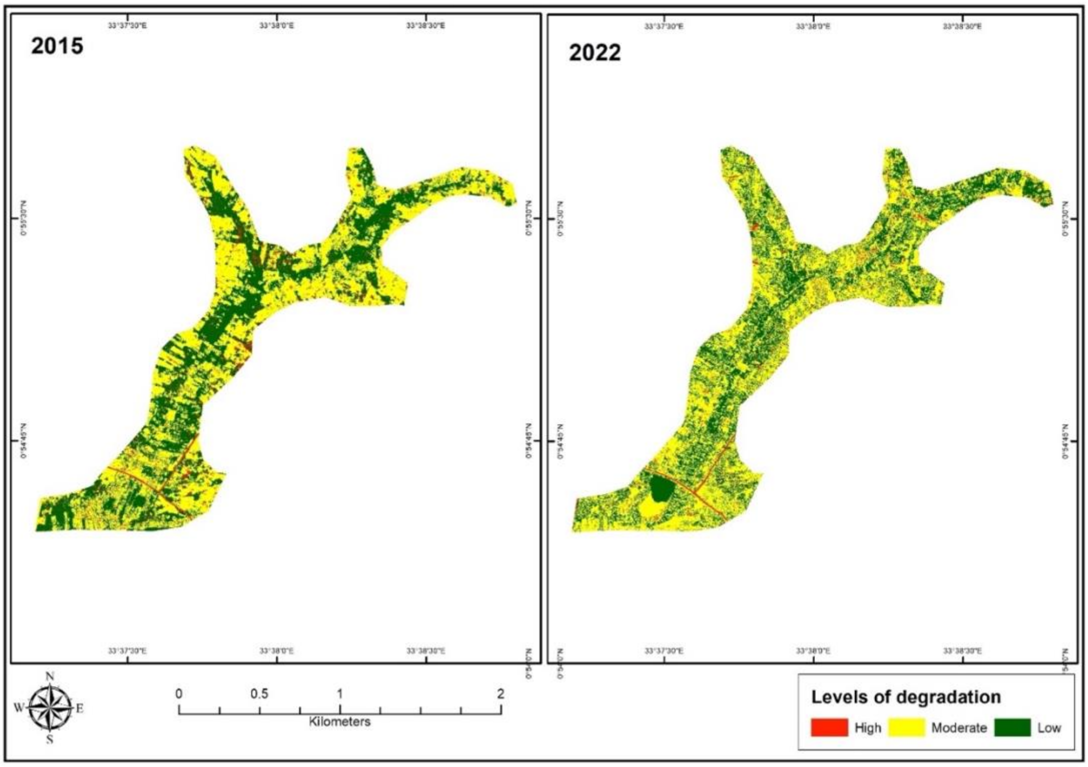


Figure 29: Wetland degradation levels in Namutumba



12.2.3. Comparison sites in western Uganda

Figure 30: Wetland degradation levels in Bushenyi

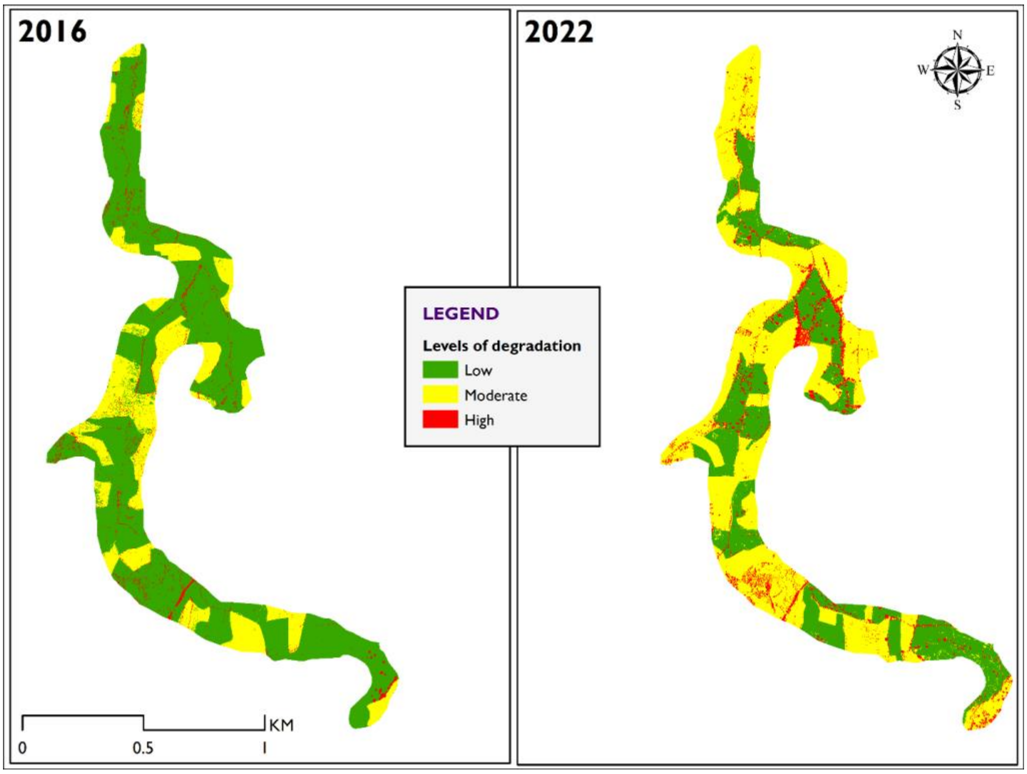


