

# **BINDURA UNIVERSITY OF SCIENCE EDUCATION**



PROMOTING SCIENCE FOR HUMAN DEVELOPMENT

**FACULTY OF SCIENCE AND ENGINEERING  
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**RESILIENCE BUILDING STRATEGIES FOR FARMER-MANAGED  
WETLAND-BASED AGROECOSYSTEMS IN MBERENGWA DISTRICT,  
ZIMBABWE**

**BY**

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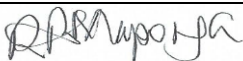
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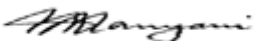
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## Declaration

I, Manyakaidze Pascal, registration number B226350A declare that this dissertation entitled “RESILIENCE BUILDING STRATEGIES FOR FRAMER-MANAGED WETLAND-BASED AGROECOSYSTEMS IN MBERENGWA DISTRICT, ZIMBABWE” is my original research conducted under the supervision of Dr. R. Maponga. This work has not been submitted before, for any higher and tertiary education degree and examinations. The sources that I consulted are cited in the document and acknowledged as full references.

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## **Abstract**

The resilience of smallholder farming communities has been put under test due to the increasing magnitude and frequency of shocks and hazards. Wetlands have been providing critical life support to people, nature, and climate in local communities whose livelihoods are dependent on the utilization of natural resources. Trends in wetland shrinkage, degradation, species extinction, and loss of habitats triggered worrisome discussions across the globe. The study aimed to evaluate the resilience-building strategies for farmer-managed wetlands-based agroecosystems in semi-arid and rainfall marginal areas, with a focus on the Nyororo wetland in the Mberengwa district. Determining the resilience of wetlands agroecosystems in sustaining pressure from the changing climate and human needs was a key aspect of the study.

A mixed method was used in data collection and analysis as informed by the interpretivism and objectivism research philosophies underpinning the study. The mixed methods approach enabled the study to benefit from multiple knowledge domains including professional ecological knowledge (PEK) scientific ecological knowledge (SEK), bureaucratic ecological knowledge (BEK), technological ecological knowledge (TEK), and local ecological knowledge (LEK). Information gathered through various tools including questionnaires, focus group discussions, key informant interviews, secondary data, remote sensing, and scientific measurements informed by different knowledge domains were synthesized to bring the resilience picture around wetland-based agroecosystems. The study findings on wetland degradation, species extinction, invasion by noxious weeds and alien plant species, and shrinking in wetlands call for urgent action. The lack of information about wetlands species and their diversity was a hindrance to community conservation efforts. Due to increasing aridity, communities were identified to have increased dependence on wetlands than dryland areas for agriculture. Resilience-building strategies including the adoption of seasonal livelihoods programmes, ecosystems-based adaptation (EbA), and anticipatory action planning (AAP) proved to be effective and sustainable ways of wetlands agroecosystems conservation. The study recommended the need for financial mechanisms to support scientific research needed to close the gap in the lack of data on species and their diversity. Stakeholders need to swiftly implement the promising wetland agroecosystems resilience-building strategies that bring positive outcomes for people, nature, and climate.

## Dedication

*For the love I have for my children,*

*“Theophilus & Laticia”*

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## Abbreviations and Acronyms

AEZ	-	Agroecological Zone
CBO	-	Community Based Organization
CSA	-	Climate Smart Agriculture
FAO	-	Food and Agricultural Organization of the United Nations
ILKS	-	Indigenous and Local Knowledge Systems
MRDC	-	Mberengwa Rural District Council
PES	-	Payments for Ecosystems Services
PIC	-	Prior Informed Consent
USGS	-	United States Geographical Survey
WFP	-	World Food Programme
ZIMVAC	-	Zimbabwe Vulnerability Assessment Committee

## **CHAPTER 1: INTRODUCTION**

### **1.1. Introduction**

This introductory chapter provides an overview of the research process. The chapter sets the tone of the study through the background, thematic, and theoretical considerations. The statement of the problem, the study objectives, and the methodological considerations of the study are presented. The scope and study delineation, significance, and ethical considerations were presented in this chapter. This chapter concludes by outlining the overall structure of the thesis.

### **1.2. Background to the study**

The resilience of smallholder farmers is increasingly becoming a global issue. Smallholder farmers in marginalized rural areas have been on the receiving end due to the increasing recurrence of multiple shocks and hazards (Tol, 2021). Despite being the producers of over two-thirds of global food (IFAD, 2014), their means of production have continued to be threatened by climatic and economic shocks, among others. The declining rainfall and increasing temperatures (Brazier, 2018), heightened the need for investments in irrigation infrastructure and climate-smart agriculture (FANPARN, 2017).

The global views on smallholder farmers' resilience continue to deepen in the African, Sub-Saharan (Quandt, 2021), and Zimbabwean context (IFC - World Bank Group, 2022; UNDP & Government of Zimbabwe, 2017). In the Zimbabwean context, rainfall variability continues to pose food crop production risk as the regions suitable for crop production continue to shrink (Mugandani et al., 2012; Mushore et al., 2021; Tol, 2021). Among other communities, Mberengwa district falls within the Meteorological Region III (Meteorological Services Department, 2018) is associated with some of the highest shocks and stressors (Zimbabwe Resilience Building Fund, 2016). The drought risk for smallholder farmers was noted to be on the rise due to their low asset base and poor coping mechanisms (Frischen et al., 2020). The overdependency on subsistence rainfed agriculture resulted in the deterioration of smallholder farmers' livelihoods.

Increasing difficulties in managing key livelihood resources like water (Behnassi et al., 2018) were noted to be related to climate change and variability. Rainfall patterns have chiefly become more unpredictable and unreliable (Jaison et al., 2023; Mazvimavi, 2010; Mushore, 2013). Climate change impacts continue to infiltrate the socio-economic context of the country (Chanza & Gundu-Jakarasi, 2020). Zimbabwe and Africa at larger extent continued to bear the burden of coping with drought risk as droughts are becoming more frequent and intense, undermining social and economic progress including power generation, poverty reduction (Masih et al., 2014) and the Gross Domestic Product (GDP) (Leal Filho et al., 2023; Quandt, 2021).

The coping mechanisms of rural livelihoods have been stressed due to the lack of effective recovery after the shocks. The world's under-resourced population has largely depended on humanitarian support. According to Attri et al. (2019), climate change and other shocks are driving food security to the lowest levels making recovery more challenging. The El Nino phenomenon has resulted in more droughts in Zimbabwe. According to the Zimbabwe Resilience Building Fund (2017), El Nino resulted in over 65 percent of droughts in Zimbabwe since 1963. Some of the worst droughts and biggest humanitarian appeals recorded in the history of Zimbabwe were during the El Nino period (US Department of Commerce NOAA, 2018), which led to an increase in the incidents of crop failure (Government of Zimbabwe, 2024; UNOCHA, 2019). Zimbabwe has recorded a heightened food deficit situation that witnessed an increase in the number of food insecure populations from 2.7 million people in 2022/23 consumption year to 7.2 million people in 2024/24 due to drought (Government of Zimbabwe, 2024). This has increased the proportion of aid-dependent communities and individuals (Mushore et al., 2021).

Climate-impacted communities have been over the years depending on wetlands goods and services. According to Zinhiva et al. (2014), wetlands degradation has been associated with the socio-economic pressure from the growing population. The increased dependence on wetlands goods and services has exerted immense pressure on the wetlands. This has resulted in shrinking (Hove & Chapungu, 2013), fragmentation (Chikodzi & Mufori, 2018), and general deterioration (Chikodzi & Mapfaka, 2018; Chikodzi & Mufori, 2018; Musasa &

Marambanyika, 2021). The value of wetlands goods and services continues to follow the declining patterns due to the impacts of climate change (Marambanyika et al., 2021; Musasa & Marambanyika, 2021; Russi et al., 2013; Xu et al., 2020). The farmer-managed wetlands-based agroecosystems approach is increasingly becoming more important in semi-arid communities of Zimbabwe. Wetland ecosystems in Nyororo communities are under multiple threats from climate change and human impacts. Without proper planning and coordinated utilization informed by policy, scientific, and research studies, wetlands will continue to bear the consequences of maladaptation (Barnett & O'Neill, 2010).

## **1.2 Thematic Consideration**

The resilience of smallholder farmers' agroecosystems is increasingly becoming topical due to the repeated threats from shocks and stressors. Climate and weather-related shocks and hazards are ranked highest (Marambanyika et al., 2021; Zimbabwe Resilience Building Fund, 2016). Economic challenges are also ranked fairly high due to fluctuating market prices of basic food commodities including cereals (World Food Programme, 2021).. The recurrent and intensified occurrence of droughts (Manyakaidze et al., 2024), crop pests (Government of Zimbabwe, 2016), and animal diseases (Bekele et al., 2020) were noted to be major challenges affecting food production for smallholder farmers in Zimbabwe. The identified thematic challenges will present challenges for Zimbabwe to make meaningful progress towards the attainment of the Sustainable Development Goals (Vision 2030) as enshrined in the National Development Strategy [NDS1] (Government of Zimbabwe, 2021a).

Several undocumented interventions within the agroecosystems are being implemented across semi-arid regions by smallholder farmers. These strategies need to be accounted for to ensure that they are promoted to influence the adaptive, absorptive, and transformational capacities of communities at risk (Green Climate Fund, 2022; UNDP, 2015). The government and its stakeholders have developed different policies and strategies around climate change (Government of Zimbabwe, 2017), wetlands management (Zimbabwe Wetland Policy, 2020) and climate-smart interventions (CIAT & World Bank, 2017) to ensure that all developmental interventions including agriculture will not result in maladaptation (Barnett & O'Neill, 2010).

### **1.2.1 Research Problem and Statement**

Given the above background of the study and the thematic considerations, wetlands degradation has been rampant across the globe. In Zimbabwe, wetlands cover about 3 percent of the country's, with only 21 percent of these wetlands regarded as in good conservation status, and the rest (79 percent) having been altered/degraded to some extent (Zimbabwe Wetland Policy, 2020). The lack of climate-resilient building strategies at the local level to harmonize wetland biodiversity conservation and farmer-managed agroecosystems presents a gap in the management and conservation of wetland ecosystems and the protection of communities depending on these vital ecosystems. In most cases, national-level strategies have not permeated the sub-national and local communities where wetlands exist and are being impacted by human activities and environmental change. Wetlands have been supporting local communities through the provision of goods and services, but the value of these ecosystems' services and the diversity of the species and nature of wetlands have not been determined to inform local-level conservation efforts. The government developed policies and other institutional frameworks to support wetlands conservation. Communities have been at the forefront of wetlands conservation, but wetlands ecosystem degradation is occurring at a faster rate. The study evaluated wetlands resilient building strategies to support livelihoods, and nature conservation in a climate-compatible manner.

### **1.2.2 Aim and Objectives of the Study**

To evaluate resilience-building strategies for farmer-managed wetlands-based agroecosystems in semi-arid areas.

In connection with the study's aim, the specific objectives of the research were;

- i. To assess the resilience, species diversity, and richness of Nyororo wetlands.
- ii. To assess climate-related impacts on wetland biodiversity and agroecosystems in Nyororo wetlands.
- iii. To determine resilience-building strategies employed by farmers dependent on wetland agroecosystems.

### **1.3 Theoretical Consideration and Literature Review**

The research was influenced by resilience building strategy (Green Climate Fund, 2022; UNDP, 2015) which defines the community's ability to bounce back better after the disturbance. The strategy of building resilience promotes anticipatory action thinking (Anticipation Hub, 2022; OCHA, 2024), which promotes "proactive risk management" of a system (World Food Programme, 2022a). With climate change and variability affecting both ecosystems and community livelihoods, Mberengwa district falls under the agroecological zone V (Mugandani et al., 2012), which is characterized by low erratic rainfall. The region is also defined meteorologically as region 3, which covers Matabeleland South province, Southern parts of Midlands, Southern Parts of Manicaland, and the bulk parts of Masvingo (Meteorological Services Department, 2020). Smallholder farmers who depend on ecosystems like wetlands dominate these communities. The livelihoods of these communities and coping strategies against disturbances are influenced by seasonal rainfall performance (Frischen et al., 2020; Welt Hunger Hilfe & Government of Zimbabwe, 2021; World Food Programme, 2022a), markets linkages (World Food Programme, 2021, 2022b), and other economic activities in the areas, including mining. In this view, the research investigated resilient building strategies for farmer-managed wetland agroecosystems in the Mberengwa district of Zimbabwe.

### **1.4 Methodological Consideration**

The methodological consideration section details the steps followed by the study in data collection, analysis, presentation, and reporting. According to Kothari (2004), a research methodology provides a detailed theoretical and clear systematic pathway of gathering data, analyzing, interpreting, and reporting results to solve a problem under the study. The study of this nature required in-depth analysis of the community's lived experience and related the insights with the available data from statistical and scientific domains. The study therefore employed interpretivism that is inductive by nature to meet the community's lived experience around resilience-building strategies and the use of wetlands-based agroecosystems. A mixed method approach was therefore employed due to its capability to manage multiple datasets from qualitative and quantitative domains (Onwuegbuzie & Collins, 2007). Both qualitative and quantitative data analysis were used to present findings

from the two approaches in the study aimed to investigate resilience-building strategies for farmer-managed wetlands-based agroecosystems within Nyororo wetland in the semi-arid areas of Mberengwa, as detailed in Chapter 3.

#### **1.4.1 Research Philosophy**

The study's research philosophy was considered to be critical in providing the direction and general guide for how the research is conducted (Saunders et al., 2012). The philosophy of the research provided a guide and belief on the researcher's conduct and approaches in data collection, analysis, and presentation. According to the literature, the subject of climate change received vast coverage under quantitative research approaches. This has generated convincing statistical evidence that assisted in bridging the knowledge gaps. The remaining gap is therefore evident in the practice and deployment of resilience-based strategies, which requires inductive thinking and approach in assessing smallholder farmers' strategies for building their resilience from multifaceted shocks and stressors. An inductive approach was considered in the study, and this gathered communities' lived experiences, local norms, the nurtured practices, values preserved, changing perceptions, and the future imaginations that the scientific-related objectivism approach can easily miss. The research deployed an interpretivism approach that captures the lived experiences of the population (Jackson, 2013), which is key in relating smallholder farmers' strategies and the need for attaining a climate-resilient wetlands-based agroecosystem.

#### **1.4.2 Research Design**

According to Pandey & Pandey (2015), a research design provides step by step approach for the collection, analysis, and reporting of research data. The study adopted a mixed methods design (Onwuegbuzie & Collins, 2007), in which qualitative was more dominant as influenced by the interpretivism philosophy. Quantitatively driven statistics were used in triangulating and backing the evidence generated by the qualitative approach to improve the validity and reliability of the findings.

### **1.4.3 Data Collection Tools and Sources**

The study depended mainly on primary data sources to generate empirical evidence. Primary data refers to the original research data collected by the researcher solely for the current study (Ajayi, 2017). Household questionnaires, Focus Group Discussions (FGDs), Key Informant Interviews (KIIs), Field Observations, Direct Measurements, and Transact Walks were employed as key tools for generating different primary datasets for the study. On the other hand, the researcher relied on secondary data, which was generated by other entities for other purposes (Johnston, 2017). Secondary data in this study was gathered from government departments' official records, Mberengwa Rural District Council (MRDC), 'farmer organizations' records, and Community-Based Organizations (CBOs). Secondary data sources are key in backing empirical evidence generated by primary data sources and bringing it to the study context, as alluded to by Johnston (2017) and Kabir (2016).

### **1.4.4 Data Analysis**

Data analysis in the study was informed by the pattern and form of data gathered. Both quantitative and qualitative data analysis techniques were utilized due to the mixed-method nature of the study. The Shannon-Weiner Species Diversity Index (H) was used to analyze wetlands species diversity as proven by the scientific principles and standard requirements (Spellerberg & Fedor, 2003) and (Nolan & Callan, 2006). Statistical data analysis packages including SPSS, R, and online DATAtab.net were used to analyze quantitative data (DATAtab Team, 2024), while qualitative data was analyzed using event analysis (Babbie, 2011), content analysis (Haradhan, 2018), thematic analysis (Braun & Clarke, 2006), and narrative analysis (Haradhan, 2018). Detailed step-by-step procedures are presented in Chapter 3.

