

The Sustainability of Water Abstraction from Sand Rivers as an Adaptive Strategy for Climate Change-Induced Poverty in the Nyamuzizi Watershed in Mutoko District.

By

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A thesis submitted in partial fulfilment of the requirements for the Master of Science Degree in Climate Change and Sustainable Development

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BINDURA UNIVERSITY OF SCIENCE EDUCATION



Promoting Science for Human Development

FACULTY OF SCIENCE AND ENGINEERING

Dedication

To my mother Constance Thokozile Chidza-Dube, your inspiration for my educational pursuits, which you supported with financial resources earned from *Maricho* (casual farm labouring), will forever stick in my memory!!!! May your departed soul rest in peace beloved Mom!

To my wife, Charity and my two angels, Tanatswa and Constance, I say, our lives as a family will always be anchored on education and I, therefore dedicate this Dissertation to you in recognition of the love and moral encouragement you have generously given me during the course of life as I toiled to keep our family intact and developing academically.

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List of Acronyms

ARDAS	Agricultural and Rural Development Advisory Services
BUSE	Bindura University of Science Education
CES	Cultural Ecosystem Service
COWOSOs	Case Study of Community Owned Water Supply Organisations
DEMs	Digital Elevation Models
ECD	Early Childhood Development
EMA	Environmental Management Agency
GIS	Geographic Information Systems
GMB	Grain Marketing Board
IJEST	International Journal of Engineering Science and Technology
IWRM	Integrated Water Resources Management
LULC	Land use/Land cover
MLAFWRD	Ministry of Lands, Agriculture, Fisheries, Water and Rural Development
MPI	Multidimensional Poverty Indices
NGO	Non-Governmental Organizations
PPCP	Private-Public Community Partnerships
RDC	Rural District Council
SAM	Strategic adaptive management
SDG	Sustainable Development Goal
UNDP	United Nations Development Programme
ZIMSTATS	Zimbabwe National Statistics Agency
ZINWA	Zimbabwe National Water Authority

Declaration



BINDURA UNIVERSITY OF SCIENCE EDUCATION

Faculty of Science and Engineering

Declaration by Candidate

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Qualification:

Master of Science in Climate Change and Sustainable Development

Title of Thesis:

The Sustainability of Water Abstraction from Sand Rivers as an Adaptation Strategy Against Climate Change-Induced Poverty in the Nyamuzizi Watershed in Mutoko District

Declaration:

I declare that this thesis is my original work and no similar work has been submitted before to any academic institution. I declare that all citations, references and borrowed ideas^{xii} have been properly acknowledged

Signature:

Phuza

Date:

April 25, 2024

Approval Form

The undersigned certify that they have read this dissertation and are, therefore, recommending its acceptance by Bindura University of Science Education. The title of the thesis is, “**The Sustainability of Water Abstraction from Sand Rivers as an Adaptive Strategy for Climate Change-Induced Poverty in the Nyamuzizi Watershed in Mutoko District**”. This dissertation is submitted in partial fulfilment of the Masters of Science in Climate Change and Sustainable Development degree..



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FOR CLIMATE CHANGE-INDUCED POVERTY IN
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DISTRICT

DEGREE: MASTER OF SCIENCE IN CLIMATE CHANGE AND
SUSTAINABLE DEVELOPMENT

YEAR OF AWARD 2024

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Abstract

The battle against poverty is compounded by the world wide dearth of water spurred on by climate change. Moreover, the well-being of villagers in rural settings, like the Nyamuzizi Watershed in Mutoko District, who survive on water, particularly, drawn from sand rivers, have not been sufficiently documented. This study aimed to assess the sustainability of water abstraction from the Nyamuzizi sand river as an adaptation strategy to climate change-induced poverty. The objectives of the study were to examine the adequacy of water sources within the Watershed, evaluate the alleviation of poverty through socio-economic benefits derived from the sand river, analyse the impact of water scarcity on land use and land cover patterns, and determine the effectiveness of governance frameworks in the management of water from Nyamuzizi River. A mixed method study, which included a focus group interview, open-ended individual interviews, field observation, documentary research, GIS and Remote Sensing were employed. Convenience sampling was used to select Nyahondo-Marira Ward 23 for data collection from a population of wards within the watershed of Nyamuzizi River. Officials who were interviewed were selected using a purposive sampling method. The study uncovered significant inadequacies in water resources within the area, undermining their capacity to support socio-economic development initiatives aimed at poverty alleviation within the Ward. Furthermore, the sustainability of water abstraction from sand aquifers in the Nyamuzizi River is jeopardized by widespread land use/land cover changes. These changes, coupled with an ineffective local water governance framework, pose serious threats to the long-term availability and usability of water resources in the region. In conclusion, the study recommends a hydrogeological study of the watershed, the establishment of irrigated systems on plots situated away from the river basin, as well as strengthening of sand river governance frameworks. These recommendations aim to mitigate the impact of water scarcity and land degradation, enhance agricultural productivity, and promote sustainable land and water management practices in the Nyamuzizi Watershed.