Figure 31: Wetland degradation levels in Kisoro

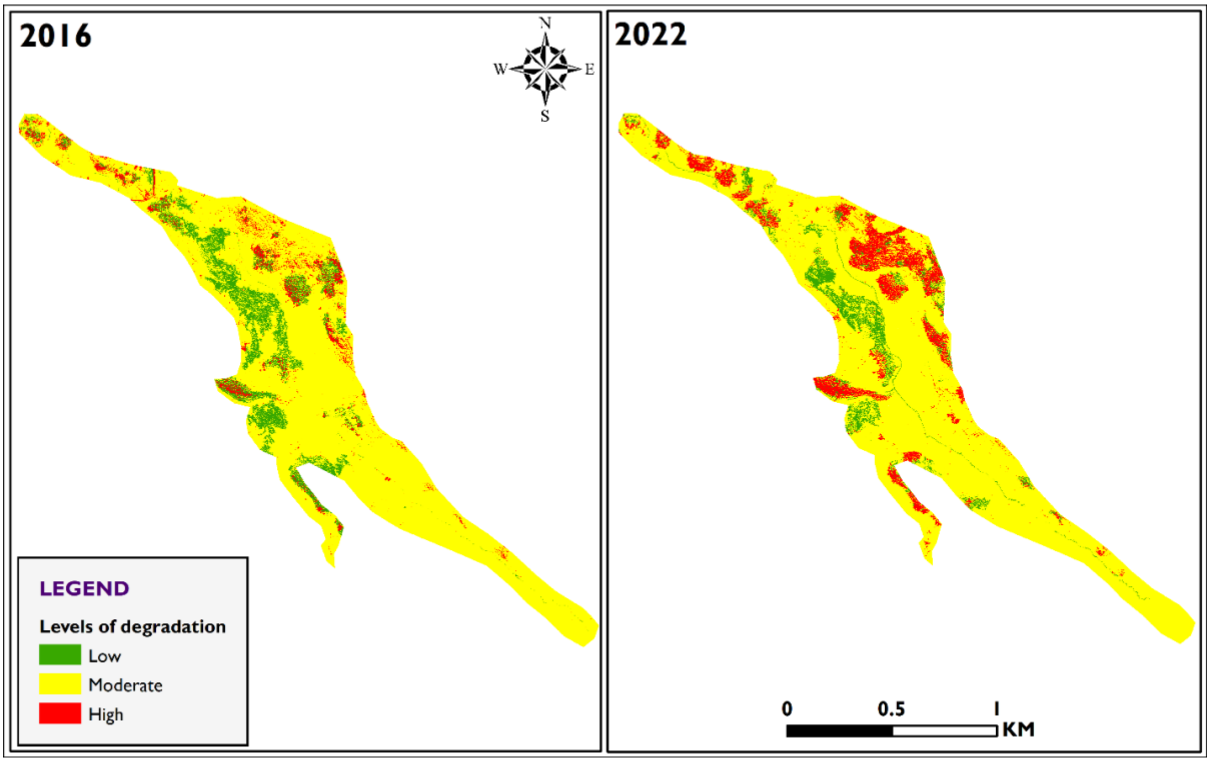


Figure 32: Wetland degradation levels in Mitooma

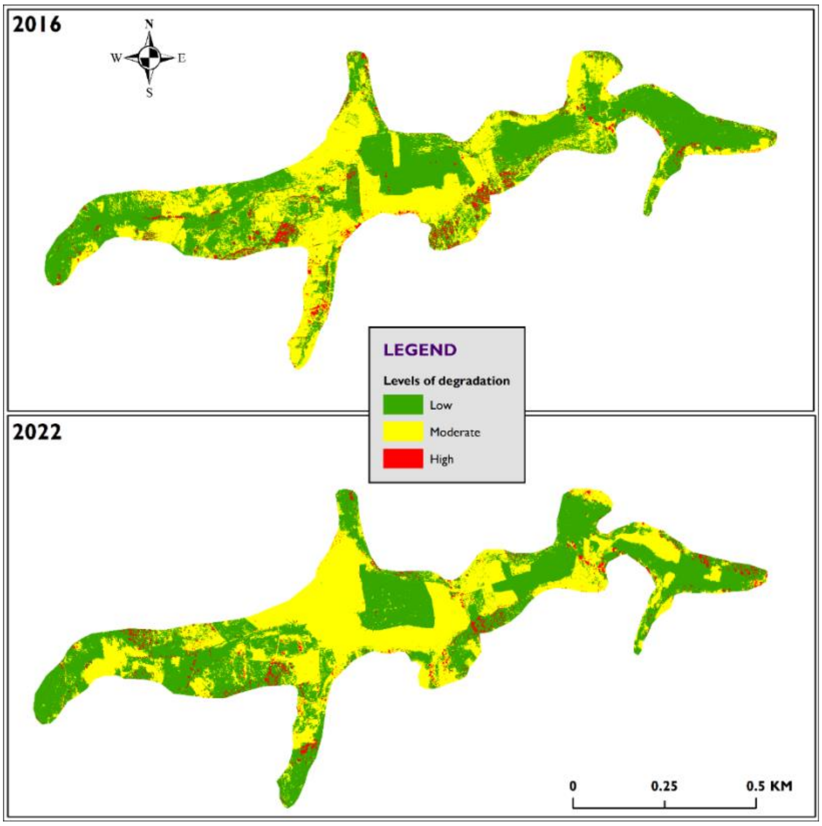
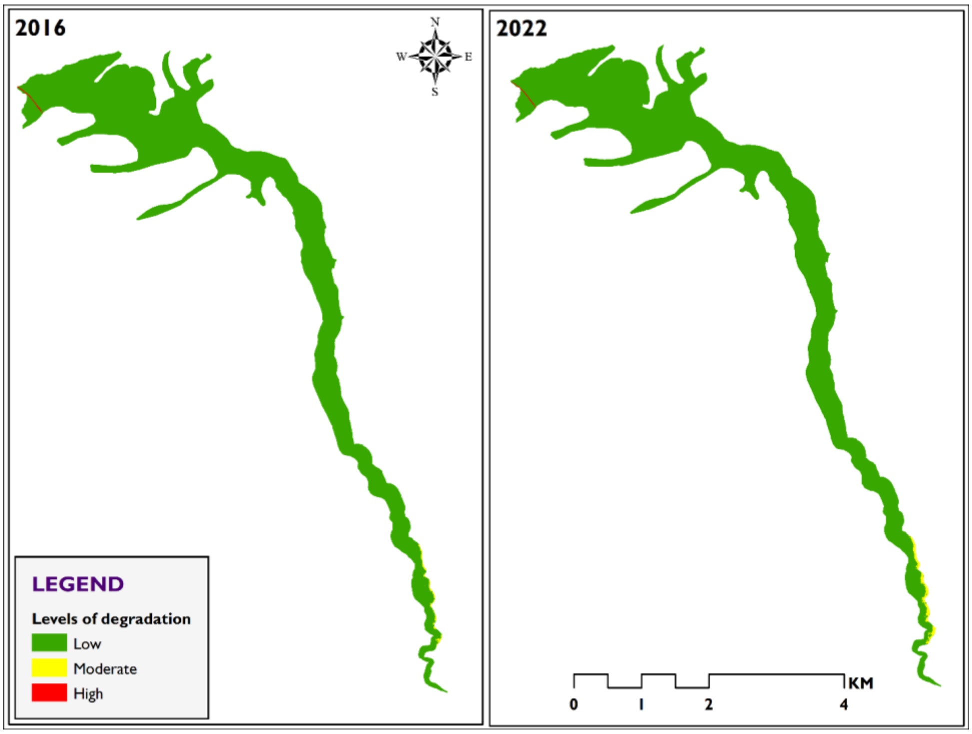