## **1.5 Significance of the Study**

The research targeted smallholder farmers from the same agroecological zone (AEZ) which is region V. These farmers again fall under the low rainfall and drought-prone meteorological region III that covers the dry areas including the southern parts of Midlands, Matabeleland South province, and parts of Manicaland. It was significant for the study to identify and document climate change and variability-related impacts on wetlands, conduct a species inventory for Nyororo wetland, and recommend resilience-building strategies required for

integration of climate change adaptation, mitigation, and community development. This strategy was earmarked to solve maladaptation affecting wetlands in Zimbabwe. When equipped with wetlands species data, communities can effectively conserve their wetlands agroecosystems.

## **1.6 Scope of the Study**

The study was conducted only in rural communities where smallholder farmers are utilizing the Nyororo wetland covering wards 30 and 31 in Mberengwa. The target group is smallholder farmers as defined FAO (2012) and IFAD, (2014). The homogeneity of the selected communities is defined by the same livelihoods and the same climate change and variability-related experiences. The targeted farmers are in the same geographical area and depend on the utilization of the same shared wetland resources.

## **1.7 Limitations of the Study**

The study may not be generalized to the entirety of smallholder farmers in Zimbabwe since the sample was obtained from only one community in the Mberengwa district. Other smallholder farmers in other areas may experience the same, but due to the differences in livelihood zones, coping strategies, and differences in climatic conditions, generalization of the same results across the smallholder farmers depending on wetlands may be difficult.

## **1.8 Ethical Considerations**

Ethics are known to be a philosophical branch responsible for governing human interaction conduct, setting up standards and norms to govern people's behaviour (Akaranga & Makau, 2016). The research required prior informed consent [PIC] (Akaranga & Makau, 2016; FAO, 2014) and clearance by authorities. The study was granted permission by the Rural District Council, the Community-Based Organization, and smallholder farmers. Respecting participant's privacy and confidentiality (Irish Council for Bioethics, 2004) was explained before the respondents were engaged, and this was guaranteed through the use of codes and pseudonyms to represent the participants. This made it difficult to link the respondents and their views.

Participation in the study was voluntary (Akaranga & Makau, 2016; Kabir, 2016) and without any tokenism to ensure no participant's rights were violated as well as no incentives were offered to influence the study outcomes. The research upholds the do-no-harm principle (Sloth, 2013), to ensure that the research process does not change people's culture, religion, setup, governance, or introduce genetically modified products and invasive alien species into the wetlands. The research processes remained non-consumptive and non-disruptive to nature.

## **CHAPTER 2: LITERATURE REVIEW**

### **2.1 Introduction**

This literature review chapter interrogated key discussions on resilience-building strategies for farmer-managed wetland-based agroecosystems. The study considered a wide range of key global, regional, national, and local level contextual literature shedding light on the resilience of smallholder farmers and wetlands agroecosystems. Organized into five different sections, subsection 2.1 presents the introductory part, followed by subsection 2.2 which interrogates theories and frameworks around resilience building. Sub-section 2.3 dealt with threats to wetlands agroecosystems. The review of literature on smallholder farmers and agroecosystems resilience was presented in section 2.4, whilst a summary of gaps in literature was covered under the final section, 2.5.

### **2.2 Resilience Building Framework and Wetland Agroecosystems**

The United Nations Development Programme (UNDP) defined resilience as the ability of the systems to “anticipate, cushion, adapt and bounce back better” from shocks in a sustainable and transformational manner (UNDP, 2015; UNDRR, 2020). Resilience-building terminology was strengthened by the Sendai Framework (United Nations, 2015), whose agenda was to influence a transformative approach in dealing with disasters by shifting from emergence and humanitarian approaches to a proactive approach that is termed resilience building.

Globally, the resilience of the population and different socio-economic support systems including the natural ecosystems are under threat from different pressures. Climate change aggravated the impacts and stretched the resilience of the world’s socio-economic system to the maximum limits. According to the World Food Programme (2021), climate change-related land degradation aggravated the suffering of smallholder farmers dependent on natural resources. Within the African context, natural disasters have played a reversal role in the development of the continent. The occurrence of floods (Abrams et al., 2017; IFRC, 2021), droughts (FEWSNET, 2024; Masih et al., 2014), COVID-19, and the general economic recession weakened the socio-economic fabric of the nation (Runganga & Mhaka, 2021; The

World Bank, 2022). Inequalities around the world's economies and within the regions were identified to have been further deepened by climate change. The impacts of climate and other pressures have put a huge strain on the ecosystems and reduced their provisioning, regulatory, and cultural services (Abrams et al., 2017; Musasa & Marambanyika, 2021; Swiderska et al., 2018).

Environmental and economic changes were identified to have increased the proportion of the population dependent on humanitarian assistance. In Zimbabwe, the noted increase in people who required food aid rose from 5.1 million during the 2015/2016 agricultural season (Government of Zimbabwe, 2016; ZIMVAC, 2016) to 7.6 million in the 2023/2024 season, and a further economic burden reaching USD429.3 million in the basket for humanitarian assistance (Government of Zimbabwe, 2024). Being one of the world's most drought-prone countries, Zimbabwe recorded frequent recurrent droughts that undermined food production and declining agricultural-related earnings (SADRI, 2021). The deteriorating livelihood in Zimbabwe, with most smallholder farmers failing to produce enough food for the full consumption year, resulted in economic strain and the resilience of the agro-based economy (Sithole et al., 2023).

A consensus on the negative effects of climate change was noted to be more visible in the socio-economic spheres of the society (Chanza, N., & Gundu-Jakarasi, 2020), with more actions being required by the planning authorities to prioritize resilience measures for the sustenance of the country's natural resources-based economy (Brazier, 2015, 2018; Mushore et al., 2021). The increase in drought risk and frequency (World Bank Group, 2021) was noted with rainfall in some areas deviating negatively from the 670mm national mean. This was evidenced by the shrinkage of the food production zone and expansion of semi-arid zones (Mugandani et al., 2012), increasing the cost of food production in Zimbabwe.

The impact of El Nino-induced droughts in Zimbabwe has left the natural support system weakened and strained to support the needs of the society. Implications of drought on water resources were noted by many scholars. The reduction in surface water availability in Zimbabwe's semi-arid regions further reduced the country's coping capacity (Frischen et al., 2020; Love et al., 2005; Samu & Akintuğ, 2020). Groundwater management has grown to be

one major challenge in communities affected by droughts. Low levels of groundwater replenishment due to droughts (Manyakaidze et al., 2024), were noted to have resulted in a strain on the water supply system that supports over 90 percent of the rural population.

A huge strain on the ecosystem was noted due to the impacts of drought in Zimbabwe. This created huge gaps in making ecosystems work in support of community resilience (Rizvi et al., 2015). In most cases, climate change resulted in increased and intensified use of natural resources including wetlands, which are sensitive ecosystems, leading to their degradation due to maladaptation (Barnett & O'Neill, 2010). The Ramsar Convention (1971) defined wetlands as *“areas of marsh, fen, peatland or water whether natural or artificial, permanent or temporal, with water that is static or flowing, fresh or brackish or salty, including areas of marine water the depth of which at low tide does not exceed six metres.”* The Zimbabwe Wetland Policy (2020) indicated that wetlands as *“areas that are seasonally or permanently water saturated”* Cases of wetlands degradation were noted across Zimbabwe's communities including some of the internationally recognized Ramsar sites like Driefontein grasslands (Fakarayi et al., 2015; Marambanyika et al., 2021; Musasa & Marambanyika, 2021) and Monavale vlei (Sharai et al., 2020), due to agriculture and human settlements. Wetland fragmentation (Chikodzi & Mufori, 2018; Zinhiva et al., 2014) and shrinkages (Hove & Chapungu, 2013) were identified to have resulted in the reduction of goods and services that the communities got from the ecosystem.

Based on the identified threats including socio-economic pressures on smallholder food systems and wetlands degradation, the resilience-building framework provided anchorage for this study. The need to strike a balance within the people, nature, and climate nexus calls for further investigation into the sustainability of resilience-building strategies employed in farmer-managed wetland-based agroecosystems. The dependence on wetlands ecosystems by smallholder farmers requires further investigations and determination on the strategies that are more sustainable for both the ecosystems and community needs considering climate-induced shocks and stressors.

### **2.3 Threats to Wetlands and Agrobiodiversity**

Wetlands exist in different forms. Some are temporal whilst others are permanently inundated. Around 54 percent of wetlands are permanently waterlogged whilst 46 percent are inundated on a seasonal basis (Ramsar Convention Secretariat, 2018). The state of wetlands inundated seasonally or perennially determines the diversity of ecosystems and their services to the communities depending on them. Inland wetlands including peatlands have significant importance and are disappearing at a much faster rate than coastal wetlands (Ramsar Convention Secretariat, 2010).

The increased loss of wetlands and the disruption of their ecosystems is associated with direct negative consequences on the social and economic development of the population depending on wetland (Ramsar Convention Secretariat, 2018). Globally, studies indicated that since 1900, around 64 percent of wetlands have been lost (Ramsar Convention Secretariat, 2010), mainly due to human activities (Amenu & Mamo, 2018), including draining, wildfires, pollution, grazing, and tillage (Businge, 2017). The Ramsar Convention Secretariat (2010) revealed that at the global scale, a proportion reaching 81 percent and 36 percent of inland and coastal wetlands were lost since 1970. This assessment was done for areas where data was available. This resulted in a sharp decline in the population of wetland ecosystems. Between 1970 and 2010, the world recorded a 77 percent decline in wetland species (Ramsar Convention Secretariat, 2010).

To date, over one-quarter of wetland flora and fauna species are on the verge of extinction due to an increase in human activities that drain and deplete wetlands (Ramsar Convention Secretariat, 2018). Wetlands are key sources of fresh water. The Ramsar Convention Secretariat (2010) indicated that around 30 percent of all freshwater globally is stored in wetlands, and additionally, providing habitat for over 40 percent of species. With the growing population and intensified freshwater crises, wetlands degradation will even worsen water challenges across the globe (Concern-Worldwide, 2022).

In Africa, wetlands have huge social and economic importance. Most of the remaining wetlands are severely degraded, and they cover around 5 percent of the continent's surface

area. Africa lost around 50 percent of the wetlands since 1970, a proportion that is higher than the 40 percent lost at a global scale during the same assessment period (Ramsar Convention Secretariat, 2010). The severity of wetlands degradation can be depicted in the countries' overview. In Uganda, the area covered by wetlands declined from 13 percent in 1994 to 10.9 percent in 2008, respectively (Businge, 2017). Over 80 percent of the population in Uganda are farmers and around 69 percent of these farmers depend on wetland ecosystems for their livelihoods.

In South Africa, wetlands are attached a huge ecological, social, and economic value (Department of Environment Forestry and Fisheries, 2020). These ecological hotspots are important to the South African economy (Adeeyo et al., 2022). South Africa designated a total of 26 Ramsar sites, and wetlands cover around 2.4 percent of the country's surface area. Wetlands in South Africa follow an uncontested pattern of decline, with 48 percent of wetlands categorized as critically endangered, 12 percent endangered and 5 percent regarded as in the vulnerable state (Adeeyo et al., 2022).

Being a landlocked country, Zimbabwe considers wetlands as key ecological zones with the highest biodiversity (Zimbabwe Wetland Policy, 2020). Wetlands in Zimbabwe cover around 3 percent of the country's surface. From the total, 21 percent of wetlands are considered to be in good conservation status, whilst 79 percent of wetlands are regarded as degraded or altered with different levels of degradation (Zimbabwe Wetland Policy, 2020). Most of the threatened species find their habitat in wetlands. Wetlands in Zimbabwe are regarded as Important Bird Areas [IBA] (Fakarayi et al., 2015, 2016). Most scholars indicate that wetlands losses due to human activities (Chikodzi & Mufori, 2018; Hove & Chapungu, 2013; Marambanyika & Beckedahl, 2016b), is aggravated by climate change (Chikodzi & Mapfaka, 2018). Studies conducted by Zinhiva et al. (2014) revealed that the degradation of wetlands in Gutu district's Mutubuki community was due to cultivation and grazing by livestock. The shrinkage of wetlands in Chivi as noted by Hove & Chapungu (2013) follows the same crop cultivation pattern. These findings on agricultural-related wetland degradation concur with findings of the research done in the Driefontein Grasslands Ramsar Site by Fakarayi et al., (2015) and Marambanyika & Beckedahl (2016b).

Studies revealed that wetland ecosystems are the world's largest pools of biological diversity (Russi et al., 2013; Tanwie et al., 2024; T. Xu et al., 2019). This makes wetlands more important considering the diversity of life within them are key enablers for provisioning, regulatory, and cultural services (X. Xu et al., 2020). Some scholars including Tabengwa (2015) recommended the implementation of an ecosystem-based approach in harmonizing agriculture and wetlands conservation. Marambanyika & Beckedahl (2017) further recommended the need for strengthening wetlands management through institutional arrangements. The Ramsar Convention Secretariat (2018), identified the need for strengthening financial tools to incentivize wetlands conservation activities. The need for national, sub-national, and local wetlands inventories remains a gap that most scholars (Ramsar Convention Secretariat, 2018; Tanwie et al., 2024; Wetlands International, n.d.) recommended for implementation across wetland ecosystems.

Research has shown that human activities and their impacts on wetlands have attracted global attention (Joshi et al., 2021; T. Xu et al., 2019; X. Xu et al., 2020). At the continental level, African scholars and reports concurred that human impacts are greater than natural causes of wetlands degradation (Department of Environment Forestry and Fisheries, 2020; DWAF, 2008; Ngwenya & Marambanyika, 2021). In Zimbabwe, scholars revealed that wetland degradation occurred irrespective of location. Mhlanga et al. (2014) revealed the threats of urban wetlands with Harare recording 400 percent shrinkage in wetlands covered area between 1984 and 2018. This was due to an increase in the built-up areas that occupied some of the wetland spaces. Sharai et al. (2020) supported the findings on urban wetlands degradation due to human activities in Zimbabwe. More studies conducted in rural areas revealed findings related to human impacts and weaker institutional arrangements. (Hove & Chapungu, 2013; Marambanyika & Beckedahl, 2016a; Musasa & Marambanyika, 2021) Research that directly addresses climate change science and the impacts on wetlands located in local communities is still lagging and requires prioritization.

#### **2.4 Smallholder Farmers and Agroecosystems Resilience**

At a global scale, around 1 billion people depend on wetland ecosystems for their livelihoods, and the population dependent on these key ecosystems benefits from a rich

biological diversity, which comprises around 45 percent of total global ecosystem services [USD14.9 million] (Ramsar Convention Secretariat, 2018). The majority of communities benefiting from wetlands globally are the local indigenous rural people, whose livelihoods are attached to natural resource utilization (Brander & Schuyt, 2010; Russi et al., 2013). The sustainability of wetlands-dependent communities and wetlands ecosystem conservation have been under the spotlight across the globe.

A noted increase in the number of smallholder farmers depending on wetland ecosystems for its regulatory, supportive, and provisioning services for diversified goods and services was viewed as a key source of conservation challenges by different stakeholders (Wetlands International, n.d.). When it comes to resilience, wetlands are more resilient and highly productive than drylands. Peatlands, other type of terrestrial wetland ecosystem are known for their massive storage of carbon in quantities that are double those sequestered by global forests collectively (Ramsar Convention Secretariat, 2018; Tanwie et al., 2024; Wetlands International, n.d.). The degradation of peatlands can mean huge carbon emissions into the atmosphere and a massive contribution to global warming, therefore making the Paris Agreement targets unrealistic (Climate Action Tracker, 2020; Hermwille et al., 2017; Sachs, 2015).