Chapter 1

INTRODUCTION

1.1 Introduction

Climate change is significantly diminishing water resources, which are key to enhancing resilience among poor people. Winsemius (2018) notes that the heavy dependence of many impoverished individuals in Africa on consistent rainy seasons renders them especially vulnerable to droughts. Changes in precipitation patterns brought about by climate change are resulting in water being scarcer in some areas, particularly in arid and semi-arid areas. Poor populations that extensively rely on local water supplies for drinking, sanitation, and agricultural practices are especially affected by this scarcity. People's capacity to meet their basic needs, keep themselves well, and take part in activities that generate revenue is also negatively impacted by limited access to safe and dependable water. The aggravating problem of water scarcity due to the effect of climate change (Zhang, Chen, & Lei, 2020) now appears to be countering the goal of improving access to clean water (SDG6), thereby making the eradication of poverty (SDG1) by 2030 seem a pipe dream. Abstraction of water from sand rivers can be a sustainable mitigating measure against climate change-induced poverty in semi-arid rural areas.

1.2 Background

The deepening climate change crisis is increasingly becoming a major factor debilitating the attainment of Agenda 2030's primary goal of ending poverty. While some reports have indicated that the rate of eradicating poverty has slowed down, some have even declared that the process has stopped (Bluhm et al., 2015; Koehler, 2017; World Bank, 2022; UNDP, 2023; Fofana et al., 2023). Hallegatte et al. (2017) even predicted that climate change will present a major challenge in eliminating poverty in the time ahead. According to the United Nations Development Programme (UNDP), the Multidimensional Poverty Indices (MPI) were 30 percent in 2015 and 18 percent in 2023. Given this slow rate of progress, there is a concern that poverty may persist and potentially worsen beyond 2030, especially with the increasing impact of climate disasters on livelihoods (Mavhura, 2019).

The MPI is an annual index that shows the general combined poverty levels of developing countries around the globe. According to the UNDP, one of the barriers to halting the

global MPI decline rate is climate change (UNDP, 2023), especially in Africa. The United Nations Economic Commission for Africa (2023) reported that the continent had a poverty rate of 54.8 percent in 2022, which was more than half of the world's poor. In 2021, Zimbabwe's poverty rate was 38.3%, and it was ranked 141st out of 184 nations in the Human Development Index. In the same year, the poverty rate in rural areas, home to over half of the nation's population, was 52%.

Leicheniko and Silva (2014) assert that an examination of the intricate interplay between poverty levels and climate change reveals a nuanced and context-specific relationship. The multifaceted nature of this association necessitates a comprehensive understanding of the intricate dynamics involved. The Multidimensional Poverty Index (MPI) serves as a valuable tool in this exploration, encompassing three essential dimensions: health, education, and standard of living. By employing this multidimensional approach, researchers gain a more holistic perspective on the intricate connections between socioeconomic factors and the impacts of climate change in semi-arid rural areas.

Climate change exerts diverse impacts on dimensions of poverty. It disrupts food systems, resulting in health challenges such as malnutrition, stunted growth in children, heat-related illnesses, and prevalent waterborne diseases, particularly affecting economically disadvantaged populations (Connolly-Boutin & Smit, 2016). Resources allocated to address the consequences of climate change often extend beyond educational needs, contributing to issues like overcrowded classrooms, inadequate facilities, and a dearth of educational support networks, ultimately undermining the quality of education. Moreover, the influence of climate change extends to economic sectors, notably agriculture, fisheries, and tourism, all heavily reliant on water resources critical for sustaining livelihoods and income, especially within rural impoverished communities. This cyclically perpetuates poverty, constrains access to essential services, and diminishes prospects for social and economic progression, consequently lowering overall living standards.

1.3 Problem Statement

The increasing rainfall variability in semi-arid rural areas, attributed to climate change, has worsened poverty by significantly restricting the availability of water crucial for sustaining livelihoods. This variability, particularly prevalent in Southern Africa, has consistently been marked by the El Niño Effect, with the 2015/16 event being recorded as the most

severe in history (Hove, 2019; Mbokodo et al, 2023). Consequently, an estimated 40 million individuals experienced acute food insecurity (Hove, 2019), thereby impinging upon the educational accessibility for children residing in rural areas. The repercussions of hunger and malnutrition manifested in diminished school attendance and academic performance.