Figure 33: Wetland degradation levels in Rubirizi



12.2.4. Comparison sites in eastern Uganda

Figure 34: Wetland degradation levels in Bukedea

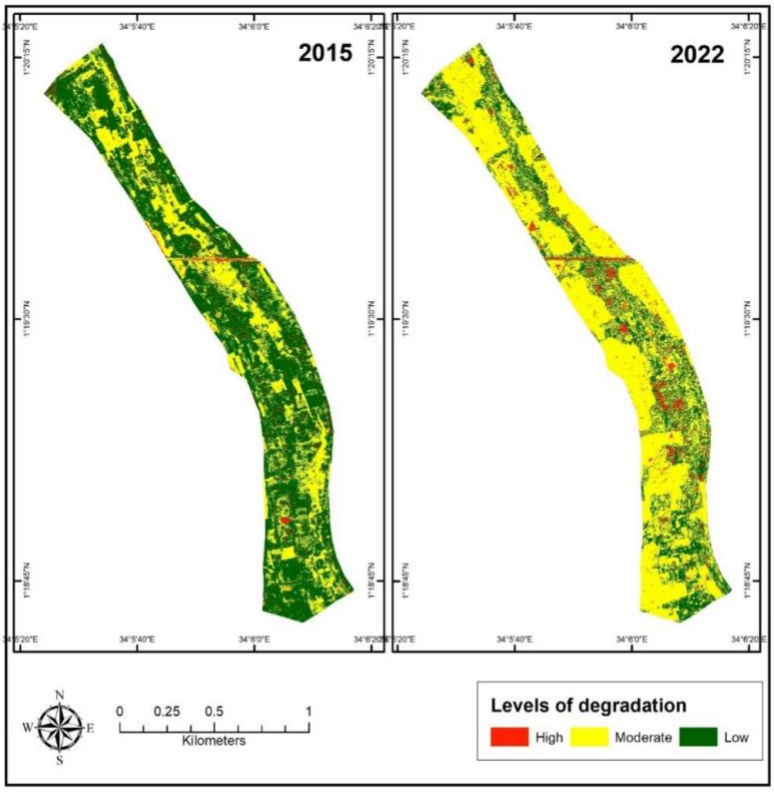


Figure 35: Wetland degradation levels in Kumi

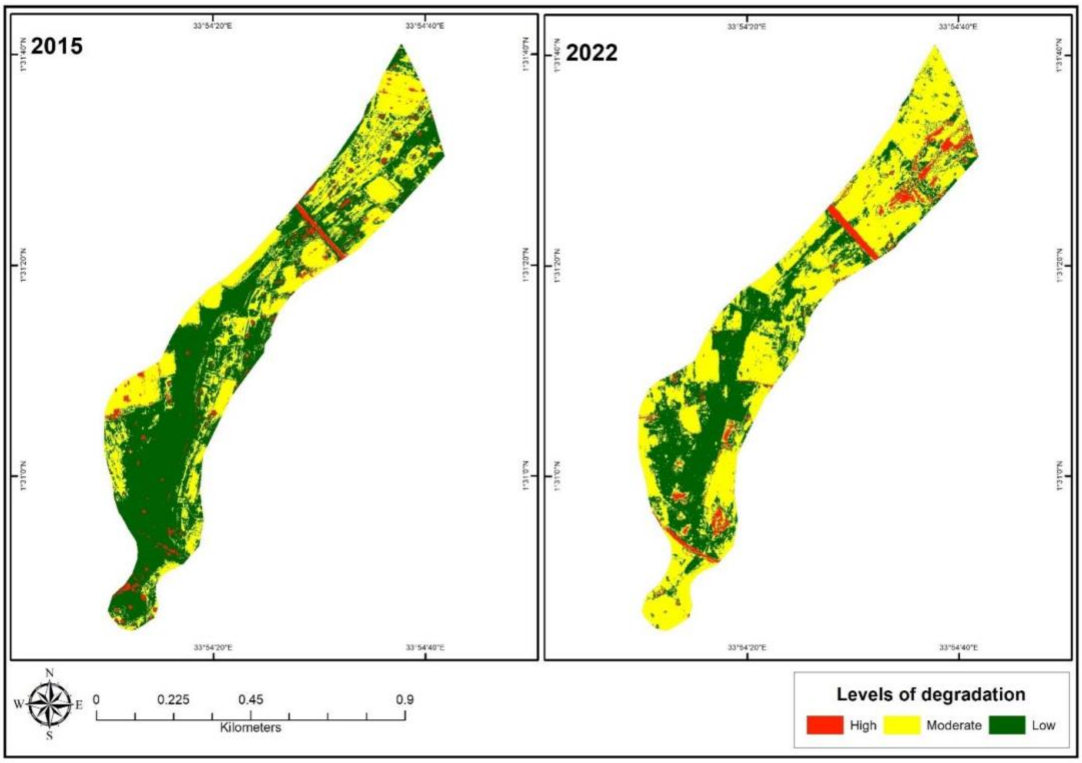


Figure 36: Wetland degradation levels in Namutumba

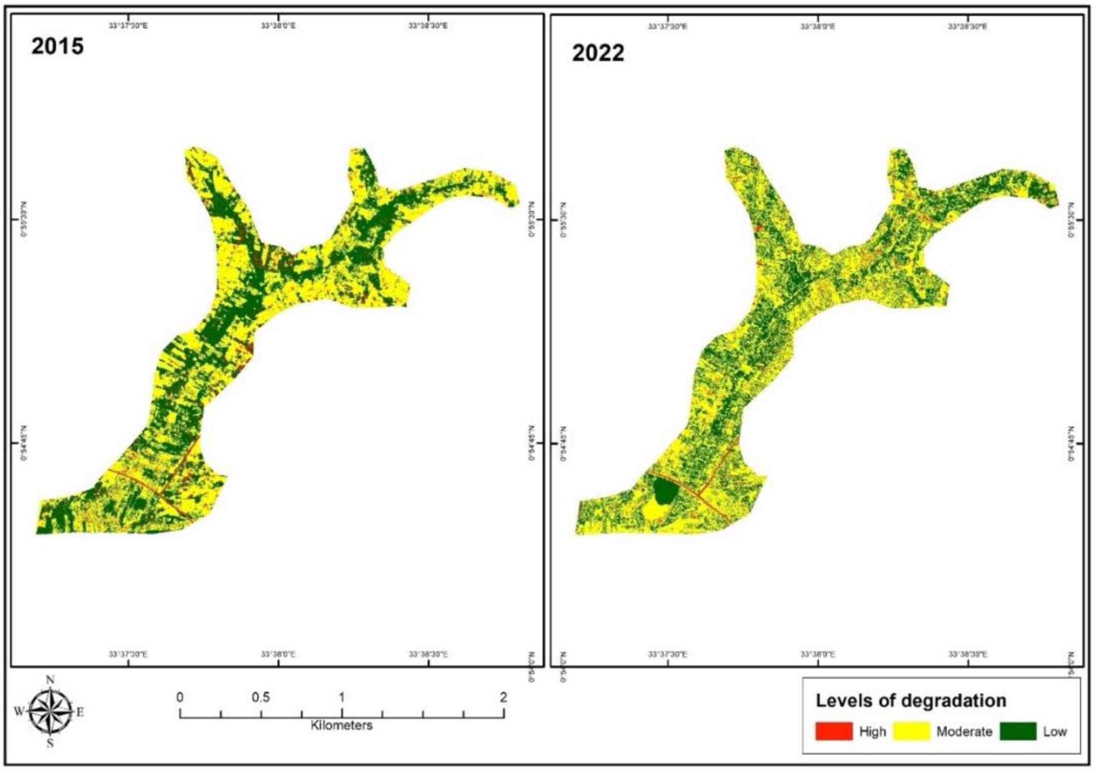
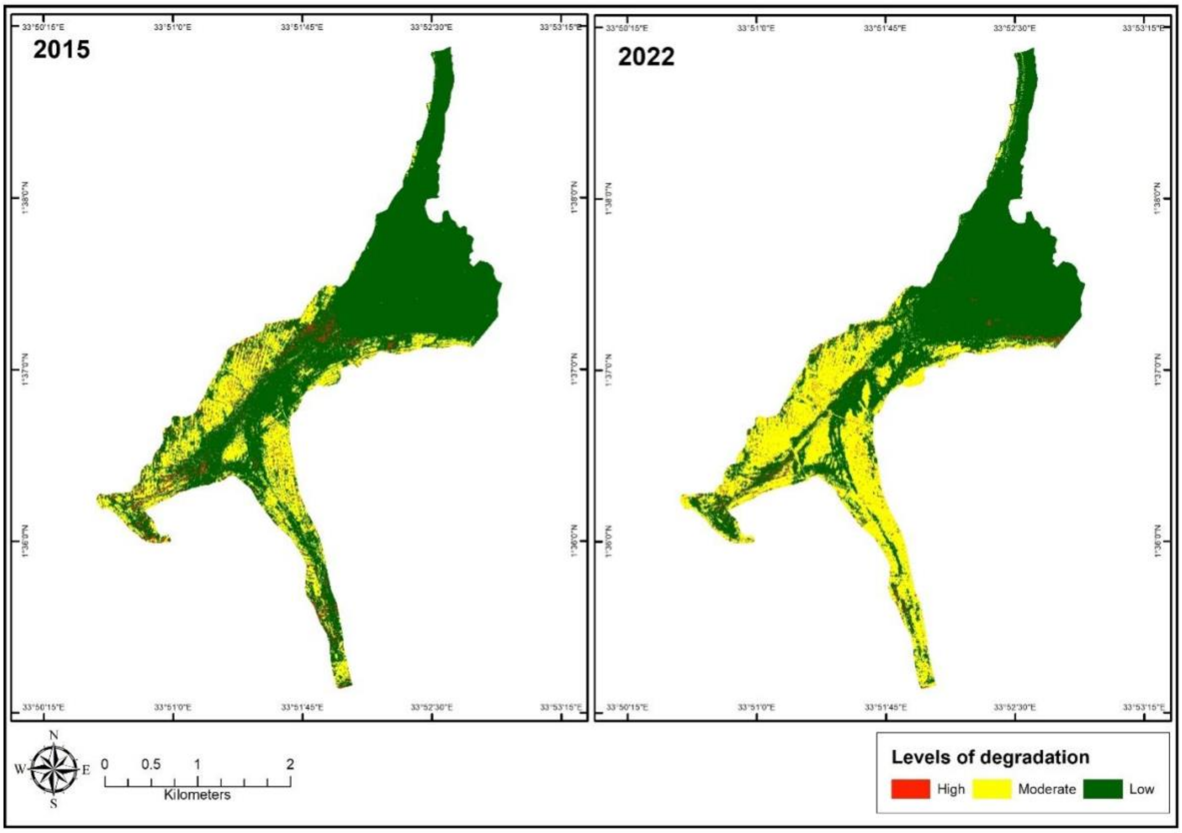