To build the resilience of key ecosystems and attain positive outcomes for the climate, people, and nature, various instruments were put in place including the green climate fund (Government of Zimbabwe, 2020), national adaptation programmes (Adaptation Fund, 2020), the different policies on climate and wetlands (FANPARN, 2017; Government of Zimbabwe, 2017; Zimbabwe Wetland Policy, 2020), and a sector-wide approach in the nationally determined contributions (Government of Zimbabwe, 2015, 2021b). Zimbabwe further integrated the Sendai Framework (United Nations, 2015; United Nations Climate Change Secretariat, 2017; van Niekerk et al., 2020) into the national programs and strengthened interministerial coordination of disasters. These efforts were meant to promote resilience building across the communities affected by natural, technological, and man-made disasters.

Despite these interventions and other donor-driven resilience-building actions, funding remained scarce to reach key wetlands ecosystems to promote their conservation and create much-needed economic opportunities and incentives for the people who depend on the ecosystems (Brander & Schuyt, 2010). The world has witnessed the rapid degradation of wetlands (Amenu & Mamo, 2018; Ramsar Convention Secretariat, 2010) and a decline in food production levels by smallholder farmers (Frischen et al., 2020). In Zimbabwe, wetlands degradation took all forms including shrinkage (Businge, 2017; Hove & Chapungu, 2013), being burnt down by veld fire (Fakarayi et al., 2016), fragmentation due to agricultural activities (Chikodzi & Mufori, 2018), drying as a result of trampling by livestock (Marambanyika et al., 2021), declining species diversity, and low water quality (Dube & Chitiga, 2011), sedimentation due to catchment degradation (Zinhiva et al., 2014), water pollution threat leading to increased nutrient loading from urban activities (Mhlanga et al., 2014), as well as invasion by alien species (Makarati et al., 2021).

The identified impacts undermine the resilience of wetlands and agroecosystems by increasing the costs of resource recovery and conservation whilst undermining the provisional, regulatory, cultural, and supportive functions of wetland ecosystems. Marambanyika & Beckedahl (2016a) stressed the need for improving stakeholder engagement and awareness about the importance of ecosystem services. Across the African continent, scholars concurred that the lack of implementation of wetlands conservation measures and frameworks in was reported in South Africa (Adeeyo et al., 2022), Zimbabwe (Marambanyika & Beckedahl, 2016a) and Uganda (Barakagira & De Wit, 2019). The existence of weaker institutional arrangements has resulted in further wetland degradation, despite wetlands being key anchors for biological diversity and rural smallholder farmers' resilience.

## **2.5 Summary of Gaps in Literature**

Despite wetlands covering around 6 percent of the global surface and providing habitat for over 40 percent of species in the world (Wetlands International, n.d.), wetlands ecological characterization remained a huge gap. Some communities and stakeholders do not have accurate information about the importance of wetlands and lack data about species diversity and richness within these key ecological hotspots (Tanwie et al., 2024; X. Xu et al., 2020).

Many scholars and sources provided evidence of wetland degradation due to human activities (Chikodzi & Mufori, 2018; Zimbabwe Wetland Policy, 2020; Hove & Chapungu, 2013; Musasa & Marambanyika, 2021; Zinhiva et al., 2014). Some of the studies relate generalized seasonal variability's influence on seasonal wetland changes over time. This created a huge gap in terms of quantifying and qualifying climate change influence on the manner and extent to which wetlands are changing. This study sought to address the climate change and wetlands science by employing information from multiple domains including technological ecological knowledge [TEK], scientific ecological knowledge [SEK], local ecological knowledge [LEK] and bureaucratic ecological knowledge [BEK], as recommended by Fleischman & Briske (2016), to provide a detailed assessment of climate information about changes noted in wetlands ecosystems.

Different strategies and practices are being implemented by communities as they try to build wetland-based livelihoods. Some of the strategies are aligned with climate-smart agriculture (CSA) (CIAT & World Bank, 2017; Nyamadzawo et al., 2015), whilst others are related to ecosystems based adaptation [EbA] (Swiderska et al., 2018). Several policies and strategies for harmonizing ecosystems and livelihoods are being formulated and implemented across the world, but there are growing fears of under-implementation and misalignment of conservation priorities (Adeeyo et al., 2022; Marambanyika & Heinz, 2017), which may lead to maladaptation (Barnett & O'Neill, 2010). Despite these efforts, wetlands were identified to be degrading at a faster rate than other ecosystems. This then created a huge gap within the body of knowledge on the existence of strategies that can save wetlands ecosystems while presenting positive outcomes for people, nature, and climate. The research therefore places much focus on the identified practical and theoretical gaps to provide new insights to the body of knowledge and influence the community of practice within resilience-building strategies for farmer-managed wetlands ecosystems and agrobiodiversity.

## CHAPTER 3: METHODOLOGY

### 3.1 Introduction

The methodology section dealt with the philosophy of the study, the design, and the methods of data collection and analysis. As pointed out by Kothari (2004) and Pandey & Pandey (2015), it is the methodology that guides the theoretical and systematic arrangement of the research plan, data collection, analysis, and interpretation in line with the study's objectives. The first section of this chapter is the introductory part, followed by the research philosophy, and finally the research design. The research design section was further divided into study location, target population and sampling procedure section, data collection, data analysis, and finally, the methodological reflection section that concluded the chapter.

### 3.2 Research Philosophy

The philosophy of the study refers to the researcher's belief that influence data the flow of processes for data collection, analysis, presentation, and reporting in the study (Ryan, 2018). Interpretivism's philosophical positionality influenced the inductive approach that the research adopted. Interpretivism allowed the researcher to explore the research participants' lived experience, dig deeper into imagination, provide meaning for some of the observed scientific and statistical backing for climate change and community resilience (Antwi & Hamza, 2015). Institutional arrangements, local norms, and values that cannot be solely revealed by scientific-related objectivism were dealt with through interpretivism.

The nature of this study further required the convergence of multiple knowledge domains and datasets. The interpretivism research philosophy, cognisant of the study objectives delivered an opportunity for utilizing the mixed methods approach that was applied conjunctively to enhance the results' validity (Easterby-Smith et al., 2015). The science-related objectivism (Turyahikayo, 2021), provided parallel scientific inquiry-based data that was critical in balancing data collection, analysis, and interpretation from different knowledge domains (Ryan, 2018). The study was, therefore, able to deal with scientific ecological knowledge [SEK], bureaucratic ecological knowledge [BEK], local ecological

knowledge [LEK], and technological ecological knowledge [TEK] (Fleischman & Briske, 2016) in a collaborative approach that influenced multidisciplinary research of value to the entire community of practitioners.

### **3.3 Research Design**

The study of this nature that combined different datasets and knowledge domains (Fleischman & Briske, 2016) required a combination of designs that delivered both qualitative and quantitative results in line with the set objectives. A mixed-method approach (Onwuegbuzie & Collins, 2007) was adopted in this study and combined qualitative and quantitative methods (Gupta & Gupta, 2008; Bujang & Adnan, 2016) that played a complementary role in answering the research objectives. A qualitative approach was chosen in line with the required responses that reflect the people's lived experiences, values, norms, and imaginations for a resilient future for smallholder farmers depending on wetland-based agroecosystems (Antwi & Hamza, 2015; Haradhan, 2018). Quantitative approaches were complementary in dealing with statistical and scientific information. The deployment of qualitative or quantitative design alone was not going to provide exhaustive information within the cross-sectional study.

#### **3.3.1 Description of the Study Area**

The research was conducted in Mberengwa Rural District Council (MRDC) jurisdiction areas, Ward 30, Nyororo wetlands (Figure 1). The area falls under agroecological zone (AEZ) V, which receives low erratic rainfall averaging between 400 and 550mm per year (Mugandani et al., 2012; ZIMVAC, 2010). The community depends on wetlands utilization as a coping mechanism against the recurrent drought. Mberengwa district falls under the livelihoods zone known as the Mwenezi-Chivi and South Midlands Communal (ZIMVAC, 2010). The livelihoods zone covers Mberengwa and surrounding Mwenezi, part of the Zvishavane and Chivi districts. The community depends on crop production, livestock rearing, casual labour, and cross-border trading. In recent years, mining activities have been supporting the communities through gold panning, chrome, and lithium mining (ZIMVAC, 2022). Key shocks and hazards affecting the areas include soil erosion, droughts (Defe & Matsa, 2021), crop

pests (Zimbabwe Resilience Building Fund, 2016), animal diseases, and fluctuating cereal prices (Dube, 2018).

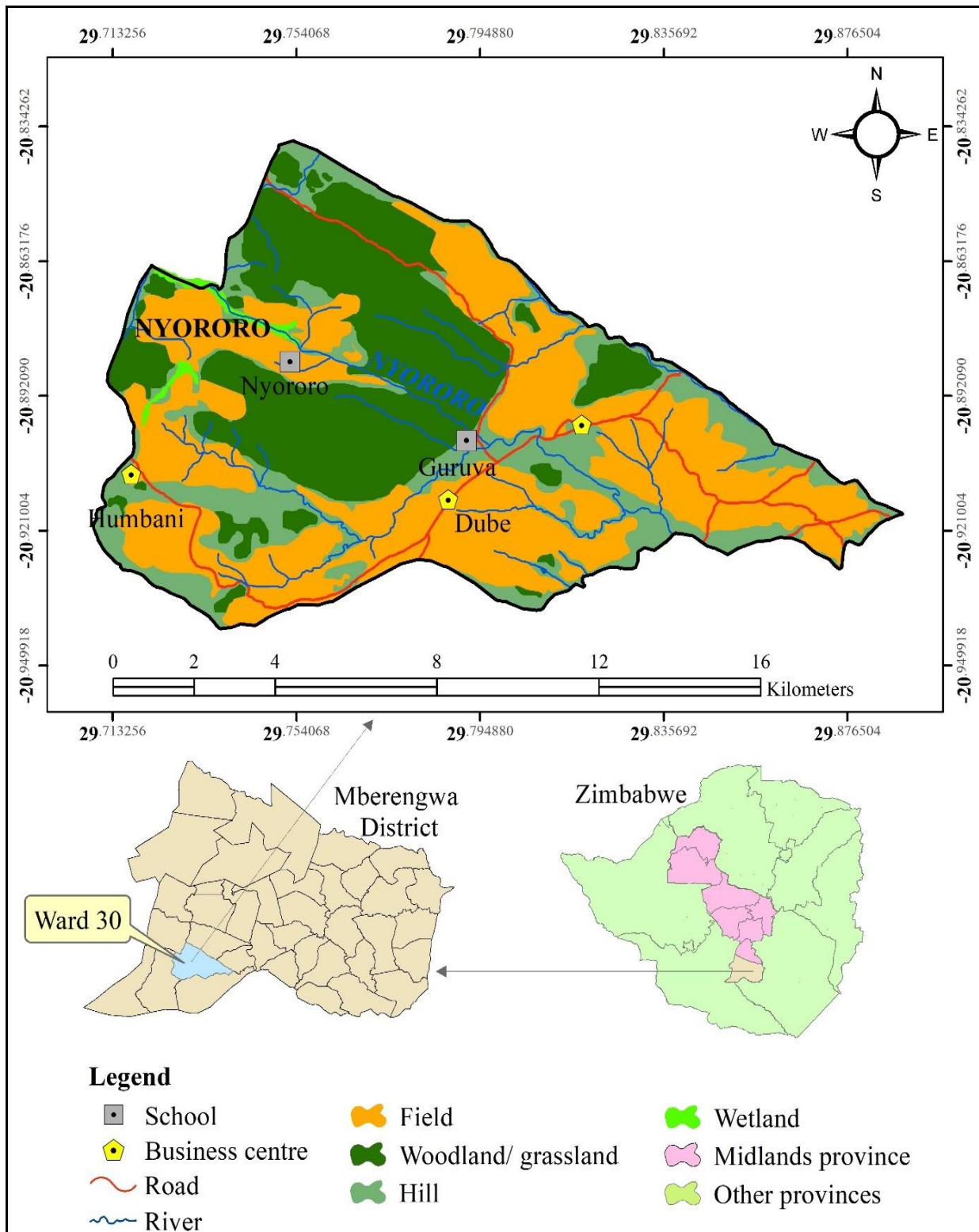


Figure 1: Location of Nyororo Wetland Study Site.  
Source: Author, 2024

### 3.3.2 Target Population and Sampling Procedures

The selection of research participants followed a predetermined sampling procedure. Sampling enabled the study to select a representative group of participants that provided a fair representation of the general population (Adhikari, 2021). Sampling was noted as a key requirement in making sure that the empirical study results are correctly inferred from the population under study (Bujang & Adnan, 2016). Different sampling techniques were used to target different groups of participants using different data collection tools, as detailed in the following sections.

#### 3.3.2.1 Sampling Techniques for Household Questionnaire Survey

A study of this nature targeting smallholder farmers required the deployment of Cochran's standard sampling equation (Charan et al., 2021; Cochran, 1963), which is considered very effective when dealing with large populations (Adhikari, 2021) like smallholder farmers. The targeted group is affected by global phenomena such as climate change (Maccarthy et al., 2021; Sachs, 2015), hence for their view to be more representative, a standard sampling technique was required (Gupta S.C. & Gupta, 2008). Cochran's standard sampling formula or equations as suggested by Adhikari (2021) was used as follows:

$$n_0 = \frac{Z^2 p q}{e^2}$$

where;

$n_0$ : Sample Size

Z: confidence level (95% acceptable in social science = 1.96)

p: prevalence/proportion of the population with desired characteristics (78% = 0.78)

q: 1-p

e: desired level of precision or acceptable margin of error (5% = 0.05)

Therefore;

$$n_0 = \frac{1.96^2 * 0.92 * (1-0.92)}{0.05^2}$$

$$= 3.8416 * 0.92 * 0.08 / 0.0025 = 113.1$$

Therefore; 113 smallholder farmers were selected for the Semi-Structured Questionnaire Survey of the Nyororo wetland users.

Cochran's equation is recommended for a study of this nature because it allows sampling to take conservative measures by assuming a larger proportion of the population (113 out of 142) to achieve a more representative sample size (Alvin, 2016; Taherdoost, 2016), whose results are easily acceptable when generalized to the larger population.

After determining that 113 smallholder farmers were required to respond to the semi-structured household questionnaire, the study employed a random sampling technique for enrolling these participants from the 142 farmers utilizing the Nyororo wetland. Simple random sampling was preferred because it allowed every member of the list of 142 Nyororo wetland users to have a fair chance of participating in the questionnaire survey. The stages for identifying these farmers included the generation of a farmer register using village registers for wetland users. Their list was generated only for those who agreed to participate in the research, in line with the need to uphold and respect prior informed consent (FAO, 2014), for Nyororo wetland users. The full farmer register for Nyororo wetland users was used to randomly select 113 participants using a computer programme. The selected farmers were coded using the NWF code for Nyororo Wetland Farmer and a unique number ranging from 01 to 142. The selected farmers were approached, allocated codes, and interviewed.

### ***3.3.2.2 Sampling for Focus Group Discussions, and Key Informant Interviews***

Purposive sampling was deployed to target key informants and participants of focus group discussions who are knowledgeable about the study topic as stressed by (Lapan et al., 2012). Purposive sampling enabled the research to target the members of the communities that are directly involved in the daily management of wetlands and those who held influential official decision-making roles as revealed by Innes & Connick (2001). Through purposive sampling, representatives of traditional leaders, wetlands user committees, local authorities, Community-Based Organizations (CBOs), and extension services providers were selected as participants in the key informant interviews and focus group discussions. Table 1 presents the participants selected and their justification.

