RESEARCH REPORT

ASSESSING THE EFFECTS OF CLIMATE CHANGE ON LIVELIHOODS, HUMAN RIGHTS, AND ENVIRONMENTAL PROTECTION IN THE WEST NILE REGION OF UGANDA

November 2025

RICE WEST NILE
Striving for Self Reliance

FRIENDS OF ZOKA
My Environment, My Life

SPACE

ACEMP
Africa Centre For Energy And Mineral Policy

Report Prepared by:

P.O BOX 481 Arua City, Uganda,
Anyafio Cell - Mvara Ward, Weatherhead Lane Odaa - Awudele Road
Tel. +256-393-238-163
E-mail: jambo@ricewestnile.org

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APPROVAL

This research, titled "**Assessing the Effects of Climate Change on Livelihoods, Human Rights, and Environmental Protection in West Nile, Uganda,**" was undertaken by a team of researchers from Muni University for the project "Strengthening Environmental Accountability and Climate Action in West Nile," implemented by RICE West Nile and its partners.

Prepared by (Muni University):

Sign _____ Date: 28/11/2025

Robert Kajobe
Director Graduate Training, Research and Innovation, Muni University

Approved by (Muni University):

Sign _____ Date: 01/04/2026

Associate Professor Simon Anguma Katrini
Vice Chancellor (VC) of Muni University, Muni University

Reviewed by (RICE West Nile):

Sign _____ Date 02/12/2025

Jackson Olema
Consortium Project Manager, Rural Initiative for Community Empowerment (RICE West Nile)

Approved by (RICE West Nile)

Sign _____ Date 1/4/2026

Pax Sakari
Executive Director, Rural Initiative for Community Empowerment (RICE West Nile)

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LIST OF ACRONYMS

CARE: Cooperative for Assistance and Relief Everywhere

FAO: Food and Agriculture Organization of the United Nations

FoZ: Friends of Zoka

IPBES: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

IPCC: Intergovernmental Panel on Climate Change

MWE: Ministry of Water and Environment (Uganda)

NEMA: National Environment Management Authority (Uganda)

OHCHR: Office of the United Nations High Commissioner for Human Rights

RICE: Rural Initiative for Community Empowerment, West Nile

SPACE: Sustainable Plan and Action for Community Empowerment

UBOS: Uganda Bureau of Standards

UNHCR: United Nations High Commissioner for Refugees

USAID: United States Agency for International Development

WRI: World Resources Institute

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EXECUTIVE SUMMARY

Livelihoods in the West Nile region of Uganda are primarily sustained through subsistence agriculture, alongside various small-scale activities such as livestock keeping, fishing along the Nile, local community-based trade, and so forth. Such livelihood strategies are highly sensitive to climate variability, including erratic rainfall, prolonged dry periods, and floods, among others. This study was undertaken to generate robust local evidence of climate change impacts on livelihoods, human rights, and environmental resources, and identify local drivers of climate vulnerability, to inform the development of appropriate adaptive interventions.

A mixed-methods approach was adopted, combining household surveys, key informant interviews, direct observation, and GIS. Sampling captured variations across districts, population groups, and livelihood types. Data collection focused on disruptions to livelihood activities, perceived human rights violations, environmental degradation, and human activities driving vulnerability. Analysis was conducted to identify overall patterns, as well as disaggregated trends by district, gender, age, disability status, and refugee/host community status, providing a nuanced understanding of vulnerability in the region.

The findings indicate that climate shocks have significantly affected livelihoods across the study area. These include increased crop failures (74.4%), reduced pastures (81.0%), and increased disease and parasite pressure (65.6%) among livestock systems, and reduced trade opportunities through declining demand (79.8%) among local petty traders. There were also signs of infrastructural damage, such as damaged roads due to floods. The highest levels of disruption were recorded in Adjumani and Obongi, areas characterized by mixed refugee and host populations. While Madi Okollo and Zombo experienced relatively lower overall disruption, certain sectors, particularly food security and water-dependent livelihoods, remained highly vulnerable. These livelihood impacts were closely linked to environmental degradation and socio-economic marginalization.

Climate-related events were perceived to undermine multiple human rights, with the most commonly reported violations affecting access to water (69.2%), food (59.0%), and health (58.1%) services. Obongi and Adjumani registered the highest proportions of respondents

reporting multiple rights infringements, reflecting the compounded pressures of climate shocks, population displacement, and limited adaptive capacity. Persons with disabilities reported slightly lower deprivation across most rights, particularly those related to food, work, and livelihood, perhaps due to existing affirmative actions. Gender differences were also evident, with women experiencing more pronounced deprivation in food security, livelihoods, housing, and participation in decision-making, while education, health, and water rights were significantly affected for both genders. Refugees faced severe deprivation in food security and livelihood opportunities, whereas nationals experienced higher exclusion from decision-making processes and, in some instances, greater health-related challenges. Youth were particularly affected in areas of work, education, livelihood, and access to water, indicating age-related disparities in climate vulnerability.

Environmental assessments revealed widespread degradation of surface water, soil, and vegetation. Reduced water volumes (77.0%) and seasonal drying (52.8) were prevalent, alongside flooding, turbidity, silting, and declines in water quality, driven largely by farming near water bodies (79.8), brick laying (68.9), grazing (53.0), and sand mining (41.8). Soil degradation manifested as bare patches, reduced fertility, gully formation, and the exposure of rock outcrops, with deforestation, firewood collection, and overgrazing identified as the main anthropogenic drivers. Vegetation loss, including tree and grassland reduction exacerbated by slash-and-burn practices, further compromised soil fertility, water retention, and ecosystem resilience.

The study identified several local human activities as key drivers of climate vulnerability. Deforestation was reported by nearly all respondents, followed closely by slash-and-burn agriculture, livestock farming, poor soil management, and charcoal and firewood use. Additional contributors included population encroachment, wetland drainage, overuse of chemical fertilizers, construction, small-scale mining, and diesel engine use. District-specific variations in these activities highlight the need for localized interventions that consider both ecological and socio-economic contexts.

In conclusion, climate change has significantly undermined livelihoods, human rights, and environmental resources in the West Nile region. Vulnerability is unevenly distributed,

disproportionately affecting women, youth, persons with disabilities, and refugees. Environmental degradation compounds exposure to climate shocks, creating feedback loops that threaten both human well-being and ecosystem integrity.

To enhance resilience, development efforts should focus on the following;

- Promote climate-smart agriculture, such as drought-tolerant crops and improved varieties of the drought-prone crops:
- Diversify income sources: There are indications of potential diversification, although livelihoods remain predominantly (89%) agriculturally based. However, the available non-farm income sources, as well as multiple agricultural enterprises, should be promoted
- Strengthen social protection measures for vulnerable groups. Ensuring equitable access to food, water, health services, education, and decision-making opportunities is critical, with particular attention to marginalized populations. However, this should be informed by a more detailed analysis of intersectionality.
- Promoting sustainable land-use practices, reforestation, soil and water conservation measures, and regulation of high-impact activities are necessary to restore ecosystem functions.
- Inclusive governance and participatory decision-making can strengthen adaptive capacity, while monitoring systems are essential to track climate impacts, environmental degradation, and rights violations.

Collectively, these interventions can reduce vulnerability, safeguard livelihoods, and maintain the ecological foundations necessary for sustainable development in the West Nile region.

1 INTRODUCTION

1.1 Background

Climate change is a serious threat to human well-being and the planet's ecological balance (Wright et al., 2024). It manifests through rising global temperatures, frequent heatwaves, erratic rainfall, prolonged droughts, and extreme weather events, which increasingly disrupt the natural systems upon which human life depends (Mwaura, 2014). These climatic shifts directly affect sectors that depend more on natural resources, such as agriculture, fishing, forestry, and agro-based industries. As a result, a wide range of socio-ecological effects ensues, including food insecurity, environmental degradation, the emergence of pests and diseases, and heightened economic vulnerability. Human activities such as deforestation, urbanisation, industrialization, and unsustainable waste management exacerbate the situation by accelerating the release of greenhouse gases (GHGs), thereby destabilizing the global carbon balance. The major GHGs include carbon dioxide, methane, and nitrogen oxides (Hegerl et al., 2019; Kanitkar and Jayaraman, 2025).

While climate change is a global phenomenon, its effects and causes are unevenly distributed. Industrialized nations have historically contributed the largest share of greenhouse gas emissions, while many developing countries, particularly those in the Global South, face the most severe consequences. Furthermore, inequities also exist within countries and communities. For instance, subsistence farmers are highly exposed to climate-induced droughts and pest outbreaks, fishing communities face declining water quality and diminishing fish stocks, and pastoralists struggle with increasingly degraded rangelands. By contrast, high-emission sectors such as transportation and manufacturing remain largely insulated from the immediate physical impacts of climate change, even though they contribute disproportionately to its causes. Existing socio-economic and cultural inequalities, including gender-based roles, disability status, and generational divisions aggravate these disparities. Such realities have brought climate justice to the centre of global and national discourse, framing climate change not only as an environmental issue but also as a matter of rights, equity, and power. The four pillars of climate justice, namely,

compensatory, distributive, procedural, and intergenerational justice, highlight the need to address both the causes and the differentiated impacts of climate change.

In Uganda, these global dynamics play out acutely at the local level. The West Nile region, characterized by high dependence on climate-sensitive livelihoods and limited adaptive capacity, is especially exposed to the effects of a changing climate. Livelihood disruptions, threats to fundamental human rights such as access to food, water, and a healthy environment, and the degradation of ecological systems are increasingly common. Yet, empirical data to inform equitable climate responses in such vulnerable regions remain sparse. This study contributes to the broader climate justice discourse by empirically assessing the effects of climate change on livelihoods, human rights, and environmental protection in the West Nile region of Uganda. It aims to support evidence-based policy and strengthen the capacity of duty-bearers to act justly and effectively in the face of climate risks.

1.2 Context

The West Nile region, located in northwestern Uganda, exemplifies the complex realities of rural communities facing the vagaries of climate change. It is predominantly characterised by an agrarian population, many of whom live under conditions of monetary (63%) and multidimensional (59%) poverty (UBOS, 2022). The region relies heavily on small-scale, rain-fed farming systems and is thus highly sensitive to climatic variability. It experiences a unimodal rainfall pattern, characterised by a long, intense rainy season followed by an equally intense dry spell, which makes it prone to both extremes of floods and drought effects of climate change. Livelihood activities are, however, nuanced by micro-zones, ranging from perennial cropping in the highlands (e.g., Zombo part of Nebbi and Arua districts) to livestock keeping and fishing in the lowlands (Adjumani, Obongi, and part of Madi Okollo), with varying vulnerability to changing rainfall patterns, prolonged dry spells, and land degradation. These differences in the micro-zones ostensibly affect the vulnerability and severity of climate change (Monaghan et al., 2012). The low altitude close to the Nile results in relatively higher temperatures and limits agricultural diversity. On the other hand, high altitude areas have lower temperatures and favour a greater agricultural

diversity, which improves their resilience. A greater part of the subregion falls between these two contrasting extremes. These vulnerabilities are further aggravated by rapid population growth, low agricultural productivity, and high rates of malnutrition. The refugee influx from South Sudan and the Democratic Republic of Congo has placed additional pressure on natural resources, especially land and water, further heightening exposure to environmental stress and threatening the viability of already fragile livelihood strategies. While Uganda has a relatively favourable Refuge strategy whereby the refugees are allotted startup land and supported to build livelihood. The allocated land (30 m by 30 m) is too small to support settlement and livelihood options. This probably explains why people sometimes engage in unsustainable practices such as deforestation and charcoal production.

In this context, the effects of climate change are not experienced uniformly. Socioeconomic status, gender, and other forms of social differentiation influence how individuals and groups experience livelihood loss, access to support systems, and the erosion of rights such as access to food, water, and a healthy environment. At the same time, local environmental degradation, driven by unsustainable land use and high dependence on biomass for energy, undermines both ecosystem health and community resilience. Despite these intersecting risks, evidence on how climate change affects human rights, ecological integrity, and livelihood opportunities in the West Nile remains limited.

1.3 Strengthening Environmental Accountability and Climate Action in West Nile-Project

This study was conceived as part of a 41-month project, titled "Strengthening Environmental Accountability and Climate Action in West Nile," implemented in the districts of Zombo, Madi Okollo, Obongi, and Adjumani by a consortium comprised of RICE West Nile (lead implementer), Friends of Zoka (FOZ), and Sustainable Plan and Action for Community Empowerment (SPACE) with funding from Royal Danish Embassy. The project's goal is "Improved protection and sustainable utilization of natural resources among the communities in West Nile Region."

The study particularly investigated climate change impacts across social and ecological dimensions, identifying key drivers of vulnerability, and mapping the availability of adaptive measures and support systems. The aim was to generate context-specific knowledge that can inform inclusive, justice-oriented climate interventions for West Nile's rural communities. As such, it lays a critical foundation for implementation by offering a baseline for comparing progress, while also generating credible, locally grounded evidence to guide climate-responsive interventions.

Climate change impacts transcend immediate manifestations such as rising temperatures, heatwaves, erratic rainfall, flooding, and the resulting agricultural losses, extending to effects on food availability and prices that exacerbate existing social and economic vulnerabilities. These include youth underemployment, limited access to social protection, and environmental degradation. Addressing these complex challenges, therefore, requires a climate justice lens, targeted advocacy, policy reform, and timely action from duty bearers at both the community and District Local Government levels. This study contributes to this discourse by unravelling *"The Effects of Climate Change on Livelihoods, Human Rights, and Environmental Protection in West Nile."*

1.4 Research objectives

The overall objective of the study was to assess the effects of climate change on livelihoods, human rights, and environmental protection in West Nile, and to generate evidence to inform climate justice-oriented interventions. This was achieved through five specific objectives, namely:

1. To examine the impact of climate change on the selected livelihood strategies in West Nile.
2. To assess available resources and support services towards livelihood resilience in West Nile.
3. To investigate the impacts of climate change on human rights in the region in West Nile.
4. To explore the effects of climate change on environmental resources, ecosystems, and protection in West Nile.
5. To investigate the main drivers of climate change in West Nile.

1.5 Research questions

The study was guided by five broad research questions, namely:

1. What local manifestations of climate change are being experienced, as identified by community members?
2. What are the main local drivers of climate vulnerability within livelihood systems? Recognising the scope, this question focused more on human-induced drivers since natural drivers operate more appreciably at the global scale and over long-time scales.
3. How have the manifestations of climate change affected each of the selected livelihood options?
4. What resources and support services are available to different social groups to strengthen livelihood resilience in the face of climate change?
5. Which human rights are most at risk due to the impacts of climate change across different societal groups?

Through answering these questions, the study divulged context-specific evidence and suggested recommendations to support the design of more inclusive, equitable, and sustainable climate actions for rural communities in the West Nile region, while directly aligning with and fulfilling the study's objectives.

1.6 Justification of the Research Questions

1.6.1 Impact of Climate Change on Selected Livelihood Strategies

The West Nile region of Uganda is predominantly rural, with communities relying heavily on subsistence agriculture, fishing, livestock keeping, and small-scale trade for their livelihoods (UBOS, 2022). These livelihood strategies are highly sensitive to climate variability and extremes, including shifts in rainfall patterns, prolonged droughts, floods, and pest infestations (Destrijcker et al., 2023; Abyot et al., 2024; NEMA, 2024). While national and regional reports highlight general vulnerability, there is limited localized evidence on how specific livelihood strategies in West Nile have been affected over time. Furthermore, the differentiated impacts on social groups such as women, youth, and refugees remain

underexplored. This study contributes empirical evidence on these variations to inform more targeted and adaptive livelihood interventions.

1.6.2 Available Resources and Support Services for Livelihood Resilience

Livelihood resilience not only depends on exposure to climate risks but also on access to enabling resources such as microcredit, quality seeds, extension services, training, and early warning systems (FAO, 2016). Although national and donor-funded projects sought to enhance resilience, their coverage, accessibility, and effectiveness in West Nile were uneven and poorly documented (MWE, 2015; USAID, 2017). This research assessed the availability and accessibility.

1.6.3 Impacts of Climate Change on Human Rights

Climate change threatens fundamental human rights, including access to food, water, shelter, education, and health (OHCHR, 2020; UNHCR, 2021). These vulnerabilities are particularly expected in the West Nile region, which hosts a large refugee population and marginalized communities. While global studies link climate stress to displacement, resource conflicts, and gender-based vulnerabilities, few systematically document these effects in Uganda. The study thus examined how climate change affects selected human rights outcomes across demographic and socio-economic groups, contributing to discussions on climate justice and protection in displacement settings.

1.6.4 Effects on Environmental Resources and Ecosystem Services

Forests, wetlands, rivers, and rangelands in West Nile provide essential ecosystem services, including water filtration, soil retention, and climate regulation (NEMA, 2019; IPBES, 2018). However, these resources face increasing pressure from both climate change and unsustainable land use, leading to reduced productivity, heightened flood risk, and biodiversity loss (WRI, 2020). Existing assessments in Uganda are fragmented, with limited integration of climate and anthropogenic pressures. The research mapped the state of key environmental resources, providing evidence to support ecosystem-based adaptation strategies tailored to West Nile.

1.6.5 Local Drivers of Climate Change

While climate change is driven by global processes, its local effects are often intensified by context-specific drivers such as deforestation, land degradation, overgrazing, charcoal burning, and unsustainable agricultural practices (IPCC, 2021; MWE, 2015). These drivers contribute to greenhouse gas emissions and reduce community resilience. However, knowledge is fragmented, with limited integration of community perspectives and socio-economic drivers. This study identified locally perceived and scientifically documented local drivers of climate stress, providing a holistic basis for designing realistic mitigation and adaptation strategies.

1.7 Cross-Cutting Issues

Aligned with principles of climate equity and inclusive adaptation, the study integrated gender, youth, persons with disabilities, and vulnerable populations as cross-cutting concerns. Evidence indicates that women and youth faced unique barriers in accessing climate information, finance, and decision-making platforms (UN Women, 2021; CARE, 2019). By disaggregating data with respect to gender, age, and other social indicators and employing participatory methods, the study ensured the inclusion of underrepresented voices. This approach enhanced research validity and grounded policy recommendations in the realities of all stakeholders.

1.8 Conceptual framework

The study adopted a conceptual framework (Figure 1) that illustrates how climate change interacts with moderating variables to influence livelihoods, human rights, and environmental systems in the West Nile region of Uganda. It recognises climate change as a major driver of socio-economic and ecological transformations, exerting both direct and indirect impacts on people's livelihoods and the sustainability of natural resources. These impacts manifest through extreme events such as prolonged droughts, increased temperatures, and recurrent floods that disrupt agricultural productivity, which forms the backbone of local livelihoods (Shivanna, 2022). The effects include increased pest and disease outbreaks, reduced crop yields, and the spread of zoonotic infections. As these

stresses intensify, households experience income losses, food insecurity, and weakened resilience, often resorting to unsustainable coping strategies that further strain natural ecosystems.

The effects of climate change are not uniform. They are moderated by a range of socioeconomic, demographic, and institutional factors that determine how communities experience and respond to climate-induced stress. Differences in income, access to land, credit, and information shape adaptive capacity, while gender, age, resource endowment, and location further influence vulnerability. The guilt of human contribution to climate change is also unevenly distributed, just as (should be) the burden of adaptation and restoration varies, raising important questions of climate justice. Institutional and policy frameworks act as additional moderating factors. Effective regulations, extension services, and interventions by government, NGOs, and private actors can enhance resilience, while weak or poorly implemented policies exacerbate vulnerability and inequality.

The combined influence of climate change and these moderating factors produces interlinked outcomes across livelihood, environmental, and social domains. At the livelihood level, households face declining productivity, poverty, and food insecurity, often turning to extractive activities such as deforestation and wetland encroachment that accelerate environmental degradation. The resulting loss of vegetation cover, soil fertility, and ecosystem stability undermines the region's ecological integrity and capacity for recovery. Socially, competition over scarce resources intensifies, leading to conflict, social fragmentation, and human rights abuses, especially among marginalized groups such as women, the elderly, and the poor. This framework, therefore, guided the study in examining how climate change affects livelihood strategies, human rights, and environmental systems, and how available resources, institutional support, and policy interventions can strengthen resilience in West Nile.

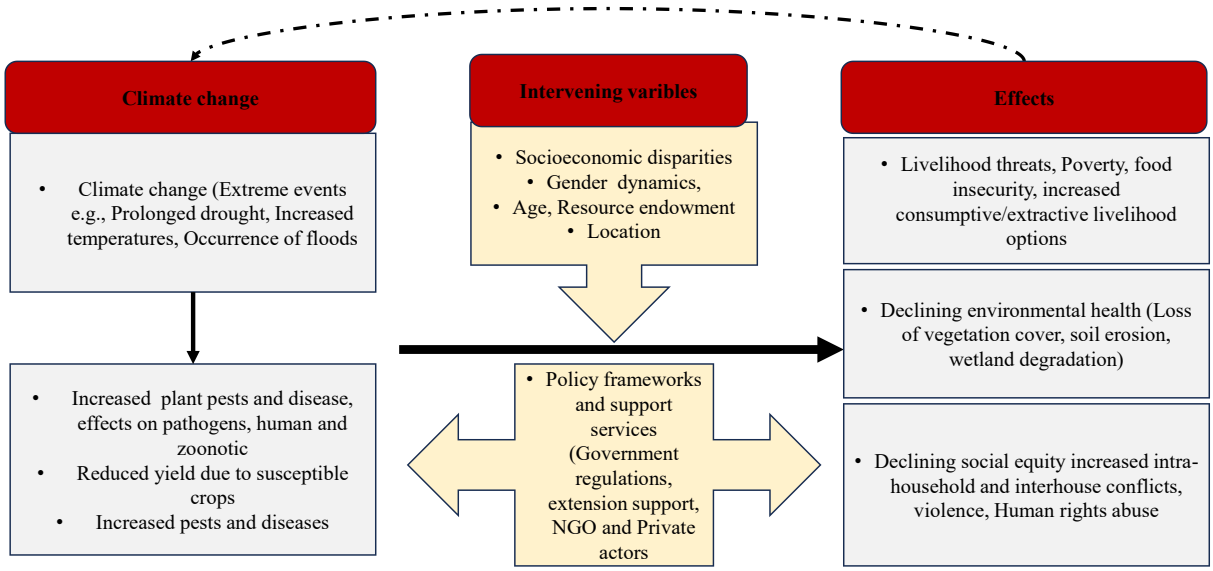

Figure 1: Conceptual framework

2 METHODOLOGY

2.1 Study area

The study was conducted in four districts of the West Nile sub-region of Uganda: Obongi, Adjumani, Madi Okollo, and Zombo. Within these districts, the study covered selected sub-counties, namely Palorinya, Itula, Aliba, Gimara, and Ewafa in Obongi; Itirikwa, Ukusijoni, Pachara, Pakelle, and Dzaipi in Adjumani; Pawor, Ullepi, Okollo, Rigbo, and Rhino Camp in Madi Okollo; and Kango, Abanga, Paidha, Atyak, and Nyapea in Zombo. These areas were purposively selected because they constitute the implementation sites of the *Strengthening Environmental Accountability and Climate Action in West Nile Project*, under which this study was conducted.

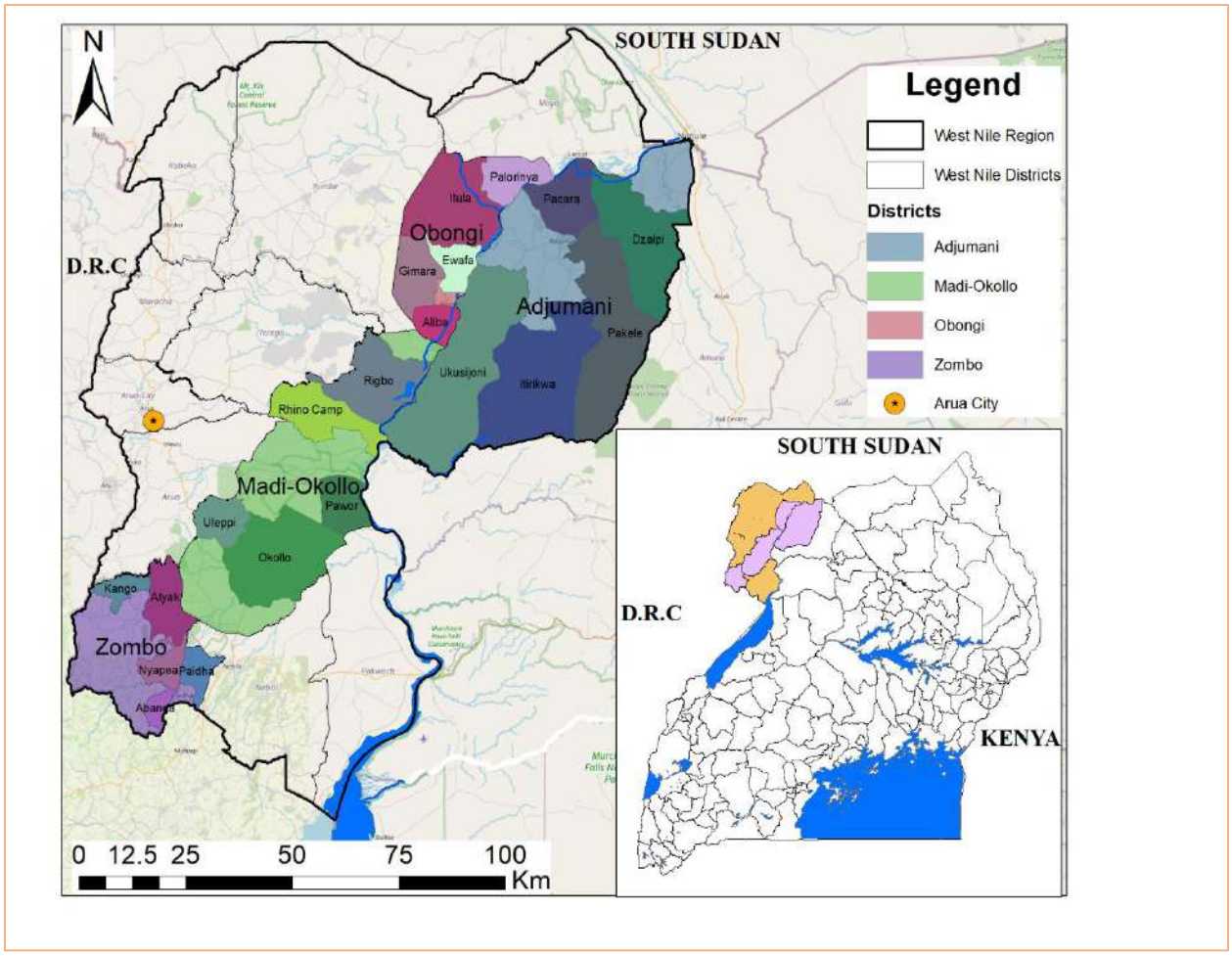

Figure 2: Location of the study area (Adjumani, Madi Okollo, Obongi, Zombo) and key reference features used for the spatial analysis

2.2 Overview of methods

The study adopted a mixed methods design integrating qualitative and quantitative approaches. It was predominantly quantitative, based on a semi-structured questionnaire, but included qualitative methods such as expert observations, informant interviews, focus group discussions, and GIS analysis. These were corroborated by a review of relevant secondary data from previous scientific studies, project reports, and national studies conducted by the Uganda Bureau of Statistics (UBOS).

The mixed methods approach was adopted in order to comprehensively understand the multifaceted and interlinked effects of climate change on livelihoods, human rights, and environmental protection in the West Nile region. This needed a combination of objective 'measurement' and subjective lived experiences and perceptions. Quantitative methods such as structured surveys and GIS analyses allowed the measurement of patterns and trends across a wide sample, providing statistically valid insights into livelihood impacts, available resources, and environmental changes to permit drawing generalizable conclusions and identifying key relationships among variables such as socioeconomic status and vulnerability. At the same time, qualitative methods captured the nuanced, lived realities of affected communities and contextualized the quantitative data as well as the triangulation of peculiar findings.