Figure 37: Wetland degradation levels in Ngora



Appendix 13. Baseline results: complete tables

Table 46: Descriptive statistics on sociodemographic indicators

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Age of the household head	48.54	48.06	0.73	582	701
Male-headed household	0.67	0.77	0.08*	609	726
Number of household members	6.30	7.32	0.00***	730	771
Adult equivalence score	3.82	4.89	0.06*	698	796
Dependency ratio (based on minors)	0.62	0.60	0.55	667	662
Household head is married	0.77	0.83	0.00***	761	905
Household head is widowed	0.16	0.11	0.01**	761	905
Household head is single	0.07	0.05	0.24	761	905
Education level of the household head	2.16	2.38	0.16	761	905
No formal education	0.25	0.16	0.16	761	905
Primary	0.53	0.53	0.95	761	905
O' Level	0.15	0.23	0.07*	761	905
A' Level	0.02	0.03	0.20	761	905
Certificate	0.01	0.02	0.67	761	905
Vocational training	0.02	0.02	0.96	761	905
Diploma	0.02	0.01	0.43	761	905
Bachelor's degree	0.00	0.01	0.36	761	905

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 47: Descriptive statistics for geographical characteristics of the household

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Years living in current house	29.95	34.46	0.02**	730	860
Owning the land where household lives	0.90	0.93	0.10*	752	900
Distance to nearby health centre (hours)	1.74	1.67	0.84	754	890
Distance to nearby market (hours)	1.81	1.71	0.60	755	890
Distance to nearby town or trading centre (hours)	1.62	1.51	0.40	755	888
Distance to nearby tarmac road (hours)	1.76	1.98	0.48	756	894

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 48: Descriptive statistics on wetland use and benefits

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Share of households using or benefiting from nearby wetland	0.76	0.77	0.93	888	756
Share of households reporting that benefits from the wetlands have changed in the last 5 years	0.82	0.80	0.81	656	579
Number of activities practised in wetlands	2.10	2.15	0.91	665	582

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 49: Descriptive statistics for wetlands and restoration

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
State of nearby wetlands: intact	0.33	0.16	0.21	852	744
State of nearby wetlands: improved	0.28	0.14	0.03**	852	744
State of nearby wetlands: degraded	0.40	0.70	0.06*	852	744

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 50: Five most frequent drivers of wetland degradation

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Cultivation from wetlands	0.62	0.61	0.96	333	518
Grazing from wetlands	0.45	0.48	0.83	333	518
Channelling water from wetlands	0.24	0.29	0.61	333	518
Over harvesting of wetland resources	0.33	0.21	0.35	333	518
Soil erosion, especially from nearby catchments/farms	0.16	0.19	0.83	333	518

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 51: Wetland restoration and sustainable management activities

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Anything done to restore and sustainably manage wetlands in this area	0.69	0.31	0.01***	859	738
If yes, what has been done:					
Demarcation of the boundary of wetlands	0.71	0.72	0.89	587	222
Sensitization of people about the benefits of wetlands	0.53	0.55	0.77	587	222
Blocking of channels	0.25	0.20	0.54	587	222

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Sensitization on the wetlands policy and environmental laws	0.20	0.28	0.48	587	222
Development and implementation of a community wetland management plan	0.08	0.18	0.27	587	222

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 52: Observations for wetland restoration and sustainable management activities in the past three years

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Awareness of project activities	0.52	0.63	0.41	485	173
There is an observable effort to protect the wetland and its catchment by several stakeholders	0.38	0.34	0.52	485	173
The area of protected and restored wetlands has increased over the past few years	0.19	0.17	0.83	485	173
I am aware of some sensitization drives about the restoration of wetlands, their catchments and inlet streams	0.12	0.10	0.77	485	173
I am aware of some demarcations of restored wetlands to create observable boundaries	0.08	0.10	0.78	485	173

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 53: Descriptive statistics on livelihood activities

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Number of livelihood activities	1.40	1.52	0.55	905	761
Livelihood activities: crop farming	0.77	0.85	0.46	815	742
Livelihood activities: livestock	0.18	0.21	0.76	815	742

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Livelihood activities: casual labouring	0.15	0.19	0.58	815	742
Livelihood activities: small business	0.11	0.13	0.42	815	742
Livelihood activities: brick-making	1.40	1.52	0.55	815	742

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 54: Descriptive statistics for household expenditure

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Share of food in total expenditure (%)	43.01	43.44	0.95	593	603
Expenditure (UGX): education e.g. school fees, books, school uniform, pens etc.	445,995.28	391,759.40	0.55	424	431
Expenditure (UGX): insurance	175,000.00	54,166.67	0.02**	10	6
Expenditure (UGX): food	116,640.81	104,808.42	0.59	593	603
Expenditure (UGX): rent	99,166.67	143,184.55	0.47	18	22
Expenditure (UGX): health care	102,123.55	91,950.00	0.67	518	488

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 55: Descriptive statistics for community-based resilience practices

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
I am aware of small-scale irrigation facilities (sprinkler and drip irrigation system, water pump) in this community	0.34	0.16	0.10*	521	563
I belong to a farmer group or cooperative on crop diversification and resilient agricultural practices	0.21	0.20	0.93	521	563

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
In my community, there is a nursery garden for multiplying improved seeds	0.02	0.01	0.61	521	563
In my community, there is a farmer field school for demonstrating to farmers resilient agricultural practices	0.03	0.01	0.05*	521	563

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 56: Descriptive statistics for household-level resilience practices