Table 1: Selection of Participants in Key Informant Interviews and Focus Group Discussions

<b>Research Participant</b>	<b>Number</b>	<b>The approach used to contact the participants</b>	<b>Justification for participation</b>
Wetlands User Committee Members	7	A meeting was held with the village head and ward Councillor to select the voluntary participants.	Wetland committees participated in focus group discussions since they knew about the key wetland activities implemented by farmers.
Extension Service Providers	2	A request was directed to district offices for government extension officers to participate. An information session was held that gave information to officers who agreed to participate voluntarily.	The selection was based on the key roles of extension officers who are technical, and responsible for training and knowledge transfer to the smallholder farmers who depend on agroecosystems.
Local Authorities	1	A letter was sent to the Chief Executive Officer (CEO) of MRDC who granted permission to interview the Environmental Officer. The officer agreed to participate in the interview.	Local authority official was targeted due to their critical role in the conservation of the environment within the area of their jurisdiction. They provided insights about community resilience and the local environmental action plans.
Traditional Leaders	4	Appointments were made for the visit, and the traditional leaders proposed a date for all village heads who depend on Nyororo wetland to convene at a central point for the information session. A new date for interviews was set in consultation with the research team.	These are the custodians of the people and environment, as given by the Traditional Leaders Act (Government of Zimbabwe, 1998). They provided key traditional and Indigenous knowledge and insights about the wetlands and their conservation
Community-Based	1	Contacts of officers from a local CBO operating in	The study interviewed the CBO representative due to their

Organizations (CBOs)		the areas were sourced from the MRDC. Appointments and information sessions were held over the phone. A key informant interview was conducted at the Nyororo micro irrigation project.	involvement in financing wetlands conservation projects, social enterprises, borehole water development, and irrigation development.
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Source: Author, 2024

Sampling was key for the study to effectively manage time and other resources. The selection of a representative sample ensured that no too-large samples were selected and this avoided wastage of resources. On the other hand, a too-small sample size was avoided to ensure a more representative sample brings conclusive and reliable results (Gowda et al., 2019)

### 3.3.3. Data Collection Tools

In line with a mixed methods approach employed by the study, both qualitative and quantitative data collection tools were used. The semi-structured household questionnaire survey and some secondary documentaries were key in quantitative data analysis. Key informant interviews, focus group discussions, field observations and transect walks were deployed for qualitative data collection, as presented in the following section.

#### 3.3.3.1 Semi-Structured Household Questionnaire Survey

The questionnaire survey for households was conducted for a sample of 113 smallholder farmers who agreed to participate in the study. These were randomly selected to respond to a set of semi-structured questions about the resilience of smallholder farmers. One key advantage of utilizing a semi-structured interview is that it allows for the collection of vast data covering multiple questions (Kielmann et al., 2012). It also allows for confidentiality and privacy of information. The collected data focused on the smallholder farmers' resilience by assessing reliance on both wetlands and drylands for food production. Questions about

historic climate impacts, shocks, and stressors as well as coping mechanisms were included in the questionnaire survey.

### ***3.3.3.2 Remote Sensing***

The study used remote sensing to assess the changes in the size of wetlands over time. The use of the United States Geographical Survey (USGS) Earth Explorer enabled the researcher to download the images for the years 1990, 2000, 2011, and 2021 during the driest period (September and October) of the four separate years. The moisture indices, Normalized Difference Moisture Indices (NDMI) were calculated for the period under assessment for the Nyororo wetland over time. This determined the changes in the areas covered by moisture since the areas with moisture for the long term can be used to determine the areas covered by wetlands.

### ***3.3.3.3 Secondary Records Review***

Secondary data was key in providing strategic and past information about the smallholder farmers' history, climate, and related data as well as the production records. Despite being generated by other entities for different purposes, the secondary data presented quality information that was produced through peer-review processes (Ajayi, 2017). Secondary sources provided both the quantitative and qualitative data that is useful for the study. Key data sources include ZIMSTATS reports, Zimbabwe Livelihoods Assessment Committee (ZIMLAC) reports project evaluation reports, policy documents, and strategic plans.

### ***3.3.3.4 Key Informant Interview***

Key informant Interviews were conducted with participants who were selected purposively to respond to a set of questions in line with the research objectives. The respondents of the key informant interviews included people with knowledge and authority to share and represent their institutions in an interview, as supported by (USAID, 1996). These were representatives of the Extension Service Organization, representatives of government departments at the district level, traditional leaders, and local authorities.

### **3.3.3.5 Focus Group Discussion**

Three focus group discussions were conducted in the form of group interviews comprised of 8 to 10 smallholder farmer representative (Mishra, 2016). One group comprised of women farmers only, the second group comprised of local leadership representatives, and the third a mixed group of youth, women, and men smallholder farmers. The researcher guided the discussion on wetlands agroecosystems resilience, wetlands goods and services, and institutional arrangement within the Nyororo wetlands. The researcher asked a set of open-ended predetermined questions to stimulate the discussion on the resilience of wetlands agroecosystems. The researcher controlled the direction of the discussion and probed further to gather detailed information useful in decision-making and understanding the context. Being comprised of different people with diversified experiences and views, the study took advantage of the discussions that generated different views and opinions about smallholder farmers' resilience through wetlands-based agroecosystems. The researcher recorded the discussion for reference and further analysis to relate to the study objectives.

### **3.3.3.6 Transect Walks and Quadrants**

#### *a) Flora/Botanical Evidence*

Transect walks were employed in conducting species inventory within the wetland areas. Guided by ecological principles, transect lines of 200 metres were followed along areas selected as interesting in determining the wetlands species availability. Within a transect line, 10 quadrants of 1 square metre each were sampled for recording wetlands species, including flora and fauna. Records of grass species and different herbaceous species were counted and recorded. The inventory recorded all woody species that were located within 10 metres by 10 metres area outside the quadrant (1-metre by 1 metre quadrants). These local species included some of the herbaceous species that were not found in the quadrant but were seen within the 10-metre by 10-metre quadrant. The names of both flora and fauna species identified in the quadrants were recorded. The researcher used pressing sheets to collect plant voucher specimens for key species that required verification, renaming, and filing in the National Herbarium. Transect walks and quadrants helped to gather species data, as these provide key ecological indicators on the health of the wetlands, determining the type, amount, and value of goods and services reaped by the community from the

wetland. The researcher conducted a species inventory with the assistance of a botanist from the National Herbarium in Harare, whose role was to provide references and guides to identify plant species. Field guides were used to identify the species. Some of these guides include the Seasonal Herbaceous Wetland Identification Handbook (Bayes & Cook, n.d.), Biodiversity Explorer (Biodiversity Explorer, 2024), Flora of Zimbabwe (Hyde et al., 2024), Southern African Bird Atlas Project 2 (SABAP, 2024), and EMA Wetland Identification Guide (Environmental Management Agency, n.d.)

#### *b) Faunal Evidence*

Different methods of identifying fauna species including insects, birds, invertebrates and vertebrates were employed. Binoculars were used for seeing birds and other fauna species that were identified from a distance to avoid ecosystem disturbances. A Global Positioning System application was used to gather coordinates and mark the observational points for sightings. Binoculars were also key in keeping track of the transect lines to ensure perfection and accuracy in data collection. The transect lines, the same as the one used for flora species were used to identify and record Nyororo wetland's fauna species. Physical encounters, droppings, footprints, and feeding habits enabled the identification and recording of fauna species within the Nyororo wetland. Fauna field guides were used to identify and correctly name the fauna species.

### **3.3.4 Data Analysis**

Data analysis was conducted for different data sets to ensure grouping of data related to each objective is done. Both qualitative and quantitative data analyses were conducted to ensure the datasets were reduced, reorganized, and arranged into meaningful units.

#### **3.3.4.1 Qualitative Data Analysis**

Qualitative data analysis formed part of data analysis due to the study's interpretivism approach (Turyahikayo, 2021). Content and narrative analysis of qualitative data helped the study to generate meaning from the data collected from focus group discussions, key informant interviews, and secondary sources.

### *i. Narrative Analysis*

Data collected through Key Informant Interviews and Focus Group Discussions were analyzed using content analysis. Due to the different experiences of different groups of people interviewed, the analysis enabled the harmonization of oral history and interpreted human memories into readable meaningful insights generated through discussions (Babbie, 2011; Haradhan, 2018).

### *ii. Content Analysis*

According to Patton (2002), content analysis involves narrowing down the meanings embedded in large volumes of data. Key patterns and trends were generated in line with the study objectives. This analysis involves data preparation, definition of key units of analysis, development of data codes, coding, formulating conclusions, and reporting the results of the analysis. The analysis of the content of information generated from discussions and reports about wetlands utilization and smallholder farmers' resilience was therefore critical in answering the objectives of the study.

### **3.3.4.2 Quantitative Data Analysis**

Quantitative data was analyzed using statistical and scientific packages that assessed the statistical and scientific significance of the results for the variables under study. The use of Statistical Package for Social Science [SPSS] (Arkkelin, 2014), R (R Core Team, 2024), Shannon-Weiner Biodiversity Index [H] (Spellerberg & Fedor, 2003), and the DATA tab online package (DATA tab Team, 2024) enabled analysis of research data into statistical outputs including descriptive statistics, Multivariate Analysis of Variance (MANOVA), Pearson's Correlation, Pair-wise scatter plots, and Bonferroni post-hoc test, all interpreted to define the statistical significance of the study claims, as presented in the following section.

### *i. Statistical Analysis*

The statistical analysis of data using R (R Core Team, 2024), DATA tab (DATA tab Team, 2024), and SPSS (Arkkelin, 2014) produced descriptive statistics, Multivariate Analysis of Variance

(MANOVA), Bonferroni, and correlation outputs for the variables under study. These were critical in identifying the statistical significance and strength of the study results.

*ii. Remote Sensed Image Analysis*

The researcher used supervised image classification to ensure high level of accuracy is achieved. Through supervised classification of images, the study developed 4 training sites within the area. These were Dube homestead, Nyororo school, Jacob's pool and the garden site. The use of these training sites enabled the classification to pick known reference points and features that will be key in guiding the overall assessment. The training sites/reference points further provided the accuracy points of reference to improve the degree of imagery assessment, especially for cases where images required merging. The training sites were demarcated by generating polygons to depict the known land uses, key features, and known areas. The choice of over 1 training site was based on the need to enhance the precision and accuracy of the remotely sensed data. The study created a signature file. Finally, the classification of images using Maximum-likelihood classification (MLC) was done, making use of the generated spectral signatures and other site features identified in the training sites.

*iii. Shannon-Wiener Species Diversity Index*

The Shannon-Wiener Species Diversity Index [H] (Nolan & Callan, 2006; Spellerberg & Fedor, 2003) was used to assess the diversity of the species in the Nyororo wetlands. Species Diversity is known globally as an important indicator of ecological health and resilience (Ramsar Convention, 2007). When the Shannon-Wiener Index [H] is higher, it relates to higher species diversity in the ecosystem. The lower the "H" denotes the lower the diversity. The amount of diversity in species is due to several ecological and physical factors interactions. The data collected using scientific measurements of applying quadrants and transects collected the numbers of different species of flora and fauna. The species were counted and related to the area of the wetland to determine the overall picture on diversity and richness of different floral and faunal evidence. Applying the Shannon-Wiener Index [H] helped in identifying areas with low or high species diversity about diversity in various management aspects. **Shannon-Weiner Index [H]** is used widely to depict the ecosystem

including species richness and evenness. The equation of Shannon Wiener Index [H] is presented as;

$$H' = -\sum_{i=1}^S p_i \ln p_i$$

Where;

$p_i$  = proportion of individuals of species  $i$ ,

$\ln$  = is the natural logarithm,

$S$  = species richness.

The  $H$  value ranges from 0 to  $H_{max}$ . The  $H_{max}$  differs for each community whilst dependent on species richness. The following are the criteria used for assessing the diversity index:

$H' \leq 1$  = Low diversity

$1 < H' \leq 3$  = Moderate diversity

$H' \geq 3$  = high diversity

The Calculator of Biodiversity ( [http://www.alyoung.com/lab/biodiversity\\_calculator.html](http://www.alyoung.com/lab/biodiversity_calculator.html) ) was used to calculate the Alpha Biodiversity (habitat) of the species recorded in the wetland under study.

### **3.4 Reflection on the Methodology**

The study was conducted in the Nyororo community covering wards 30 and 31 under Mberengwa Rural District Council. The area is occupied by smallholder farmers who speak both Shona and Ndebele languages. The interviews were conducted by the researcher who can speak both languages. Due to the nature of the research, species inventory required meeting certain standards as laid down in taxonomy and nomenclature within the botany branch of biology. The researcher contracted the service of the botanist accredited by the National Herbarium to help identify, name, and prepare plants into voucher specimens that were deposited at the Botanical Gardens for reference. This was done to comply with the set global standards on collection of plant voucher specimen and their storage in line with their existence in different phytogeographical zones of Zimbabwe.

## **CHAPTER 4: PRESENTATION OF EMPIRICAL EVIDENCE**

### **4.1 Introduction**

The findings of the research are presented in this chapter. Empirical evidence generated through statistical analysis, scientific measurements, and qualitative analysis were presented in different forms as required by the mixed methods approach. The climate-related impacts on wetlands biodiversity and agroecosystems were in the form of significant changes in wetland size, distribution of species, and reduction in the provision of goods and services supporting smallholder farmers' resilience. Resilience-building strategies were identified including the adoption of seasonal livelihoods planning, utilization of climate information for building anticipator actions, climate-smart agriculture, and adoption of social enterprises, all aimed to ensure the smallholder farmers' adaptive, absorptive, and transformative capacities are strengthened. Local institutional roles in the management of wetland agroecosystems, knowledge management, and information dissemination were identified as important enablers for resilience building. The chapter is presented in three main sections including the introduction covered under section 4.1, the presentation of the findings in sections 4.2, 4.3, and 4.4; whilst the conclusion is under 4.5.

### **4.2 The Resilience, Species Diversity, and Richness of Nyororo Wetland**

The community reported that flora and fauna species are facing extinction mainly due to high temperatures and low rainfall affecting the wetlands ecosystems. It was reported during the focus group discussion that several flora and fauna species were no longer visible, with some used to be perennial and only seen closer to water sources and during the rainy season in areas that dried up. The community was not able to determine the rate of species extinction or quantify the existing stock of species. The study conducted a species inventory survey to create a baseline that characterizes the current stock of flora and fauna within Nyororo wetlands. This was conducted in a participatory manner with communities in action, identifying the species and recording them (Figure 2).



*Figure 2: Wetland Species Data Collection – Voucher Specimen Pressing*

*Source: Author, 2024*

The study determined the ecological characteristics of the Nyororo wetland. This identified the species diversity and richness of the wetland ecosystem, as presented in the following section.

#### *Results from Shannon-Wiener Species Diversity Index [H]*

The scientific study was complemented by community support through indigenous and local knowledge systems that ascertained and validated the type of species including their names and use. The wetlands species richness and diversity were calculated using the Shannon-Wiener Species Diversity Index [H] equation (Spellerberg & Fedor, 2003).

#### 4.2.1 Species Richness

##### Plant species richness

A total of seventy-one (71) plant species (Annexure 1) from sixty-nine (69) genera and thirty-three (33) families were recorded on the Nyororo wetland (Figure 3). The identified and recorded species could be higher if the survey was conducted over two seasons.