2.1 Qualitative methods used

Qualitative methods were applied within an explanatory mixed-methods design, in which quantitative data were collected first to identify major patterns and generate initial insights. The qualitative phase thus served to validate the subsequent quantitative findings and to provide a deeper interpretation of the results from the participants' perspectives.

2.1.1 Key Informant Interviews (KIIs)

Key Informant Interviews (KIIs) were conducted with a total of 12 respondents comprising two cattle-herding youth, three farmers, three staff from project implementing partners, one sand miner, and three local council leaders selected from the study sites. Information obtained from the local council leaders focused on providing a broad overview relevant to

all study objectives, while the other respondents were engaged to provide insights on specific thematic areas and localized experiences. For instance, discussions with cattle herders explored the effects of surface water degradation on livestock health and coping strategies, while farmers and other community members provided information on their experiences with key environmental resources, livelihood impacts, and adaptation practices.

2.1.2 Observation

Observation walks were conducted in selected landscapes targeting key environmental resources such as surface water bodies, forests, and grasslands, as well as personal fields (gardens and courtyards) and other modified lands, including roadsides, sand mines, and earth extraction sites. Each observation team consisted of two to three members guided by a local expert familiar with the landscape. The exercise was guided by a checklist that focused on the condition of major natural resources in each district, particularly forests, wetlands, and rivers or streams. Observations concentrated on assessing the extent of degradation of these resources resulting from the combined influence of climate change and human activities, as well as on identifying existing conservation measures. At selected observation points, informal interviews were conducted with local stakeholders to obtain additional contextual information. Photographs were taken with verbal consent from the respective stakeholders.

2.1.3 GIS analysis

A Geographic Information System (GIS) analysis was conducted to assess land use and land cover (LULC) changes in the study area between 2001 and 2021. This enabled the identification of major environmental transformations and the quantification of how land cover categories such as forests, wetlands, croplands, grasslands, and water bodies have changed over time.

The analysis used freely available and official spatial datasets that provide adequate regional coverage. Landsat 7 (2001), Landsat 8 (2011), and Landsat 9 (2021) scenes at 30-meter resolution were obtained from the USGS Earth Explorer platform. Scenes with minimal cloud cover were prioritized. Base maps: Administrative boundaries, rivers, and roads were

acquired from the Uganda Bureau of Statistics (UBOS) and the National Forestry Authority (NFA) for georeferencing and map layout. Image processing was performed in ArcGIS Pro using standard procedures. The images were clipped to the study area and visually enhanced to improve interpretability. Supervised classification was applied using representative training samples for six main land cover categories: forest, cropland, wetland, grassland, water, and built-up areas. The Maximum Likelihood algorithm was adopted to produce consistent LULC maps for 2001, 2011, and 2021. Accuracy checks were carried out through visual comparison with high-resolution basemaps to confirm classification reliability. Classified maps were compared through post-classification change detection to determine gains and losses in each land cover type.

2.2 Quantitative survey

2.2.1 Sample Size

The sample size was based on Yamane's table (Yamane, 1967). Sample determination by this method requires two information inputs, viz, target population size (N), and the desired significance level (α). In this study, the significance level was set at 0.05 (5%), and the target number of households was approximately 183,185 (UBOS, 2024). According to these, a population size of 400 would be suggested, which translates to a subsample of 100 per district. However, the sample (in each district) had to include various interest groups who are ostensibly more prone to the climate change effect, for example, include male-headed versus female-headed households, adult versus youth-headed households, refugees versus host community, and people with disability versus those without. Moreover, it is advised that each of the subgroups should have at least 30-50 observations for descriptive and t-test analysis, or at least 100 if regression analysis is required. Thus, a district-level sub-sample of 120 and an overall sample size of 480 were selected to cater for potential missing respondents and non- response on key questions. However, the success rate was lower, especially in refugee-hosting areas of the study. Actual sample sizes are indicated in the results section.

2.2.2 Sampling design

A multi-stage sampling technique was employed to obtain a sample that ensured representation of both the geographical scope and different interest groups. In the first stage, the four districts and their respective sub-counties (five each) and villages hosting the project were purposively selected. In the second stage, quota sampling was applied to ensure inclusion of persons with disabilities (PWDs), who constituted 25% of the sample, while the remaining 75% comprised non-PWDs. This translated into a sub-sample of 30 PWDs and 90 non-PWDs from each district, which was equally distributed among the five sub-counties in each district. Among the selected villages, the implementers identified refugee-hosting villages to ensure representation of both refugees and host communities. This approach of including refugees was adopted to target those who had been fairly integrated within the host communities and were therefore assumed to have had an impact on the climate and environmental status of the area. Given that Zombo District did not host refugees, the village samples in refugee-hosting areas of Adjumani and Madi-Okollo were adjusted to achieve a more balanced representation of refugees. However, data collection in one of the selected villages in Adjumani was not possible due to practical constraints. Nevertheless, the resulting sample remained sufficient for descriptive and comparative analysis. The final selection of households followed probability proportional sampling, guided by the relative proportions of different gender and age groups as reported in the most recent population census (UBOS, 2024). According to the census, 17.5% of households in West Nile were female-headed, while 23.1% were youth-headed. The sampling frames were generated in consultation with the Local council chairpersons in respective villages.

2.2.3 Quantitative data collection and analysis

2.2.3.1 Development of the questionnaire and deployment

A structured questionnaire was developed based on the literature and expert guidance for all the objectives. It was digitized using KOBO toolbox, which is part of the open-source data kit (ODK) software. Before the actual data collection, the questionnaire was approved by RICE West Nile, pretested (at least two interviews per enumerator) from one of the villages within the district (but not included in the sample) to assess the clarity of the questions and

reliability of the objectives. Insights from the pretesting were used to develop the final version of the questionnaire. The adjustments made after pretest included refinement of some questions, splitting a few, and clarifying some phrasing.

2.2.3.2 Data analysis

The data were cleaned and analysed using Microsoft Excel and SPSS. For Objective One, summary statistics were generated to examine the impact of climate change on the selected livelihood strategies over the last decade. For Objective Two, descriptive analysis was conducted to assess the availability of local strategies and support services that enhance livelihood resilience. Analysis for Objective Three focused on identifying and describing the major human rights abuses or deprivations associated with different livelihood options in the context of climate change. For Objective Four, descriptive statistics were used to explore the perceived effects of climate change on environmental resources, ecosystems, and protection efforts, complemented by GIS analysis to visualize spatial patterns. Finally, analysis for Objective Five employed descriptive statistics to identify and summarize the main drivers of climate change in the West Nile region. For all objectives, results were disaggregated by district, gender, age group, and nationality to capture contextual variations.

2.2.3.3 Data quality assurance

The questionnaire was deployed in a digital version using Kobocollect to provide for real-time data quality assessment, reduce the time needed for data entry, and minimize associated errors. The survey was conducted by nine trained enumerators who were conversant with the languages of the study sites. As part of the quality assurance, all data collection tools were pre-approved by RICE West Nile, the lead implementer of the project.

2.2.3.4 Ethical considerations

Informed consent: Participant's consent was obtained at the beginning of the interview or any other data collection event. This was ensured by adding a compulsory question in the digital tool seeking consent and providing verbal consent for KII and observation.

Anonymity: Personal identification data, such as names, GPS coordinates, and telephone contacts, were collected to aid follow-up, such as random verification of the data for a given enumerator. However, they were not shared with any third party.

Sensitive questions: The questionnaire was co-developed by a balanced team, reviewed by the RICE team, and pre-tested before use. These checks ensured that information collected was only addressing the stated objectives and that no sensitive information was collected.

Confidentiality: Information collected from the respondents was handled with confidentiality. Data access was only allowed to the responsible persons, namely, the enumerators, Muni Research team, and the respective authorities in RICE West Nile.

Ethical clearance: The research proposal and all associated tools were reviewed and approved by the Directorate of Graduate Training, Research and Innovation, Muni University.

3 FINDINGS

3.0 Introduction

This chapter presents the empirical findings of the study and offers a brief reflection on their potential implications. A more comprehensive interpretation of these results is provided in the discussion chapter. The presentation begins with a profile of the respondents, outlining key socioeconomic characteristics that shape household vulnerability and adaptive capacity. This is followed by results organised according to the study objectives. The first set of findings describes the socioeconomic profile of the respondents, including disability status, gender of the household head, participation in producer groups, and levels of education, experience, household composition, landholding, and proximity to trading centres. These variables provide an essential foundation for understanding how different groups experience and respond to climate risks.

The chapter then presents results related to the core objective of assessing the effects of climate change on selected livelihood strategies in West Nile. This includes an overview of dominant livelihood activities, spatial evidence of agrarian dependence, alternative income sources, and reported climate impacts on these activities. The analysis further identifies available resources and support services that households rely on to strengthen resilience, as well as the adaptation strategies used across different socioeconomic typologies. Additional results highlight patterns of access to external assistance. Subsequent sections examine participants' perceptions of climate justice and document reported human rights risks associated with climate change. These are disaggregated by district, disability status, gender, refugee or host community identity, and age group to illuminate differences in lived experiences.

The chapter also presents evidence on environmental impacts, including land use and land cover change from 2001 to 2021, degradation of surface water resources, manifestations of soil degradation, human activities driving these trends, and loss of vegetation. The final section synthesizes local drivers of climate vulnerability, providing insight into underlying pressures that continue to shape exposure, sensitivity, and adaptive capacity across the region

3.1 Socioeconomic profile of the respondents

This subsection provides an overview of the study sample with respect to key socioeconomic and demographic attributes considered relevant for targeting or nuancing climate change actions.

3.1.1 Persons living with disability

The study adequately represented persons living with disabilities (PWD) (Table 1). On average, nearly 30% of the study participants were PWD, with the highest proportion observed in Adjumani district (33.7%) and the lowest in Zombo district (21.6%). These relative proportions are higher than the national (13.2%) and regional (14.6%) prevalences (UBOS, 2022), but were necessary to adequately capture the voice of PWD in this study. It is imperative to specifically target PWD in climate action programs and interventions to ensure equity, as they face barriers in accessing adaptation strategies and are often excluded from climate action initiatives.

Table 1: Percentage of household heads living with disability

			Household head has a disability (%)	
		N	No	Yes
District	Adjumani	95	66.3	33.7
	Madi Okollo	122	72.1	27.9
	Obongi	113	64.7	36.3
	Zombo	102	78.4	21.6
Overall		432	70.1	29.9

3.1.2 Gender of the household head

The households were predominantly led by males with a frequency of nearly 60% (Table 2). However, there was notable variability between districts, the highest (65%) noted in Madi-Okollo and the lowest in Adjumani (53.7%). While households are predominantly male-led, the frequency of female-headed households is fairly high (>30%), which suggests the need

for targeted actions since female-headed households are generally more resource-constrained in terms of labour, capital, and physical resources such as land. As such, they are more vulnerable to climate change.

Table 2: Gender composition of the house hold head

			Gender of HHH (%)	
		n	Female	Male
District	Adjumani	95	46.3	53.7
	Madi Okollo	122	35.2	64.8
	Obongi	113	42.7	57.3
	Zombo	102	35.6	64.4
Total		432	39.7	60.3

3.1.2.1 Gender composition of the household head desegregated by nationality

The gender composition of household heads varied noticeably between refugee and host communities. Among refugee households, females constituted the majority of household heads, accounting for 55.4% (Table 3). In contrast, the host population was predominantly male-headed, with 62.8% male household heads. These patterns suggest that refugee households may face unique vulnerabilities associated with a higher proportion of female-headed households, including greater caregiving burdens and potentially limited access to productive resources.

Table 3: Gender composition of the house hold head by nationality

			Gender	
		n	**Female**	**Male**
Nationality	Refugee	56	55.4	44.6
	Host Population	376	37.2	62.8
	Total	432	39.6	60.4

3.1.3 Membership in producer groups

Membership in producer groups varied considerably across districts (Table 4). Overall, about a quarter (27 %) of the respondents reported belonging to a producer group. The highest participation was observed in Adjumani, where 72% were group members. In contrast, membership was much lower in Madi-Okollo (31 %), Obongi (21 %), and especially Zombo (6 %). These differences suggest that opportunities for collective action and access to group-based support services are unevenly distributed across the sub-region. Respondents in districts with stronger producer organizations, such as Adjumani, may be better positioned to access training, inputs, and markets, while those in other districts may rely more on individual arrangements. These dynamics may also be linked to differences in development and external actors in the area.

Table 4: Membership to producer groups across the region

			Membership to producer group (%)	
		n	No	Yes
District	Adjumani	95	28	72
	Madi Okollo	122	78	22
	Obongi	113	84	16
	Zombo	102	94	6
Overall		432	73	27

3.1.3.1 Membership in producer group by gender

The results show that there was no significant gender difference in membership to producer groups (Table 5). Both women and men reported nearly identical levels of participation, with about 27% belonging to a producer group. This similarity indicates that barriers to joining producer groups are not gender-specific but are likely shaped by broader structural or contextual factors. As such, interventions aiming to strengthen producer organizations should focus on addressing these shared constraints so that all farmers, regardless of gender

Table 5: Membership in producer group by gender

		Membership to producer group	
		No	Yes
Gender	Female	73.0	27.0
	Male	72.7	27.3
Total		72.8	27.2

3.1.3.2 Membership in producer group by nationality

The findings show that there was no significant difference in producer group membership between refugees and host community members. Among refugees, 23.2% belonged to a producer group compared to 27.4% in the host community, while the majority in both groups were not members (Table 6). This pattern suggests that the constraints that limit participation in producer groups are shared across nationalities rather than being specific to either group.

Table 6: Membership in producer groups by different nationalities

		Membership to producer group	
		No	Yes
Nationality	Refugee	76.8	23.2
	Host community	72.6	27.4
Total		73.1	26.9

3.1.4 Household head age, education, and experience

The mean age of household heads across all districts was 43.7, ranging from 41.0 years in Obongi to 48.0 years in Adjumani (

Table **8**). Formal education levels differed across districts, with an overall mean of 5.4. Madi Okollo and Obongi had higher average education (6.2 and 6.0 years, respectively), whereas Zombo and Adjumani had lower levels (4.2 and 4.7 years, respectively). Household heads reported an average of 19.7 years of farming experience, albeit with a wide variation (SD =

15.8). Zombo respondents had the highest experience (28.5 years), followed by Madi Okollo (22.9 years), Obongi (11.6 years), and Adjumani (10.6 years). These findings indicate that the target area generally has low literacy levels, particularly Zombo and Adjumani districts, which is likely to affect their perception of nature as a living system and the uptake of conservation measures. However, the respondents appear to have a fairly long experience in their operations. Perhaps they have developed critical context-specific knowledge of climate change action through experiential learning.

3.1.5 Household Size and Active Labour

The average family size across the districts was 6.4 members (Table 7;

Table **8**), which is slightly higher than the regional average of 5.1 reported by UBOS in 2024. Adjumani had the largest families (8.5 members), while Zombo had the smallest (5.6 members). The average number of household members in active labour age was nearly half (3.7), suggesting a dependence ratio close to one (

Table **8**). Adjumani district had slightly higher active labour (5.4) than other districts, which ranged between 3.3 and 3.7. Family size is key in rural households since it is the major source of labour for the household. It is therefore instrumental for implementing climate change action.

3.1.6 Landholding and Distance to Trading Centers

Table 7: Summaries of socioeconomic attributes

Statistic	Min	Mean	SD	Max
Age of HHH	16	43.5	15.5	87
Formal education (yr)	0	5.7	3.3	16
Working experience	0	18.4	15.5	72
Family size	1	6.5	3.2	20
Active labour age group	0	3.7	2.2	20
Land (ha)	0.03	1.56	3.10	40.00

Distance to nearest town (km)	0	9.1	12.9	70

On average, respondents owned 1.6 hectares, but with a very high variability (SD = 3.3) (Table 7). Obongi district had the highest mean landholding (2.0 ha) and Zombo the lowest (1.0 ha) (Table 8). These differences are probably related to the respective populations of the districts. Similarly, the distance to the nearest trading centre showed wide variation (SD = 11.4) but centred around a mean of 8.4 km, with Madi Okollo being the furthest (15.5 km) and Obongi the closest (2.7 km). The distance to the town centre affects input and product markets and associated transaction costs such as transport. Consequently, it affects the adoption of conservation practices that might require the use of external inputs.

Table 8: Socioeconomic attributes disaggregated by district

District	Statistic	HHH age (yrs)	Working experience (yrs)	Formal education (yrs)	Land (ha)	Distance to nearest town centre (km)	Family Size	Active labour age
Adjumani	Mean	43.8	10.2	6.3	1.4	6.3	7.8	4.6
	N	95	95	95	92	95	95	95
	SD	14.70	9.95	3.22	0.97	3.64	3.76	2.95
	Min	21	0	0	0.1	1	1	1
	Max	86	50	15	6	20	20	20
Madi Okollo	Mean	44.6	22.3	6.0	1.7	17.8	5.9	3.2
	N	125	125	124	125	125	125	125
	SD	16.47	16.17	3.47	1.37	20.80	3.09	1.82
	Min	19	0	0	0.2	1	1	0
	Max	87	72	16	8	70	15	10
Obongi	Mean	40.9	11.7	6.1	2.0	2.7	6.9	3.6
	N	117	117	116	116	117	117	117
	SD	15.49	10.45	3.37	5.70	4.54	3.01	1.97
	Min	16	0	0	0.03	0	1	1
	Max	83	50	16	40	25	15	11
Zombo	Mean	44.7	28.8	4.2	1.0	8.5	5.5	3.4

	N	104	104	104	103	104	104	104
	SD	14.86	15.88	2.82	0.70	1.89	2.49	1.97
	Min	19	2	0	0.2	2	1	0
	Max	85	70	14	4.4	10.5	14	10

Socioeconomic attributes disaggregated by nationality status

Refugee household heads had noticeably fewer years of working experience, averaging 13.6 years compared to 19.4 years in the host community (Table 9). Formal education levels were low in both groups and did not differ significantly. Access to land showed the strongest contrast, with refugees cultivating only about 0.4 ha on average while host community households operated around 1.7 ha. Refugees also lived closer to town centres, at about 4.6 km compared to 9.8 km. Their families were larger, averaging 7.6 members compared to 6.3 in the host community, although both groups had a similar number of active labour-age members. Age differences between the two groups were minimal. Given that refugees are initially allocated 30 m by 30 m plots to start life, the observed average of 0.4 ha indicates that many have found ways to increase their operational land beyond the initial entitlement.

Table 9: Socioeconomic attributes disaggregated by nationality status

Nationality	Statistic	**HHH age** (yrs)	**Working experience** (yrs)	**Formal education** (yrs)	**Land (ha)**	**Distance to nearest town centre** (km)	**Family**	**Active labour age**
Refugee	Mean	42.7	13.6	5.9	0.4	4.6	7.6	3.7
	N	56	56	56	56	56	56	56
	SD	15.81	10.46	2.97	0.45	7.10	3.58	1.96
	Min	18	1	0	0.09	0.5	1	1
	Max	75	40	15	2	48	16	8
Host community	Mean	43.8	19.4	5.5	1.7	9.8	6.3	3.6

	N	376	376	374	371	376	376	376
	SD	15.44	15.99	3.26	3.31	13.52	3.13	2.26
	Min	16	0	0	0.03	0	1	0
	Max	87	72	16	40	70	20	20

Socioeconomic attributes disaggregated by gender

Male heads had higher formal education, averaging 6.4 years compared with 4.5 years for females, and slightly larger landholdings, averaging 1.7 ha versus 1.4 ha. Family size, work experience, number of active labour-age members, and distance to the nearest town centre were similar across genders.

Gender		HHH age	Working experience	Formal education	Land (ha)	Distance to nearest town centre	Family size	Active labour age
Female	Mean	44.0	18.7	4.5	1.4	8.7	6.8	3.7
	n	174	174	173	173	174	174	174
	SD	15.77	15.97	3.23	3.15	13.20	3.21	2.27
	Min	19	0	0	0.09	0	1	0
	Max	87	70	15	40	70	16	14
Male	Mean	43.1	18.2	6.4	1.7	9.4	6.3	3.6
	n	267	267	266	263	267	267	267
	SD	15.33	15.15	3.18	3.06	12.67	3.21	2.22
	Min	16	0	0	0.03	0	1	0
	Max	87	72	16	40	70	20	20

3.2 Impact of climate change on the selected livelihood strategies in West Nile.

3.2.1 Major livelihood strategies

Farming was the dominant livelihood option among the surveyed households[1] (Figure 3; Figure 4). Nearly nine out of every ten respondents (89.4%) identified farming as their main source of livelihood. Only a small share depended primarily on other activities such as fishing (3.1%), local trade (3.1%), boda-boda transport (1.3%), civil service (1.0%), hiring out labour (0.8%), casual work (0.5%), pension (0.5%), or mechanical work (0.3%). This pattern underscores the agrarian nature of rural livelihoods in the study area and highlights the centrality of agriculture. People's livelihood is therefore highly dependent on natural resources such as land, vegetation and water. The limited diversity of livelihood options also suggests low resilience to climate-related shocks.

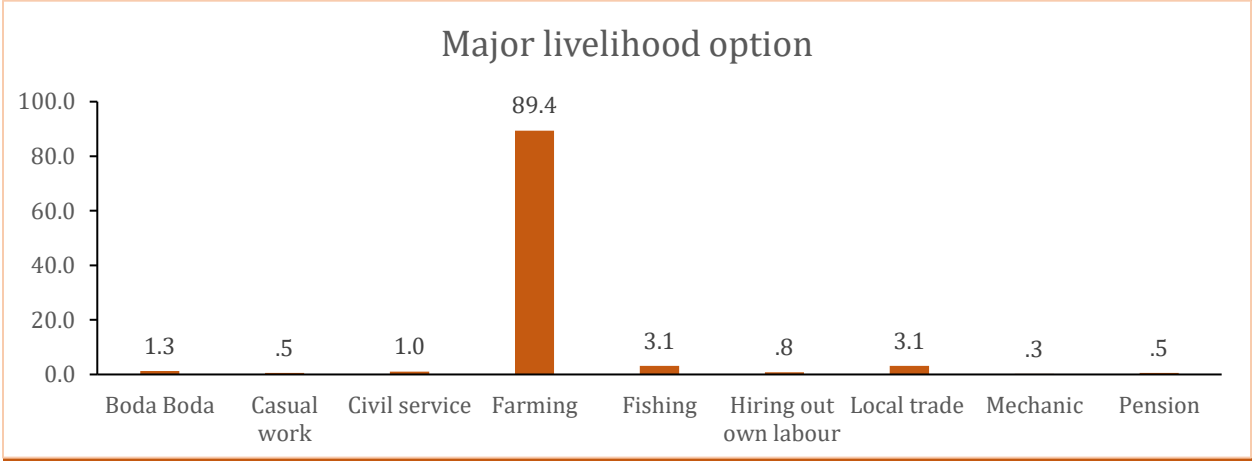

Figure 3: Major livelihood options across the study area

3.2.1a Spatial Evidence of Agrarian Dominance (GIS/LULC 2021)

Spatial analysis of 2021 land use and land cover (LULC) corroborates evidence of the agrarian character of the West Nile region. As illustrated in Figure 4, cropland is a predominant land cover type across all four project districts: Zombo, Madi Okollo, Obongi, and Adjumani, occupying vast portions of the landscape relative to forest, grassland,

[1] The initial analysis plan included disaggregation of findings with respect to main livelihood option. However, this was dropped since variation in livelihood option was minimal. The proceeding findings were presented as pooled or disaggregated by the district and other socioeconomic attributes which appeared influential.

wetland, or built-up areas. This pattern spatially mirrors the survey finding that 89.4% of households rely on farming as their primary source of livelihood. The dominance of cropland reflects long-term expansion driven by population growth, food demand, and limited off-farm employment opportunities. Forested and wetland areas appear fragmented and concentrated in narrow strips along rivers or steep slopes, highlighting growing land pressure and conversion of marginal ecosystems for cultivation. The spatial distribution thus reinforces the conclusion that livelihoods in the West Nile region are highly dependent on natural resources, particularly land and vegetation, and are therefore vulnerable to climate variability and land degradation.

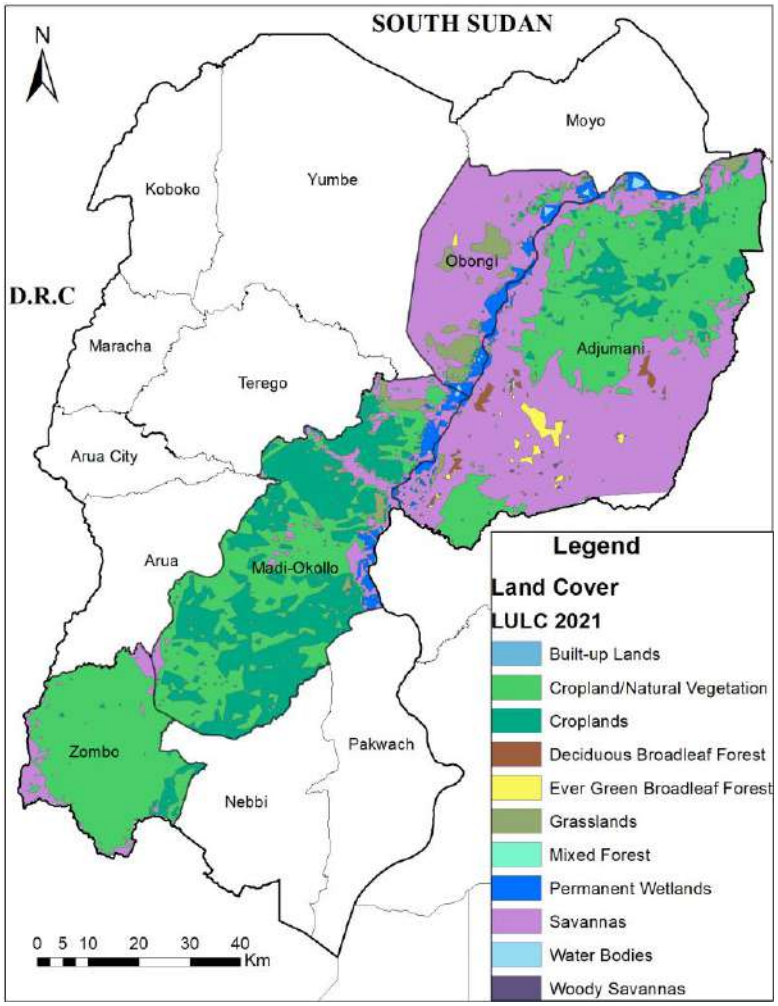

Figure 4: Land Use and Land Cover Map for 2021, Cropland, Grassland, Forest, Wetland, Water, and Built-up Areas.

3.2.2 Alternative income sources

Figure 5 shows the various alternative income sources among respondents. Animal production was the most common source, accounting for 24.5% of all alternative livelihood activities, followed by petty trade (21.8%), the fish value chain (15.6%), and food produce sales (15.2%). These findings reflect the central role of agriculture and related enterprises in household economies. Artisan work, such as operating salons, cobblers, plumbing, mechanics, and others (12.7%), and labour hire (7.7%) were also notable, showing engagement in semi-skilled and casual employment opportunities.

Relatively fewer respondents relied on charcoal and firewood (5.4%), boda boda transport (4.5%), saving and credit activities (2.5%), and salary or pension income (2%), while other sources contributed marginally. The frequency of degrading activities of charcoal and fire was comparatively low, but over a large population, it can have serious effects on the finite vegetation resources.