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
I received training on crop diversification and resilient agricultural practices.	0.30	0.27	0.51*	521	563
I received agricultural inputs (improved vegetable seeds, herbicides, hoes, pangas).	0.13	0.41	0.08	521	563
I received training on alternative livelihoods (aquaculture, goat farming, vegetable growing, poultry, piggery, beekeeping).	0.13	0.22	0.36	521	563
I received pigs.	0.12	0.05	0.03**	521	563
I received goats.	0.08	0.02	0.09*	521	563

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 57: Descriptive statistics on crop farming and land

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Carrying out crop farming	0.84	0.87	0.70	859	755
Number of crops grown by the household	5.55	5.54	0.99	714	659
Number of parcels for crop production	2.37	3.33	0.01**	692	654

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Size of land for crop production (acres)	2.75	3.93	0.02**	691	646
Customary ownership	0.52	0.69	0.00***	713	658
Privately owned	0.49	0.37	0.29	713	658
Rented	0.12	0.10	0.70	713	658
Borrowed for free	0.03	0.00	0.09*	713	658

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 58: Descriptive statistics on the most frequent cereal and rice crops grown

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Households that grow:					
Wheat	0.00	0.00	0.95	681	619
Maize	0.62	0.52	0.47	681	619
Rice	0.17	0.31	0.21	681	619
Sorghum	0.20	0.37	0.15	681	619
Millet	0.26	0.27	0.94	681	619

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 59: Land allocation for the three most frequent cereal crops (acres)

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Land allocated for maize	1.34	1.25	0.40	370	253
Land allocated for millet	1.13	1.06	0.42	143	98
Land allocated for sorghum	1.85	1.12	0.13	79	169

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 60: Crop production (kg) for the three most frequent cereal crops

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Quantity harvested of maize	241.23	229.16	0.83	361	294
Quantity harvested of sorghum	189.40	153.29	0.35	84	207
Quantity harvested of millet	60.97	68.83	0.58	165	129

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 61: Crop productivity (kg/acre) for the three most frequent crops

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Area productivity of maize	187.37	208.62	0.64	340	245
Area productivity of sorghum	93.31	152.84	0.21	67	163
Area productivity of millet	58.63	72.65	0.38	138	95

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 62: Descriptive statistics on rice production

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
All rice is grown in wetlands	0.96	0.93	0.72	114	190
if yes, then the amount of land allocated for rice in wetlands (acres)	1.28	1.38	0.36	94	155
if no, then the amount of land allocated for rice in wetland (acres)	1.40	1.67	0.44	5	9
if no, then the amount of land allocated for rice upland (acres)	0.75	0.90	0.26	4	10
Rice production (kg)	407.48	413.01	0.94	103	168

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 63: Descriptive statistics on the most frequent crops grown

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Vegetables and melons					
Doodo (amaranthus dubius)	0.19	0.19	0.94	631	587
Eggplant	0.22	0.15	0.29	631	587
Cabbages	0.19	0.11	0.04**	631	587
Oil seed crops					
Ground nuts	0.45	0.54	0.35	631	610
Soya beans	0.10	0.10	0.97	630	610
Linseed	0.00	0.02	0.17	630	610
Root/tuber crops					
Cassava	0.62	0.62	0.98	674	635
Sweet potatoes	0.52	0.54	0.82	674	635
Irish potatoes	0.05	0.15	0.40	674	635
Leguminous crops					
Beans	0.63	0.57	0.53	680	630
Cow peas	0.05	0.12	0.14	679	630
Peas	0.02	0.10	0.21	679	630
Fruits and nuts					
Banana (fruits)	0.44	0.28	0.03**	547	541
Avocado	0.16	0.13	0.55	546	541
Mangoes	0.08	0.09	0.81	546	541
Beverage and spice crops					
Coffee Arabica (old)	0.19	0.11	0.23	632	628
Coffee Robusta (old)	0.07	0.06	0.54	632	628
Coffee Robusta (clonal)	0.09	0.01	0.13	632	628
Growing improved crop varieties	0.05	0.17	0.08*	690	655

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 64: Descriptive statistics on land allocation last season

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Vegetables and melons					
Doodo (amaranthus dubius)	1.07	1.16	0.29	60	51
Eggplant	0.93	1.00	0.23	76	53
Cabbages	1.06	1.39	0.12	70	49
Oil seed crops					
Groundnuts	1.12	1.18	0.31	221	267
Soya beans	1.04	1.19	0.01***	55	42
Linseed	1.00	1.00	-	2	6
Root/tuber crops					
Cassava	1.26	1.09	0.28	329	291
Sweet potatoes	1.21	1.40	0.56	198	229
Irish potatoes	1.33	3.06	0.00***	24	88
Leguminous crops					
Beans	1.14	1.56	0.07*	332	250
Cow peas	2.23	1.10	0.06*	26	61
Peas	0.63	0.97	0.36	8	33
Fruits and nuts					
Banana (food)	1.22	1.31	0.59	188	102
Avocado	1.02	1.20	0.14	56	55
Mangoes	0.94	0.97	0.57	31	29
Beverage and spice crops					
Coffee Arabica (old)	1.11	1.29	0.05**	109	62
Coffee Robusta (old)	0.95	1.00	0.41	42	25

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Coffee Robusta (clonal)	1.15	1.00	0.32	40	4

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 65: Descriptive statistics on crop production in the previous season

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Vegetables and melons					
Doodo (amaranthus dubius)	30.65	21.87	0.63	93	97
Eggplant	69.90	33.89	0.39	125	81
Cabbages	113.43	90.95	0.51	96	61
Oil seed crops					
Groundnuts	124.09	176.37	0.09*	249	313
Soya beans	174.58	85.09	0.01***	62	58
Linseed	36.67	84.00	0.40	3	7
Root/tuber crops					
Cassava	338.54	323.82	0.92	348	323
Sweet potatoes	308.88	208.59	0.37	243	292
Irish potatoes	280.60	1167.55	0.00***	20	94
Leguminous crops					
Beans	111.19	143.66	0.21	398	335
Cow peas	418.05	191.24	0.11	22	72
Peas	45.00	91.83	0.04**	14	48
Fruits and nuts					
Banana (food)	210.84	261.68	0.66	203	129
Avocado	81.35	86.84	0.85	84	67
Mangoes	202.08	79.84	0.46	38	32

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Beverage and spice crops					
Coffee Arabica (old)	205.89	369.55	0.29	117	62
Coffee Robusta (old)	141.21	209.63	0.01***	43	27
Coffee Robusta (clonal)	198.36	52.86	0.05**	58	7

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 66: Descriptive statistics on yields in most frequently grown vegetables, crops and other harvest

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Vegetables and melons					
Doodo (amaranthus dubius)	35.84	19.82	0.52	50	45
Eggplant	74.18	44.84	0.49	65	51
Cabbages	98.54	74.88	0.57	59	49
Oil seed crops					
Groundnuts	123.52	171.84	0.08*	206	257
Soya beans	177.42	95.60	0.02**	54	42
Sim sim	50.00	93.00	0.47	2	6
Root/tuber crops					
Cassava	269.52	355.64	0.43	292	252
Sweet potatoes	287.27	181.30	0.38	158	214
Irish potatoes	176.47	629.02	0.00***	16	88
Leguminous crops					
Beans	101.31	118.63	0.37	320	248
Cow peas	282.59	180.74	0.15	22	60
Peas	28.60	95.34	0.02**	5	32
Fruits and nuts					