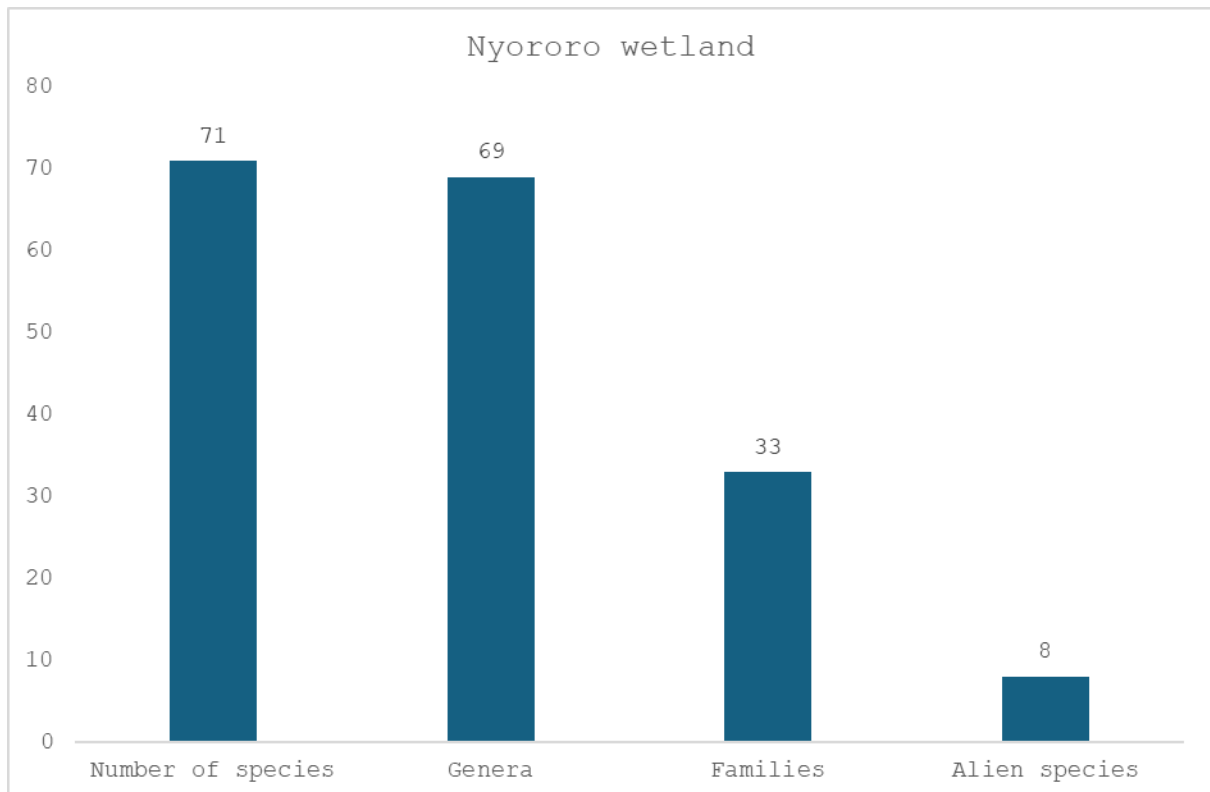


Figure 3: Number of species, genera, families, and alien plants recorded on Nyororo wetland

Source: Author, 2024

##### Wetland alteration by Invasive Alien Species and human activities

A total of 8 invasive alien species, representing 11.3 percent of the total species identified in the Nyororo wetland, including *Lantana camara* (Figure 4.3). The Convention on Biological Diversity (CBD) defines an alien species as “a species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce” (Kourantidou et al., 2022). An invasive alien species was further defined by Kourantidou et al. (2022) as an “alien species which threatens ecosystems, habitats, and other species”. The community

indicated that these unwanted species are claiming space that used to be occupied by indigenous species. According to Masters & Norgrove (2023), climate change has set new boundaries by determining seasonality and environmental favourability of noxious weeds and other alien species. This has disrupted the provisioning services like the food web and food systems as claimed by Tabengwa (2015). Habitat loss including breeding sites for grey crowned and wattle cranes was identified in line with the findings of Fakarayi et al. (2016) study in Driefontein wetlands. The habitat used to be stable when the wetland ecosystem was defined as pristine (Environmental Management Agency, n.d.; National Wetlands Management Guidelines, Government of Zimbabwe, Harare, Zimbabwe., 2021), but the farmers indicated increased crop cultivation, veld fires, and grazing by livestock changed the wetland to the altered state, as defined by Otte et al. (2021).



*Figure 4: Lantana Camara Invasive Alien Species in Nyororo Wetland*

*Source: Author, 2024*

Invasive alien species were noted to take advantage of the changing environmental conditions like aridity brought by drought. The smallholder farmers reported that the identified alien species like *Lantana camara* are multiplying much faster due to climate change-induced droughts and high temperatures. They occupy the altered and unfavourable space where native plants find it difficult to thrive (Masters & Norgrove, 2023). The invasive alien species are defined as noxious and unwanted in the conservation of the Zimbabwean ecosystem. Some of the most dominating alien plant species recorded in the wetlands are indicated in Table 2

Table 2: Alien Species Identified in Nyororo Wetland

Scientific name	Family name	Common name	Status
<i>Agave sisalana</i>	Asparagaceae	Sisal	Alien, ornamental, hedge, fibre
<i>Psidium guajava</i>	Myrtaceae	Guava	Alien, fruit tree
<i>Richardia scabra</i>	Rubiaceae	Mexican clover	Alien, weed
<i>Verbena bonariensis</i>	Verbenaceae	Purple top	Alien, weed

Source: Author, 2024

### Fauna species richness

Figure 5 below gives a summary of fauna species recorded in Nyororo wetland. A total of 16 fauna species were recorded on Nyororo wetland including 5 avifauna, 4 invertebrates, 2 amphibians, 2 insects, 2 mammals, and a single mollusc species (Table 3).

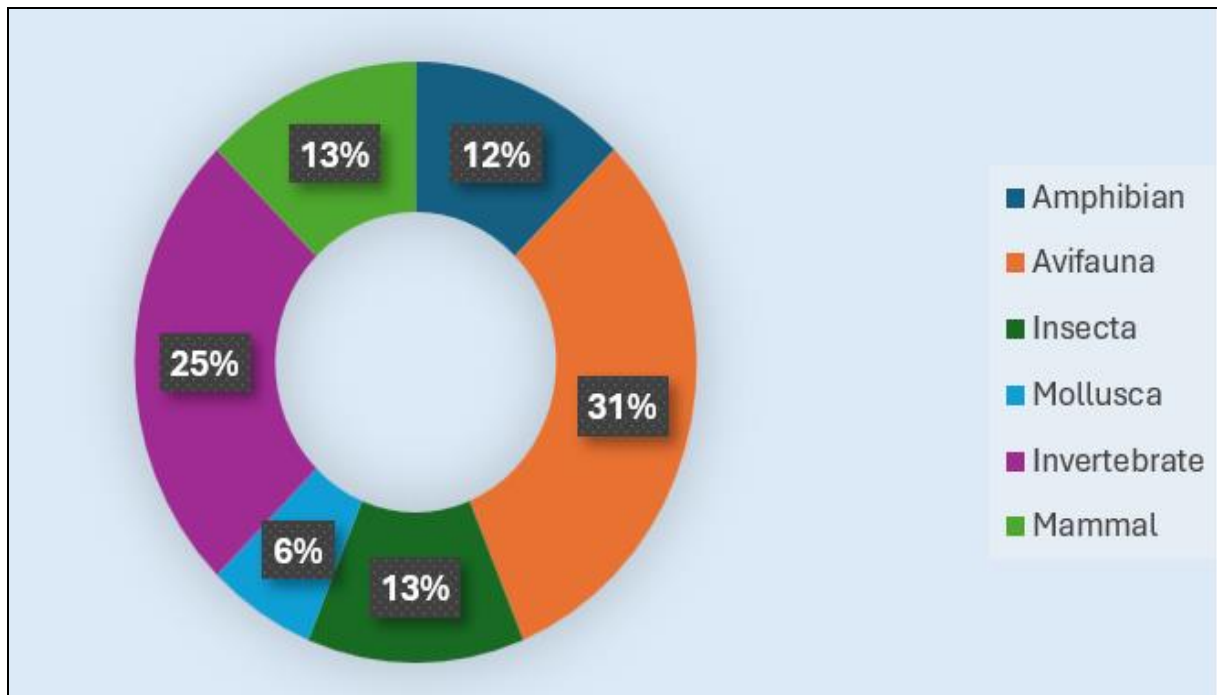


Figure 5: Fauna species recorded on Nyororo wetland  
Source: Author, 2024

Table 3: Fauna species of importance listed on Nyororo wetland

Nyororo wetland	Family	Common name	Fauna type	Status
<i>Amietia angolensis</i>	Ranidae	Angola river frog	Amphibian	Lc
<i>Ardea cinerea</i>	Ardeidae	GreyHeron	Fauna	Lc
<i>Bubulcus ibis</i>	Ardeidae	Cattle Egret	Fauna	Lc
<i>Hyperolius sp.</i>	Hyperoliidae	<i>Hyperolius sp.</i>	Amphibian	Lc
<i>Ischnura elegans</i>	Coenagrionidae	Blue-tailed Damselfly	Invertebrate	Lc
<i>Orthetrum brachiale</i>	Libellulidae	Tough skimmer	Invertebrate	Lc
<i>Otomys irroratus</i>	Muridae	Southern African Vlei Rat	Mammal	Lc
<i>Palpopleura portia</i>	Libellulidae	Portia widow	Invertebrate	Lc
<i>Papilio demodocus</i>	Papilionidae	<i>Papilio demodocus</i>	Insecta	Lc
<i>Phalacrocorax africanus</i>	Phalacrocoracidae	Reed cormorant	Avifauna	Lc
<i>Phymateus sp</i>	Pyrgomorphidae	Milk locust	Insecta	Lc
<i>Potamochoerus porcus</i>	Suidae	Bush pig	Mammal	Lc
<i>Pycnonotus tricolor</i>	Pycnonotidae	Dark-capped Bulbul	Avifauna	Lc
<i>Trithemis arteriosa</i>	Libellulidae	Red dragonfly	Invertebrate	Lc
<i>Vanellus coronatus</i>	Charadriidae	Crowned lapwing	Avifauna	Lc
<i>Achatina fulica</i>	Achatinidae	Giant snail	Mollusca	Lc

Source: Author, 2024

No fauna species of conservation concern were recorded on the Nyororo wetland (Table 3). Due to the threats posed on wetland habitat, the wetland fauna species identified were very few, and this calls for extended conservation programme to be considered by communities.

#### 4.2.2 Species Diversity

The species diversity recorded on Nyororo wetland was generally high. A total of four (4) transect lines were conducted during the study. These were names 1 to 4. Transect line number 2 recorded the highest species diversity (3.245), followed by transect 1 (3.108), transect 3 (2.578), and lastly transect 4 (2.399) with moderate species diversity (Figure 6). The high species diversity can be related to the more productivity in the ecosystem which will form a stable ecosystem. This then calls for Nyororo wetland to be protected to maintain and even increase the diversity of species recorded. It was noted that the wetland provides habitat to specially protected species. A single specially protected Indigenous plant species was identified at the edge of the wetland, as *Anselia africana* (Leopard orchid) as indicated in Parks and Wildlife Act 14/75 (Seventh Schedule Amendment) Section 48 (PARKS AND WILD LIFE ACT. Chapter 20:14., 2014).

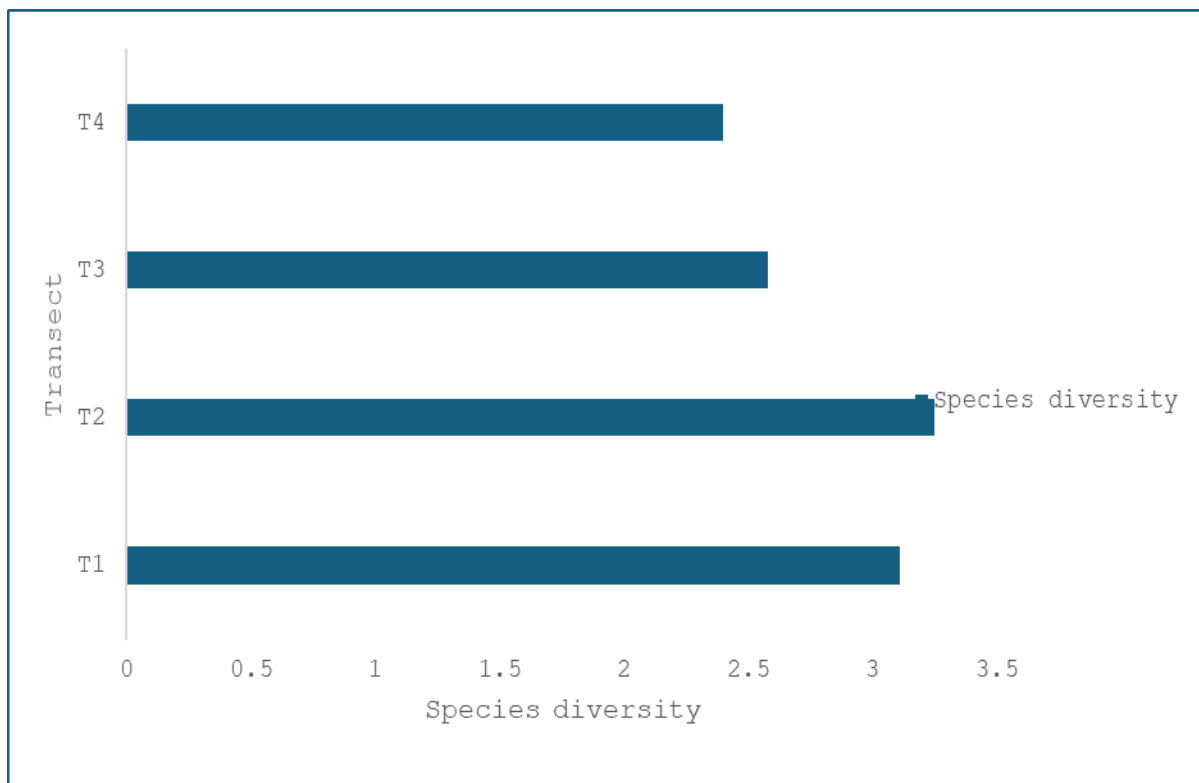


Figure 6: Species diversity recorded on Nyororo wetland

Source: Author, 2024

### **4.3 Climate-Related Impacts on Wetlands Biodiversity and Agroecosystems**

The study gathered data in response to the objective of climate-related impacts on wetland biodiversity and agroecosystems. This section presents the findings of the study in line with top-ranked climate-related impacts on wetlands biodiversity and agroecosystems.

#### ***4.3.1 Droughts Impacts on Food and Water for Wetland Agroecosystems***

All the participatory data collection tools (questionnaire, focus group discussion, and key informant interviews) revealed that drought was a top-ranked climate-related challenge affecting wetlands biodiversity and agroecosystems. When probed about the signs and manifestations of droughts, the respondents pointed out the following.

- a) *Low seasonal rainfall totals* were a common phenomenon whose chances of occurring are greater than 65 percent. The extension services providers and the farmer group committee indicated that the area receives 4 low seasonal rainfall years every 6 seasons.
- b) *Late-onset rainfall* was reported indicating that effective rainfall for all farmers to plant has shifted from the previous mid-October to December or January. The situation is associated with the reduced planting time for smallholders. This was reported to have negative implications on crops that require a lengthy growing season, including finger millet despite its drought tolerant, groundnuts which is key in the diet of communities and sunflowers.
- c) *Mid-season dry spells* were reported to be in the form of a huge break in rainfall for over 28 days, affecting soil moisture and plant health. The situation was reported by a proportion reaching 95 percent of the questionnaire respondents
- d) Early rainfall cessation was described as a situation happening when the farmers expect to receive the rainfall until the end of the season at the end of March, but it was noted that it is now frequent that rainfall can just stop in January or February. This was related to the 2023/2024 season that witnessed crop wilting

Of major interest was the occurrence of all these drought-related phenomena within one growing season. The smallholder farmers reported that this was the case in the 1991/92 season, 2015/16 season, and 2023/24 season. The study assessed these years and identified that all these conditions have led to Zimbabwe’s largest humanitarian crisis that attracted some of the largest global appeals when the country declared the drought as a state of emergence (Government of Zimbabwe, 2016, 2024).

To assess the significance of the findings in the claims by respondents, the study employed descriptive statistics (Table 4) to assess drought-related claims and their significance for the period covering 1980 to 2020. It was noted that the area’s average annual rainfall was 482.94mm was far below the national average of around 670mm (The World Bank Group, 2020, 2021; ZIMSTAT, 2016). The rainfall standard deviation was recorded to be 186.79mm, implying the deviation from the mean was high. The farmers reported that their rainfall is no longer predictable, meaning it is highly variable and affects their cropping patterns and availability of water for their agricultural activities. To further confirm the claims that climate-induced droughts, mid-season dry spells, late-onset, and early cessation are affecting food production, the descriptive statistics indicated that crop yields in the drylands were deviating from the mean with a higher margin than crop yields in wetlands. The standard deviation for dryland yields was 668.38 kg from the mean of 866.25KG, as compared to the smaller deviation of 198.41 kg of wetland yields against its mean of 892.6 kg (Table 4.3). Furthermore, smallholder farmers’ records indicated that farmers are yielding more cereals in wetlands than dryland yields due to inherent soil moisture that promotes plant growth.