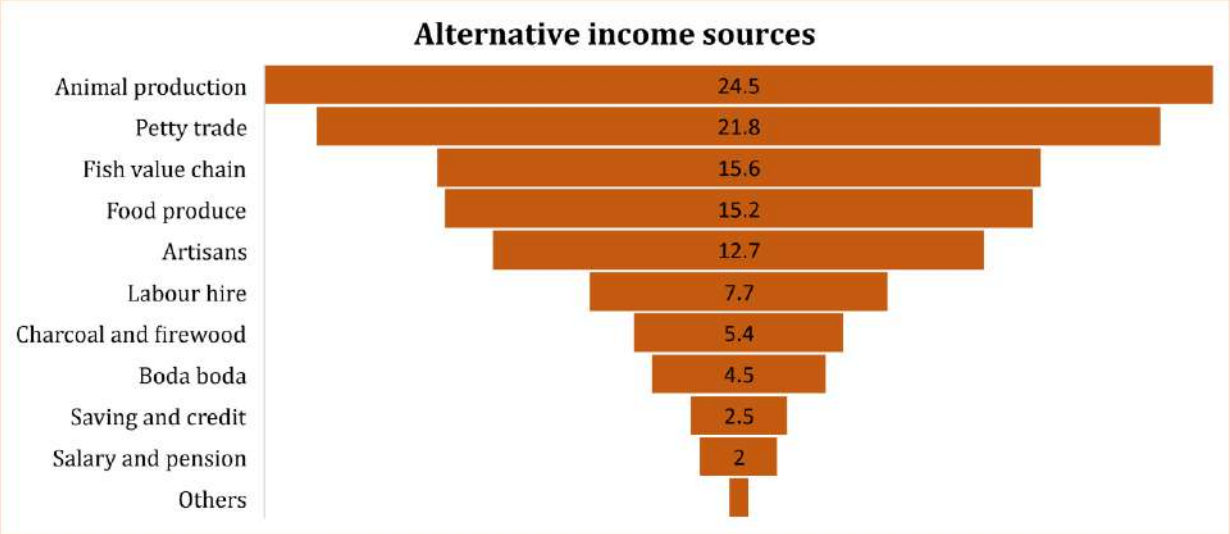

Figure 5: Alternative sources of income in the study area

3.2.2.1 Alternative income sources by district

Alternative household livelihood options varied across districts in West Nile (Table 10). In Adjumani, animal production was the dominant alternative, engaging 47.4% of households, followed by artisans (16.8%) and petty trade (13.7%), with minimal involvement in the fish value chain (5.3%) and no participation in food produce. In Madi Okollo, food produce was most common (41.6%), followed by animal production (31.2%), labour hire (20.0%), petty trade (16.8%), and fish value chain activities (20.0%). In Obongi, labour hire (33.3%), the fish value chain (33.3%), and petty trade (27.4%) dominated, while food produce (12.8%) and animal production (19.7%) were less common. In Zombo, petty trade was the main alternative livelihood (28.8%), with limited engagement in artisans (5.8%) and animal production (1.0%), and no participation in charcoal, firewood, food produce, or the fish value chain.

Table 10: Alternative income sources disaggregated by nationality

District	n	Artisans	Charcoal & Firewood	Petty trade	Labour hire	Food produce	Animal production	Fish value chain
Adjumani	95	16.8	3.2	13.7	5.3	0.0	47.4	5.3
Madi Okollo	125	14.4	9.6	16.8	20.0	41.6	31.2	20.0
Obongi	117	13.7	7.7	27.4	33.3	12.8	19.7	33.3
Zombo	104	5.8	0.0	28.8	0.0	0.0	1.0	0.0
Total	441	12.7	5.4	21.8	15.6	15.2	24.5	15.6

3.2.2.2 Alternative income sources by gender

Gender differences in livelihood activities were evident. Petty trade was strongly female-dominated, with about 33% of women engaged in it compared to 14% men. Men were more involved in artisanship, where 15% participated compared to 9% of women, and they were the only ones participating in boda-boda transport at 7.5%. Men also had greater involvement in the fish value chain (18%, compared to 12% among women). Animal production was common for both genders but slightly higher among men (26% compared to 22% for women), while women were more engaged in selling food produce (19%, compared to 13% for men). Other activities, such as charcoal and firewood and labour hire, showed relatively small gender differences.

Table 11: Alternative income sources disaggregated by gender

Gender	Female	Male	Overall
n	174	267	441
Artisans	8.6	15.4	12.7
Boda-boda	0.0	7.5	4.5
Charcoal & Firewood	8.0	3.7	5.4

Petty trade	33.3	14.2	21.8
Animal production	21.8	26.2	24.5
Fish value chain	12.1	18.0	15.6
Labour hire	6.3	8.6	7.7
Food produce	19.0	12.7	15.2

3.2.3 Climate change impacts on livelihood

3.2.3.1 Local manifestations and perceived impacts of climate change

Results indicated that the majority of the farmers perceived the reality of climate with nearly nine out of ten (88%) answering in the affirmative (Figure 6). The major manifestations of climate change in the area are presented in the preceding subsection.

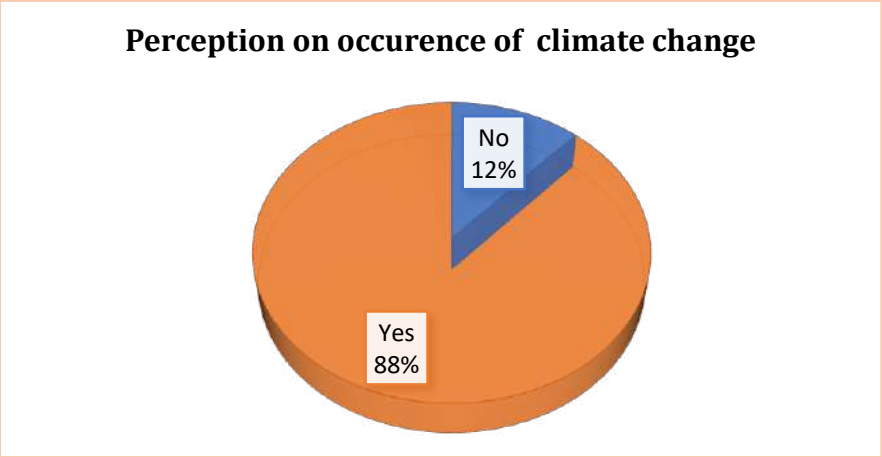

Figure 6: Perception of the reality of climate change

3.2.3.2 Major manifestations of climate change

Perceptions across the West Nile sub-region indicate that increased temperatures (93.3%), irregular rainfall patterns (82.5%), prolonged droughts (79.4%), and delayed onset of rains (76.9%) are the most widespread manifestations of climate change (Figure 7). These patterns indicate that the area has become progressively warmer and drier, with greater intra-seasonal rainfall variability. The prominence of temperature and rainfall-related indicators underscores the chronic and region-wide nature of climatic stress, which directly affects cropping calendars, soil moisture, and yields, calling for urgent action.

In Adjumani District, high frequencies of prolonged droughts (88.0%), floods (69.6%), and temperature rise (87.0%) reflect the dual exposure of this landscape to both heat stress and

flood risk. This is probably attributed to its position along the Nile corridor, where flash floods occur in low-lying settlements while adjacent areas experience water scarcity and heat extremes. On the other hand, Madi Okollo District shows relatively lower flood incidence (5.9%) but similarly high reporting of drought (78.8%) and increased temperatures (91.5%). Field-based vulnerability profiles link these perceptions to declining rainfall reliability and recurrent dry spells that shorten the growing season and exacerbate food insecurity.

In Obongi District, flood perception remains notably high (62.0%), possibly due to seasonal overflows of the Nile and associated displacement. However, the district also exhibits strong perceptions of delayed rains and irregular rainfall (84.8% and 94.9%, respectively), reinforcing evidence of erratic seasonal patterns in floodplain ecosystems. Finally, Zombo District, which is located in the highlands, presents a distinct pattern dominated by delayed rains (94.0%), irregular rainfall (90.0%), increased temperatures (100.0%), and intense storms (35.0%). These align with local observations of storm-induced landslides, hail damage, and unseasonal rainfall that disrupt crop production and soil stability.

Overall, the evidence suggests two interacting trends: First, a region-wide shift in temperature and rainfall regimes, and localized intensification of extreme weather events shaped by topography and hydrology. These manifestations aggravate the exposure of smallholder systems in the West Nile to both chronic climatic stress and acute episodic shocks, with implications for soil fertility, crop reliability, and livelihood security.

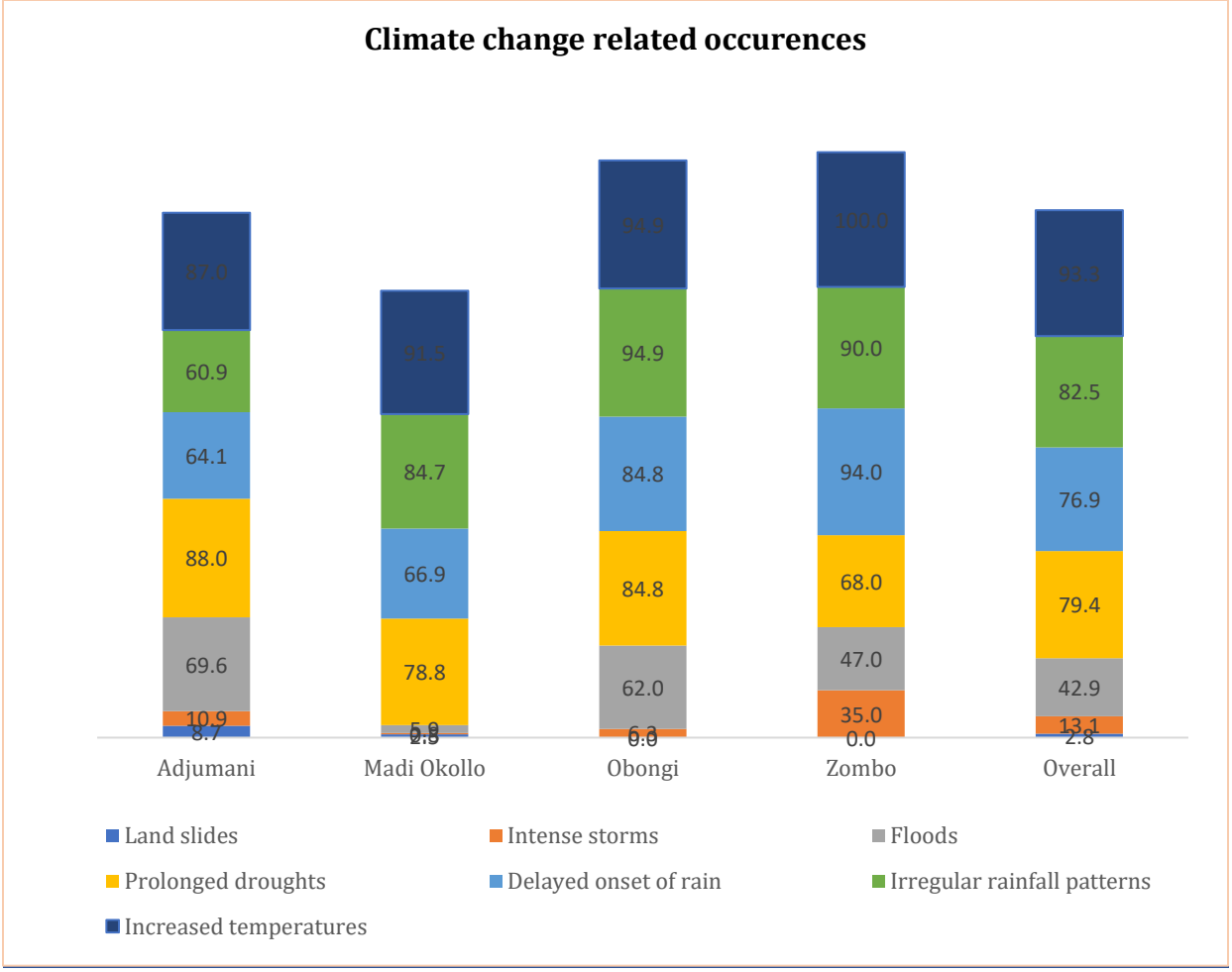

Figure 7: Manifestations of climate change locally reported

3.2.3.3 Effect of Climate Change on Crop Production

Climate change has a profound and widespread impact on crop production in the West Nile sub-region, affecting nearly every stage of the farming process. Across the four districts, nearly all farmers reported reductions in yields, with an average of 94.6% experiencing lower production (Figure 8). Delays in planting and harvesting were also common, affecting over 80% of respondents, while complete crop failure was reported by roughly three-quarters of farmers. Increased pests and diseases, poor-quality produce, and post-harvest losses were also frequently noted, highlighting the multiple ways in which changing climatic conditions are undermining agricultural productivity and food security.

When examined at the district level, some variations emerge. In Adjumani, the majority of farmers reported reduced yields (94.7%) and poor-quality produce (70.5%), with delays in planting and harvesting and significant levels of post-harvest loss and complete crop failure also noted. Farmers in Madi Okollo similarly experienced widespread yield reductions and delayed agricultural operations, alongside high rates of complete crop failure and poor-quality produce, although post-harvest losses were comparatively lower. In Obongi, the impact of climate change was particularly pronounced in terms of pest and disease incidence (93.2%) and reduced yields (97.4%), with almost all farmers affected and many experiencing significant delays in planting and harvesting. Interestingly, complete crop failure and post-harvest losses were somewhat lower in Obongi than in other districts. Zombo appeared to be the most severely affected district overall, with nearly universal reductions in yield, very high rates of complete crop failure, and widespread problems with pests, post-harvest losses, poor-quality produce, and delays in planting and harvesting.

These findings demonstrate that while climate change poses a serious threat to crop production across the entire West Nile sub-region, the nature and severity of its effects vary by district. Zombo and Obongi face the most extreme challenges, whereas Adjumani and Madi Okollo experience slightly less severe but still substantial impacts. The variable nature of these effects underscores the urgent need for locally adapted climate-resilient farming practices, early warning systems, and strategies aimed at mitigating both yield losses and post-harvest risks.

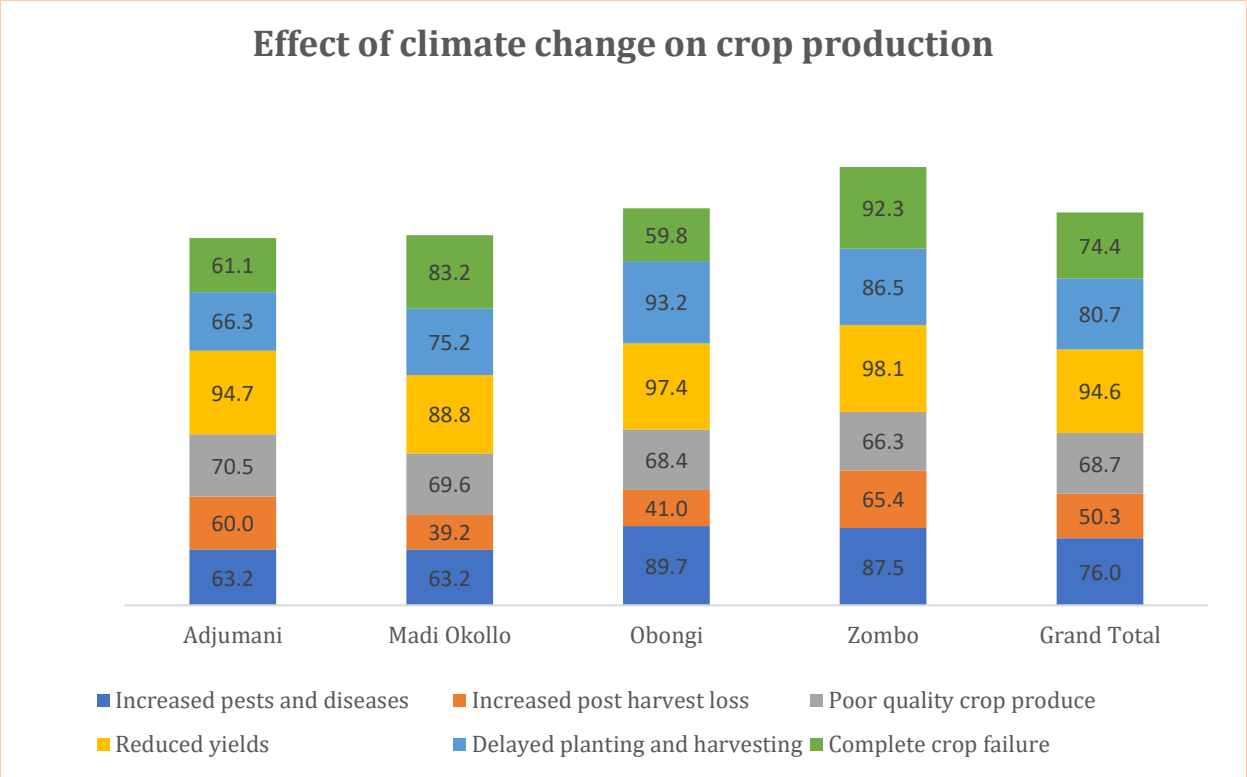

Figure 8: Effects of climate change on crop production in the area

A GIS-based comparison of LULC data between 2001 and 2021 reveals pronounced transformations across the landscape, reflecting the combined pressures of population growth, livelihood expansion, and environmental change. Cropland expanded substantially from 811.19 km^2 in 2001 to 1,236.14 km^2 in 2021, representing a net gain of about 425 km^2 (52 percent). Much of this expansion occurred through the conversion of forest, wetland mosaics, and savanna vegetation, as illustrated in Figure 9. During the same period, the savanna ecosystem, once the dominant vegetation formation, declined by approximately 405 km^2, while woody savannas decreased slightly by 1.76 km^2 and grasslands expanded by 29.65 km^2. These shifts indicate a trend toward ecological simplification, with woody and mixed savannas giving way to herbaceous cover and cropland driven by grazing pressure, selective logging, and recurrent fires. The expansion of cropland and cropland–natural vegetation mosaics, which now dominate the regional landscape, corresponds with demographic trends reported by UBOS (2022) showing annual population growth rates above 3 percent and strong dependence on rain-fed agriculture. The conversion of fallows,

grasslands, and marginal woodlands into cultivation areas represents an extensive adaptation to declining crop yields under increasingly erratic rainfall patterns. However, the attempt to sustain crop production through land expansion accelerates deforestation, soil degradation and loss of ecological buffers leading to positive feedback in climate related menaces.

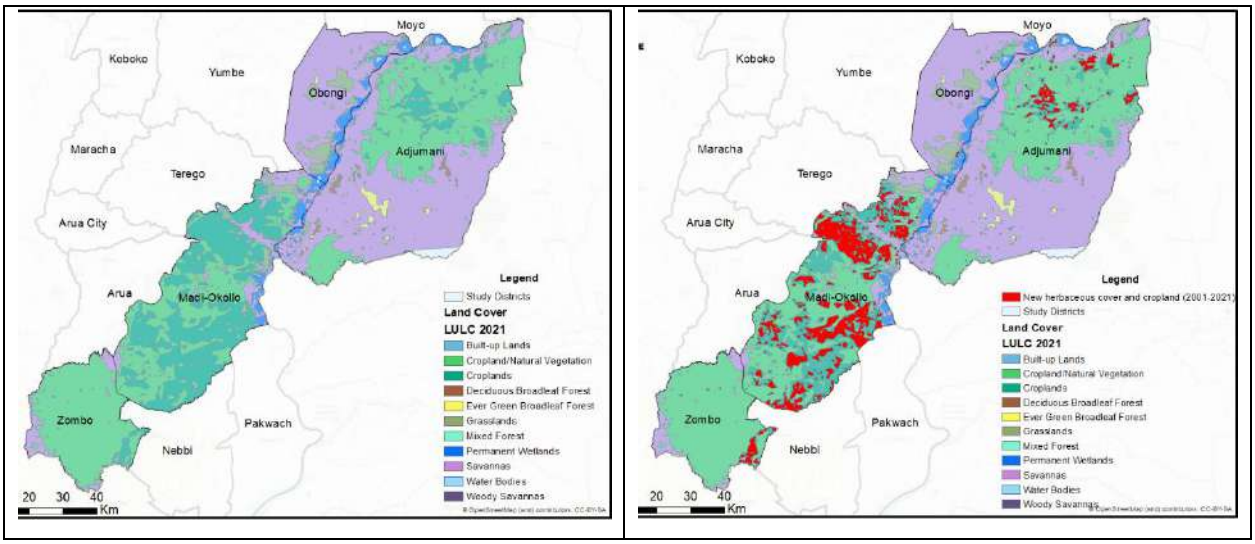

Figure 9: Spatial distribution of new herbaceous cover and cropland resulting from the conversion of savanna ecosystems (2001–2021)

3.2.3.3a Effects of climate change on crop production disaggregated by nationality

Climate-related shocks affected both refugees and host communities, but the severity differed across specific impacts. Figure 10: Effect of climate change on crop production, disaggregated by nationality. Reduced yields were nearly universal in both groups, affecting about 95% of households. Host communities, however, reported far more issues with poor-quality produce (72%) compared to 52% among refugees. A similar pattern appeared for delayed planting and harvesting, affecting 83% of host households and only 66% of refugees. Complete crop failure showed the sharpest contrast: 80% of host households experienced it compared to only 38% of refugees. This difference is likely linked to the larger plots cultivated by hosts, which expose them more fully to climate stress than the smaller, more intensively managed refugee plots. Other impacts, such as increased postharvest losses and rising pest and disease pressure, were reported at fairly similar levels across the two groups.

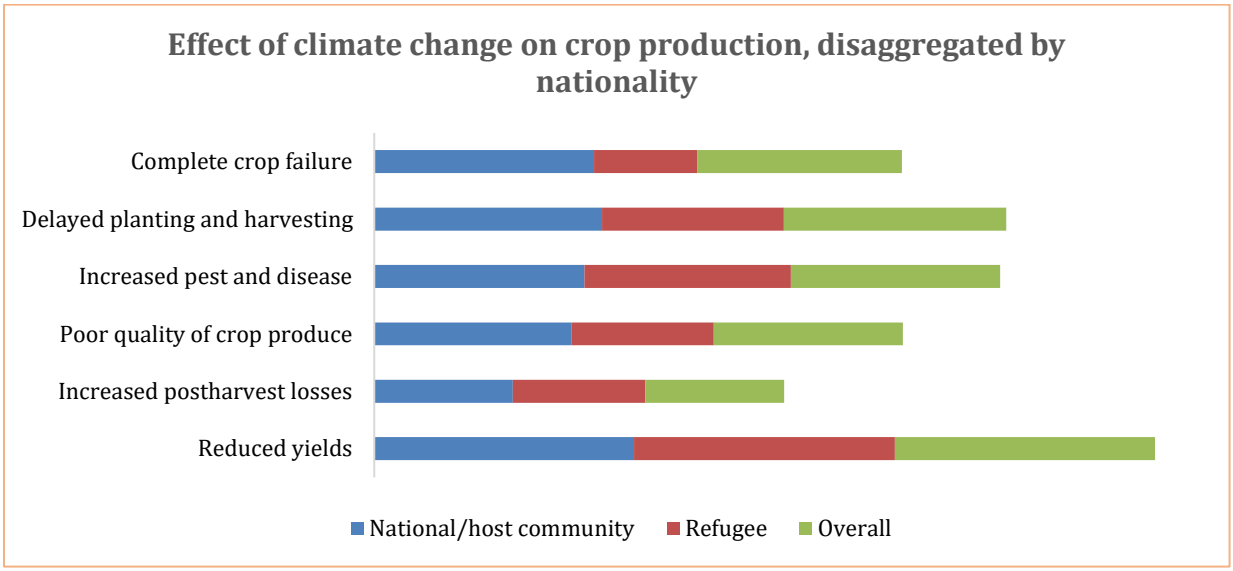

Figure 10: Effect of climate change on crop production, disaggregated by nationality

3.2.3.4 Most Susceptible Crops to Climate Change

The data reveal that different crops exhibit varying levels of susceptibility to climate-related stresses across the West Nile sub-region, with some consistently more affected than others (Figure 11). Overall, maize emerged as the most vulnerable crop, with 65.3% of farmers reporting susceptibility, followed by beans and groundnuts, both at 51.0%. Tomato (39.2%) and sesame (29.9%) were also commonly affected, while crops such as coffee (1.6%), pigeon peas (3.9%), and peas (3.4%) were comparatively less susceptible. These trends indicate that staple cereals and legumes, which form the backbone of local diets and livelihoods, are disproportionately at risk under changing climatic conditions.

District-specific patterns highlight notable variations in crop vulnerability. In Adjumani, tomato (52.6%) was the most frequently affected crop, followed by sesame (49.5%), maize (49.5%), beans (47.4%), and groundnuts (47.4%). Other crops such as cabbage, onion, and soybean also showed moderate susceptibility, reflecting the broad impact of climate stress on both staples and vegetables. Madi Okollo presented a somewhat different pattern, with maize and groundnuts as the most affected (both 57.6%), while sorghum (24.8%), tomato (24.8%), cowpeas (16.8%), and banana (4.0%) showed varying degrees of vulnerability.

Obongi exhibited extreme susceptibility for maize, with an overwhelming 98.3% of farmers reporting it as affected, highlighting the district's particular vulnerability in cereal production. Other crops impacted in Obongi included cowpeas (50.4%), beans (44.4%), tomato (41.9%), onion (41.9%), and groundnuts (42.7%), whereas crops like coffee, pigeon peas, and millet were relatively unaffected. In Zombo, beans were the most susceptible crop, with 91.3% of farmers reporting impact, followed by groundnuts (55.8%), maize (51.9%), and tomato (41.3%). Cabbage and onion were moderately affected, while crops such as peas, pigeon peas, sorghum, and okra experienced minimal vulnerability.

These findings illustrate that while staple cereals and legumes are consistently the most climate-sensitive crops across the sub-region, there is notable district-level variation in susceptibility. Maize is particularly vulnerable in Obongi, beans in Zombo, and tomatoes in Adjumani, suggesting that climate adaptation strategies should be tailored not only to crop type but also to local agroecological conditions to effectively mitigate losses.

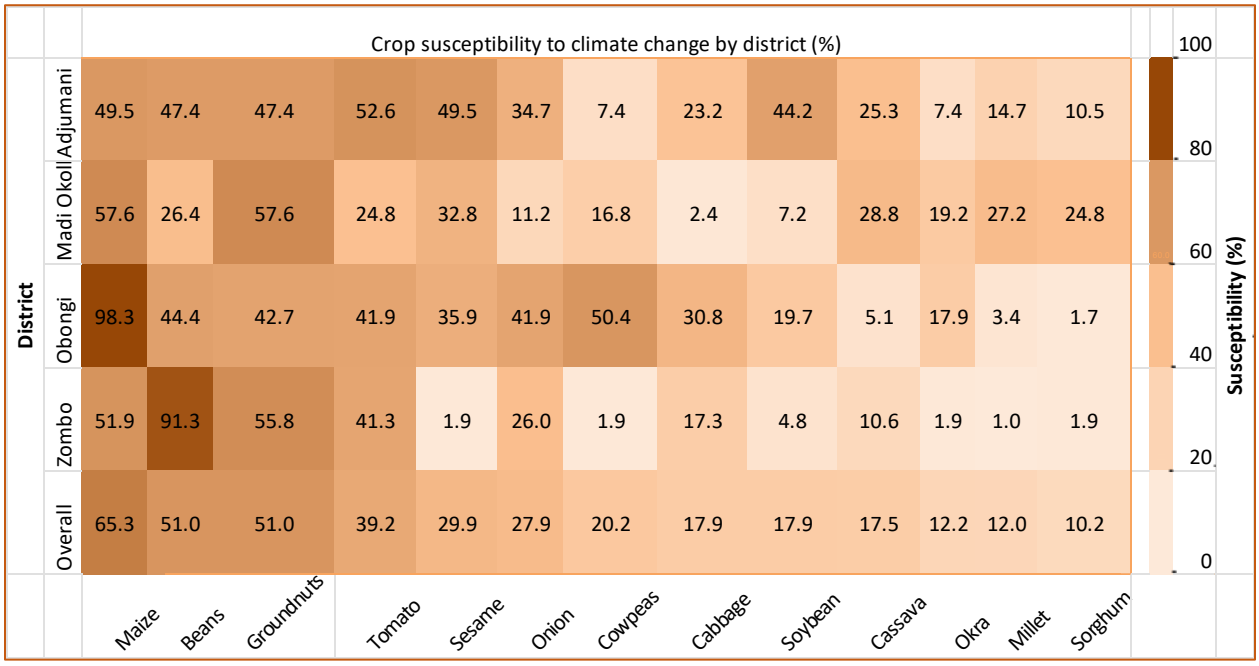

Figure 11: Most climate change susceptible crops in West Nile sub-region

3.2.3.5 Most Tolerant Crops to Climate Change

Similar to susceptibility, the data indicate substantial variation in the degree of crop tolerance to climate change across districts in the West Nile sub-region (Figure 12). Overall, cassava (81.9%) and sorghum (57.4%) emerged as the most climate-tolerant crops, followed by banana (56.2%) and millet (35.1%). At district level, Adjumani showed relatively high tolerance for cassava (69.5%) and sorghum (76.8%), with millet (58.9%) also performing comparatively well. Madi Okollo displayed strong cassava tolerance (90.4%), with moderate resilience observed in sorghum (54.4%) and banana (28.8%). Obongi exhibited the highest levels of crop tolerance overall, with cassava (76.9%) and sorghum (91.5%) performing particularly well, while banana (81.2%) and millet (41.9%) also showed notable resilience. In Zombo, cassava (88.5%) and banana (80.8%).