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Banana (food)	179.61	216.33	0.69	171	96
Avocado	102.55	82.53	0.69	56	53
Mangoes	260.43	70.25	0.32	28	20
Beverage and spice crops					
Coffee Arabica (old)	180.43	313.89	0.26	108	56
Coffee Robusta (old)	146.55	223.33	0.00***	40	24
Coffee Robusta (clonal)	158.09	31.25	0.16	40	4

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 67: Descriptive statistics on the most frequent challenges to crop production

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Pests and diseases	0.83	0.91	0.17	694	655
Price fluctuations	0.38	0.54	0.22	694	655
Unreliable rainfall	0.33	0.39	0.38	694	655
Low soil fertility	0.29	0.35	0.63	694	655
Prolonged dry spells	0.23	0.34	0.33	694	655

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 68: Descriptive statistics on challenges in crop production

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Reduced yields	0.92	0.89	0.74	683	652
Reduced incomes	0.64	0.72	0.54	683	652
De-incentive to grow improved varieties	0.08	0.17	0.12	683	652

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Food insecurity	0.33	0.42	0.34	683	652
Malnutrition	0.10	0.23	0.13	683	652

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 69: Descriptive statistics on access to markets

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Having access to multiple selling points (markets)	0.62	0.63	0.87	694	656
Travel time to sell agricultural produce: < 1 km	0.40	0.49	0.19	674	646
Travel time to sell agricultural produce: 1-2 km	0.30	0.23	0.41	674	646
Travel time to sell agricultural produce: 2-3 km	0.13	0.09	0.64	674	646
Travel time to sell agricultural produce: 3-5 km	0.06	0.09	0.59	674	646
Travel time to sell agricultural produce: > 5 km	0.10	0.10	0.97	674	646

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 70: Descriptive statistics for Sustainable land management

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Using sustainable land management practices in the garden	0.38	0.29	0.45	671	652
Number of sustainable land management practices practised by household	2.12	3.41	0.07*	255	191
Sustainable land management practices: inter-cropping	0.49	0.77	0.04**	255	191

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Sustainable land management practices: crop rotation	0.36	0.65	0.01**	255	191
Sustainable land management practices: mulching	0.56	0.29	0.04**	255	191
Sustainable land management practices: cover crops	0.18	0.30	0.35	255	191
Sustainable land management practices: use of animal and green manure	0.13	0.34	0.09*	255	191
Who mainly decides on the SLM practices to be applied: adult male	0.69	0.83	0.20	249	183
Who mainly decides on the SLM practices to be applied: adult female	0.27	0.15	0.16	249	183
Who mainly decides on the SLM practices to be applied: female youth	0.02	0.00	0.29	249	183
Who mainly decides on the SLM practices to be applied: male youth	0.02	0.02	0.65	249	183

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 71: Descriptive statistics for post-harvest handling

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Post-harvest handling	0.20	0.30	0.50	586	585
Transport of crop produce	0.14	0.28	0.04**	586	585
Selling the crop produce	0.24	0.32	0.39	586	585

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 72: Descriptive statistics for the use of agricultural incomes

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Buy household items such as soap, salt and sugar	0.65	0.78	0.14	686	649
Pay health and medical services	0.54	0.66	0.19	686	649
Buy assets such as land, bicycles	0.17	0.22	0.34	686	649
Buy agricultural inputs	0.11	0.26	0.15	686	649
Pay loans	0.11	0.19	0.22	686	649

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 73: Descriptive statistics on gender and agriculture

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Who mainly receives information about good agricultural practices?					
Adult male	0.65	0.72	0.55	249	181
Adult female	0.29	0.25	0.76	249	181
Female youth	0.02	0.00	0.06*	249	181
Male youth	0.04	0.02	0.45	249	181
Who mainly benefits from the income from agricultural produce					
Adult male	0.69	0.66	0.64	623	594
Adult female	0.27	0.22	0.15	623	594
Female youth	0.02	0.05	0.28	623	594
Male youth	0.02	0.07	0.20	623	594

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 74: Descriptive statistics for labour by demographic categories

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Participation of adult males in clearing the garden (%)	32.28	43.18	0.04**	333	522
Participation of adult females in clearing the garden (%)	47.10	31.52	0.01***	333	522
Participation of adult females in harvesting (%)	52.16	40.72	0.02**	333	344

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 75: Descriptive statistics for agriculture inputs

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Household uses:	0.07	0.14	0.24	638	636
Fertilizer	0.07	0.14	0.24	638	636
Pesticide/herbicide/insecticide	0.14	0.48	0.01**	638	636
Seeds	0.37	0.47	0.38	638	636
Machinery	0.03	0.01	0.42	638	636
Hired labour	0.13	0.22	0.21	638	636
Costs (UGX):					
Fertilizer	174,871.79	217,151.16	0.65	39	86
Pesticide/herbicide/insecticide	82,455.56	101,038.06	0.55	90	289
Seeds	108,903.62	374,190.41	0.15	221	292
Machinery	172,450.00	101,250.00	0.31	20	4
Hired labour	400,320.99	279,932.35	0.27	81	136

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 76: Descriptive statistics for livestock profile

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Having livestock	0.33	0.46	0.23	854	753
Goat	0.74	0.64	0.27	280	347
Cattle	0.47	0.69	0.00***	280	347
Chicken	0.36	0.49	0.07*	280	347
Pig	0.21	0.29	0.24	280	347
Sheep	0.13	0.30	0.11	280	347
Tropical livestock score for household	1.82	1.94	0.70	279	345
Having improved livestock breeds	0.10	0.06	0.28	274	347

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 77: Descriptive statistics for sources of pasture used by households when raising livestock

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Wetlands	0.63	0.72	0.44	275	333
Within crop farms	0.36	0.49	0.29	275	333
Rangelands	0.27	0.08	0.10*	275	333
Forests	0.15	0.05	0.09*	275	333
Processed feeds	0.02	0.01	0.51	275	333

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 78: Descriptive statistics for land management practices performed by households in relation to livestock

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Livestock management practices					
Pest, parasites and disease control	0.61	0.71	0.57	264	330
Rotational grazing or paddocking	0.20	0.17	0.77	264	330
Manure management	0.08	0.16	0.27	264	330
Practising afforestation within the farm	0.05	0.11	0.25	264	330
Pasture management	0.07	0.07	0.95	264	330

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 79: Descriptive statistics for livestock products

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Milk	0.40	0.42	0.87	211	286
Horns	0.28	0.40	0.32	211	286
Cow manure	0.10	0.41	0.00***	211	286
Meat	0.27	0.08	0.05**	211	286
Yoghurt	0.01	0.06	0.04**	211	286

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 80: Descriptive statistics for livestock value chain

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Transportation of livestock	0.58	0.62	0.75	262	340
Application (spraying) of inputs	0.35	0.57	0.15	262	340
Grazing of animals	0.22	0.30	0.51	262	340

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Purchase of livestock	0.10	0.05	0.31	262	340
Making of livestock products	0.05	0.04	0.93	262	340
Selling of livestock	0.19	0.22	0.72	296	242
Total cost of livestock inputs	141,945.89	159,000.00	0.77	231	303

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 81: Descriptive statistics for challenges in managing livestock

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Pests, parasites and diseases	0.82	0.93	0.01***	273	344
Inadequate pastures	0.35	0.41	0.54	273	344
Price fluctuations	0.27	0.45	0.22	273	344
Prolonged dry spells	0.23	0.37	0.27	273	344
Limited land for livestock	0.25	0.24	0.85	273	344

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 82: Descriptive statistics for challenges in managing livestock