*Table 4: Descriptive Statistics*

	n	Mean	Std. Deviation
Annual Rainfall (mm)	40	482.94	186.79
Dryland Yields (KGs)	40	866.25	668.38
Wetland Yields (KGs)	40	892.6	198.41

Crop production was further reported to have been undermined by reduced land utilization in drylands due to unfavourable drought conditions. Farmers reported that they only put a small portion under crop production in drylands when they receive few rainfalls. It was further reported that more land is put under crop cultivation when the seasonal rainfall performance was forecasted to be good. The study used Pearson’s Correlation to assess the farmers’ claims on the relationship between the arable areas put under crop cultivation in wetlands and drylands against the seasonal rainfall performances as presented in (Table 5) and Figure 7.

*Table 5: Pearson’s Correlation Analysis*

<b>Null hypothesis</b>	<b>Alternative hypothesis</b>
There is no correlation between seasonal rainfall amounts, the area under cropping in dryland, and area under cropping in wetland	There is a correlation between seasonal rainfall amounts, area under cropping in dryland, and area under cropping in wetland

*Correlation Matrix and Significance*

		Annual Rainfall (mm)	Area (Ha) Under dryland cropping	Area (Ha) under Wetlands copping
Annual Rainfall (mm)	Correlation	1	0.49	-0.29
	p		.09	.344
Area (Ha) Under dryland cropping	Correlation	0.49	1	-0.66
	p	.09		.015
Area (Ha) under Wetlands copping	Correlation	-0.29	-0.66	1
	p	.344	.015	

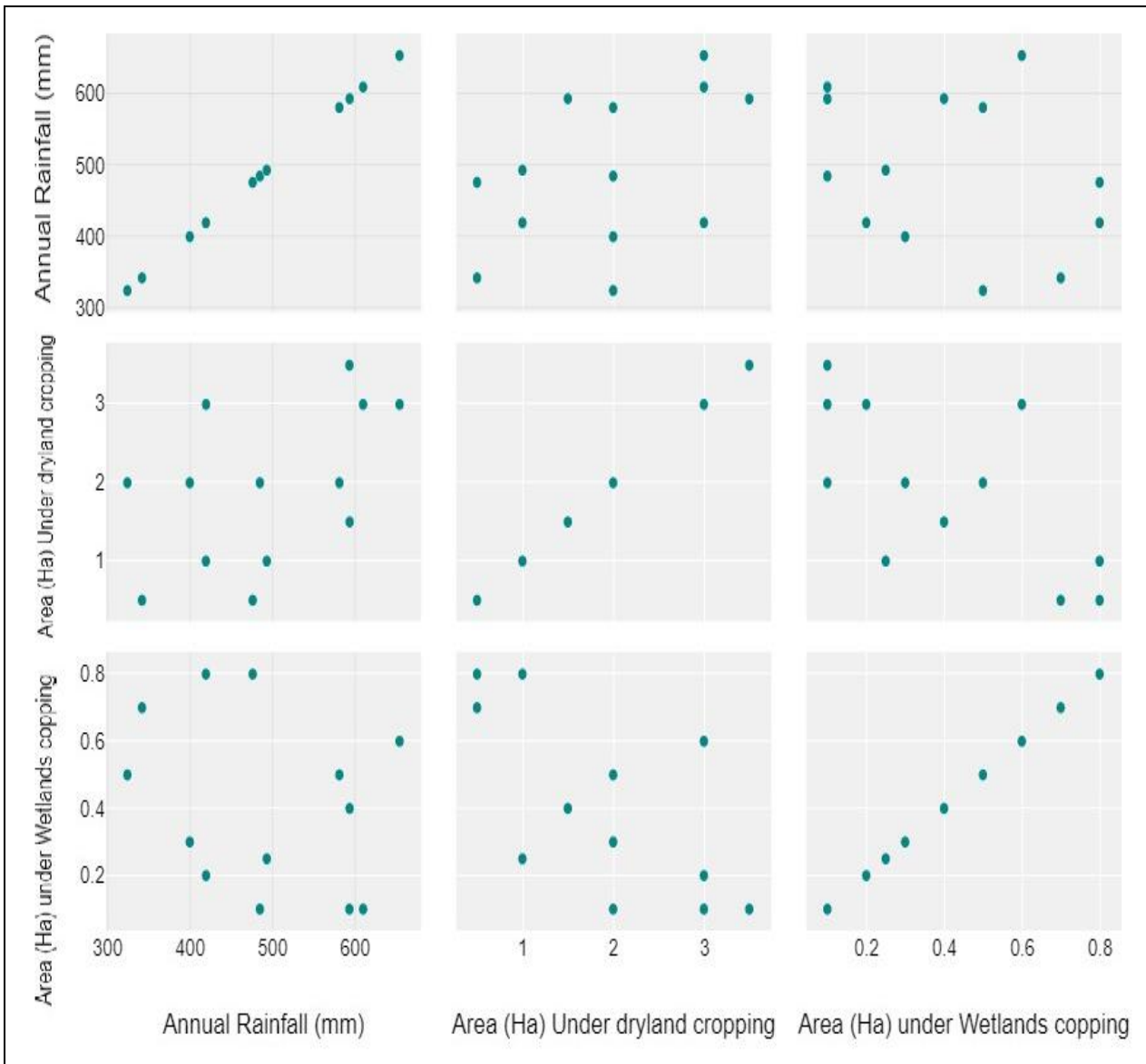


Figure 7: Visualization of Pair-wise Scatter  
 Source: Author, 2024

The following pairs were analyzed:

Area (Ha) under wetland cropping vs Area (Ha) under dryland cropping, (P-Value = 0.015)

There is a moderate inverse relationship between dryland and wetlands areas under cropping, as confirmed by the correlation of -0.66. The inverse relationship explains that when the area under cropping in wetlands increases, it results in a decrease in the area under dryland, and vice versa. The p-value = 0.015 is less than 0.05; therefore, we reject  $H_0$  and conclude that there is a statistically significant relationship between the pair.

Rainfall (mm) vs Area (Ha) under dryland cropping, (P-Value =0.09)

The correlation of the pair (0.49) indicates a weak relationship. The p-value of 0.09 for dryland hectares (Ha) under crop cultivation each year and rainfall (mm) is greater than 0.05, therefore we fail to reject  $H_0$  and conclude that there is no statistically significant correlation between the pair. This indicated that the assumption by farmers that the area under dryland crop cultivation was declining was not statistically significant.

Rainfall (mm) vs Area (Ha) under wetland cropping, (P-Value = 0.344)

The correlation of the pair (-0.29) indicates a weak relationship. The p-value of 0.344 for wetland hectares (Ha) under crop cultivation each year and rainfall (mm) is greater than 0.05, therefore we fail to reject  $H_0$  and conclude that there is no statistically significant correlation between the pair. This indicated that the assumption by farmers that the area under wetland crop cultivation was increasing is not statistically significant.

#### **4.3.2 Increased Cases of Crop Pests and Animal Diseases**

The key informants and focus group discussion participants indicated that climate change has heightened the incidence of crop pests and animal diseases. One farmer highlighted that *Spodoptera frugiperda* (Fall Army Worms) was first noticed in the year 2015 when the country was under drought. Today, Fall Army Worm is considered a serious migratory pest that is spreading across the globe (Kansiime et al., 2019). Farmers reported that the use of chemicals proved effective in the control of fall army work, despite the health and ecological threats and disruptions associated with chemicals. When asked about the application and effectiveness of Push-Pull system (Bay, 2020; Guera et al., 2021), which is dependent on the ecological processes, they indicated that the pest response inhibits temporal and spatial responses due to climate change and variability factors that alter seasonal temperature and rainfall performance.

The outbreak of *Theileriosis* (January Disease) was also noted to have caused serious damage to the smallholder farmers whose livelihoods depended on crop and livestock integration. Over 95 percent of participants in the questionnaire survey agreed that

theileriosis was first reported in the year 2018, and 60 percent of these respondents revealed that they lost over 45 percent of their cattle herd due to the disease. The officials who responded to the key informant interviews concurred with smallholder farmers and indicated an overall reduction of 30 percent in the livestock population due to theileriosis. Crop pests and animal diseases were globally found to be following the climate change patterns, with high temperatures and low rainfall increasing livestock susceptibility to the disease (FAO, 2018; Oluwagbemi et al., 2022).

#### ***4.3.3 Shrinkage of Wetlands Areas***

Smallholder farmers indicated that the Nyororo wetland was shrinking at a faster rate. During field observations and transect walks, the researcher identified dry wooden tree poles that were used to fence the gardens. These wooden poles are located 120 metres in dry land, far from the place where there are wetlands features and plant indicator species. This was explained as the indicator for the shrinking wetland. To assess the extent of shrinkage, the study used remote sensing techniques, the USGS Earth Explorer to identify the changes in soil moisture indices. The Normalised Difference Moisture Index (NDMI) was calculated from the downloaded images of 1990, 2000, 2011, and 2021 (Figure 8)

A slight increase in the area covered by water was identified between 1990 and the year 2000. Between the years 2000 and 2021, the results confirmed a decline in the area covered by surface wetlands [represented by moisture] (Figure 8). When probed for an explanation, the participants of key informant interviews and focus group discussions highlighted that this situation was correct and associated with high temperatures, low rainfall, and increased wetland cultivation factors. The remote sensing alluded that climate change in Zimbabwe altered wetlands by reducing their coverage as indicated by the shrinkage of moisture-covered zones depicting wetlands as confirmed by the study conducted by Bhaga et al. (2020).

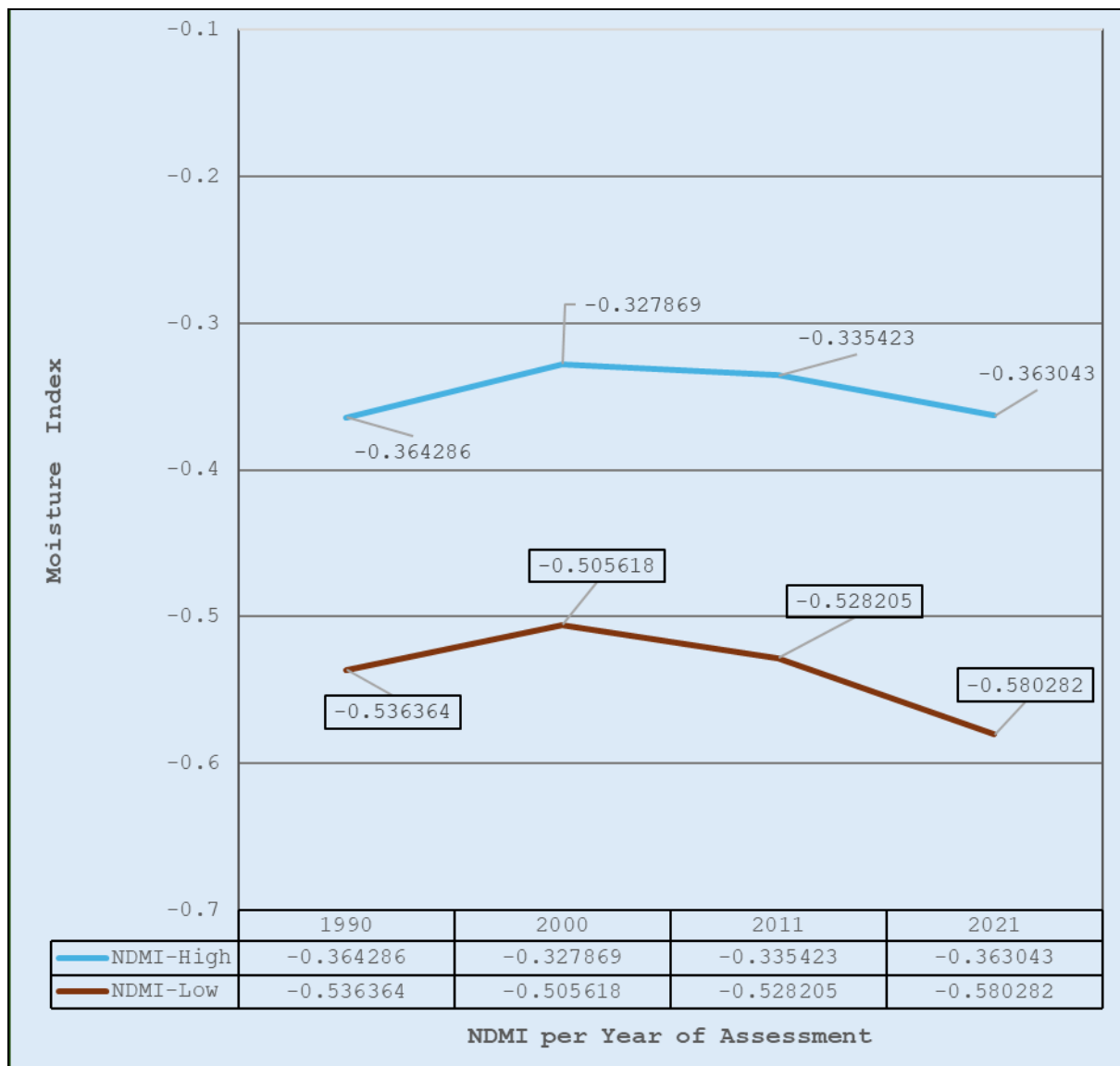


Figure 8: Nyororo Normalised Difference Moisture Indices (1990 to 2021)

Source: Author, 2024

#### 4.4 Resilience Building Strategies for Wetlands Agroecosystems

After identifying the impacts of climate change on Nyororo wetland agroecosystems, the study was also concerned with determining wetland ecosystem-based resilience-building strategies that help farmers develop absorptive, adaptive, and transformative capacities (Green Climate Fund, 2022), in response to the changing climate. The main reason was to identify the sustainability proposed or implemented by smallholder farmers utilizing Nyororo wetland, without leading to maladaptation (Barnett & O’Neill, 2010). Several promising and sustainable strategies were identified by the study. Building the community’s Anticipatory

Actions Plans (AAP), using Ecosystems-based Adaptation (EbA), and Seasonal Livelihoods Planning (SLP) were ranked as high and promising strategies for achieving a climate-livelihoods-ecosystems nexus.

#### ***4.4.1 Anticipatory Action***

Participants of the key informant interviews and focus group discussion indicated that they have been learning over time as the climate continues to bring different seasonal rainfall performances and varied temperature regimes. The use of climate information in planning their food crop production was identified as one key area enabling wetland users to determine the land preparation, inputs, type of crops, and the time for planting. It was noted that when there is forecast of a normal to above-normal rainfall (Meteorological Services Department, 2020), smallholder farmers use this as planning information in anticipation of a good cereal harvest. During a bad season with the forecast of below normal, the farmers start destocking livestock and planting traditional grains that perform better with little rainfall. The study noted that crop production patterns in both drylands and wetlands followed the rainfall performance (Figure 9).

Since 2001, more farmers reported that they relied more on wetlands for food production than drylands. This was possibly due to changing and highly variable rainfall patterns that undermined food production in semi-arid and arid regions like Mberengwa in the AEZ V (Mugandani et al., 2012). An inverse relationship that depicted a declining dryland crop yield and increasing wetland crop yields over time was noted (Figure 9). The changing climatic conditions may account for the increasing wetland crop cultivation preference by most smallholder farmers as depicted by the overall increase since the year 2001. Economic challenges might have played an aggravating role in influencing the observed trend.