Comparatively, the least tolerant crops across all districts were tomato (3.9%), soybean (4.5%), beans (5.2%), and cowpeas (9.3%). These crops are known to be more sensitive to temperature fluctuations, moisture stress, and pest outbreaks conditions increasingly prevalent under climate change. The observed site-specific differences in crop tolerance can be attributed to variations in agroecological conditions, local farming practices, and microclimatic factors. For example, cassava and sorghum performed particularly well in Madi Okollo and Obongi, likely due to their adaptability to both drought and variable rainfall patterns. In contrast, the low tolerance of tomato and legumes across all districts reflects their dependence on stable moisture and temperature regimes for optimal growth.

Overall, the findings suggest that promoting cassava, sorghum, banana, and millet could enhance resilience in smallholder production systems under a changing climate. These crops not only withstand climatic stresses but also provide a reliable food base where more sensitive crops, such as tomatoes and beans, fail. However, a local expert noted that some extreme events such as hail storms are also affect cassava severely.

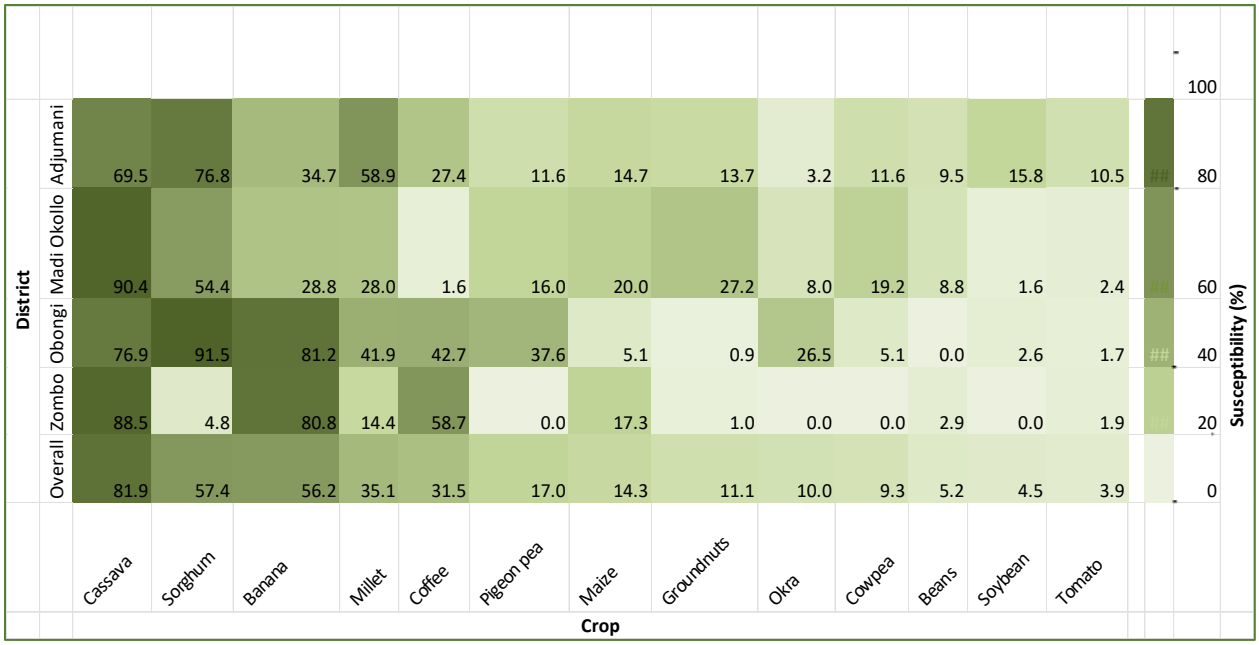

Figure 12: Most climate tolerant crops in West Nile

3.2.3.6 Effect of climate change on livestock production in West Nile

The findings indicate that climate change is exerting multifaceted pressure on livestock production systems across West Nile, with notable variation among districts (Figure 13). Water shortage (81.5%) and reduced pasture availability (81.0%) stand out as the most widespread effects, especially in Madi Okollo (94.3% and 81.1%), Obongi (87.0% and 85.0%), and Adjumani (76.8% and 70.5%). These shortages directly constrain livestock feeding, mobility, and health, often forcing farmers to trek longer distances in search of grazing areas and water.

Perhaps as a result of feed and water scarcity are productivity losses. Reduced feed intake and eventual decline in milk yield, weight gain (45.4%) are also prevalent due to heat stress (38.2%). These concerns were majorly raised in Obongi (77.0% and 44.0%) and Adjumani (68.4% and 54.7%). Heat stress not only limits animals' appetite but also weakens body condition, further exacerbating reduced fertility (47.5%). This was also frequent in Adjumani (66.3%) and Zombo (56.7%). These combined effects result in higher mortality rates (42.8%) and increased disease and parasite pressure (65.6%), with Zombo (80.8%)

and Obongi (65.0%) being particularly affected. The persistence of warm, humid conditions in these areas encourages parasite survival and disease transmission, further undermining herd productivity.

Economic and social repercussions are evident, such as increased cost of feed and veterinary care (27.3%) noted in Obongi (43.0%) and Adjumani (42.1%). These pressures translate into loss of income (27.1%), with Obongi (36.0%) and Zombo (34.6%) registering the highest economic impacts. Meanwhile, conflicts over land and water resources (39.0%), especially in Obongi (57.0%) and Zombo (48.1%), reveal the growing social strain linked to competition for dwindling feed and water resources.

In a nutshell, the results reveal that climate change impacts on livestock in West Nile are both ecological and socioeconomic, with dryland districts (Adjumani, Obongi, and Madi Okollo) facing acute shortages of feed and water, leading to cascading productivity and income losses. In contrast, Zombo, in the highland experienced heightened disease and parasite pressure, perhaps due to changing microclimates. These findings highlight that the climate crisis in the region is not only depleting natural resources but also reshaping livelihood stability, animal health, and social relations, pointing to the need for integrated adaptation measures such as improved water harvesting, resilient fodder systems, and climate-tolerant livestock breeds.

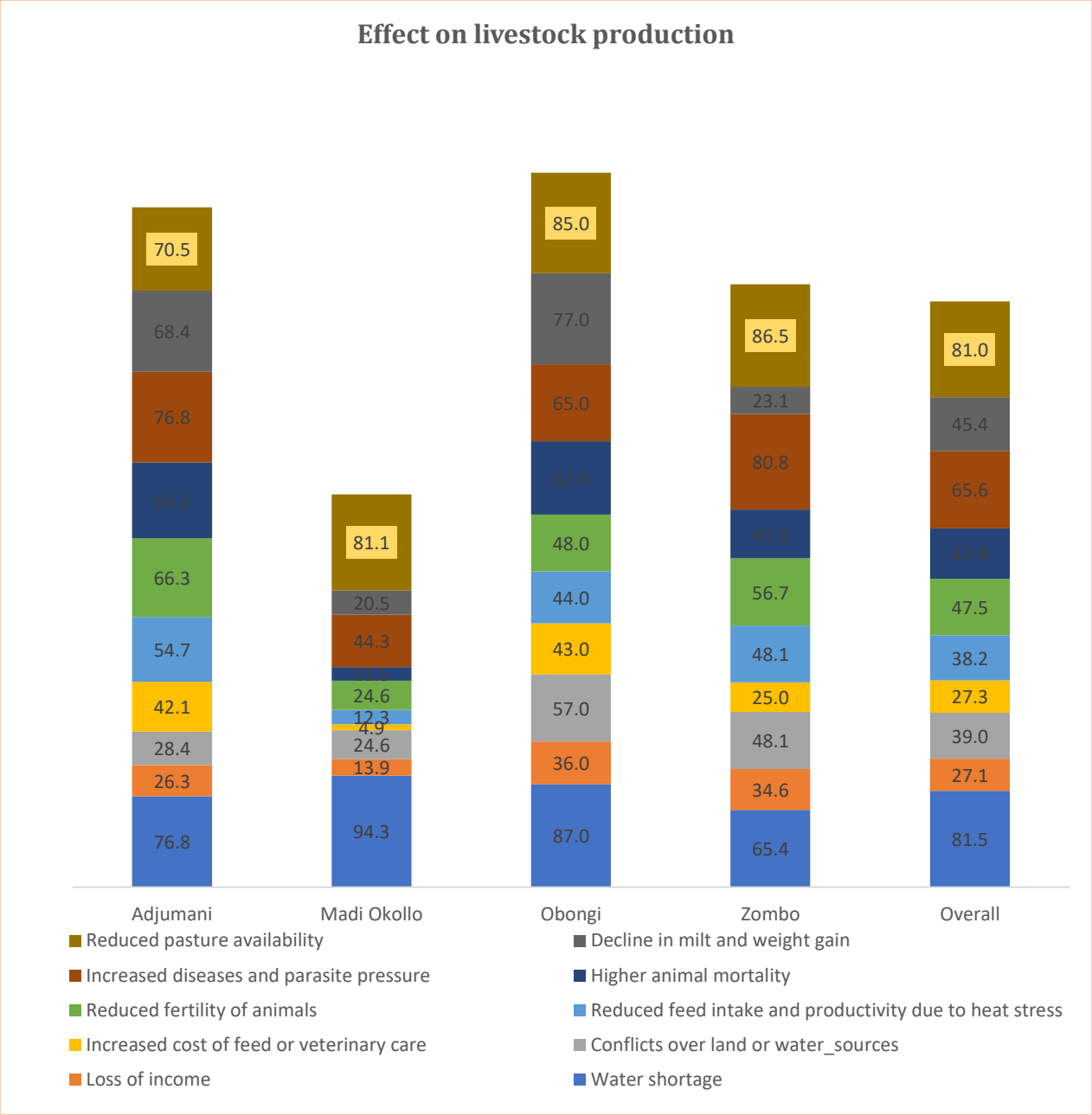

Figure 13: Effects of climate change on livestock production in West Nile

Furthermore, a GIS-based comparison of the 2001 and 2021 LULC data shows that the savanna ecosystem, once the dominant vegetation formation, decreased by 405.04 km^2, while woody savannas declined slightly by 1.76 km^2. In contrast, grasslands expanded by 29.65 km^2. This overall shift suggests an ecological simplification, with woody savannas giving way to herbaceous cover and cropland, driven by grazing pressure, selective logging,

and recurrent fires. Such transitions erode habitat diversity and constrain livestock-based livelihoods that depend on mixed savanna mosaics. Similar vegetation shifts have been documented in semi-arid parts of northern Uganda and across the Sudano-Sahelian belt, associated with rising temperatures and intensified land use.

3.2.3.6a Effect of climate change on livestock production in West Nile disaggregated by nationality

Livestock-related challenges revealed both shared pressures and notable contrasts across the two groups. Loss of income from livestock was far more common among hosts (28.6%) than among refugees (7.3%). Conflicts over grazing land and water were also higher among hosts (39.9% compared to 26.8%). Reduced reproductive fertility was widely reported in both groups, with hosts slightly higher at 48.2% and refugees at 41.5%. Refugees more often (31.7%) mentioned high feed or veterinary costs than hosts (26.1%), and reported a higher frequency of reduced milk production or weight gain (56.1%) compared to 43.9% among hosts. Shortage of water was also more frequent among hosts (84.1%) than the refugees (61.0%), and so was the case with reduced pasture availability. These exceptionally high levels of water and pasture scarcity suggest that grazing-based systems in the region are already stretched beyond their ecological limits. The markedly low livestock income losses among refugees may also reflect their smaller herd sizes and limited dependence on livestock, highlighting different levels of exposure to climate-related shocks.

Effect	National/host community	Refugee	Overall
Loss of income from livestock and livestock products	28.6	7.3	27.1
Conflicts over grazing land or water sources	39.9	26.8	39.0
Reduced reproduction fertility of animals	48.2	41.5	47.5
Increased cost of feed or veterinary care	26.1	31.7	27.3
Heat stress on animals	38.5	31.7	38.2
Decline in milk production or weight gain	43.9	56.1	45.4
Higher animal mortality rates	42.3	46.3	42.8
Increased animal diseases or parasites	66.0	63.4	65.6
Shortage of water for animals	84.1	61.0	81.5
Reduced pasture availability	81.7	73.2	81.0

3.2.3.7 Effects of climate change on fisheries resources in West Nile

Results show that decline in fish stocks is the most widespread manifestation of climate change across the region, with particularly high proportions in Obongi (93.9%) and Adjumani (91.6%) (Figure 144). These findings indicate that increasing water temperatures, erratic rainfall, and sedimentation have reduced fish populations in the Nile and its tributaries. Zombo (61.2%) and Madi Okollo (46.3%) reported comparatively lower declines, likely reflecting their limited dependence on large water bodies. Conflicts over fishing resources were also most pronounced in Adjumani (68.4%) and Obongi (63.4%), where fishing remains a major livelihood source, and competition over dwindling fish stocks has intensified. In contrast, Zombo (3.9%) and Madi Okollo (4.5%) recorded very low levels, consistent with their smaller-scale and less commercial fishing activities.

Post-harvest losses were relatively moderate overall (21.3%), but higher in Obongi (45.1%) and Adjumani (33.7%), reflecting inadequate preservation infrastructure and fluctuating weather conditions that accelerate spoilage. Zombo (1.9%) and Madi Okollo (4.5%) similarly reported minimal losses since fishing is not as important there. The increased cost of fishing

was a major concern in Obongi (75.6%) and Adjumani (66.3%), likely driven by the need to travel longer distances and use more fuel or advanced gear to access remaining fish stocks. The costs were lowest in Madi Okollo (19.4%) and Zombo (33.0%), due to lower fishing intensity. Water pollution was reported most in Adjumani (58.9%) and Obongi (50.0%), where agricultural runoff and settlement activities along riverbanks are more pronounced. Zombo (9.7%) recorded the lowest pollution concern, consistent with its upland location and fewer water-based activities.

Finally, changing water levels emerged as a significant manifestation in Obongi (75.6%) and Madi Okollo (64.2%), consistent with their proximity to the Albert Nile where seasonal fluctuations and backflows are common. Adjumani (48.4%) also reported notable changes, whereas Zombo (5.8%) showed minimal concern due to limited exposure to large water systems. Overall, the findings highlight strong spatial variation in the manifestation of climate change effects on fisheries. Districts with major water bodies (Adjumani and Obongi) show more pronounced and multifaceted impacts, while upland districts (Zombo and Madi Okollo) experience fewer but still notable changes, particularly in water levels and pollution.

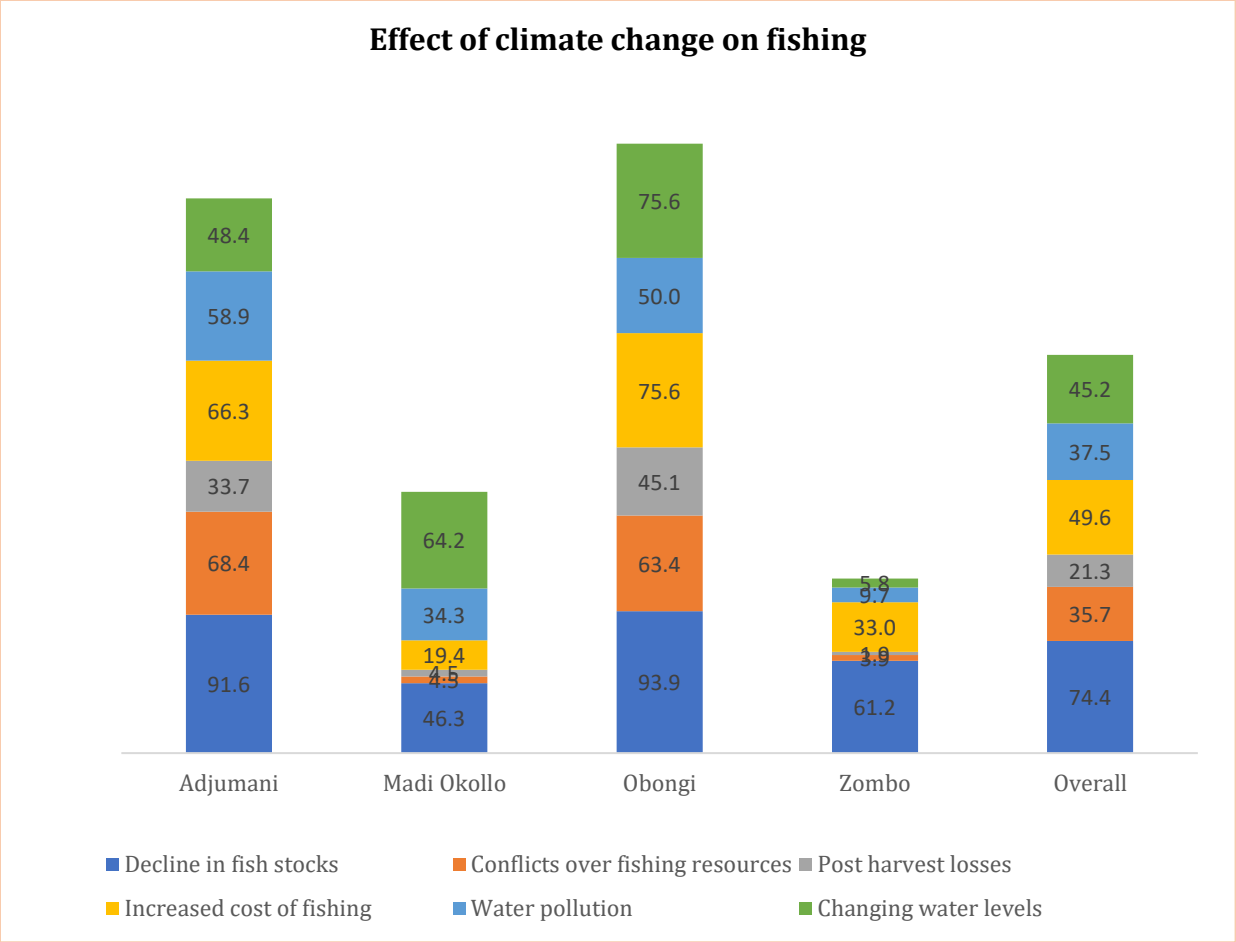

Figure 14: Effect of climate change on Fisheries resources in West Nile

GIS analysis indicated wetland contraction and riparian conversion as most evident along major watercourses, mirroring reported declines in fish stocks and increasing conflicts over fishing grounds and fisheries resources. Specifically, the area classified as permanent wetlands declined sharply from 281.01 km^2 in 2001 to 200.34 km^2 in 2021, a loss of about 28.7% (Figure 155). This reduction reflects extensive encroachment for cultivation, brick making, and settlement expansion within riparian zones. The contraction of wetlands, together with a slight decline in water bodies (–2.68 km^2), points to a cumulative loss of natural water storage capacity and filtration services. Hydrologically, this undermines the region's resilience to both drought and flooding, heightening exposure among downstream communities.

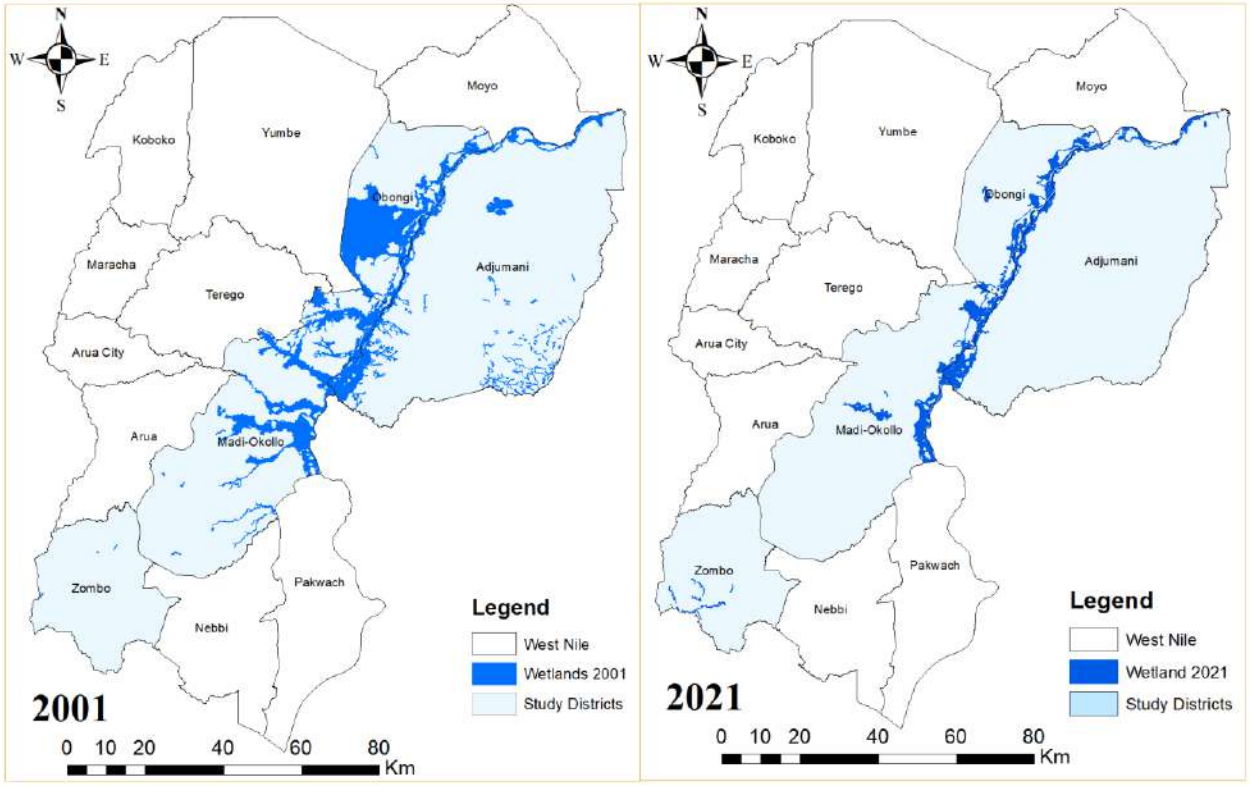

Figure 15: Visual comparison of areas designated as wetlands between 2011 and 2021 in the study area

3.2.3.7a Effect of climate change on fisheries, disaggregated by nationality

Fishing-related challenges showed both shared pressures and clear contrasts between refugees and host communities (Table 1). Conflicts over fishing grounds were reported far more by refugees (57.6%) than by host communities (32.7%), pointing to stronger competition for limited fishing spaces. Host respondents more often cited changing water levels, with nearly half mentioning it (47.1%) compared to about a quarter of refugees (24.2%). Postharvest losses were similar for both groups, at about 21%. Increased fishing costs were also comparable, with 49.3% among hosts and 48.5% among refugees. Water pollution was mentioned at close levels (37.3% and 33.3%, respectively). The sharpest shared concern was declining fish stocks, reported by 81.8% of refugees and 73.2% of hosts.

Table 12: Effect of climate change on fishing, diaregated by nationality

Nationality	National/host community	Refugee	Overall
Conflicts over fishing grounds	32.7	57.6	35.7
Changing water levels	47.1	24.2	45.2
Post-harvest losses	21.6	21.2	21.3
Increased costs of fishing	49.3	48.5	49.6
Water pollution	37.3	33.3	37.5
Decline in fish stocks	73.2	81.8	74.4

3.2.3.8 Effect of climate change on small-scale businesses in West Nile

The results reveal that climate change has significantly affected the performance and resilience of small-scale businesses across the West Nile region, largely through reduced consumer demand, increased operational expenses, and disruptions in transportation systems (Figure 16). Overall, reduced demand (79.8%) is the most prevalent effect, with the highest proportions reported in Adjumani (88.3%), Madi Okollo (84.8%), and Obongi (83.7%). These declines are likely linked to reduced household purchasing power as climate-induced shocks undermine agricultural and livestock incomes, the backbone of rural economies. Lower cash flow among consumers constrains spending on non-essential goods and services, forcing many small businesses to scale down operations or temporarily close.

Increased transportation costs (62.9%) and transport disruptions (65.0%) represent another major channel through which climate change constrains business activity. While Zombo (94.2%) recorded the most frequent transport disruptions, likely due to hilly terrain and poor road conditions exacerbated by heavy rains. Adjumani (67.0%) and Obongi (58.2%) also reported substantial impacts. These conditions affect both the supply of goods and access to markets, raising transaction costs and prices.

Increased operational costs (52.4%) were most severe in Obongi (84.7%), suggesting that extreme weather events and energy-related challenges have raised the cost of running small enterprises, possibly those reliant on refrigeration, water pumping, or transport. In contrast,

Madi Okollo (24.0%) recorded the lowest operational cost increase, possibly due to its smaller, less capital-intensive business activities.

Overall, the findings point to an interconnection between climatic variability, infrastructure fragility, and local economic activity. Climate change affects small-scale enterprises both directly, through physical disruptions and increased operating expenses, and indirectly, through declining consumer purchasing power and unstable supply chains. Adjumani, Obongi, and Zombo appear to be the most affected districts, though for potentially different reasons: Adjumani and Obongi due to reduced demand and cost escalation, and Zombo due to transport-related disruptions. Clearly, climate shocks are eroding the profitability, reliability, and resilience of local business systems, underlining the need for targeted adaptation measures such as climate-resilient infrastructure, improved market linkages, and affordable energy solutions to safeguard small enterprises in the region.

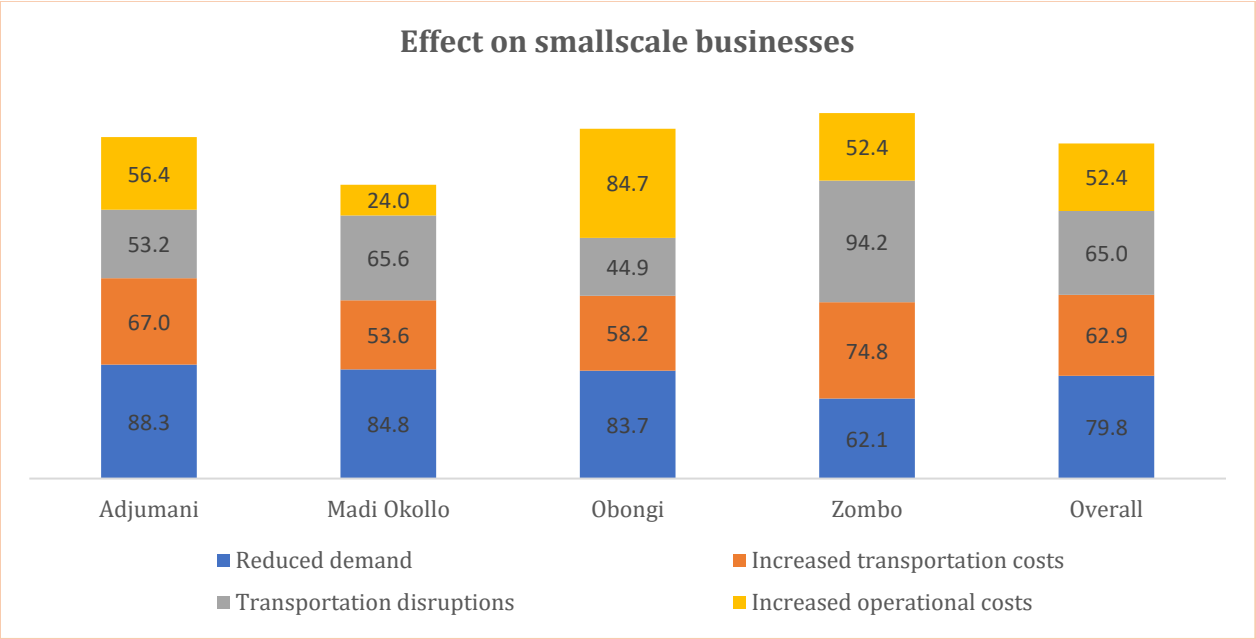

Figure 16: Effect of climate change on small businesses in West Nile

3.2.4 Available resources and support services for resilience

3.2.4.1 Coping Strategies for Crop Production in West Nile

Results indicate that farmers in West Nile employ a variety of coping strategies based on own resources to sustain livelihood under climate stress. To begin with crop production (Figure 17), water management strategies are the most widely adopted. Water harvesting is especially prevalent in Obongi (94.0%) and Adjumani (91.6%), reflecting reliance on seasonal rainfall and the need to conserve water for critical growth periods. Lower frequencies in Madi Okollo (72.8%) and Zombo (60.6%) perhaps indicate both lower water stress or limited infrastructure. Supplemental irrigation through manual techniques (e.g., watering cans and bottles) or simple small-scale irrigation are also used, particularly in Adjumani, though adoption is minimal in Madi Okollo and Zombo. These strategies demonstrate a strong district-level adaptation to water scarcity.