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Participation of adult females in inputs application (%)	29.34	16.00	0.07*	46	90
Participation of hired labour in inputs application (%)	10.26	29.11	0.09*	46	90
Participation of adult males in milking of animals (%)	63.90	53.65	0.05*	55	82
Participation of adult females in selling livestock products (%)	14.08	31.55	0.04**	45	29

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 83: Descriptive statistics for where livestock are sold and the income generated from the sale of livestock and livestock products

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Where livestock are sold					
Local/community markets	0.66	0.91	0.00***	269	344
Home	0.42	0.22	0.01***	269	344
Regional market	0.09	0.10	0.80	269	344
Kiosk shop	0.07	0.01	0.18	269	344
Exclusively to an intermediary/dealer	0.05	0.02	0.35	269	344
Total earnings from selling livestock (UGX)	504,740.42	596,794.21	0.61	235	311
Total earnings from selling livestock products (UGX)	367,867.34	132,201.64	0.01***	196	243

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 84: Food diversity of households

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
HDDS	6.73	7.17	0.61	866	756
Consumed cereals	0.84	0.85	0.92	818	736
Consumed roots and tubers	0.87	0.91	0.61	813	722
Consumed pulses, legumes and nuts	0.87	0.90	0.49	829	749
Consumed vegetables and leaves	0.83	0.81	0.82	799	724
Consumed fruits	0.76	0.69	0.61	811	724
Consumed meat, poultry or offal	0.62	0.66	0.79	789	730
Consumed fish	0.70	0.64	0.57	809	738
Consumed milk, yoghurt, other dairy products	0.40	0.40	0.99	798	729
Consumed honey, sugar, sugar products	0.47	0.49	0.91	804	731
Consumed oil, fats or butter	0.17	0.22	0.47	795	700
Consumed beverages	0.45	0.54	0.45	799	732
Consumed eggs	0.24	0.33	0.47	789	730

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 85: Food insecurity experience of households

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
FIES – last 12 months	0.82	0.98	0.27	781	735
FIES – last 30 days	1.49	1.49	1.00	430	470
Unable to eat healthy and nutritious food	0.40	0.47	0.47	430	470
Ate only a few kinds of food	0.23	0.46	0.04**	430	470
Skipped a meal	0.36	0.28	0.38	430	470

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Ate less than you thought you should	0.25	0.14	0.19	430	470
Household ran out of food	0.14	0.09	0.42	430	470
Were hungry but did not eat	0.08	0.03	0.21	430	470
Went without eating for a whole day	0.03	0.02	0.84	430	470
None of the above	0.05	0.04	0.94	430	470

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 86: Descriptive statistics for shocks in the last 12 months

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Was your household affected by shocks such as droughts and floods in the last 12 months?					
Drought	0.85	0.83	0.83	340	415
Flood	0.40	0.47	0.58	340	415
Strong winds	0.30	0.47	0.14	340	415
Hailstorms	0.31	0.33	0.75	340	415
Landslide	0.06	0.19	0.27	340	415
Response to shocks					
Relied on own savings	0.49	0.66	0.05**	323	403
Changed eating patterns	0.38	0.40	0.91	323	403
Received unconditional help from relatives/friends	0.37	0.30	0.56	323	403
Received unconditional government help	0.21	0.12	0.31	323	403
Sold crop stock	0.04	0.21	0.03**	323	403

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 87: Descriptive weather and climate statistics

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Weather and climate early warning information					
Receiving early weather and climate warning information	0.20	0.22	0.76	818	743
Is the weather and climate early warning information (forecasts) accurate?	0.46	0.53	0.63	161	157
Sources of the early warning information: FM radios	0.71	0.89	0.12	159	159
Sources of the early warning information: community announcements	0.26	0.15	0.17	159	159
Sources of the early warning information: community village meetings	0.22	0.08	0.06*	159	159
Sources of the early warning information: places of worship (churches/mosques)	0.20	0.10	0.50	159	159
Sources of the early warning information: mobile phones (SMS messages)	0.11	0.07	0.23	159	159
Climate impacts in area					
Experienced climate change or variability in this area	0.43	0.62	0.2121	821	748
Climate change impact: prolonged dry spells	0.59	0.59	0.9898	352	464
Climate change impact: increased temperatures	0.40	0.57	0.2424	352	464
Climate change impact: increased extreme events such as drought and floods	0.40	0.49	0.5656	352	464
Climate change impact: change of planting seasons	0.36	0.44	0.2626	352	464
Climate change impact: unpredictable and erratic rainfall patterns	0.25	0.35	0.4242	352	464

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Climate impacts on agriculture					
Reduced crop yields and productivity	0.91	0.88	0.69	349	461
Reduced livestock productivity	0.28	0.60	0.00***	349	461
Increased food prices	0.34	0.49	0.21	349	461
Limited availability of pastures	0.28	0.38	0.41	349	461
Reduced quality of pastures	0.26	0.39	0.07*	349	461
Climate impacts on wetlands					
Impact of climate change on wetland: decline/loss of wetland benefits	0.73	0.78	0.58	351	459
Impact of climate change on wetland: drought	0.60	0.66	0.77	351	459
Impact of climate change on wetland: drying of wetland vegetation	0.32	0.48	0.37	351	459
Impact of climate change on wetland: reduced water levels in wetlands	0.25	0.33	0.54	351	459
Impact of climate change on wetland: flooding	0.16	0.33	0.19	351	459

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 88: Descriptive statistics for connections of household and their attitude to risks

Variable	Treatment mean	Comparison mean	p-value	No. of obs. treatment	No. of obs. comparison
Having insurance	0.01	0.00	0.25	752	880
Being a leader in a local church or mosque	0.18	0.15	0.54	749	872
Having a position in the local government	0.12	0.11	0.73	749	874

Note: Column 4 displays the p-value for the differences in mean values between treatment and comparison households. Standard errors are clustered at the district level. Significance levels are indicated by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Appendix 14. Power calculations

Table 89: Power calculations

Indicator	Mean	Baseline sd	ICC	Total sample	Min. detectable effect size	MDES stand	% change
Income sources	1.38	0.84	10%	1,500	0.14	0.17	10%
Income sources	1.38	0.84	20%	1,500	0.17	0.20	12%
Income	1,831.61	2,854.58	10%	1,500	476.74	0.17	26%
Income	1,831.61	2,854.58	20%	1,500	578.74	0.20	32%
Food sec (HDDS)	5.15	1.42	10%	1,500	0.24	0.17	5%
Food sec (HDDS)	5.15	1.42	20%	1,500	0.29	0.20	6%
Food sec (MAHFP)	3.12	1.93	10%	1,500	0.32	0.17	10%
Food sec (MAHFP)	3.12	1.93	20%	1,500	0.39	0.20	13%
Food sec (HFIA)	6.22	5.46	10%	1,500	0.91	0.17	15%
Food sec (HFIA)	6.22	5.46	20%	1,500	1.11	0.20	18%

Appendix 15. Baseline results: Tables by gender of the household head

Table 90: Baseline results by gender of household head: demographics

Variable	Female-headed household		Male-headed household		Total	p-value
	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	N/Clusters	
Age of the household head	384	50.26	899	47.50	1,283	0.15
	8	(1.33)	8	(1.10)	8	
Adult equivalence score	320	4.14	864	4.47	1,184	0.34
	8	(0.48)	8	(0.47)	8	
Dependency ratio (based on minors)	291	0.62	770	0.61	1,061	0.81
	8	(0.03)	8	(0.02)	8	
Married	384	0.43	951	0.93	1,335	0.00***
	8	(0.05)	8	(0.02)	8	
Widowed	384	0.45	951	0.03	1,335	0.00***
	8	(0.04)	8	(0.01)	8	
Single	384	0.12	951	0.04	1,335	0.01**