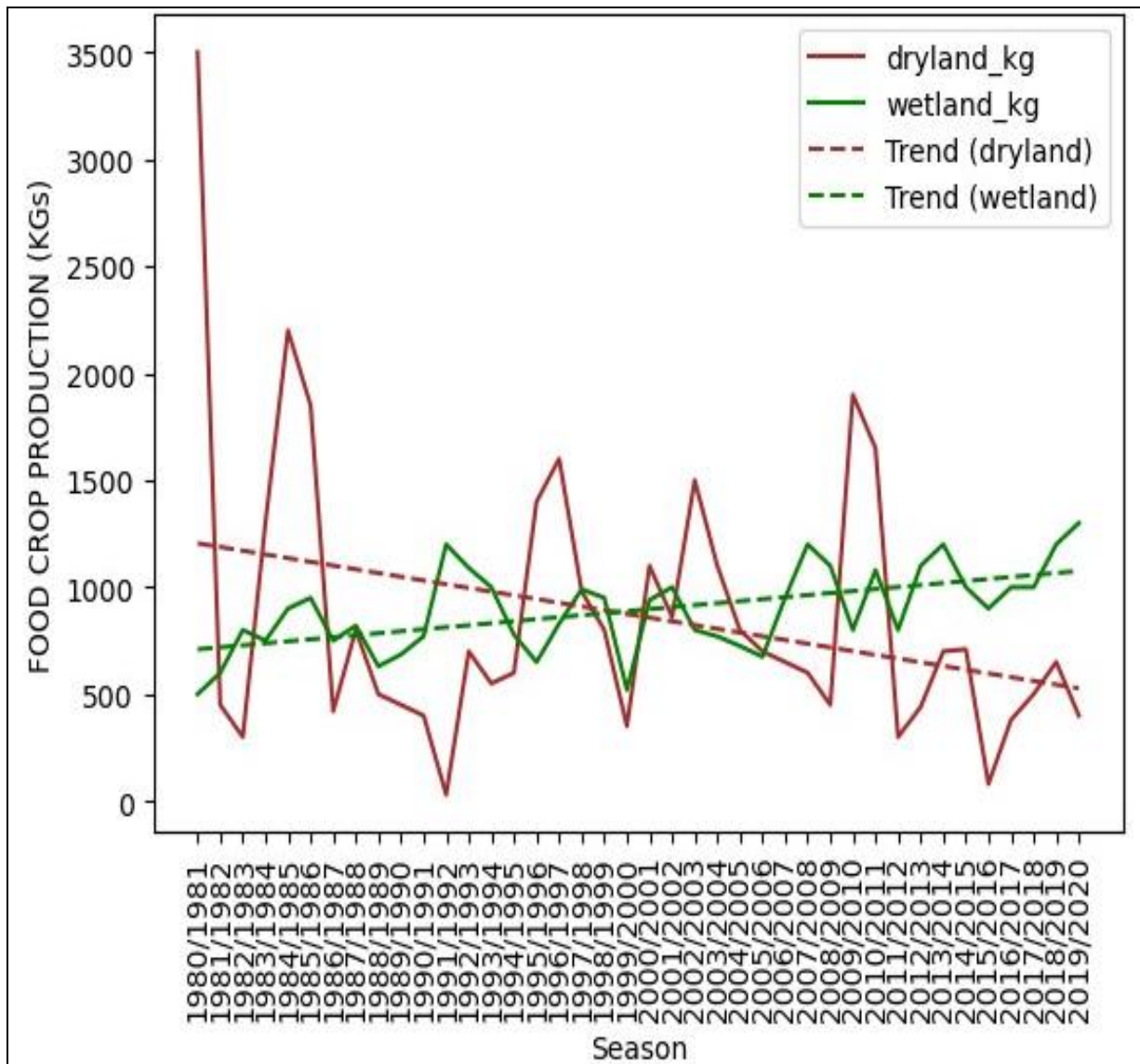


Figure 9: Trends in cereal crop production between wetlands and drylands (1980-2020)  
 Source: Author, 2024

The research further confirmed the smallholder farmers' claim by assessing the statistical significance of the noted changes using the below (Table 4.5) Multivariate Analysis of Variance (MANOVA). The following hypothesis provides the claim.

$$H_0: \mu_1 = \mu_2 = \mu_3$$

H1: Not all treatment effects are the same

Table 6: Multivariate Analysis of Variance (MANOVA) – R Output

	Df	Pillai	approx. F	num Df	den Df	Pr(>F)	$\eta^2$
Annual_.rainfall	1	0.34606	9.7902	2	37	0.0003867 ***	0.25
Residuals	38						
	Df	Wilks	approx F	num Df	den Df	Pr(>F)	
Annual_.rainfall	1	0.65394	9.7902	2	37	0.0003867 ***	0.25
Residuals	38						
	Df	H-Lawley	approx. F	num Df	den Df	Pr(>F)	
Annual_.rainfall	1	0.5292	9.7902	2	37	0.0003867 ***	0.25
Residuals	38						
	Df	Roy	approx F	num Df	den Df	Pr(>F)	
Annual_.rainfall	1	0.5292	9.7902	2	37	0.0003867 ***	0.25
Residuals	38						

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 Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

### P – Values

Results of the MANOVA indicate that all 4 test statistics (Pillai, Wilks, H-Lawley, and Roy) have p-values = 0.0003867, which is less than 0.05. Therefore, the study rejects  $H_0$  and concludes that there is a significant difference in the treatment effects (inherent soil moisture to crop yields harvested from wetlands and drylands)

### Effect Size ( $\eta^2$ - Eta Squared)

The eta squared ( $\eta^2$ ) value is 0.25 (25%), representing the proportion of the variance in the dependent variables that are attributable to the soil moisture conditions (dryland and wetland). In this context, 25% of the variance in the dependent variables can be explained by the differences between the levels of soil moisture between wetlands and drylands. The eta squared value of 0.25 suggests a large effect size. This translated into a 25% difference in yield due to the inherent moisture in wetlands than drylands.

According to Cohen (1988), the statistical power represented by limits for the effect size Eta-Quadrat are .01 (small effect), .06 (medium effect), and .14 (large effect). The study results indicate a much higher production level as represented by eta squared ( $\eta^2$ ) 0.25, depicting the critical value of provisioning services offered by wetlands for communities affected by droughts.

### Bonferroni Post-hoc-Test

After realizing that there are statistically significant differences in the effects of soil moisture in both wetlands and drylands under different seasonal rainfall performances, the Bonferroni post-hoc test (Table 7) was conducted to identify the pairs with the most significant differences.

*Table 7: Bonferroni post-hoc test*

<u>contrast</u>	<u>estimate</u>	<u>SE</u>	<u>df</u>	<u>t.ratio</u>	<u>p.value</u>
Dryland Yields (KGs) - Wetland Yields (KGs)	0.247	0.078	37.0	3.16	0.0033
Dryland Yields (KGs) - Annual Rainfall (mm)	-0.391	0.105	37.0	-3.72	0.0006
Wetland Yields (KGs) - Annual Rainfall (mm)	-0.638	0.131	37.0	-4.86	<0.0001

The results of dryland yields (KGs) versus wetland yields (KGs) under the same rainfall resulted in a p-value = 0.0033, which confirms a significant difference in crop yields influenced by inherent soil moisture. Smallholder farmers therefore increased wetlands crop production under the changing climatic conditions to avert the effects of drought on food production. This is one aspect of anticipatory action planning that builds the resilience of wetlands-based agroecosystems.

#### **4.4.2 Ecosystems-based Adaptation (EbA)**

During the field observations and focus group discussions, the participants revealed their benefits from wetlands including food, water, and fibre for their livelihood needs. Ecosystems-based Adaptation (EbA) was noted to be a resilient way of sustaining the climate-water-food nexus (Rizvi et al., 2015; Swiderska et al., 2018). The challenge indicated included the continued shrinking of the wetland despite offering critical life support. In the case of the year 1992 when the district and the country received very low, below 200mm of rainfall, the wetland was reported to have supported Mberengwa, and Filabusi communities with drinking and livestock water. Nyororo wetland is enabled to support the community's resilience through water provision throughout the dry seasons during low rainfall years. For

successful wetland agroecosystem interventions, the communities underscored the need to protect, implement wise use, and Enhance coordination in the wetlands conservation.

#### 4.4.3 Seasonal Livelihoods Planning

The respondents of a household questionnaire survey indicated that their livelihoods are related to different seasonal rainfall performances. It was noted by 92 percent of respondents that both wetlands utilization patterns are influenced by seasonal rainfall performance. When asked about priorities for wetland utilization in both drought years (Figure 10) and good seasonal rainfall years (Figure 11), the respondents indicated that domestic water supply remains the major priority for wetland water use. After prioritizing domestic water, many farmers indicated that during the drought year, more water is needed for watering livestock, followed by crop cultivation. Sustaining the wetlands goods was the fourth priority and the fifth priority was spiritual and cultural needs.

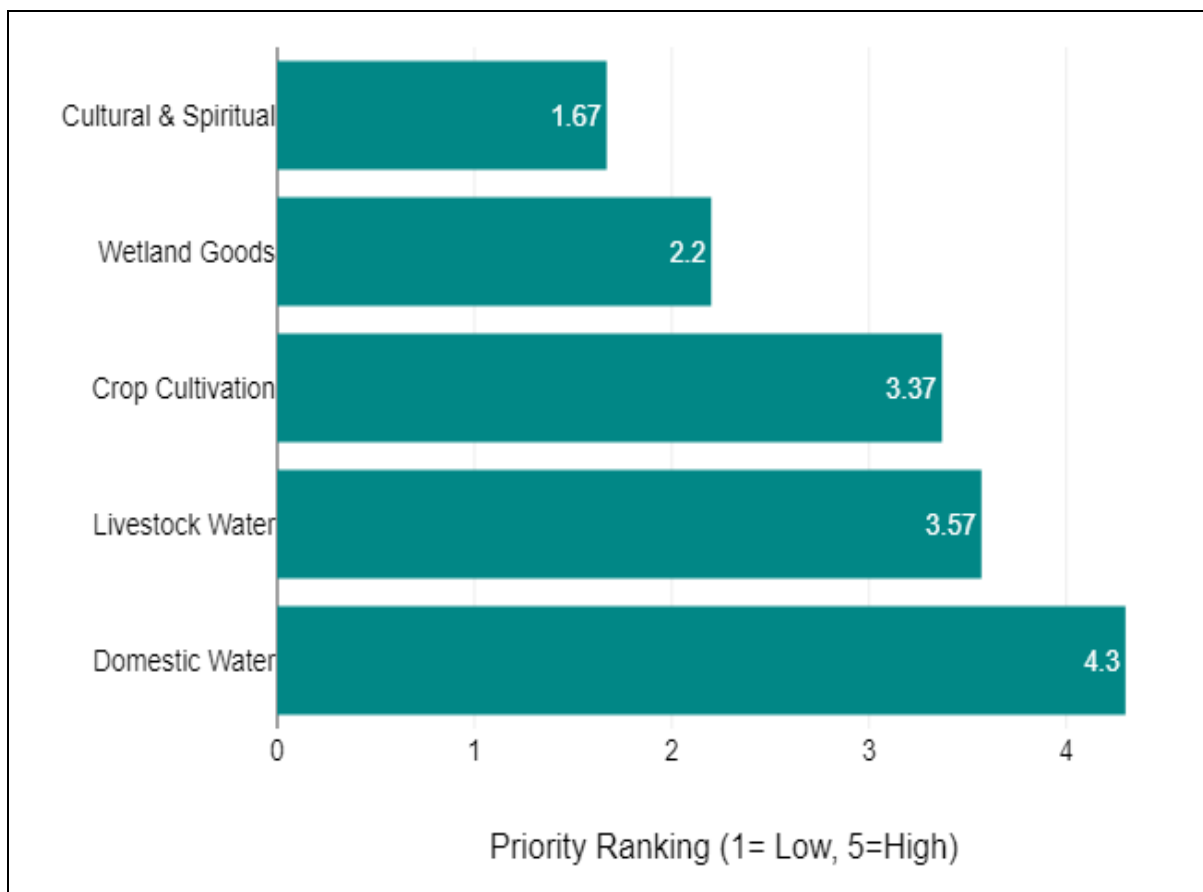
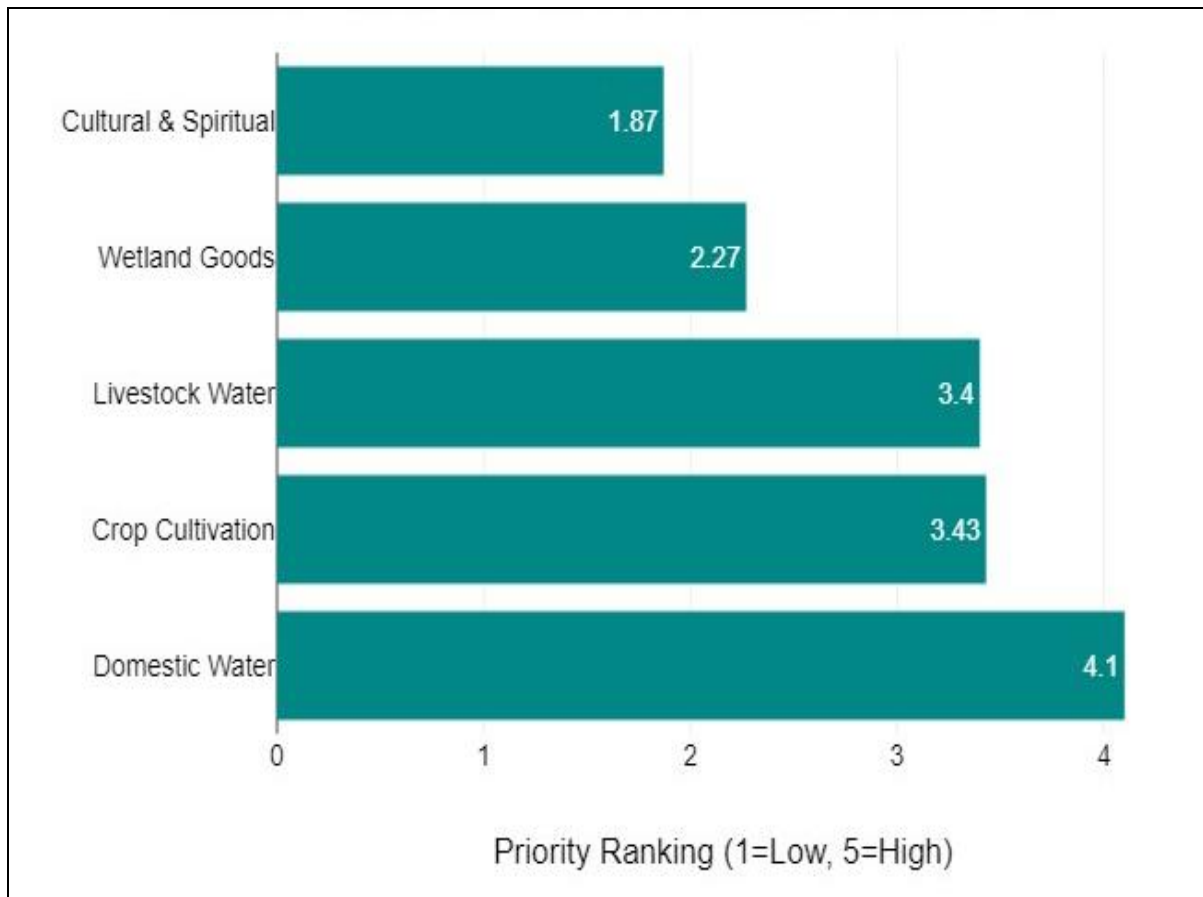


Figure 10: Wetlands Utilization Priority for a Drought Year

Source: Author, 2024

In both the good rainfall season and the drought season, smallholder farmers place more priority on wetland water in the domestic water supply. The good seasonal rainfall year priority replaced the livestock water with crop cultivation prioritized in a drought year. When probed for an explanation, the focus group discussion concurred that during a good rainfall season, livestock have access to other temporal water sources, hence the priority is shifted towards irrigation for cultivated crops.