Other adaptation strategies include planting adjustments. Early planting is practiced almost universally in Adjumani (100%), suggesting a highly localized response to shifting rainfall patterns. Staggered planting is used less frequently overall (12.8%), mostly in Adjumani (47.4%), indicating some attempt to spread risk across planting periods. The higher relative frequency of these technologies in Adjumani could be related to previous development activities operating in the district.

Adaptations in crop choice, such as the use of tolerant varieties, are moderately adopted across all districts, with the highest use in Obongi (72.4%) and Adjumani (69.5%). This indicates an awareness of crop resilience to drought, pests, or flooding, though adoption remains lower in Zombo (56.7%) and Madi Okollo (55.3%). Land-use adjustments are less common. Practices such as lowland/swamp cultivation are most observed in Adjumani (62.1%) but are very low elsewhere, reflecting limited access or ecological suitability of wetlands. However, the low adoption of this practice reduces the environmental threat. There are a few economic coping mechanisms, notably reducing household expenses, particularly in Obongi (68.1%) and Adjumani (64.2%), highlighting the financial strain climate events place on farm households.

Overall, Adjumani and Obongi appeared the most proactive in implementing multiple strategies, likely because they are more exposed to climatic extremes such as erratic rainfall and drought, and more vulnerable members (the refugees). Madi Okollo and Zombo, while less exposed or having lower capacity, still employ selective strategies, mainly around water management. Overall, the data reflect a mixed approach to coping, where farmers combine water conservation, crop adjustment, planting strategies, and economic measures to sustain production under increasing climatic pressures.

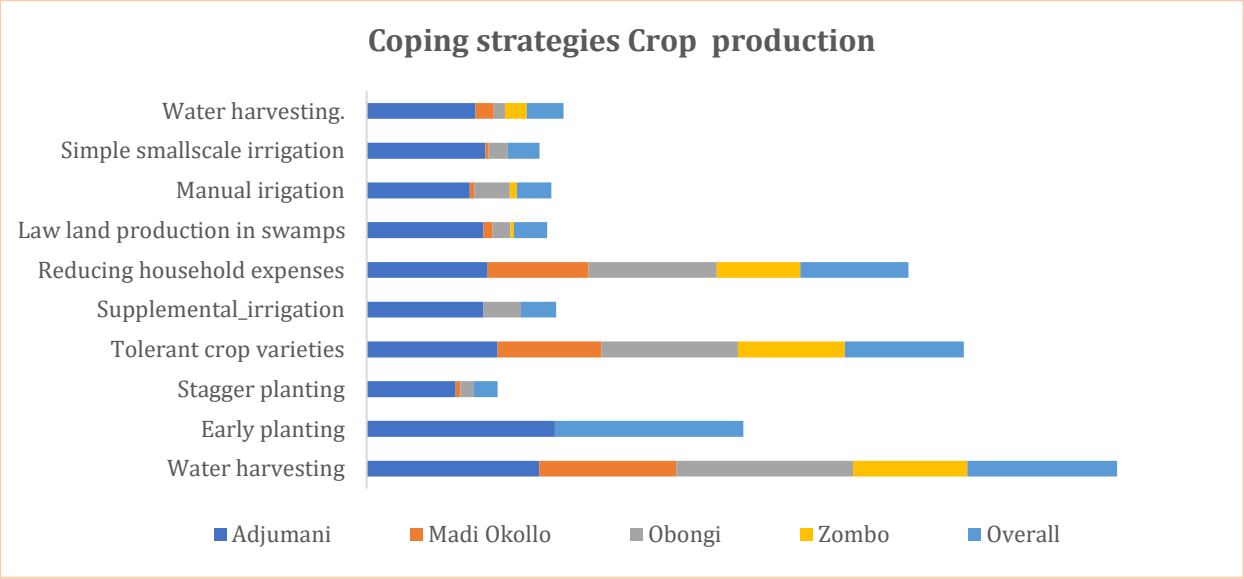

Figure 17: Local coping strategies to the effects of climate change on crop production

3.2.4.2 Coping Strategies for Animal Production in West Nile

Similar to crop production, the research revealed a notably diverse portfolio of coping strategies to sustain livestock production under climate-induced stresses (Figure 18). The most widely adopted strategies are moving animals to other areas (transhumance, 61.7%), rainwater harvesting and storage (44.8%), diversifying income sources (55.7%), buying supplemental fodder (22.9%), or own production and conservation of fodder (23.8%). These practices reflect a combined emphasis on mobility, water management, feed security, and livelihood diversification as the main pillars of resilience across the region. Less commonly used strategies include relying on social networks (9.1%), valley dams (22.1%), and

construction of animal shelters (20.0%), indicating that formal and communal support structures are underutilized or constrained by resources.

Zooming into district-specific patterns, Adjumani shows the most intensive and diversified coping strategies. Farmers here widely adopt rainwater harvesting (84.2%), diversifying income sources (86.3%), transhumance (74.7%), reducing stock size by selling (71.6%), and buying supplemental fodder (64.2%). They also use fodder production and conservation (63.2%), diversifying livestock species (51.6%), and improved breeds (30.5%), reflecting proactive, multi-dimensional responses to feed, water, and income shocks. Construction of animal shelters (19.0%) and vaccination (26.3%) are moderately practiced, indicating a partial focus on animal health and protection.

In Obongi, coping strategies are similarly robust but show a stronger focus on animal health and mobility. Vaccination (72.8%), transhumance (72.8%), improved breeds (37.9%), and diversifying livestock species (42.7%) are widely practiced, alongside moderate adoption of income diversification (56.0%) and reducing stock size by selling (37.9%). Fodder management practices such as buying supplemental fodder (31.1%) and own production/conservation of fodder (34.0%) are also moderately employed. Animal shelter construction (34.9%) is more common here than in other districts, reflecting the emphasis on protecting livestock from climatic extremes.

Zombo farmers rely primarily on mobility and water-related strategies, with transhumance (51.9%), rainwater harvesting (31.7%), and construction of animal shelters (22.1%). Adoption of income diversification (39.4%), vaccination (32.7%), and improved breeds (21.2%) is moderate, while fodder management and reducing stock size by selling are minimally practiced. This pattern suggests adaptation primarily through mobility and protective measures, rather than intensive management or financial interventions. It is also probably related to the lower animal densities in the district compared to the drier areas.

Madi Okollo displays the lowest intensity of coping strategy adoption. Transhumance (50.0%) and income diversification (45.5%) are the main strategies, followed by moderate vaccination (36.4%). All other strategies like fodder management, construction of shelters,

and use of improved breeds, are minimally adopted, reflecting either lower exposure to climatic extremes or constraints in resources and technical capacity. Reliance on social networks (2.5%) is almost negligible across the district.

In summary, Adjumani and Obongi emerge as districts with the most diversified and intensive coping strategies, addressing multiple dimensions of livestock resilience, namely mobility, feed, water, health, and income. Zombo and Madi Okollo, in contrast, adopt fewer strategies, often limited to mobility, basic health interventions, and selective water management. At the regional level, mobility, water conservation, and income diversification are the dominant coping mechanisms, underscoring the portfolio approach farmers take to buffer livestock production against climate variability and shocks in West Nile.

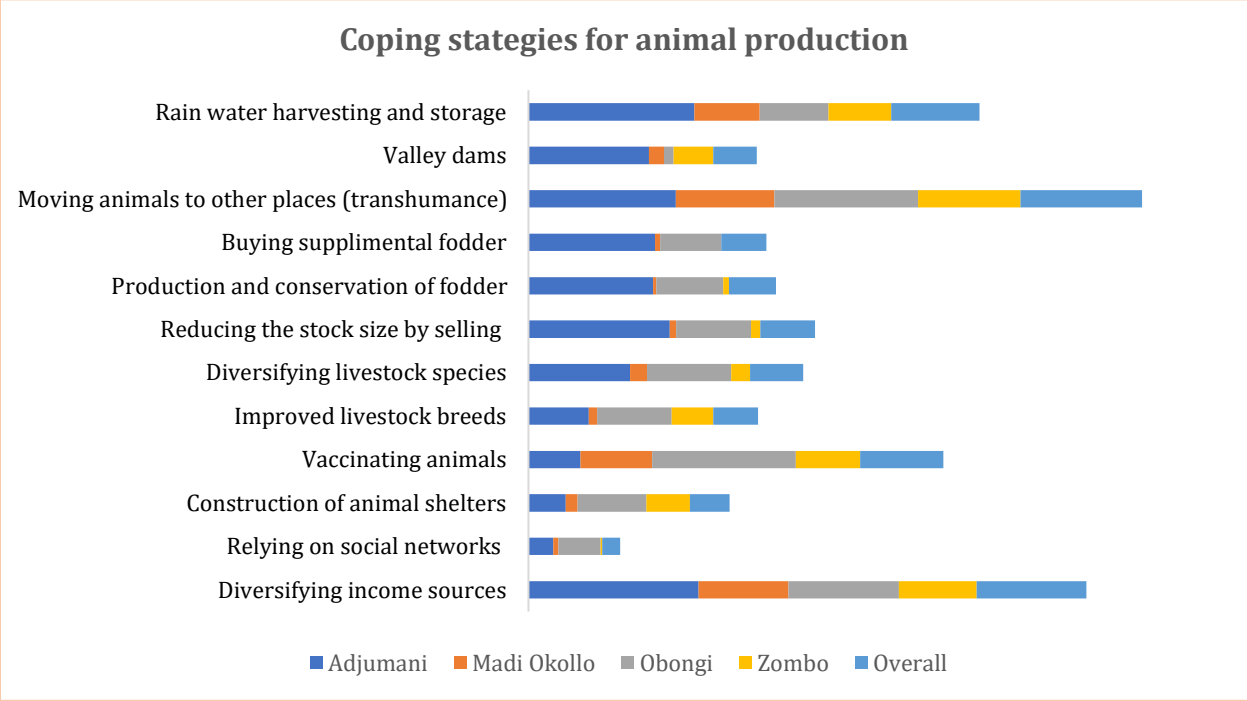

Figure 18: Local coping strategies to the effects of climate change on animal production

3.2.4.3 Coping Strategies for Fishing in West Nile

The study showed a limited range of coping strategies for the fishing industry in West Nile (Figure 19). Diversifying income sources was the most widely adopted strategy, with an

overall adoption of 55.7%. Adoption was highest in Adjumani (86.3%), followed by Obongi (56.0%), Madi Okollo (45.5%), and Zombo (39.4%). This indicates that households reliant on fishing supplemented their income through alternative livelihood activities, especially in districts most affected by declining fish stocks or disruptions in fishing activities. Fish farming was much less common, with an overall adoption of 9.4%. The highest adoption is in Adjumani (21.1%) and Obongi (18.1%), while Madi Okollo and Zombo reported no adoption. This suggests limited engagement with aquaculture, likely due to resource, technical, or financial constraints.

Overall, the data indicate that income diversification dominates coping strategies for fishing, while adoption of alternative production methods like fish farming remains low, reflecting both the risk-averse nature of fishing households and barriers to establishing aquaculture systems.

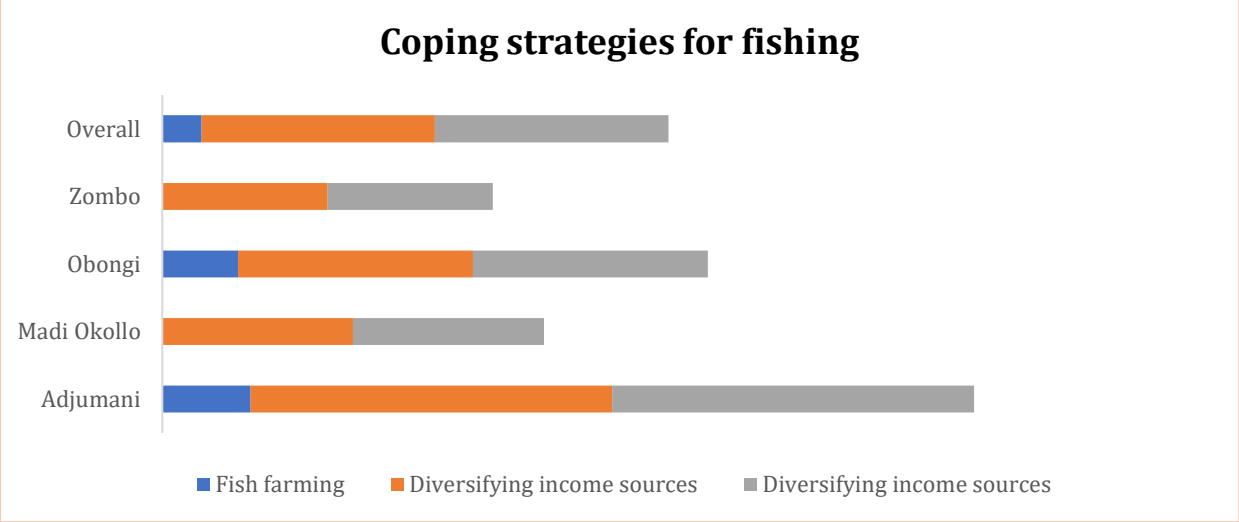

Figure 19: Local coping strategies to the effects of climate change on the fishing industry

3.2.5 Climate adaptation strategies among different socioeconomic typologies

Towards understanding climate justice dynamics within the region, the study included a disaggregation of the local adaptive capacity considering different socioeconomic attributes

such as gender, nationality, and living with disability. This subsection provides insights where such disaggregation revealed significant differences.

3.2.5.1 Adaptation Strategies Among Persons with Disabilities

Analysis of coping strategies by PWD status reveals that, for most measures, adoption levels are fairly similar between PWD and non-PWD households (data not presented). However, a few critical differences stand out (Figure 20). PWD households were less likely to reduce household expenses, as indicated by the lower frequency (48.4%) compared to 61.8% of the non-PWDs. Similarly, proportionally fewer (42.7%) PWDs reported shifting to alternative income sources such as petty trade or labour compared to 52.3% from the non-PWD counterparts. These differences are possibly due to financial or labour constraints. Conversely, PWD households appear more likely to destock or sell animals during droughts (34.7%) than their non-PWD counterparts (24.7%), as a coping mechanism when mobility or labour-intensive strategies are less feasible. The most striking disparity was in mobility-based livestock strategies, particularly transhumance, where PWD households adopted this strategy much less frequently (23.4%) than other colleagues (61.7%), reflecting physical or logistical limitations.

Overall, while PWD households generally employ similar coping strategies to non-PWD households, the most significant gaps occur in labor and mobility-intensive measures, highlighting areas where targeted support could improve resilience and inclusivity in adaptation interventions.

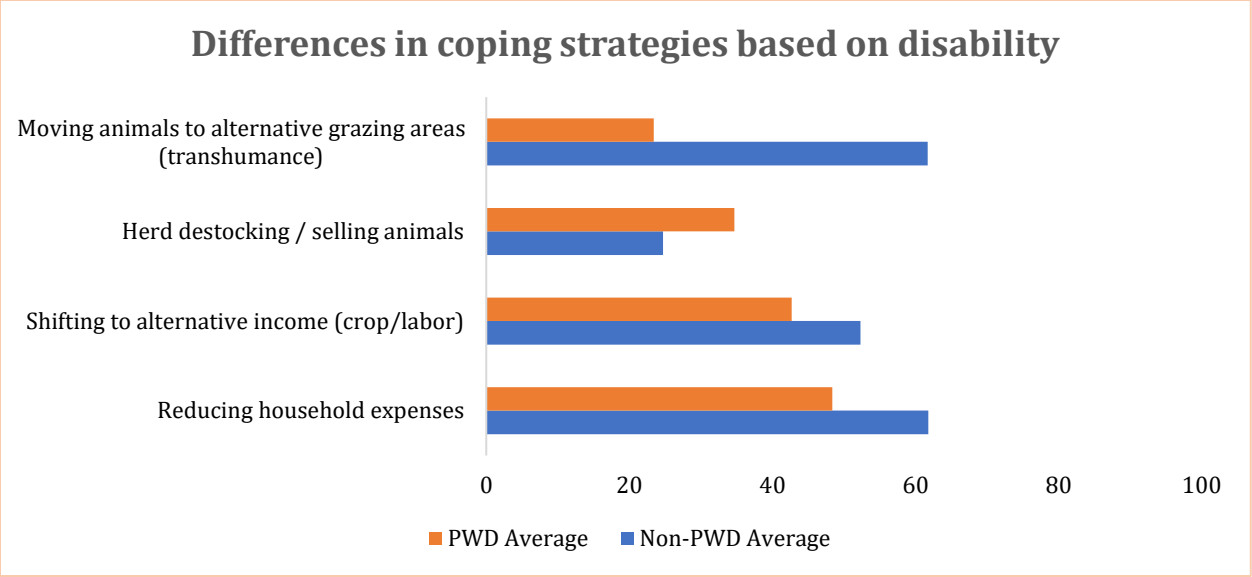

Figure 20: Coping strategies, disaggregated with PWD status

3.2.5.2 Adaptation Strategies Among Refugees

The analysis of coping strategies by nationality and refugee status revealed distinct patterns in livelihood adaptation across West Nile. Refugee households exhibited a marked reliance on mobility- and resource-intensive strategies compared to host community households. For example, nearly all refugee households (98.2%) use alternative water sources for rain-fed production, compared to 76.6% of host households. This suggests that refugees, often with limited access to land and water infrastructure, prioritize strategies that secure basic production resources. Similarly, strategies involving mobility were more prevalent among refugees than hosts. For example, temporary labor migration was more frequent (67.9%) compared to 47.9% among hosts, and transhumance for livestock (72.7%) compared to 59.9%, respectively. This pattern reflects their adaptive response to spatial and temporal constraints on grazing land, water, and employment opportunities. No wonder it was also very common for data collectors to fail to locate Refugees due to temporary migration. Host households, in contrast, have more consistent access to local land and social networks, enabling them to diversify income sources through crop farming, petty trade, and local labour (51.8% vs. 29.5%).

Interestingly, fish farming, though generally low across both groups, was higher among refugee households (19.6%) compared to hosts (7.5%), indicating selective adoption of alternative production methods when feasible. Other strategies, such as staggered planting, supplemental irrigation, or constructing animal shelters, show minimal differences, suggesting broad similarities in technical coping strategies where access and labour requirements are not limiting.

Implications for policy and programming are significant. Refugee households' reliance on mobility and water-focused strategies highlights the vulnerability of their livelihoods to external shocks, such as restricted access to grazing areas or water points, conflict, or climate variability. Interventions should therefore focus on improving access to water infrastructure, secure grazing areas, and labor opportunities, as well as supporting income-generating alternatives that are feasible within the constraints faced by refugee households. Host community households, while better able to diversify income, may also benefit from strengthening mobility-independent strategies and expanding access to sustainable water and fodder management.

Therefore, the nationality/refugee disaggregation uncovers meaningful differences that reflect structural inequalities and access limitations, emphasizing the need for targeted, inclusive support that addresses both the resource constraints of refugees and the optimization of existing adaptive strategies among host communities.

3.2.5.3 Adoption of coping strategies by gender

Analysis of coping strategies by gender indicated that adoption rates were generally similar between male and female-headed households, with most strategies showing only minor differences. Female-headed households slightly led in certain livestock-related strategies, including herd destocking during droughts (33.7% among women and 23.6% for males) and diversifying livestock species (33.1% and 22.8%, respectively), as well as rainwater harvesting (50.6% and 40.9%). For the majority of crop, water, and income-related measures, adoption rates are very similar, indicating that gender does not substantially influence coping strategies in this context.

3.2.5.4 Adoption of coping strategies by age group

Analysis of livelihood coping strategies by age showed that youth-headed households and non-youth households adopted most strategies at very similar rates, with only minor differences. Youth households slightly led in income diversification, with 59.9% of youth households reporting adoption compared to 53.6% of non-youth households, and in rainwater harvesting, adopted by 47.5% of youth versus 43.4% of non-youth households. Non-youth households slightly lead in temporary labour migration, with a frequency of 51.2% compared to 46.9% among youth, and transhumance for livestock (62.6% and 59.7% respectively). For the majority of crop, livestock, and water management strategies, including early planting, fish farming, tolerant crop varieties, herd destocking, and alternative water sources, adoption rates are almost identical. These findings indicate that age does not substantially influence the choice or intensity of livelihood coping strategies, with youth and non-youth households showing broadly comparable patterns of adaptation.

3.2.6 Access to External Support

Overall access to external support among respondents was generally low, with only about 17% reporting that they had ever received any form of assistance related to livelihoods or climate resilience. This indicates that most households continue to rely primarily on their own resources and informal coping mechanisms. District-level variations were, however, evident: Obongi District had the highest proportion of beneficiaries (37.7%), likely reflecting the concentration of humanitarian and development agencies in its refugee-hosting areas (Figure 21). Madi Okollo followed distantly with 16%, while Adjumani (7.4%) and Zombo (4.8%) recorded notably lower levels, implying weaker institutional and programmatic reach in these districts.

From qualitative data, the few cases of external assistance received mainly took the form of financial, technical, and input-related support, occasionally combined. The support efforts were largely channelled through government programs, often complemented by NGOs and, to a lesser extent, community-based groups and private markets. Financial support included small grants and subsidies, while technical support typically covered training and advisory

services. Input-related assistance mainly involved seed, feed, or equipment distribution, though shortages and irregular supply were common. Most beneficiaries accessed these supports occasionally rather than consistently, highlighting both the limited coverage and the sporadic nature of external assistance in the region.

Among social groups, persons with disabilities (PWDs) reported slightly greater access to support (26.8%) than their non-PWD counterparts (12.6%), suggesting growing efforts toward inclusion in aid and development initiatives. Nevertheless, access across both groups remained generally low. Other characteristics, such as gender and age, did not show meaningful differences, implying that access is more influenced by location and program presence than by individual attributes.

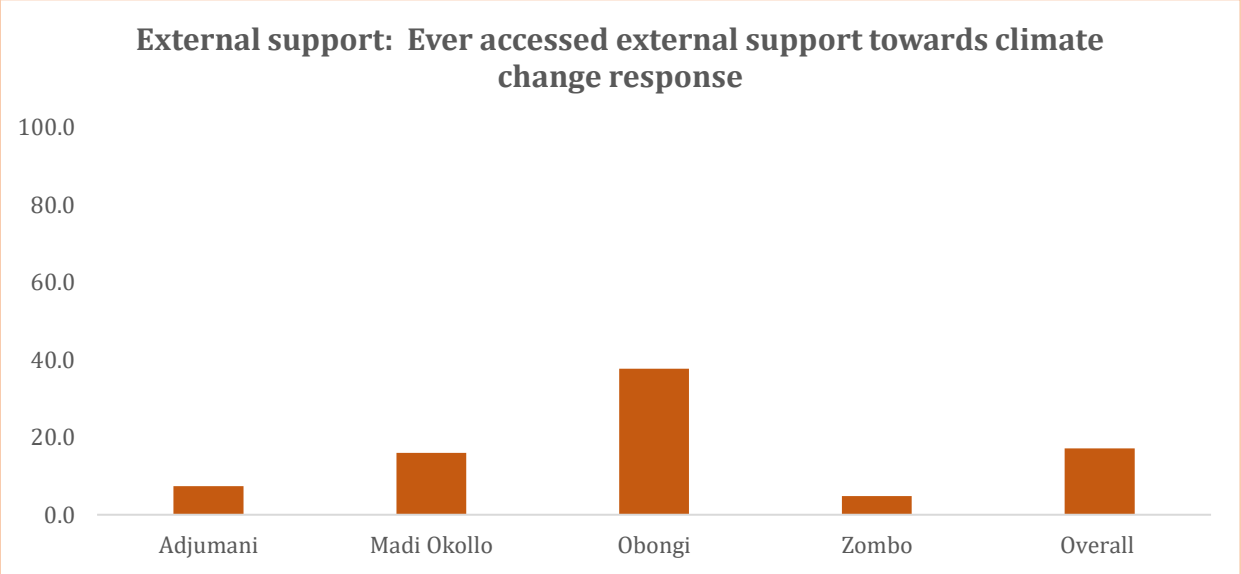

Figure 21: Frequency of respondents who had ever received external climate-related support

3.2.6.1 Access to extension services across districts

Overall access to extension services across the surveyed districts was moderate but uneven, averaging 29 percent across the different thematic areas (Figure 22). The highest outreach was reported in crop production (43.2%), followed by natural resource restoration (34.3%) and soil and land management (32.7%). Access was comparatively lower in animal

production (29.1%), rainwater harvesting (24.9%), and fish farming (19.7%), while safe and approved fishing practices had the least coverage (9.8%). These figures suggest that most extension efforts remain focused on traditional crop-based interventions, with limited diversification toward integrated resource management and aquaculture.

District-level variations were pronounced. Adjumani District consistently reported the highest access across most domains, with 91.6% of respondents reached for crop production, 71.6% for rainwater harvesting, and 66% or more for animal production, natural resource restoration, and soil management. This reflects Adjumani's relatively stronger institutional presence and active engagement of extension agents, partly linked to its large refugee-hosting programs. Obongi followed moderately, especially in fish farming (42.7%) and crop production (52.1%), consistent with its growing involvement in diversified livelihood activities. In contrast, Madi Okollo and Zombo registered markedly lower access to almost all service areas. In Madi Okollo, the highest recorded access was only 27.9% for crop production, with all other domains below 15%. Zombo reported even lower outreach, with barely 6.8% accessing crop production advice and just 1.0% receiving guidance on water harvesting or fishing. These gaps indicate significant spatial disparities in extension delivery, likely reflecting differences in infrastructure, staffing, and project coverage.

The overall pattern points to an imbalance in both thematic focus and territorial reach of extension services in West Nile. While crop-focused support remains relatively strong, other crucial domains such as water management, aquaculture, and sustainable resource restoration are underserved. Strengthening integrated and equitable extension systems across districts is therefore critical for building holistic livelihood resilience.