Variable	Female-headed household		Male-headed household		Total	p-value
	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	N/Clusters	
	8	(0.02)	8	(0.01)	8	
Years in current house	371	30.30	907	36.36	1,278	0.01**
	8	(1.30)	8	(2.08)	8	
Education level household head	384	1.92	951	2.46	1,335	0.00***
	8	(0.07)	8	(0.07)	8	
No formal education	384	0.31	951	0.15	1,335	0.00***
	8	(0.05)	8	(0.03)	8	
Primary	384	0.53	951	0.53	1,335	0.94
	8	(0.05)	8	(0.04)	8	
O' Level	384	0.13	951	0.20	1,335	0.00***
	8	(0.01)	8	(0.02)	8	
A' Level	384	0.00	951	0.03	1,335	0.01***
	8	(0.00)	8	(0.01)	8	
Certificate	384	0.02	951	0.02	1,335	0.91

Variable	Female-headed household		Male-headed household		Total	p-value
	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	N/Clusters	
	8	(0.01)	8	(0.01)	8	
Vocational training	384	0.01	951	0.02	1,335	0.01***
	8	(0.00)	8	(0.00)	8	
Diploma	384	0.01	951	0.02	1,335	0.09*
	8	(0.00)	8	(0.01)	8	
Bachelor's degree	384	0.00	951	0.01	1,335	0.06*
	8	(0.00)	8	(0.01)	8	

Table 91: Baseline results by gender of household head: sustainable management practices

Variable	Female-headed household		Male-headed household		Total	p-value
	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	N/Clusters	
Sustainable land management practices: inter-cropping	99	0.66	283	0.58	382	0.12
	8	(0.06)	8	(0.06)	8	
Sustainable land management practices: crop rotation	99	0.42	283	0.52	382	0.19

Variable	Female-headed household		Male-headed household		Total	p-value
	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	N/Clusters	
	8	(0.13)	8	(0.10)	8	
Sustainable land management practices: mulching	99	0.51	283	0.45	382	0.28
	8	(0.15)	8	(0.14)	8	
Sustainable land management practices: cover crops	99	0.22	283	0.27	382	0.58
	8	(0.07)	8	(0.07)	8	
Sustainable land management practices: use of animal and green manure	99	0.16	283	0.24	382	0.22
	8	(0.05)	8	(0.07)	8	

Table 92: Baseline results by gender of household head: number of sustainable management practices

Variable	Female-headed household		Male-headed household		Total	p-value
	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	N/Clusters	
Using sustainable land management practices in the garden	293	0.34	767	0.37	1,060	0.69
	8	(0.08)	8	(0.05)	8	

Variable	Female-headed household		Male-headed household		Total	p-value
	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	N/Clusters	
Number of sustainable land management practices conducted by household	99	2.49	283	2.81	382	0.43
	8	(0.37)	8	(0.47)	8	

Table 93: Baseline results by gender of household head: Practices and factors contributing to local climate change

Variable	Female-headed household		Male-headed household		Total	p-value
	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	N/Clusters	
Practices and factors contributing to local climate change: cutting down trees	177	0.77	482	0.81	659	0.47
	8	(0.07)	8	(0.04)	8	
Practices and factors contributing to local climate change: encroachment of wetlands	177	0.62	482	0.71	659	0.01***
	8	(0.06)	8	(0.05)	8	
Practices and factors contributing to local climate change: poor farming methods	177	0.45	482	0.46	659	0.59
	8	(0.08)	8	(0.08)	8	

Variable	Female-headed household		Male-headed household		Total	p-value
	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	N/Clusters	
Practices and factors contributing to local climate change: over grazing	177	0.36	482	0.38	659	0.56
	8	(0.10)	8	(0.08)	8	
Practices and factors contributing to local climate change: environmental degradation	177	0.34	482	0.36	659	0.87
	8	(0.07)	8	(0.04)	8	

Table 94: Baseline results by gender of household head: wetland restoration and management activities

Variable	Female-headed household		Male-headed household		Total	p-value
	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	N/Clusters	
Demarcation of the boundary of wetlands	197	0.73	460	0.70	657	0.61
	8	(0.11)	8	(0.11)	8	
Sensitization of people about the benefits of wetlands	197	0.53	460	0.55	657	0.82
	8	(0.08)	8	(0.06)	8	
Blocking of channels	197	0.24	460	0.27	657	0.62

Variable	Female-headed household		Male-headed household		Total	p-value
	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	N/Clusters	
	8	(0.08)	8	(0.07)	8	
Sensitization on the wetlands policy and environmental laws	197	0.18	460	0.23	657	0.10*
	8	(0.05)	8	(0.07)	8	
Development and implementation of a community wetland management plan	197	0.09	460	0.13	657	0.28
	8	(0.04)	8	(0.04)	8	

Table 95: Baseline results by gender of household head: challenges to crop production

Variable	Female-headed household		Male-headed household		Total	p-value
	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	N/Clusters	
Challenges to crop production: pests and diseases	298	0.84	778	0.90	1,076	0.16
	8	(0.036)	8	(0.02)	8	
Challenges to crop production: price fluctuations	298	0.38	778	0.46	1,076	0.09*
	8	(0.05)	8	(0.05)	8	
Challenges to crop production: unreliable rainfall	298	0.30	778	0.38	1,076	0.07*

Variable	Female-headed household		Male-headed household		Total	p-value
	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	N/Clusters	
	8	(0.06)	8	(0.05)	8	
Challenges to crop production: low soil fertility	298	0.30	778	0.32	1,076	0.63
	8	(0.08)	8	(0.06)	8	
Challenges to crop production: prolonged dry spells	298	0.23	778	0.28	1,076	0.16
	8	(0.06)	8	(0.06)	8	

Table 96: Baseline results by gender of household head: livelihood activities

Variable	Female-headed household		Male-headed household		Total	p-value
	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	N/Clusters	
Number of livelihood activities	384	1.30	951	1.52	1,335	0.04**
	8	(0.11)	8	(0.15)	8	
Livelihood activities: crop farming	353	0.76	895	0.83	1,248	0.02**
	8	(0.04)	8	(0.05)	8	
Livelihood activities: livestock farming	353	0.13	895	0.22	1,248	0.08*
	8	(0.03)	8	(0.06)	8	

Variable	Female-headed household		Male-headed household		Total	p-value
	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	N/Clusters	
Livelihood activities: casual labouring	353	0.16	895	0.15	1,248	0.97
	8	(0.03)	8	(0.02)	8	
Livelihood activities: small-scale businesses	353	0.12	895	0.11	1,248	0.52
	8	(0.04)	8	(0.03)	8	
Livelihood activities: brick-making	353	0.02	895	0.07	1,248	0.03**
	8	(0.01)	8	(0.02)	8	

Table 97: Baseline results by gender of household head: food diversity and insecurity indicators

Variable	Female-headed household		Male-headed household		Total	p-value
	N/Clusters	Mean/(SE)	N/Clusters	Mean/(SE)	N/Clusters	
HDDS	376	6.60	927	7.04	1,303	0.19
	8	(0.61)	8	(0.56)	8	
FIES - 12 months	192	1.64	529	1.45	721	0.23
	8	(0.26)	8	(0.15)	8	

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