*Figure 11: Wetlands Utilization Priority for Good Rainfall Season*  
Source: Author, 2024

#### **4.5 Chapter Conclusion**

In conclusion, this chapter presented the empirical evidence of the research in line with the objectives. Climate change impacts on wetland biodiversity and agroecosystem, ecological characterization of Nyororo wetland, and the resilience-building strategies findings were presented. This chapter informed the discussion, analysis, and recommendations presented in the final section of the research report, Chapter 5.

## **CHAPTER 5: DISCUSSION, RECOMMENDATIONS, AND CONCLUSION**

### **5.1 Introduction**

This section presents a summary of the research findings and discusses practical implications, whilst giving recommendations for both research and practical application gaps. The chapter is organized into five sections, with introductory section 5.1 being the first, followed by section 5.2 of summary of key findings. Section 5.3 presents information on practical implications and recommendations, whilst sections 5.4 and 5.5 provide pointers for future research and the conclusion, respectively.

### **5.2 Summary of key Findings**

The study revealed that a huge information gap around wetlands' ecological characterization exists in Nyororo wetland, despite its importance. Communities did not have information about species inventory, the diversity of life, and the richness of species within their community. This points to a larger scale gap existing within Zimbabwe, Africa, and other continents. As noted in the South African case (Adeeyo et al., 2022), and in Zimbabwe (Zimbabwe Wetland Policy, 2020), authorities and communities managing wetlands lack scientific and decision-making information about the ecological characteristics of their wetlands.

The Nyororo community indicated that there is a rapid decline in wetland goods and services reaped by the society due to noted shrinkages and degradation of the wetland. Pressure from the community, livestock, and changes in rainfall and temperature regimes affected the availability of life-supporting materials and services. These community views were supported by the Ramsar Convention that indicated that over 25 percent of wetland species are facing extinction, resulting in a direct negative impact on the well-being of the people, the services by nature, and the climate's positive outcomes (Ramsar Convention Secretariat, 2018).

Lack of financial instruments for wetlands conservation was identified as a challenge undermining community actions on wetlands conservation. Over the past 50 years, the

traditional leaders indicated that they sustained the wetlands using community efforts without the required additional financial support to scale up ecosystems-based adaptation (EbA). Lack of engagement, programme, and policy directions on below-the-ground carbon trading remains a huge untapped resource (Ramsar Convention Secretariat, 2010).

The declining water quality and species abundance and composition were identified by the study as a challenge that will undermine the resilience of smallholder farmers. Encroachment of invasive alien species due to the increasing aridity of some sections of the wetland was noted by the study. Findings by other scholars on the possible influence of climate change on wetlands utilization included their shrinkage and fragmentation (Musasa & Marambanyika, 2021; Nyamadzawo et al., 2015) and ecosystems degradation (Adeeyo et al., 2022; Fakarayi et al., 2015). Mwenge et al. (2021) stressed that key biological diversity hotspots are under threat from climate change that played an aggravating role in influencing wetland land use and cover changes. In Zimbabwe, the study was supported by Zimbabwe Wetland Policy (2020) and UNDP (2017) reports on the devastating impacts of the El Nino phenomena, which occur more frequently and cause 62 percent of the recorded below-normal rainfall.

The study identified several strategies for building resilient wetland agroecosystems. These are used by smallholder farmers, and some require supportive arrangements for them to be effective. The use of an ecosystem-based adaptation (EbA) was noted in cases where farmers created buffer zones to reduce interference with wetland water sources while implementing organic farming to increase food production without damaging the environment. Several social enterprises including fruit tree propagation, and indigenous poultry multiplication outside the wetland environment were noted to increase farmers' income and relieve the pressure exerted on the Nyororo wetland by the growing population. Diverting the attention to other businesses was noted to have an impact on building resilience by increasing alternative livelihoods. With the shrinkages of food production zones in Zimbabwe as identified by Mugandani et al. (2012) due to shifting agroecological zones, wetlands in natural region V are also shrinking in response to the identified pattern of aridity. The study's remote sensing revealed through the Normalised Difference Moisture Index (NDMI) that wetlands-covered areas shrunk significantly from 1990 to 2021.

### **5.3 Practical Implications and Recommendations**

Based on the provided summary of the findings, the study identified the following practical implications and recommendations.

Wetland ecological characterization to determine the diversity and richness of species (Nolan & Callan, 2006; Spellerberg & Fedor, 2003) needs to be scaled up at all levels as a national, sub-national, and local level intervention to save the species from extinction and help with awareness raising for all stakeholders. This will be a foundational step in ensuring sustainability in the conservation of wetlands.

One key missing action was the watershed approach in wetlands conservation. The Nyororo wetland conservation was implemented as an isolated intervention that continued to suffer from the threatening activities implemented by various stakeholders in the watershed. The study is of the view that developing positive outcomes for people, nature, and climate within the wetland ecosystem requires a collective and a nexus approach. Using a watershed approach is recommended as a way of harmonizing activities connected to the health of the wetland and the resilience of the dependent community.

Financial mechanisms are key requirements for wetlands ecosystems' sustenance. Most wetlands are key resources for subsistence farming communities, whose income levels are very low to move forward the conservation agenda. The Ramsar Convention Secretariat (2010), revealed that wetlands sustainability and resilience depend on funding to move the action. In Uganda (Barakagira & De Wit, 2019), South Africa (Adeeyo et al., 2022), and Zimbabwe (Zimbabwe Wetland Policy, 2020), the stakeholders continue to blame the lack of implementation of wetlands conservation frameworks due to the absence of financial mechanisms. Despite having information about the value of carbon sequestered within wetlands, there is no consideration for turning the fortunes of wetlands-dependent communities through carbon trading.

An ecosystem-based adaptation (EbA) proved to be a key practical solution to help conserve the wetland. Scholars including Tabengwa (2015) recommended the use of an ecosystems-

based adaptation in harmonizing agricultural activities and wetlands conservation. The study recommends the need for standardization of the EbA approach. The standardization measures should be context-specific and informed by the studies, to ensure that there will not be any cases of maladaptation.

Strengthening the anticipatory action plans (AAP) is recommended as a key strategy for saving lives and ecosystems through climate-informed decisions. During the research data collection stage, the farmers highlighted that they depend more on the extension staff for climate information dissemination and advisories. Due to mobile network challenges, the absence of internet connectivity presented limiting factors hindering services from permeating down to the communities. Addressing the last mile in terms of access to climate information services, as identified by Unganai et al. (n.d.) and (World Meteorological Organization [WMO], 2021) will be a huge step towards resilient communities and ecosystems.

#### **5.4 Suggestions for Future Research**

The study acknowledges that limitations based on the coverage, methodological approach, and local context may affect the generalization of the findings to a larger context. Based on the limitations, key findings, and discussions, the study suggests further research in the following areas;

- i. Detailed wetland scientific ecological characterization covering national, sub-national, and regional local scale as recommended by (Joshi et al., 2021). This will be critical in saving the wetlands and restoring ecosystem services. Generating new knowledge will help raise community awareness of the wetland's role in sustaining people, nature, and the climate's positive outcomes.
- ii. Further studies are recommended to support the new anticipatory action planning thinking (Coughlan de Perez et al., 2022; FAO, 2023) and the progress made in helping communities to become more resilient to multi-faceted shocks and stressors.

- iii. Researching the progression in aligning conservation with seasonal livelihoods planning (SLP) that was initiated in Zimbabwe by the World Food Programme (2021) is key in preparing and aligning wetlands-dependent communities to the seasonal and climatic variability.
- iv. There is a need for further investigations on opportunities and barriers around moving from research and theoretical views of ecosystems-based adaptation (EbA) to programme and policy action. These studies will enable the communities dependent on wetlands and their stakeholders to bridge the practice gap and influence a community of practice around coping with the fast-changing ecological nature of wetlands in drylands.
- v. Research on financial mechanisms tailor-made for incentivizing wetlands conservation is urgent, as recommended by Ramsar Convention Secretariat (2018). Peatlands are known to be a type of wetlands that stores over 50 percent of global carbon stock (Tanwie et al., 2024). Studies may propose various ways of unlocking sustainable carbon-related income from Peatlands, and the local communities may benefit and develop the resilience of their livelihoods and ecosystems.

### **5.5 Concluding Remarks**

A detailed discussion, analysis, and recommendations were presented in this final chapter. The findings and implications of the lack of wetland species data were hindering conservation efforts by the community. The ecological characteristics of Nyororo wetland indicate a degrading wetland that requires a cocktail of measures and the participation of multiple stakeholders to protect the ecosystems. The existing ecosystems-based adaptation (EbA) and the seasonal livelihoods planning (SLP) used by a few members of the community require implementation at the watershed level to enhance wetlands agroecosystems sustainability. There is a great need for the resilience strategies discussed by the research to be implemented in practical terms to influence a community of practice. The unavailability of financial mechanisms was discussed and analyzed as a key gap that needs attention to finance ecosystems-based conservation and community coping strategies.

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## Annex 1: List of Plant Species for Nyororo Wetland

Plant species	Family
<i>Albizia amara</i>	Fabaceae-Mimosoideae
<i>Andropogon eucomus</i>	Poaceae
<i>Anselia africana</i>	Orchidaceae
<i>Bidens pilosa</i>	Asteraceae
<i>Bridelia mollis</i>	Euphorbiaceae
<i>Celtis africana</i>	Celtidaceae
<i>Centella asiatica</i>	Apiaceae
<i>Chamaecrista mimosoides</i>	fabaceae-caesapinoideae
<i>Chironia palustris</i>	Gentianaceae
<i>Commelina diffusa</i>	Commelinaceae
<i>Crinum macowanii</i>	Amarylidaceae
<i>Crotalaria sphaerocarpa</i>	Fabaceae-Papilionoideae
<i>Croton megalobotrys</i>	Euphorbiaceae
<i>Cynodon dactylon</i>	Poaceae
<i>Cyperus denudatus</i>	Cyperaceae
<i>Cyperus esculentus</i>	Cyperaceae
<i>Cyperus involucratus</i>	Cyperaceae
<i>Cyperus laxiflorus</i>	Cyperaceae
<i>Datura ferox</i>	Solanaceae
<i>Digitaria milanjiana</i>	Poaceae
<i>Digitaria ternata</i>	Poaceae
<i>Diospyros mespliformis</i>	Ebenaceae
<i>Ekebergia capensis</i>	Anacardiaceae
<i>Englerophytum magalismontanum</i>	Sapotaceae
<i>Eragrostis heteromera</i>	Poaceae
<i>Eragrostis inamoena</i>	Poaceae
<i>Eriosema psoraliodes</i>	Fabaceae-Papilionoideae
<i>Erythrococca trichogyne</i>	Euphorbiaceae
<i>Eucalyptus sp.</i>	Myrtaceae
<i>Euclea racemosa</i>	Ebenaceae
<i>Ficus sur</i>	Moraceae
<i>Fimbristylis dichotoma</i>	Cyperaceae
<i>Floscopa glomerata</i>	Commelinaceae
<i>Fuirena pachyrhiza</i>	Cyperaceae
<i>Hemarthria altissima</i>	Poaceae
<i>Juncus oxycarpus</i>	Juncaceae
<i>Justicia stricta</i>	Acanthaceae
<i>Kyllinga melanosperma</i>	Cyperaceae
<i>Kyllingiella sp</i>	Cyperaceae
<i>Lipocarpa chinensis</i>	Cyperaceae
<i>Lippia javanica</i>	Lamiaceae
<i>Lolium perenis</i>	Poaceae

<i>Ludwigia stolonifera</i>	Onagraceae
<i>Melia azedarach</i>	Meliaceae
<i>Mimusops zeyheri</i>	Sapotaceae
<i>Nymphaea nouchali</i>	Nymphaeaceae
<i>Panicum repens</i>	Poaceae
<i>Paspalum pyramidalis</i>	Poaceae
<i>Paspalum scrobiculatum</i>	Poaceae
<i>Persicaria attenuata</i>	Polygonaceae
<i>Persicaria serrulata</i>	Polygonaceae
<i>Phragmites australis</i>	Poaceae
<i>Phragmites mauritianus</i>	Poaceae
<i>Psidium guajava</i>	Myrtaceae
<i>Pycreus macranthus</i>	Cyperaceae
<i>Pycreus polystachyos</i>	Cyperaceae
<i>Richardia scabra</i>	Rubiaceae
<i>Ricinus communis</i>	Euphorbiaceae
<i>Rothea myricoides</i>	lamiaceae
<i>Scleria dregeana</i>	Cyperaceae
<i>Scleria flexuosa</i>	Cyperaceae
<i>Searsia chirindensis</i>	Anarcadiaceae
<i>Sesbania macrantha</i>	Fabaceae-Papilionoideae
<i>Setaria incrassata</i>	Poaceae
<i>Spermacoce senensis</i>	Rubiaceae
<i>Sphaeranthus randii</i>	Asteraceae
<i>Spilanthes mauritiana</i>	Asteraceae
<i>Sporobolus pyramidalis</i>	Poaceae
<i>Syzygium cordatum</i>	Myrtaceae
<i>Tabenamontana elegans</i>	Apocynaceae
<i>Tagetes minuta</i>	Asteraceae
<i>Thelypteris confluens</i>	Thelypteridaceae
<i>Tithonia rotundifolia</i>	Asteraceae
<i>Triumfetta annua</i>	Tiliaceae
<i>Typha capensis</i>	Typhaceae
<i>Vachellia sieberiana</i>	Fabaceae-Mimosoideae
<i>Vernonia glabra</i>	Asteraceae
<i>Waltheria indica</i>	Sterculiaceae

## Annex 2: Questionnaire for Smallholder Farmer

### Section A: Administrative Information

District		Ward						
Household Code		Sex of Respondent	Female		Male			
Respondent Age Group	18-35	36-50		51-65		66 +		
Length of Stay in the Area (years)		1-10		11-20		21-30	31+	

### Section B: Climate change and wetlands agroecosystems

#### B1. Climate change and wetlands agroecosystems

Challenges for wetland	Impacts	Actors and Actions	Effectiveness

#### B2. List the main conservation practices and their impact in safeguarding the Nyororo wetland

Practice	Actors	Effectiveness

Any other comments on conservation and climate change impact management practices.		

Section C: Wetlands Goods and Services Benefiting the Community

	List Services	Any Comment
Provisioning		
Regulatory		
Cultural		
Supportive		

## Section D: Resilience

D1. Estimated area (ha) under production (Dryland versus Wetland) over the years

Year (1980-2022)	Dryland (ha)	Wetland (ha)	Comment

D2. Estimated food Crop harvest (Dryland versus Wetland over years in Kilograms

Year (1980-2022)	Dryland (KG)	Wetland (KG)	Comment

D3. List and explain the different resilience-building strategies for wetland agroecosystems.

Strategies	How it works	Additional Comment

D4. Identify any gaps in building resilience:

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D5. Any assessments conducted?

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D6. Any other comments

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***End of Questionnaire Survey***

## **Annex 3: Focus Group Discussion Guide**

The facilitator will be guided by the following steps:

### Preparatory

1. Setting Ground Rules for the Exercise
2. Explanation of the study
3. Understanding the group dynamics and composition.

### Research Related Discussions

1. Discussion on Nyororo wetland coverage and utilization.
2. Climate change impacts. Community observations and experiences.
3. Wetland water changes over time
4. Wetland species change over time
5. Institutional actors and supporters for Nyororo wetland conservation
6. Resilience-building strategies for wetland users
7. Remaining gaps and challenges
8. Any other areas of concern for this discussion?

## **Annex 4: Key Informant Interview Guide**

The interviewer will be guided by

### Preparatory

1. Explanation of the study
2. Request for understanding of the Key Informant's role as an individual/institution.
3. Climate change impacts. Community observations and experiences.
4. Wetland water changes over time
5. Wetland species change over time
6. Resilience-building strategies for wetland users
7. Request for records on arable and wetland areas cultivated over time
8. Request for production records over time.
9. Remaining gaps and challenges
10. Any other areas of concern for this discussion?