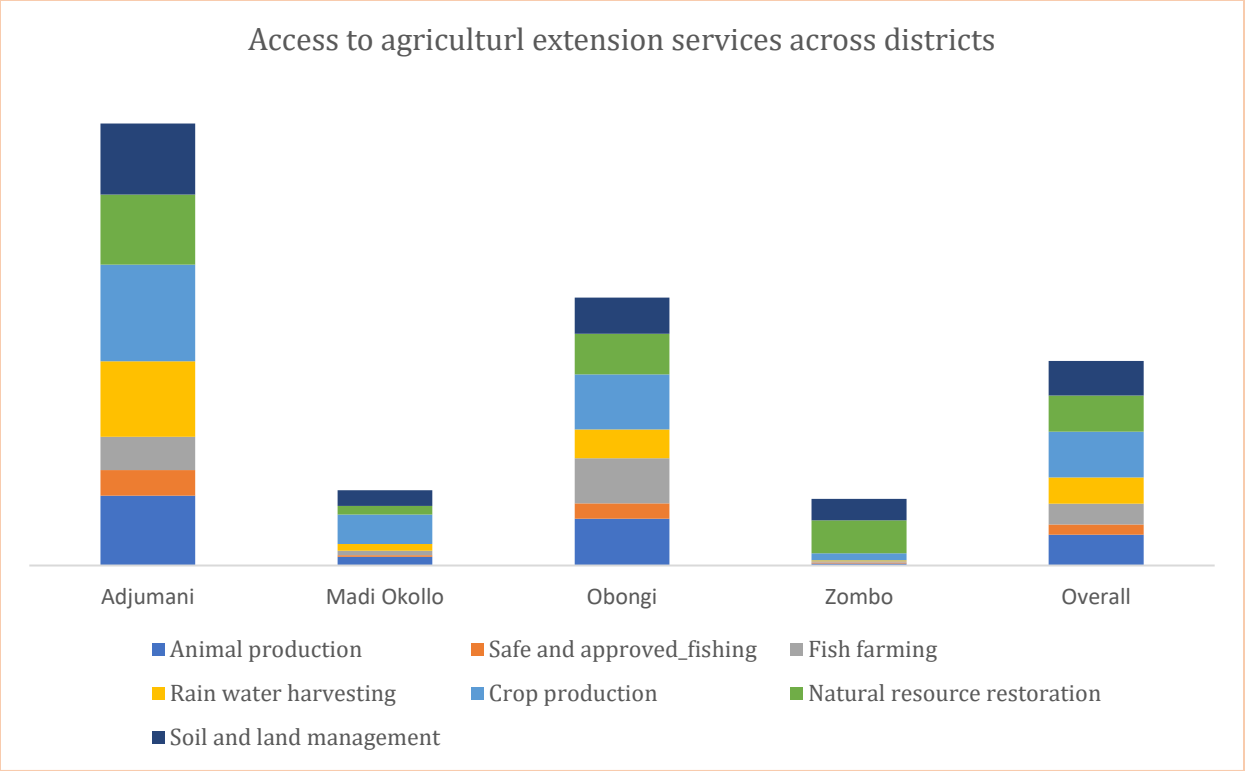

Figure 22: Access to agricultural extension support in the region

3.2.6.2 Access to extension by refugees and the host community

Disaggregation by community status revealed further disparities in access to extension services (Figure 23). On average, host communities reported slightly higher access (around 29% overall) compared to refugees (24%). While both groups benefited most from crop production support (43% among hosts and 46% among refugees), marked contrasts emerged in other areas. Refugees appeared to have slightly better outreach in safe and approved fishing (19.6%) and fish farming (25%), reflecting the focus of several humanitarian livelihood programs on aquaculture and wetland resource use. Conversely, host communities had substantially higher access in animal production (31%), natural resource restoration (36%), and soil and land management (34%), suggesting their stronger linkages to government agricultural systems.

Overall, the data point to a thematic segmentation of extension services whereby refugee-targeted programs tended toward fisheries and water management, and host communities

benefiting more from terrestrial farming and conservation services. Such differences underscore the need for better coordination between humanitarian and government-led extension efforts to achieve balanced livelihood outcomes across both populations.

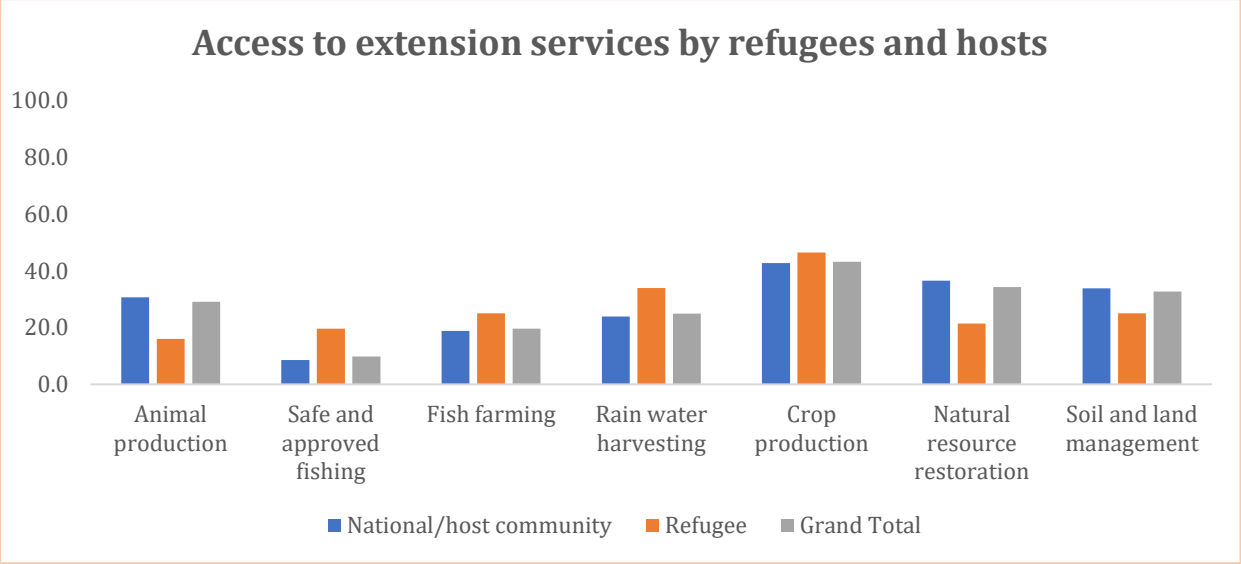

Figure 23: Access to agriculture extension support: Disaggregated ted by nationality/refugee status

3.2.6.3 Access to Extension Services by Gender

When disaggregated by gender, access to extension services showed modest but consistent differences, generally favouring men. On average, male respondents reported higher access to crop production (49.1%), rainwater harvesting (33.5%), and animal production (31.8%) services compared to females, who reported 39.4%, 19.3%, and 27.3%, respectively. However, the gender gap was narrower or even reversed in some areas. For example, natural resource restoration training was accessed by 35.6% of males and 32.4% of females, and safe and approved fishing training reached 15.6% of females compared to 6.1% of males. Overall, men appeared to have slightly greater engagement with extension programs, particularly those targeting climate adaptation, mitigation, and resilience, while women's access remained lower. This is likely stemming from gendered divisions of labour and unequal information channels. These findings underscore the need for gender-responsive extension

approaches that enhance women's participation, especially in agricultural and climate-resilient livelihood initiatives.

3.2.6.4 Access to Extension Services by age group

Young people reported slightly higher access to several extension services. In animal production, 34% of youth had received support compared to 27% of older adults. A similar pattern appeared in fish farming, where youth reached 23% against 18% among older adults. Crop production services showed the widest gap, with youth at 48% and older adults at 41%, while natural resource restoration also favored younger respondents, 37% compared to 33%. Access to the remaining services showed only marginal differences between the two age groups. Overall, these differences are not substantial enough to warrant disaggregation, suggesting that extension support, particularly those targeting climate adaptation, mitigation, and resilience, is broadly limited across age groups.

3.3 Participants' perception of climate justice

A majority of respondents (58%) perceived that the burden of climate change is equitably distributed, while 42% felt it was not (Table 13). Variation between districts was mild: 61.3% of respondents in Adjumani felt the burden was shared equitably, compared to 67.2% in Madi Okollo, 57.8% in Obongi, and 45.5% in Zombo. Considering the distribution of the burden across livelihood options, crop production emerged as the most burdened by climate change responses (49%), followed by animal production (24%), small-scale business or petty trade (14%), and fishing (13%). This pattern is, however, also linked to the relative frequency of the livelihood options within the society and perhaps the relative cumulative contribution to the climate change-related threats.

Access to climate change adaptation and support services remains generally low, with only 44% of respondents reporting equitable access. However, in a gender lens, women were disproportionately disadvantaged, representing 77% of those with limited access, while men accounted for 23%. Age-related disparities were also evident: the elderly (39%) and youth (39%) faced greater barriers than mid-age adults (22%). Wealth status also strongly

influenced access, with the poor comprising 92% of those most disadvantaged compared to just 8% of the rich. Persons with disabilities were similarly affected, with only 37% reporting fair access to support services.

Participation in climate-related decision-making was limited: Merely 7.5% of respondents reported "always" participating, whereas 23% reported "never" participating. Certain livelihoods and societal groups were frequently left out of interventions: fishing (37%), crop production (29%), and small-scale business (20%) were most often excluded, while persons with disabilities (31%), youth (31%), and women (19%) were the societal groups most commonly overlooked.

These findings indicate that climate adaptation, mitigation, and resilience measures are not reaching all groups equitably, highlighting the need for targeted interventions that prioritize the most burdened livelihood options and the most disadvantaged societal groups.

Table 13: Respondents' perceptions around climate justice

Indicator	Category	%
Perception of equitable burden	Yes	58.3
Most burdened livelihood option	Crop production	48.8
Equitable access to support	Yes	44
Most disadvantaged gender (access to support)	Women	77.2
Most disadvantaged age group	Elderly (over 65 y)	39.4
Most disadvantaged wealth group	Poor	91.8
Fair access to CC support for PWD	Yes	36.8
Participation in decision-making (procedural justice)	Sometimes	38
Livelihoods often left out	Fishing	37.4
Societal groups mostly left out	People with disability	31.4

3.4. Human rights at risk due to climate change

3.4.1 Perceived Human Rights Violations by District

The analysis revealed widespread perceptions of human rights violations across districts in the West Nile region, with notable variation in the type and extent of deprivations experienced (Figure 24). Overall, the most frequently reported violations were related to the right to water (62.9%), right to food (59.0%), and right to health (58.1%), suggesting that climate-related shocks have significantly affected access to basic needs and essential services. Moderate levels of violation were reported for the right to livelihood (49.0%) and right to education (54.4%), reflecting the broader socioeconomic disruptions linked to climate stress.

At the district level, Obongi and Adjumani recorded the highest proportions of respondents reporting violations across multiple rights domains. In Obongi, over 90% of respondents reported infringement of the right to food, and more than 80% cited violations of the right to health (82.9%) and right to education (78.6%). According to experienced informants operating in the area, the right to education is specifically prone to extreme rainfall events such as floods and hailstorms in refugee setting. Similarly, in Adjumani, high levels of reported violations were observed in the right to food (88.4%), right to work (67.4%), and right to livelihood (71.6%), indicating that the effects of climate variability are strongly felt in areas with mixed refugee and host populations.

In contrast, Madi Okollo and Zombo reported relatively lower proportions of perceived violations for most rights, although certain specific concerns stand out. In Zombo, respondents reported notably high infringements of the right to participation in decision-making (61.2%) and the water right (78.6%), indicating governance and environmental stress issues despite lower overall exposure to displacement-related impacts. Madi Okollo, meanwhile, reported fewer violations across most rights, but the persistence of food insecurity (44.4%) and limited livelihood options (21.0%) still indicates vulnerability.

Taken together, these findings suggest that climate-related events are perceived to have significantly undermined multiple human rights in the West Nile region, particularly those

related to food security, water access, and health. The spatial differences likely reflect varying exposure levels, livelihood dependencies, and adaptive capacities across districts.

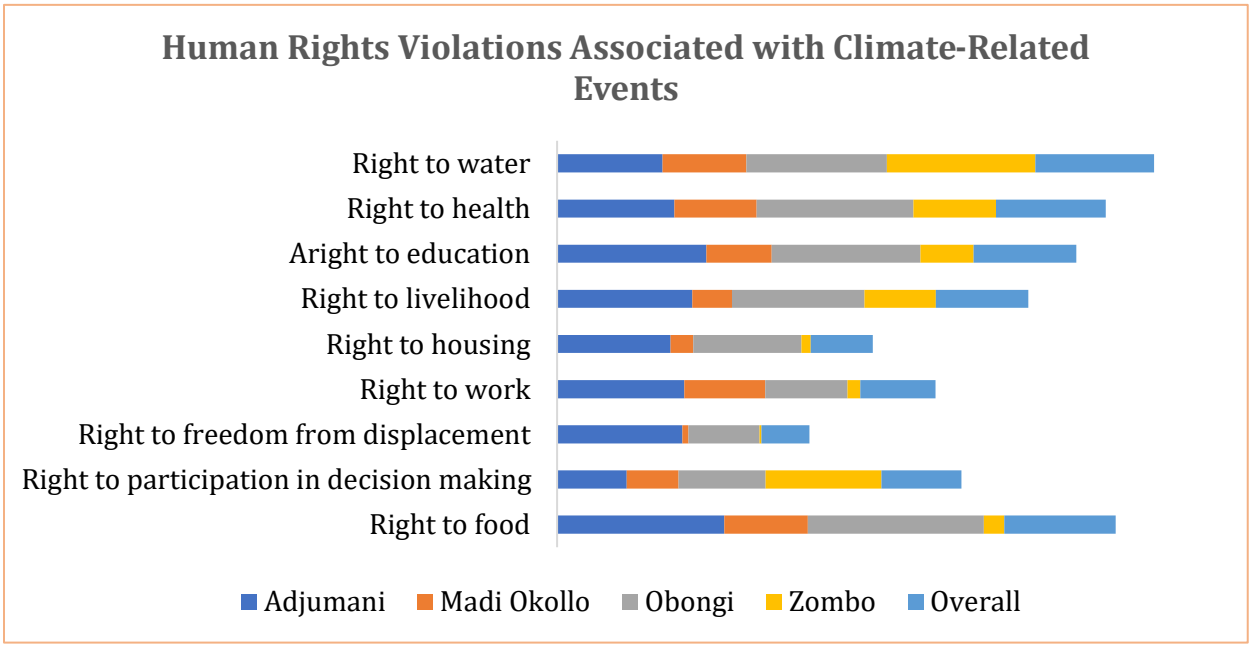

Figure 24: Perceived Human Rights Violations Associated with Climate-Related Events across districts

3.4.2 Perceived Human Rights Violations by Disability Status

Persons with disabilities reported lower levels of perceived deprivation across most rights compared to non-PWD respondents (Figure 25). For example, deprivation related to the right to food stood at 57.1% among PWDs compared to 64.3% among non-PWDs. A similar pattern was observed for the right to participation in decision making, with 41.9% among PWDs compared to 44.2% among non-PWDs, and for the right to freedom from displacement, with 23.9% among PWDs compared to 28.7% among non-PWDs. Economic and social rights showed the same trend. Deprivation of the right to work was 37.9% among PWDs compared to 45.7% among non-PWDs. For the right to housing, deprivation stood at 31.6% among PWDs compared to 36.4% among non-PWDs. The right to livelihood showed 48.5% among PWDs compared to 50.4% among non-PWDs, and the right to education showed 52.8% among PWDs compared to 58.1% among non-PWDs. Two rights did not

follow this pattern. Both PWDs and non-PWDs reported 58.1% deprivation for the right to health, while the water right showed slightly higher deprivation among PWDs at 63.5% compared to 61.2% among non-PWDs.

Overall, the findings show that non-PWD respondents reported higher deprivation across most rights, with only small differences in health and water. This pattern may reflect the effects of existing affirmative action and targeted support programmes for persons with disabilities, which could be helping to reduce or cushion deprivation among PWDs relative to the general population, even though overall levels of vulnerability remain high for both groups.

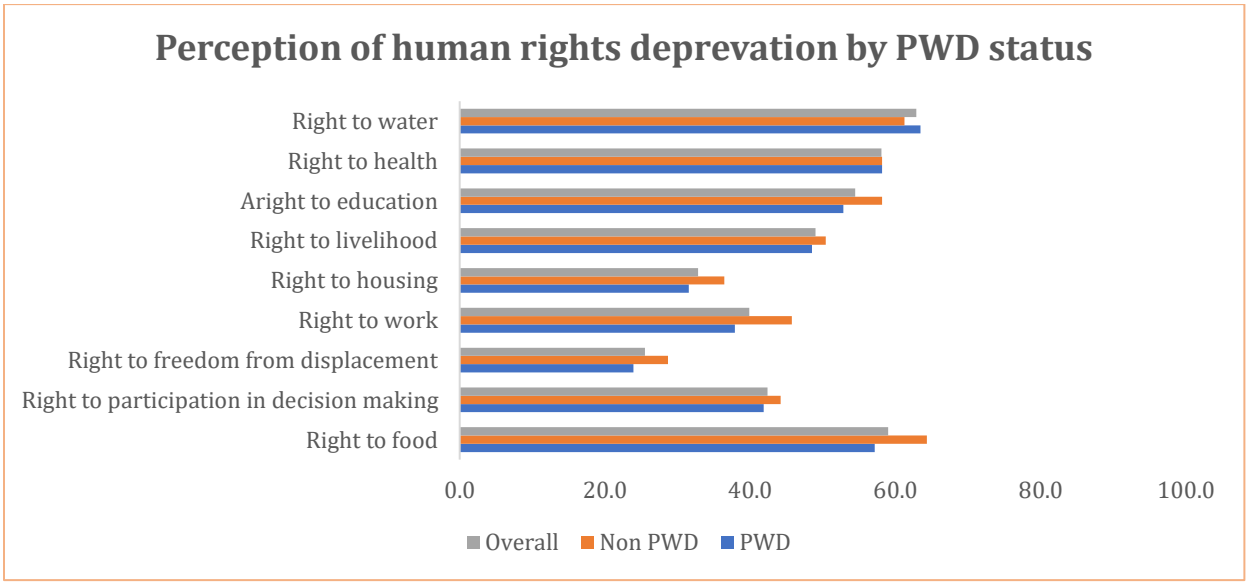

Figure 25: Perceived Human Rights Violations Associated with climate change: Disaggregated by disability status.

3.4.3 Perceived Human Rights Violations by Gender

The data reveal gender differences in reported experiences of rights violations due to climate-related events (Figure 26). Overall, females reported higher levels of rights deprivation than males across almost all categories. For the right to food, 64.2% of females reported experiencing violations, compared to 55.6% of males, with an overall rate of 59.0%. This indicates that food insecurity linked to climate events affects women more severely than men. Regarding participation in decision-making, 48.6% of females reported

deprivation, whereas only 38.3% of males did, suggesting that women are more frequently excluded from decisions that may affect their livelihoods and well-being.

The right to freedom from displacement was also more commonly violated among females (32.4%) than males (21.1%), reflecting greater vulnerability to forced relocation due to climate impacts. Similarly, the right to work (45.1% vs 36.5%) and the right to livelihood (57.8% vs 43.2%) showed higher deprivation among women, highlighting disproportionate socio-economic impacts.

Housing violations were reported by 37.0% of females and 30.1% of males, while education-related deprivation was similar across genders (55.5% for females, 53.8% for males). Health and water rights also showed notable deprivation, with females slightly more affected (60.7% vs 56.4% for health; 63.6% vs 62.4% for water).

Overall, the findings indicate that women are more likely than men to experience climate-related rights violations, particularly in areas of food security, livelihoods, and decision-making. Rights such as education, health, and water are highly affected for both genders, reflecting widespread vulnerability to climate events in the study area.

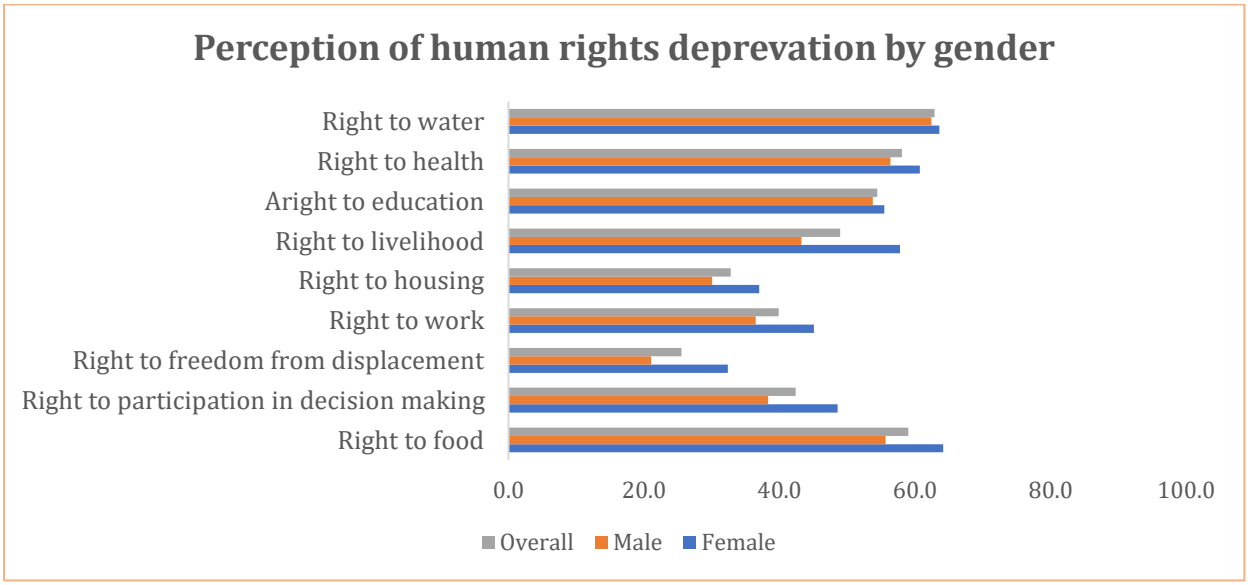

Figure 26:Perceived Human Rights Violations Associated with climate change: Disaggregated by gender

3.4.4 Perceived Human Rights Violations by refuges and host community

The data highlight differences between nationals/host communities and refugees in experiencing climate-related rights violations. Overall, refugees reported much higher levels of deprivation for some rights, while nationals experienced higher deprivation in others (Figure 27).

The right to food was notably more violated among refugees, with 85.7% reporting deprivation compared to 55.3% of nationals. This indicates severe food insecurity among refugee populations during climate-related events. In contrast, the right to participation in decision-making was substantially lower for refugees (10.7%) than for nationals (47.3%), reflecting their exclusion from decision-making processes affecting their communities and livelihoods.

Deprivation in freedom from displacement was similar between the two groups (25.0% for refugees, 25.4% for nationals), suggesting that climate-related displacement affects both populations comparably. Rights to work and livelihood showed contrasting patterns: nationals reported higher deprivation in the right to work (42.0% vs 28.6%), whereas refugees reported greater deprivation in the right to livelihood (66.1% vs 46.5%), highlighting economic vulnerability among displaced populations.

Housing-related violations were slightly higher among refugees (35.7%) compared to nationals (32.6%). Education-related deprivation was comparable (55.4% vs 54.3%), whereas health and water rights showed mixed patterns: nationals reported higher health-related deprivation (59.1% vs 51.8%), while refugees reported lower deprivation in access to water (51.8% vs 64.4%).

Overall, these results indicate that refugees face particularly severe deprivation in food security and livelihood, while nationals experience more frequent violations in participation and access to certain social services like water and health. This underscores the differential vulnerabilities between host communities and refugee populations in the face of climate-related events.

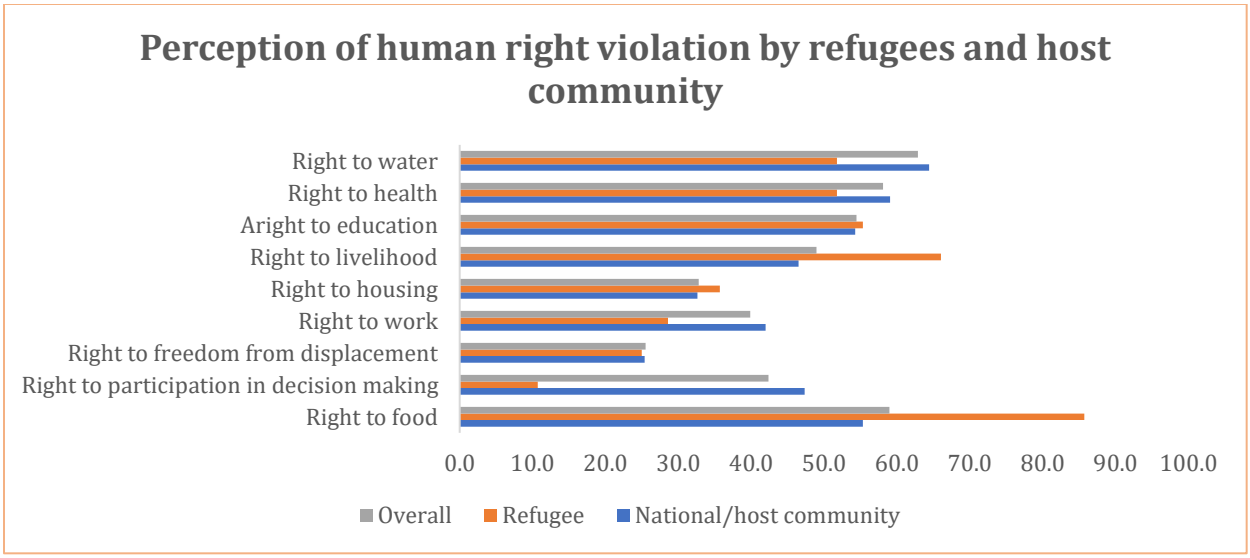

Figure 27: Perceived Human Rights Violations Associated with climate change: Disaggregated between refugees and host community

3.4.5 Perceived Human Rights Violations by age group

Variations existed in climate-related rights violations between youth and non-youth respondents. Overall, youth reported higher deprivation in some rights, while non-youth reported higher deprivation in others (Figure 28).

For the right to food, youth reported slightly lower deprivation (57.1%) compared to non-youth (59.9%), indicating that food insecurity is experienced across age groups but slightly more among older respondents. Regarding participation in decision-making, youth experienced higher deprivation (46.3%) than non-youth (40.4%), suggesting that younger individuals are more excluded from decisions affecting their livelihoods and community affairs.

Deprivation in freedom from displacement was higher among youth (27.9%) compared to non-youth (24.3%), while the right to work also followed this pattern, with youth reporting greater deprivation (46.3%) versus non-youth (36.6%). Housing-related deprivation was slightly higher for youth (34.7%) compared to non-youth (31.8%).

Similarly, youth reported more frequent deprivation in livelihood (51.7% vs 47.6%) and education (55.8% vs 53.8%), indicating that climate-related events disproportionately affect

their economic opportunities and access to learning. Health and water rights also followed this pattern, with youth experiencing higher deprivation (59.9% vs 57.2% for health; 66.0% vs 61.3% for water).

Overall, the findings suggest that youth are particularly vulnerable to climate-related rights violations, especially in areas of work, livelihood, education, and access to water, highlighting the need for targeted interventions to reduce age-related disparities in climate vulnerability.

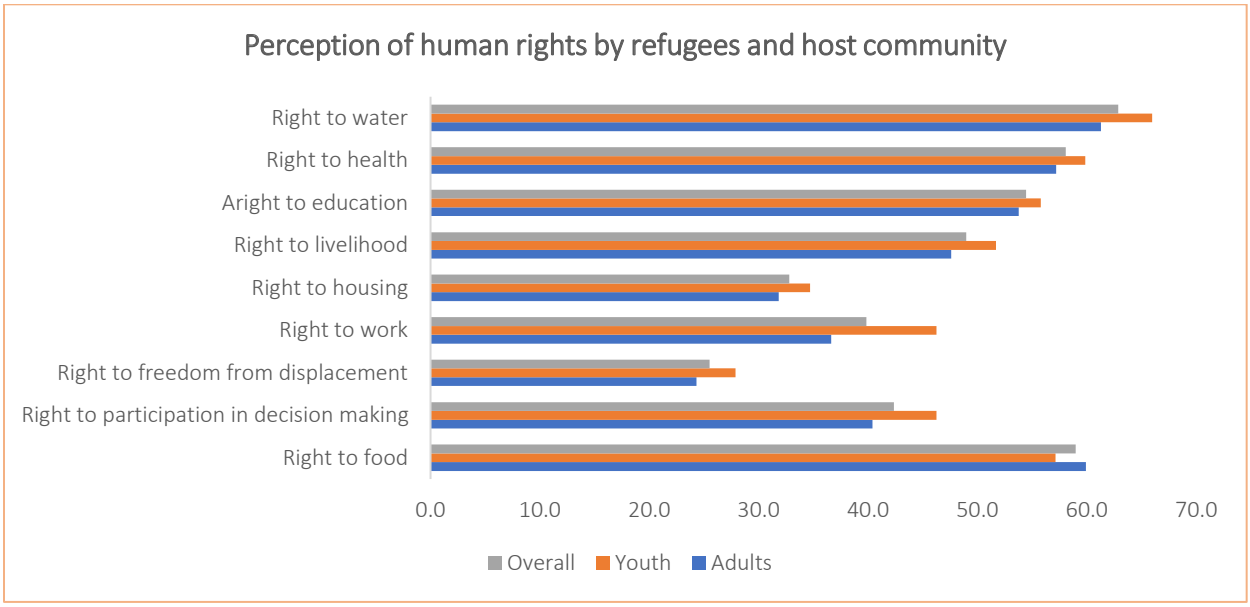

Figure 28: Perceived Human Rights Violations Associated with climate change: Disaggregated by age group

3.5 Impacts on environmental resources and ecosystems

3.5.1 Land Use and Land Cover Change, 2001–2021

A comparative analysis of Landsat-derived LULC data for 2001, 2011, and 2021 indicated significant changes in land cover, shaped by demographic pressure, livelihood expansion, and local land-use practices across the study districts. Side-by-side maps of both years (Figure 29) illustrate a shift toward cropland and cropland/natural vegetation mosaics, with concurrent declines in forest and permanent wetland cover. Table 6 summarises area estimates by class and quantifies both long-term change (2001-2021) and the most recent decade trend (2011-2021). The results indicate substantial cropland expansion (+425 km^2;

+52%), contraction of permanent wetlands (–81 km^2; –29%), and reconfiguration of the cropland/natural vegetation mosaic (–830 km^2; –24%), the latter reflecting conversion to more continuous cropland in many locations. Forest categories exhibit mixed signals: evergreen broadleaf shows net growth since 2001 but declined in the last decade, while mixed forest contracted sharply overall. Savannas increased relative to 2001 but receded during 2011–2021 in some districts, suggesting dynamic edge conversions at the agriculture–savanna interface.

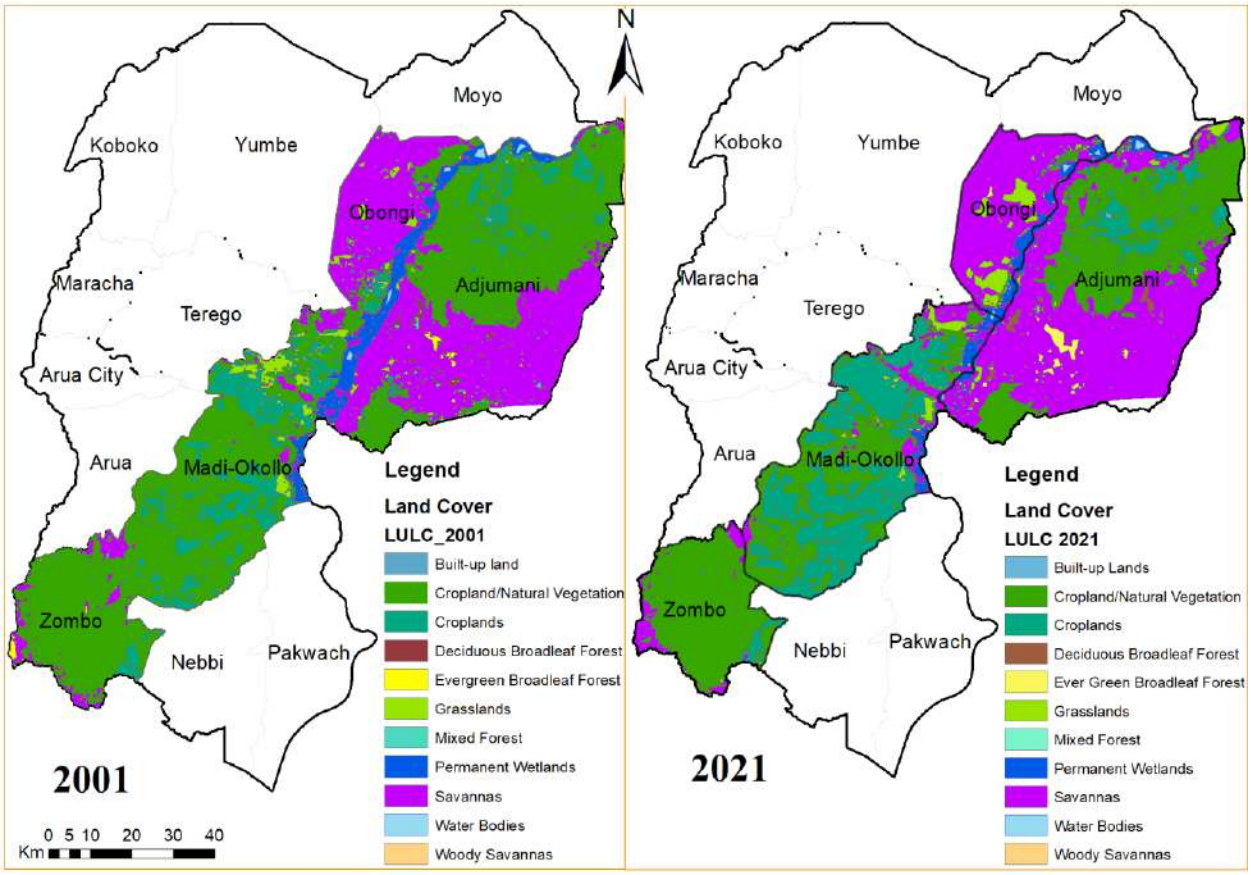

Figure 29: Side by side map showing land use change between 2001 and 2021

The data portray a progressive conversion of different land covers into agricultural land: croplands expanded by ~425 km^2 since 2001, while mosaic areas contracted by ~830 km^2, consistent with consolidation of cultivation and shorter fallow cycles. This reconfiguration coincides with the loss of permanent wetlands (–29%) and declines in mixed forest, reducing ecological buffers that regulate runoff, support dry-season water, and sustain biodiversity.

Although the evergreen broadleaf forest was higher in 2011 than in 2001, it fell during 2011-2021, signalling pressure on remaining high-value stands in the most recent decade. Savanna and grassland signals are mixed: both are greater than in 2001, yet savannas declined by ~214 km^2 during 2011–2021, pointing to recent conversions at the savanna–cropland edge. Built-up land remains a very small share of the region and is relatively stable, reinforcing that the dominant land-cover driver is rural smallholder expansion, not urban sprawl. Collectively, these shifts help explain reported water quantity/quality issues, soil exposure and gullies, and vegetation loss detailed in Sections 5.2–5.6, and they highlight where restoration and climate-smart land management should be prioritised. The spatial trends in natural resources concur with respondents' perceptions as discussed in the preceding sections.

Table 14: Grid code LULC_2021 Area 2021 (Km2) Area 2001 ((Km2)) Area Change (2001-2021) % Change (2001-2011)

LULC class	2001	2011	2021	Change 2001→2021 (km^2)	Change 2001→2021 (%)
Evergreen broadleaf forest	18.74	61.02	47.26	**+28.52**	**+152.2%**
Deciduous broadleaf forest	30.83	23.95	31.45	**+0.62**	**+2.0%**
Mixed forest	9.83	8.66	2.19	**–7.64**	**–77.7%**
Woody savannas	1.83	1.51	3.59	**+1.76**	**+96.2%**
Savannas	2,034.94	2,653.57	2,439.98	**+405.04**	**+19.9%**
Grasslands	154.25	152.99	183.91	**+29.66**	**+19.2%**
Permanent wetlands	281.01	221.61	200.34	**–80.67**	**–28.7%**
Croplands	811.19	1,215.37	1,236.14	**+424.95**	**+52.4%**
Built-up areas	1.22	1.10	1.10	**–0.12**	**–9.8%**
Cropland/Natural Vegetation Mosaic	3,476.07	2,484.64	2,645.88	**–830.19**	**–23.9%**
Water bodies	12.54	7.03	9.86	**–2.68**	**–21.4%**

Notes: (i) Areas are clipped to the study boundary; totals may differ slightly across years due to cloud masking and classification tolerances. (ii) "Cropland/Natural Vegetation Mosaic" denotes mixed pixels/landscapes where cropland co-occurs with grasses/shrubs or fallows at sub-pixel scales.

3.5.2 Degradation of Surface Water

Figure 30: Water degradation through erosion and deposition

Consistent with the GIS-based findings, analysis of participants' perceptions about surface water reveals significant degradation, albeit with substantial variability across districts (Figure 31). Overall, reduced water volume was the most commonly reported manifestation, affecting 77% of respondents across all districts, which aligns with the observed decline in permanent wetland cover between 2001 and 2021. This was particularly pronounced in Adjumani (90.5%) and Madi Okollo (79.6%), highlighting widespread perceptions of

diminishing water availability. Relatedly, over 40% of the respondents noted cases of complete drying up of surface water during the dry season. This was most severe in Adjumani (65.3%) and Obongi (53.5%), indicating pronounced seasonal water scarcity in these districts.

Floods were also significant concerns, 52.8% of respondents reporting this increased occurrence. Zombo reported the highest increase of flooding (59.8%), suggesting localized susceptibility to extreme rainfall events or poor drainage. In contrast, Madi Okollo reported increase in flooding (22.1%), indicating more resilient hydrological conditions or different seasonal patterns. Water quality deterioration, manifested as increased silting (29.3%), turbidity (49.2%), unpleasant taste (49.6%), and bad odour (51.3%), was reported across all districts. Adjumani experienced the highest levels of silting (68.4%) and bad odour (68.4%), while Zombo and Madi Okollo reported higher turbidity (62.7%) and unpleasant taste (48.3–48.0%). Obongi was particularly affected by bad odour (75.9%), suggesting significant pollution or organic matter accumulation.

In summary, the survey findings indicate that surface water in these districts is under increasing stress from both quantity-related issues, such as reduced volume and seasonal drying, and quality-related issues, including turbidity, silting, and organoleptic deterioration, which are also consistent with the spatial analysis. The district-specific variations underscore the need for localized interventions to safeguard water resources and ensure sustainable access for communities.

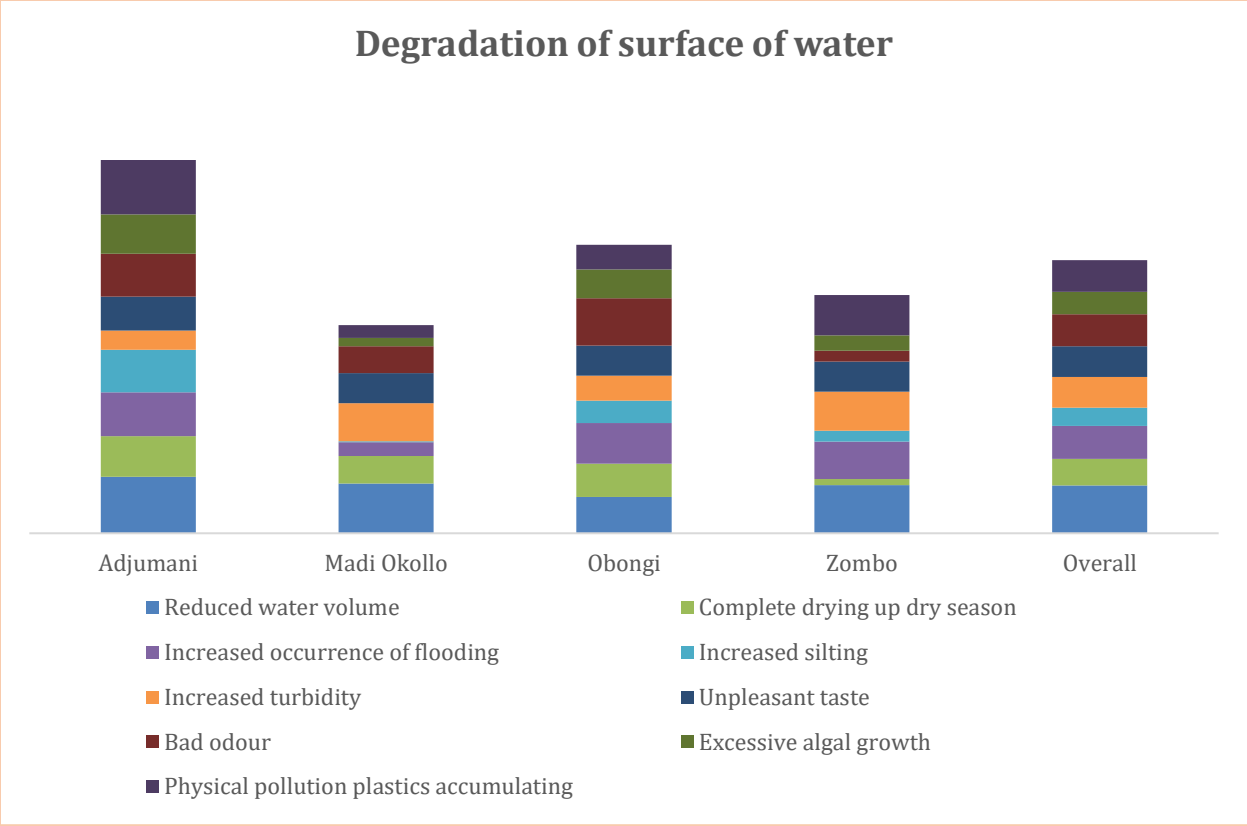

Figure 31: Degradation of the surface water resources

3.5.3 Human Activities and Degradation of Surface Water

Figure 32: Sand mining, a major human activity threatening the surface water system

The increasing degradation of surface water in the districts of Adjumani, Madi Okollo, Obongi, and Zombo is largely influenced by human activities (Figure 33). Across the study area, farming close to water bodies was the most prevalent activity, reported by 79.8% of respondents overall. This practice was particularly pronounced in Zombo (100%), Obongi (83.2%), and Adjumani (78.9%), suggesting that agricultural encroachment directly threatens water availability and quality.

Brick laying was also widespread (68.9%), with Obongi (94.7%) and Adjumani (74.7%) showing the highest intensity. The extraction of materials for construction near water bodies can exacerbate erosion and sedimentation. Extensive grazing affected 53% of respondents overall, especially in Zombo (58.8%) and Madi Okollo (55%), contributing to soil

compaction, bank erosion, and nutrient runoff. Sand mining, while less common (41.8%), was significant in Zombo (63.7%) and Adjumani (61.1%), reflecting localized pressures on riverbeds and streams. These human activities are mirrored in the observed patterns of water degradation.

Therefore, surface water degradation in these districts is closely linked to human activities such as farming near water bodies, brick laying, grazing, and sand mining. The district-specific variations in both human activities and water degradation highlight the need for targeted interventions, combining sustainable land-use practices, community education, and regulation of high-impact activities to safeguard water resources for current and future use.

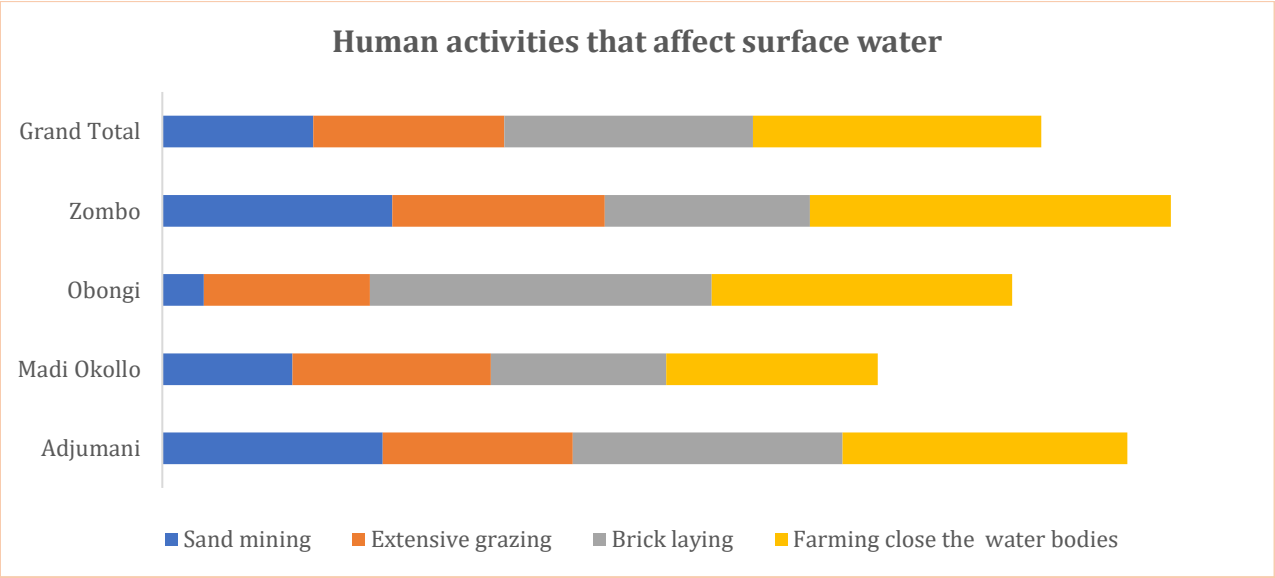

Figure 33: Human activities driving the degradation of surface water resources

3.5.4 Manifestations of Soil Degradation

Soil degradation is a rampant challenge across the districts of Adjumani, Madi Okollo, Obongi, and Zombo, with both physical and fertility-related manifestations (Figure 34). Overall, bare patches were the most frequently reported indicator, affecting 71.8% of respondents. This problem was particularly severe in Adjumani (91.5%) and Zombo (88.3%), suggesting widespread loss of vegetative cover and exposure of the soil surface to erosion processes. Reduced soil fertility was reported by 67.2% of respondents overall, with

the highest incidence in Madi Okollo (81.6%) and Adjumani (67.0%). This highlights the critical decline in soil nutrient status, likely affecting agricultural productivity and crop yields.

The presence of rock outcrops, an indicator of advanced land degradation and soil loss, was observed by 37.6% of respondents overall. Adjumani (77.7%) and Zombo (39.8%) reported the highest occurrence, whereas Obongi had minimal exposure (9.4%), reflecting spatial differences in underlying geology and erosion severity. Gully formation, another severe form of soil erosion, affected 51.3% of respondents overall. Adjumani (62.8%) and Madi Okollo (60.0%) experienced the highest levels, indicating significant landscape destabilization and potential loss of arable land. Zombo reported relatively lower gully prevalence (32.0%), suggesting less intense water erosion in certain areas.

Therefore, soil degradation in these districts manifests through a combination of surface exposure, fertility decline, rock outcrops, and gully formation, with clear district-specific patterns. The findings underscore the urgent need for site-specific soil conservation interventions to restore soil health, improve productivity, and prevent further land degradation.

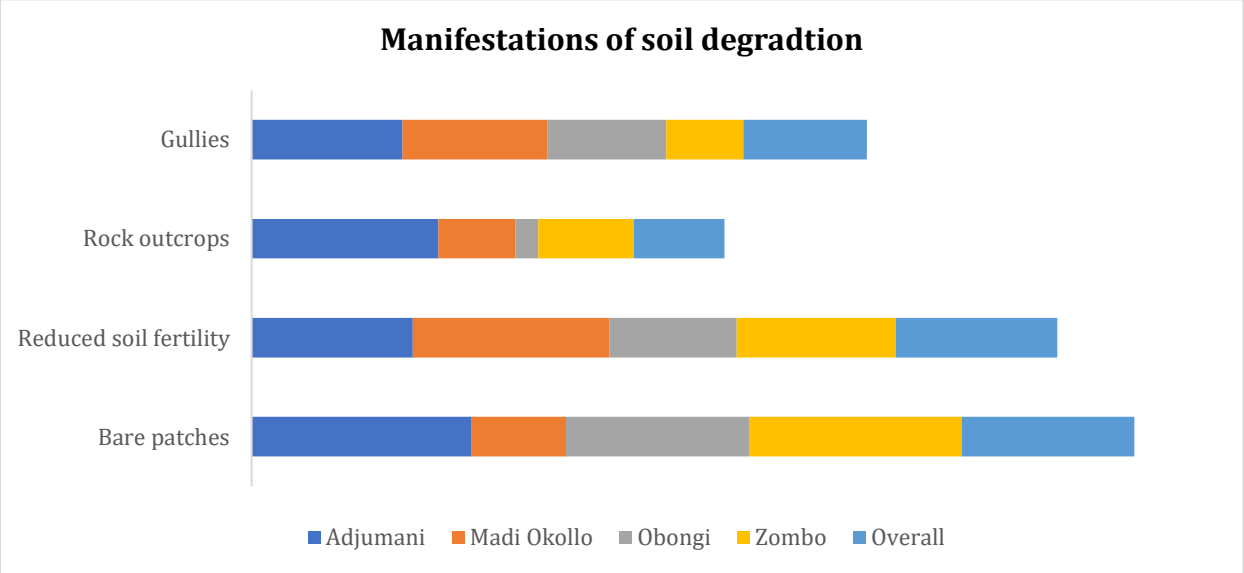

Figure 34: manifestation of soil degradation in the region

Figure 35: Gullies, a characteristic indicator of soil erosion

3.5.5 Human Activities Driving Soil Degradation

The analysis of human-induced pressures on soil across Adjumani, Madi Okollo, Obongi, and Zombo shows that anthropogenic activities are accelerating land degradation (Figure 36). Deforestation emerged as the most widespread activity, affecting 95.6% of respondents overall. Zombo (98.0%), Obongi (96.6%), and Madi Okollo (95.1%) reported the highest prevalence, indicating extensive tree removal for timber, fuel, and agricultural expansion. Firewood collection and charcoal burning were reported by 87.4% of respondents overall, with Zombo (97.1%), Obongi (88.8%), and Madi Okollo (90.2%) showing particularly high engagement. These practices contribute to vegetation loss, reduce soil organic matter, and increase vulnerability to erosion. Overgrazing affected 69.7% of respondents overall, with the highest levels in Adjumani (94.7%) and Madi Okollo (73.2%). The concentration of livestock in certain areas exacerbates soil compaction, disrupts vegetative cover, and accelerates the formation of bare patches and gullies.

Overall, the findings indicate that deforestation, firewood collection, and overgrazing are the principal human activities driving soil degradation in these districts. The district-specific variations highlight the need for targeted interventions, including sustainable land management practices, reforestation, controlled grazing, and alternative energy sources to mitigate the ongoing loss of soil fertility and structural integrity.

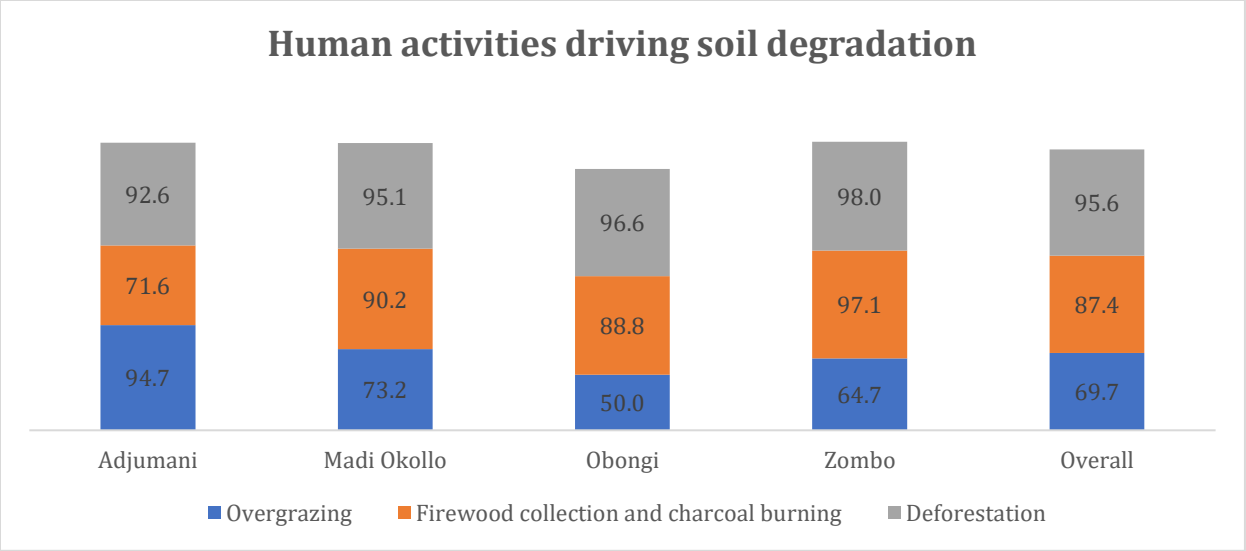

Figure 36: Human activities driving soil erosion

Figure 37: Tree cutting for charcoal and wood fuel. A threat to forest cover

3.5.6 Loss of vegetation

Across Adjumani, Madi Okollo, Obongi, and Zombo, there is clear evidence of extensive vegetation loss (Figure 38), which is also consistent with the spatial analysis. Large areas of open land and reduced grasslands are widespread, indicating a significant decline in natural cover. Tree loss, including both reduced tree density and fallen trees, is commonly observed, reflecting pressures from both natural disturbances and human activities. Slash-and-burn practices are also prevalent, particularly in Adjumani and Zombo, contributing to the reduction of tree cover and grasslands. Collectively, these observations indicate that vegetation loss is a major driver of ecosystem degradation, exacerbating soil erosion, reducing soil fertility, and diminishing water retention capacity.

The district-specific patterns highlight localized pressures: some districts show more extensive clearing of land and tree removal, while others experience higher rates of grassland decline. These trends reinforce the need for targeted vegetation management and restoration interventions, such as reforestation, controlled burning, and sustainable land-use planning, to stabilize soils, protect water resources, and maintain ecosystem resilience.

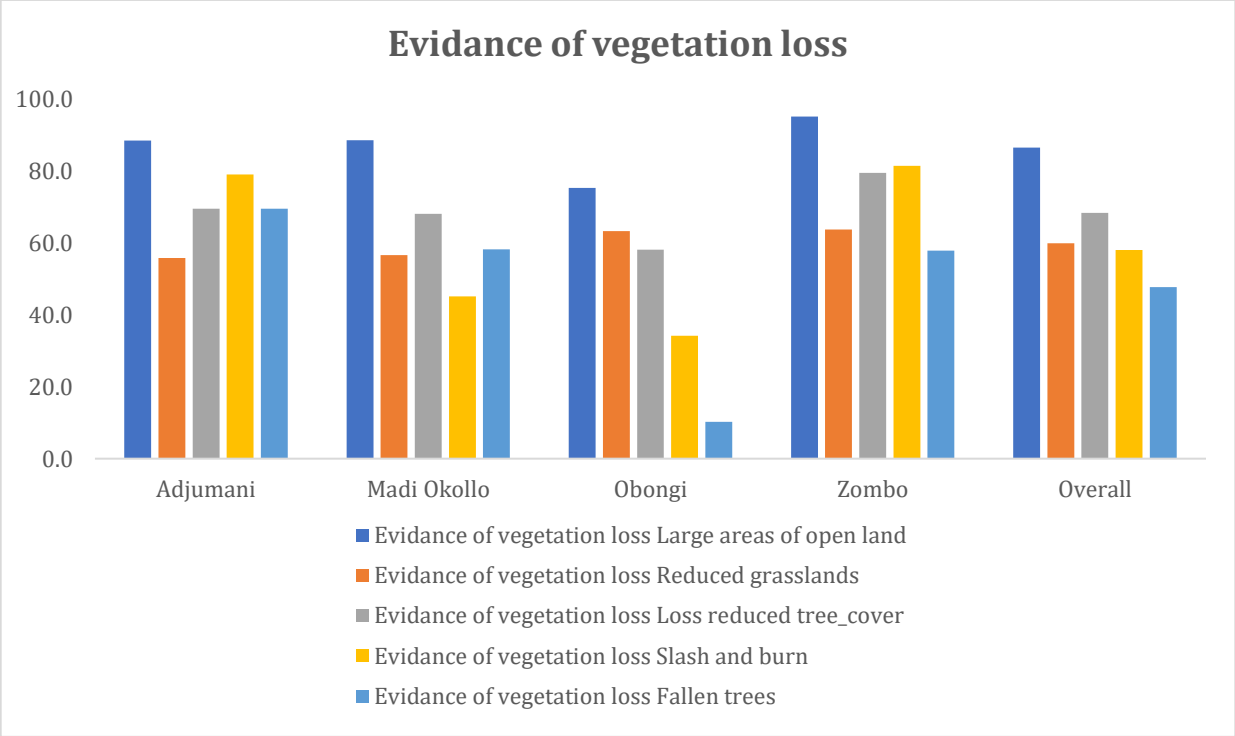

Figure 38: Evidence of vegetation loss across the region

3.6 Local drivers of climate vulnerability

Figure 39: Extensive encroachment on natural forest for agricultural production

Across the four districts, several human activities were identified as key drivers of climate change, with notable quantitative differences among them (Table 15: General drivers of environmental degradtaion in the study area). Deforestation emerged as the most commonly reported driver in all districts, with nearly all respondents in Zombo (100 %), Obongi (99.1 %), and Adjumani (97.9 %) mentioning it, and slightly fewer in Madi Okollo (93.5 %). Deforestation reduces the rate of capture of atmospheric carbon through photosynthesis. Slash-and-burn agriculture was also widespread, reported by all respondents in Zombo (100 %) and by 88.9 % in Obongi, 80.9 % in Adjumani, and 60.2 % in Madi Okollo. The practice of burning contributes to greenhouse gas emissions through the release of the otherwise stored carbon back into the atmosphere. Similarly, livestock farming was frequently cited, with 84.0 % in Adjumani, 64.4 % in Zombo, 53.7 % in Madi Okollo, and

47.0 % in Obongi. This too is a major contribute of greenhouse emissions, especially methane. Traditional extensive production systems are particularly notorious for large volumes of methane emissions.

Poor soil management was particularly common in Adjumani (87.2 %) and Zombo (67.3 %), followed by Madi Okollo (61.0 %) and Obongi (45.3 %). The overuse of chemical fertilizers followed a similar pattern, highest in Adjumani (77.7 %) and Zombo (64.4 %), but lower in Obongi (43.6 %) and Madi Okollo (10.6 %).

Charcoal and firewood use was another major contributor, with high proportions in Obongi (73.5 %), Adjumani (72.3 %), and Zombo (63.5 %), compared to only 19.5 % in Madi Okollo. Likewise, encroachment due to population pressure was most prevalent in Obongi (80.3 %) and Zombo (65.4 %), moderate in Adjumani (53.2 %), and minimal in Madi Okollo (3.3 %).

District-level contrasts were also observed for wetland drainage and construction activities. Wetland drainage was most frequently reported in Zombo (66.3 %) and Adjumani (53.2 %), while construction was reported by 62.5 % in Zombo and 47.9 % in Adjumani but by less than 1 % in Madi Okollo. Small-scale mining followed a similar pattern, reported by half of the respondents in Adjumani (50.0 %) and 45.3 % in Obongi, but only 0.8 % in Madi Okollo. Small-scale diesel engines were reported by 53.2 % in Adjumani, 43.3 % in Zombo, 42.7 % in Obongi, and only 4.1 % in Madi Okollo.

Overall, when aggregated across districts, the most dominant drivers were deforestation (97.5 %), slash-and-burn agriculture (81.7 %), livestock farming (61.0 %), poor soil management (63.9 %), and charcoal and firewood use (55.7 %), while the least reported were small-scale mining (32.6 %) and diesel engines (34.2 %).

Table 15: General drivers of environmental degradtaion in the study area

District	Adjumani	Madi Okollo	Obongi	Zombo	Overall
Deforestation	97.9	93.5	99.1	100.0	97.5
Slash and burn agriculture	80.9	60.2	88.9	100.0	81.7
Poor soil management	87.2	61.0	45.3	67.3	63.9
Livestock farming	84.0	53.7	47.0	64.4	61.0
Charcoal and firewood	72.3	19.5	73.5	63.5	55.7
Encroachment due to population_ pressure	53.2	3.3	80.3	65.4	49.3
Wetland drainage	53.2	25.2	47.0	66.3	46.8
Overuse of chemical fertilisers	77.7	10.6	43.6	64.4	46.6
Construction	47.9	0.8	44.4	62.5	37.2
Small-scale diesel engines	53.2	4.1	42.7	43.3	34.2
Small-scale mining	50.0	0.8	45.3	40.4	32.6

4 GENERAL SYNTHESIS AND RECOMMENDATIONS

4.1 Impact of climate change on the selected livelihood strategies in West Nile

The results indicate that farming remains the backbone of the economy in West Nile region with modest diversification into diverse crops, integration with animal production, as well as other livelihood options, including petty trade, and fishing in areas close to the Nile, artisan activities, small-scale mining (sand mining), transport services ('boda boda'). No single alternative appears dominant, suggesting that households depend on a diversified mix of livelihood options. This diversity likely serves as a coping strategy to reduce vulnerability and manage seasonal or market-related risks. The diversity of income sources, though modest, suggests that households are actively spreading risk across several livelihood activities in response to the uncertainties linked to climate variability.

Since many of these alternatives, e.g., animal production, food production, and the fish value chain, are climate-sensitive**,** households remain vulnerable to weather shocks, droughts, and floods that can simultaneously affect multiple income streams. The absence of a clearly dominant or stable income source further underscores economic fragility**,** as climate stressors could easily disrupt the balance among these interdependent livelihoods. However, the diversification also indicates adaptive capacity**,** where farmers and traders adjust their portfolios to buffer against income losses during adverse seasons.

The findings indicate that climate change is widely recognized by households across West Nile, with nearly 88% of respondents acknowledging its reality. Farmers identified increased temperatures, irregular and delayed rainfall, prolonged droughts, and occasional flooding as the most frequent local manifestations. District-level variations reflect local topography and hydrology: for example, Adjumani and Obongi experience both drought and flood events along the Nile corridor, while Zombo's highlands are characterized by delayed rains and occasional intense storms.

Crop production is the livelihood component most directly affected. Nearly all farmers reported reduced yields, with over 80% experiencing delays in planting and harvesting, and about three-quarters reporting complete crop loss in extreme cases. Maize, beans, and

groundnuts were identified as the most susceptible crops, while cassava, sorghum, banana, and millet were more resilient. District-specific trends show maize vulnerability is pronounced in Obongi, beans in Zombo, and tomatoes in Adjumani, reflecting agroecological variation and localized climatic pressures. These patterns highlight the need for crop- and site-specific adaptation strategies to maintain agricultural productivity under variable climate conditions.

Livestock production is also affected, primarily through water and pasture scarcity, reported by over 80% of respondents. Heat stress reduces feed intake and productivity, while increased disease and parasite incidence compromise animal health. Reduced fertility and higher mortality further exacerbate livelihood risks, particularly in Obongi, Adjumani, and Zombo. Adaptation pressures vary with district context: dryland areas experience acute water and feed shortages, while highland areas face disease and parasite challenges linked to changing microclimates.

Fisheries and small-scale businesses are indirectly impacted. Declines in fish stocks were most pronounced in Adjumani and Obongi, where households depend heavily on large water bodies. Conflicts over fishing resources, water pollution, and post-harvest losses further constrain the sector. Small businesses are affected through reduced consumer demand, increased operational costs, and transport disruptions, particularly in Zombo, where hilly terrain compounds the effects of heavy rains. These findings illustrate the interconnected nature of rural livelihoods, where climatic stress on agriculture and livestock propagates through other economic activities.

Overall, the evidence demonstrates that climate change exerts consistent pressure across all livelihood sectors in West Nile, affecting both productivity and household resilience. The effects vary by district and livelihood type, emphasizing the need for locally tailored adaptation strategies that combine agricultural, livestock, fisheries, and economic considerations to maintain sustainable livelihoods.

Specific recommendations to improve livelihood resilience

Towards improved resilience of the livelihoods, the study makes the following recommendations:

- **Promote Climate-Resilient Crops**: Encourage adoption of locally adapted, tolerant crops such as cassava, sorghum, banana, and millet, while providing extension support and improved varieties for susceptible ones; maize, beans, groundnuts, and tomatoes. This will reduce climate-related crop losses.
- **Strengthen Livestock Adaptation Measures**: Support water harvesting, fodder production and conservation, and health interventions (vaccination, improved breeds) to mitigate feed and water shortages, heat stress, and disease pressures on livestock.
- **Support Fisheries Management and Aquaculture:** Introduce community-based fisheries management and promote small-scale aquaculture to address declining fish stocks, conflicts over resources, and income losses from fisheries.
- **Integrate Livelihoods into Broader Climate Planning:** Develop locally informed climate adaptation plans that consider interconnections among agriculture, livestock, fisheries, and small-scale businesses to maintain income, food security, and social stability.

4.2 Available resources and support services towards livelihood resilience in West Nile

The study revealed that households across West Nile employ a range of coping strategies to sustain their livelihoods under climate stress. Adaptation approaches were most commonly informed by local experience and immediate resource availability rather than formal interventions. Water management, crop adjustments, and income diversification emerged as dominant strategies. There was notable variation in adoption across districts, reflecting differences in exposure to climate extremes, agroecology, and resource access. Overall, Adjumani and Obongi demonstrated the most diversified and proactive adoption of coping measures, while Zombo and Madi Okollo showed selective or lower-intensity adaptations. These findings underscore the importance of a context-specific understanding of resilience, where local knowledge and practical feasibility drive responses.

Coping Strategies in Crop Production

Farmers widely adopted water-related interventions, including rainwater harvesting and small-scale irrigation, particularly in Obongi (94%) and Adjumani (92%), highlighting the critical role of water security under prolonged drought and erratic rainfall. Crop adjustments, such as early planting, staggered planting, and use of climate-tolerant varieties, were moderately employed, with the highest uptake in Adjumani and Obongi. Lowland or swamp cultivation, though less common, provided an additional buffer against rainfall variability, particularly in flood-prone areas. Financial strategies, such as reducing household expenditures, complemented these agronomic measures, which demonstrate an integrated approach farmer take to manage multiple stressors. The observed portfolio of practices reflects both reactive and anticipatory adaptations, indicating that farmers combine environmental, agronomic, and economic measures to sustain production.

Coping Strategies in Livestock Production

Livestock management adaptations focused on mobility, water access, feed security, and animal health. Transhumance was widely practiced across districts, with over 60% of households relocating animals to access grazing and water. Rainwater harvesting for livestock, fodder supplementation, and conservation were applied to address feed shortages, particularly in Adjumani and Obongi. Health-focused strategies, including vaccination and adoption of improved breeds, were more prominent in Obongi, reflecting district-level emphasis on disease mitigation. Income diversification and selective reduction of herd size by selling animals further enhanced household resilience, highlighting the socio-economic dimension of adaptation. In contrast, Zombo and Madi Okollo relied primarily on mobility and basic water measures, reflecting both lower exposure and limited access to supplementary resources.

Coping Strategies in Fisheries

Households dependent on fishing exhibited limited coping options. Income diversification was the most frequently reported strategy, especially in Adjumani (86%) and Obongi (56%), indicating that alternative livelihood sources are critical where fish stocks decline due to temperature rise, sedimentation, or changing water levels. Fish farming was minimally

adopted (overall 9%), perhaps due to constraints in capital, technical knowledge, and infrastructure. These findings suggest that, despite the pronounced ecological impacts on fisheries, adaptation remains constrained and largely reactive, with limited potential for scaling without targeted support.

Coping Strategies in Small-Scale Businesses

Small-scale enterprises faced indirect effects of climate change through reduced consumer demand, increased operational costs, and transport disruptions. Households mitigated these impacts mainly by adjusting business operations or diversifying income sources. Transport-related disruptions were most significant in Zombo due to hilly terrain and poor road conditions, whereas demand reduction and cost escalation were more pronounced in Adjumani and Obongi. These patterns highlight the interconnected nature of rural livelihoods, where climate-induced stress on agriculture and livestock directly undermines broader economic activity, reinforcing the need for integrated support measures that enhance both production and market resilience.

As a whole, the evidence demonstrates that livelihood resilience in West Nile is multi-dimensional, relying on a combination of environmental, agronomic, economic, and social strategies. The effectiveness of these coping mechanisms varies across livelihood types and districts, reflecting differences in exposure, resource availability, and local capacity. Strengthening adaptive capacity requires targeted interventions that build on existing practices, enhance access to resources, and promote sustainable diversification of both production and income streams.

Specific recommendations towards improved resilience

- **Enhance Access to Water and Irrigation Infrastructure:** Invest in rainwater harvesting, small-scale irrigation, and water storage facilities to strengthen crop and livestock resilience under drought and erratic rainfall.
- **Promote Diversified Livelihood Portfolios:** Encourage income diversification through off-farm activities, small enterprises, and alternative livelihood sources to reduce vulnerability from climate-induced shocks.
- **Build Capacity for Community-Led Adaptation:** Provide training, extension services, and knowledge-sharing platforms for farmers, pastoralists, and fishers to optimize use of coping strategies, including early planting, staggered planting, transhumance, and fodder management.
- **Strengthen Institutional and Market Support:** Improve access to credit, input supply, veterinary services, market linkages, and transport infrastructure to enable households to implement coping strategies effectively and sustain livelihood resilience.

4.3 Impact of climate change on human rights in West Nile

The findings indicate that climate change has widespread and multidimensional impacts on human rights across the West Nile region, with clear differences across districts and social groups. Overall, the rights most affected are access to water, health services, and food, reflecting the severe pressure that climate-related events place on basic needs and essential services. Livelihoods and education are also significantly disrupted, highlighting the broader socio-economic consequences of climate variability.

At the district level, Obongi and Adjumani appear to be the most affected. In Obongi, violations of food, health, and education rights are especially pronounced, pointing to extreme vulnerability to climate shocks. In Adjumani, high deprivation in food, work, and livelihoods suggests that the combined presence of refugee and host populations amplifies the impacts of climate events. In contrast, Madi Okollo and Zombo experience fewer overall violations, although challenges remain, particularly in participation in decision-making and access to water, suggesting that governance and environmental pressures continue to affect these communities.

Across social groups, women are disproportionately affected in food security, livelihoods, and participation in decision-making, reflecting gendered vulnerabilities to climate impacts. Refugees experience severe deprivation in food and livelihood, while host communities face more challenges in participation and access to services. Youth are particularly vulnerable in work, education, livelihood, and water access, highlighting the age-specific dimensions of climate vulnerability.

Therefore, the observed patterns reveal intersecting vulnerabilities. Districts with higher exposure to climate hazards, socially marginalized groups, and mixed refugee-host populations face compounded deprivation across multiple human rights. Rights to food, water, health, and livelihoods emerge as the most critical areas of concern, indicating that climate impacts in West Nile not only threaten basic survival but also exacerbate pre-existing social inequalities. Addressing these challenges requires context-specific interventions that consider the spatial, demographic, and social dimensions of vulnerability and aim to strengthen adaptive capacity and equitable access to essential services.

Specific recommendations towards prioritizing and addressing the pressing climate-related human rights issues

- **Prioritize food, water, and health security:** The study shows that the rights to food, water, and health are the most frequently violated across districts and population groups. Interventions should focus on improving access to these basic needs through climate-resilient agriculture, reliable water supply systems, and strengthened community health services, particularly in highly affected districts such as Obongi and Adjumani.
- **Target socially marginalized and vulnerable groups:** Women, youth, and refugees reported higher deprivation across multiple rights domains. Climate interventions must be inclusive, ensuring these groups benefit from livelihood support, education continuity programs, and other services tailored to their specific vulnerabilities.
- **Strengthen livelihoods and work opportunities**: Deprivation of work and livelihood rights was especially pronounced among women, youth, and refugees. Supporting climate-resilient income-generating activities, vocational training, and employment

programs in affected districts can help reduce economic vulnerability and enhance adaptive capacity.

4.4 Effects of climate change on environmental resources, ecosystems, and protection in West Nile.

The study found that environmental resources and ecosystems in West Nile are experiencing notable stress under changing climatic conditions. Surface water resources showed signs of both reduced availability and declining quality. Reduced water volumes were widely reported, particularly in Adjumani and Madi Okollo, while seasonal drying, turbidity, silting, and unpleasant taste or odor were common across districts. Localized differences were observed, with Zombo reporting relatively higher flooding and Adjumani and Obongi facing more severe dry-season shortages. These patterns suggest that both chronic and seasonal water stress affect community access and ecosystem functioning.

Soil degradation was prevalent across the four districts. Indicators included bare patches, declining fertility, gully formation, and exposed rock outcrops. Adjumani and Zombo showed the highest levels of surface exposure and erosion, whereas Madi Okollo reported higher incidences of fertility decline. Vegetation loss, including reductions in tree cover and grasslands, was also widespread. These patterns were linked to both climatic stress and human activities such as slash-and-burn farming, overgrazing, and fuelwood collection, which reduce soil protection and limit natural regeneration.

Human activities were observed to contribute noticeably to environmental degradation. Farming close to water bodies, sand mining, deforestation, overgrazing, and charcoal production were reported across districts. While these practices support local livelihoods, they appear to accelerate soil and water degradation and reduce ecosystem resilience, highlighting the interaction between human pressures and climate effects.

Specific recommendations

- **Strengthen water resource management at the community level:** Promote small-scale water harvesting, storage, and efficient use techniques to buffer households against seasonal shortages and maintain water availability for domestic and agricultural use.

- **Implement site-specific soil conservation measures:** Encourage adoption of low-cost practices such as contour farming, cover cropping, mulching, and gully stabilization to reduce erosion and maintain soil fertility, particularly in highly degraded areas like Adjumani and Zombo.
- **Support targeted vegetation restoration and management:** Facilitate reforestation, controlled grazing, and community-led tree planting initiatives to restore tree cover, protect grasslands, and improve ecosystem resilience. Promote sustainable land-use practices and awareness.
- **Engage communities in education and participatory planning** to reduce high-impact activities near water bodies, such as sand mining and intensive farming, balancing livelihood needs with environmental protection.

4.5 General Drivers of Climate Change

The assessment of human activities across Adjumani, Madi Okollo, Obongi, and Zombo highlights multiple drivers contributing to climate change. Deforestation for farmland expansion and other purposes emerges as the most widespread driver, affecting nearly all communities, and represents a major source of carbon emissions and loss of ecosystem services. Slash-and-burn agriculture and livestock farming are also significant contributors, releasing carbon dioxide and methane, and intensifying local and regional climate impacts.

Other land-use and development activities play important but variable roles across districts. Construction of roads and small towns, encroachment into forested areas, and wetland drainage for agriculture or settlements disturb ecosystems and release stored carbon. Similarly, small-scale mining, often artisanal in nature, contributes to the degradation of local habitats.

Energy and soil management practices further compound the problem. Reliance on charcoal and firewood and the use of small-scale diesel engines release pollutants and reduce forest cover, while poor soil management and overuse of chemical fertilizers lead to soil carbon loss and nitrous oxide emissions. The relative intensity of these activities varies by district: Adjumani and Zombo show particularly high pressures from deforestation, poor soil

management, and biomass use, while Madi Okollo exhibits lower intensity for most drivers, reflecting differences in land use, population density, and local practices.

Overall, the findings indicate that climate change in these districts is driven by a complex mix of land-use change, energy practices, agriculture, and resource extraction, highlighting the need for integrated strategies. Approaches such as reforestation, sustainable land management, improved agricultural practices, and the adoption of clean energy can help reduce emissions, conserve ecosystems, and build resilience to climate change.

Specific recommendation towards lessening the local drivers of climate change

- **Promote reforestation and afforestation initiatives:** Encourage tree planting and restoration of degraded forest patches to enhance carbon sequestration, maintain ecosystem services, and reduce the impacts of deforestation and slash-and-burn practices.
- **Support sustainable agricultural and soil management practices:** Introduce practices such as crop rotation, agroforestry, reduced tillage, and balanced fertilizer use to maintain soil carbon, reduce greenhouse gas emissions, and improve long-term agricultural productivity.
- **Facilitate adoption of clean energy alternatives:** Expand access to low-emission energy sources, such as improved cookstoves, solar, and biogas, to reduce reliance on firewood and charcoal while lowering local air pollution and carbon emissions.
- **Integrate land-use planning and ecosystem protection**: Strengthen district-level planning and enforcement to minimize encroachment into forests, wetlands, and sensitive ecosystems, and regulate small-scale mining and construction activities to reduce habitat degradation and carbon release.

4.6 Climate Justice in the West Nile Sub-Region

Climate justice has increasingly become central to the framing of adaptation and resilience initiatives across Sub-Saharan Africa. It extends beyond the question of who is most exposed to climate risks to include who benefits from adaptation support, who participates in

decision-making, and whose knowledge counts in shaping local responses. In the West Nile sub-region of Uganda, where agriculture, fisheries, and natural resource-based livelihoods dominate, climate change is not only an environmental issue but also a distributive and procedural one, cutting across gender, age, and occupational lines. Climate justice in West Nile reflects a triple asymmetry: communities contribute negligibly to global greenhouse gas emissions, yet face disproportionate climate exposure, while simultaneously experiencing uneven access to adaptation resources and decision-making power.

This study examined climate justice among smallholder households in West Nile through two complementary approaches. The indirect assessment explored fairness in access, coverage, and participation, for example, how youth and adults, or men and women, differ in receiving extension services, training, and other forms of institutional support. The direct assessment, in turn, examined explicit perceptions of fairness regarding the distribution of climate change burdens and the equity of adaptation responses. We intentionally employed both approaches. Indirect indicators capture structural or procedural inequities that might not be consciously perceived or openly discussed, especially among marginalized groups whose voices may be muted in survey data. Conversely, direct questions about fairness uncover actual socially desirable answers, especially where benefits are linked to government or NGO support. The combination thus allows a more balanced view of justice, spanning both its measurable and perceptual dimensions.

4.6.1 Distributional Justice: Access to Support and Services

From the indirect assessment, distributional justice concerns how benefits and burdens of climate action are shared. In the West Nile context, access to agricultural and environmental extension services provides a useful proxy. Findings reveal disparities across both livelihood systems and social identities as briefly explained below.

4.6.1.1 Access to support services across age groups (Youth vs adults)

With respect to age group, findings show that youth generally received less coverage in most service domains compared to older adults. For instance, only about 27% of youth had

accessed extension services on animal production compared to 34% among adults, and a similar gap was observed in crop production and soil-land management. Access to fish farming extension, a relatively new livelihood option in the sub-region, was particularly low across all groups but slightly higher among adults (23%) than among youth (18%).

Such disparities suggest a subtle generational inequity in how institutional support is targeted. Older farmers are more likely to be enrolled in existing farmer groups or cooperatives, through which extension services are commonly delivered. Youth, often engaged in casual labour, transport (boda boda), or short-term ventures, remain outside these established structures and are exposed to climate risk without safety nets. The consequence is that while young people are rhetorically prioritized in climate adaptation discourse, the actual flow of information and resources favours older household heads. This pattern reflects what Sultana (2022) terms "everyday injustices," ordinary administrative or programmatic biases that cumulatively produce structural exclusion.

4.6.1.2 Access to support services by different genders

Gender-based differences, though narrower, also showed a similar trend with age groups. Men reported marginally higher access to extension in soil and land management than women, suggesting the persistence of gendered gatekeeping in technical domains traditionally seen as "male." However, women were relatively more represented in training related to rainwater harvesting and natural resource restoration, areas where community-based groups and NGOs have been particularly active. These trends show that climate-related support systems, even when framed as gender-inclusive, may reproduce existing social divisions through sectoral specialization.

4.6.2 Procedural Justice: Participation and Voice

Procedural justice concerns who participate in decision-making and whose perspectives inform planning processes (Fraser, 2009). The survey revealed limited opportunities for effective participation in climate adaptation initiatives across all respondent categories. While most local actors were recipients of information or services, few were directly

involved in setting priorities or monitoring project outcomes. Youth and women were particularly underrepresented in planning natural resource management and land restoration. Moreover, meaningful procedural justice requires influence over resource allocation, not passive participation.

4.6.3. Direct Assessment of Climate Justice

To complement the indirect analysis, respondents were also asked explicit questions about fairness in the distribution of climate change burdens and benefits. A substantial proportion (42%) perceived that the impacts of climate change were not equally distributed across social groups. Respondents frequently cited that poorer households, women, and youth are more exposed to crop failures, food insecurity, and loss of income, yet receive less support in recovery.

Interestingly, these direct perceptions mirror disparities identified in the indirect analysis. For instance, the groups with lower service coverage (youth and women) were also those most likely to perceive inequity. This coherence reinforces the validity of the findings, suggesting that respondents' lived experiences align with measurable disparities. Yet, the direct justice questions also revealed internal contradictions: in some communities, respondents who were themselves major beneficiaries of NGO projects still perceived unfairness at the regional or district level. This may reflect a broader moral judgment about justice, a recognition that fairness is not just about personal benefit but about societal balance.

However, direct justice assessments remain vulnerable to social desirability bias. In contexts where programs are ongoing, respondents may avoid criticizing implementing agencies or may exaggerate fairness to maintain good relations. Conversely, others may overstate injustice, hoping it will attract more assistance. This reinforces the importance of combining both direct and indirect methods: while the latter capture objective disparities, the former illuminate how communities make sense of them.

4.6.4 Integrating Indirect and Direct Findings

Taken together, the two approaches reveal a multi-layered picture of climate justice in the West Nile sub-region. The indirect evidence highlights systemic inequalities in access, coverage, and participation, whereas the direct evidence captures the moral and emotional dimensions of fairness as perceived by communities. In many respects, both converge on the conclusion that climate adaptation in the region remains partially just some progress has been made in gender inclusion, but youth and poorer households continue to face structural disadvantages.

The complementary use of both lenses also underscores the complexity of measuring justice in development interventions. Indirect indicators provide quantifiable evidence useful for policy planning and resource allocation, while direct perceptions offer insight into legitimacy and trust, the social glue of adaptation governance. Combining the two yields a more comprehensive understanding that can guide both programmatic adjustments and future research.

Specific recommendations to advance climate justice in West Nile

- **Expanding outreach** to youth and non-traditional farmers through innovative extension delivery models, including digital platforms and community-based facilitators.
- **Institutionalizing participation**, ensuring that youth and women's representation in planning committees translates into real decision-making power.
- **Recognizing diverse knowledge systems**, integrating local ecological indicators into extension materials, and participatory monitoring frameworks.
- **Enhancing accountability mechanisms**, such as social audits or community scorecards, to make justice concerns visible and actionable.

CONCLUSION

Climate change in the West Nile sub-region of Uganda affects multiple aspects of life, including agriculture, livestock, fisheries, small businesses, and access to essential services. Farming remains the backbone of livelihoods, with households relying on a mix of crops, animals, and alternative income sources to spread risk, but this remains weak. Variations in rainfall, prolonged droughts, and occasional floods reduce productivity and increase vulnerability, while different districts experience unique climate pressures that require locally tailored responses.

Human rights are closely linked to these climate impacts. Access to food, water, health services, and livelihoods is most affected, especially in districts such as Obongi and Adjumani. Socially marginalized groups, including women, youth, persons with disabilities, and refugees, face heightened deprivation, reflecting both structural inequalities and the uneven distribution of support. These challenges indicate that climate change not only threatens survival but also reinforces pre-existing social and economic vulnerabilities.

Environmental resources are also under stress. Water availability and quality are declining, soils are degrading, and vegetation cover is decreasing due to a combination of climate variability and human activities such as deforestation, overgrazing, and unsustainable farming practices. The evidence shows that climate change interacts with local land-use patterns and resource pressures, emphasizing the need for integrated approaches that protect ecosystems while supporting sustainable livelihoods.

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