Water scarcity poses significant challenges to semi-arid rural areas in Zimbabwe, where vulnerable communities heavily rely on water availability to sustain their livelihoods (Matunhu, 2022). In these regions, access to reliable water resources is an awkward experience for several families, with many enduring the pain of walking longer than 30 minutes (UNICEF/WHO, 2015) to the nearest water source. The scarcity of water is depriving rural communities of the means to derive sustainable development benefits that enhance resilience against poverty reinforced by climate change. Such benefits include food security, good health and well-being, quality education, employment, a source of income, and a basic standard of living (Nephawe, N., et al, 2021).

In the face of increasing climate change-induced poverty in the Nyamuzizi Watershed of Mutoko District, the sustainability of water abstraction from sand rivers emerges as a critical adaptation strategy. However, the effectiveness and long-term viability of this strategy remain uncertain due to potential ecological, socio-economic, and institutional challenges. Therefore, this study aims to investigate the sustainability of water abstraction from sand rivers as an adaptation to poverty induced by climate change in the Nyamuzizi Watershed, focusing on understanding the ecological impact, socio-economic implications, and institutional frameworks governing water management.

1.4 Aim of the Study

This study aims to assess the sustainability of water abstraction from sand rivers for adaptation to climate change-induced poverty in villages within the Nyamuzizi Watershed in Mutoko District.

1.5 Objectives of the Study

1. To examine the adequacy of the water sources available in a selected Ward within the Nyamuzizi Watershed in Mutoko District;

2. To evaluate the socio-economic benefits of water abstracted from the sand river in alleviating climate change-induced poverty in a selected ward within the Nyamuzizi Watershed in Mutoko District;
3. To analyse how water scarcity has impacted land use/land cover patterns in the Nyamuzizi Watershed;
4. To determine the effectiveness of the governance framework in the management of water from Nyamuzizi River in the face of climate change-induced scarcity.

1.6 Research Questions

1. How adequate are the sources of water available in a selected ward within the Nyamuzizi Watershed in Mutoko District?
2. How are the socio-economic benefits derived from water abstraction from the sand river alleviating climate change-induced poverty in a selected ward within the Nyamuzizi Watershed in Mutoko District?
3. How has water scarcity impacted on the land use/land cover patterns in the Nyamuzizi Watershed?
4. How effective is the water governance framework for managing Nyamuzizi River in the context of climate change-induced scarcity?

1.7 Significance and Justification of the Study

This section presents the significance and justification of the study on the sustainability of water abstraction as an adaptive strategy for climate change-induced poverty in semi-arid rural environments. It highlights both the importance and the potential beneficiaries of the study.

The assessment of Nyamuzizi Watershed's water resources' sufficiency suggests that water authorities should consider expanding potential water sources to address the increasing demand due to climate change. The research findings, thus, play a crucial role in working towards achieving Sustainable Development Goal Target 6.1 of ensuring universal and fair access to safe and affordable drinking water for all by 2030 (United Nations, 2015).

In the context of poverty exacerbated by climate change, one natural resource that is essential to the villagers' capacity to sustain their way of life is water from sand rivers. The findings of the evaluation of the socioeconomic advantages of using the Nyamuzizi River

for water purposes benefit not only the villagers in terms of generating income, but also other institutions such as non-governmental organizations, government departments, and private organizations that work to enhance the well-being of those living in marginalized areas. Article 7 of the 2015 Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC) emphasizes enhancing adaptive capacity, strengthening resilience and reducing vulnerability.

Environmental authorities may decide to take action to reduce the decline of flow capacity owing to siltation as a result of observations made about the effects of changes in land use and land cover patterns in the riparian zones of the Nyamuzizi River. Furthermore, the study could influence agriculture experts to help villagers establish irrigation plots that are outside the river basin and adopt agroforestry to enhance ground cover.

The study also highlights the necessity of a strong governance structure for the Nyamuzizi River's water management.. This is significant as it guarantees sustainable water abstraction practices that will benefit locals now and into the future. This study reveals the need for all stakeholders and the community to collaborate closely in all activities involving the sand river.

Future research should focus on quantifying the amount of water in the alluvial aquifer within the Nyamuzizi Watershed to guide the level of exploitation that is sustainable in view of climate change.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

The intersectionality of water resources, sustainable development, and poverty alleviation has been extensively addressed in various literatures. Scholars have recently offered perspectives on the effects of climate change on the complex interactions among these components. The focal point of concern lies in understanding the impact of climate change on impoverished communities residing in semi-arid rural areas, such as Mutoko District. In these areas, reducing poverty brought on by climate change is highly dependent on the availability of water resources.

This chapter aims to elucidate key aspects of water abstraction from sand rivers crucial for alleviating poverty exacerbated by climate change. The discourse will extensively examine research conducted by various scholars, shedding light on the socio-economic advantages derived from water extracted from sand rivers. Furthermore, it will scrutinize the reliability of water supply from these sand rivers and analyze the social and governance structures that influence the utilization of water from ephemeral rivers.

The research endeavours to address gaps that emerge from the arguments presented by scholars on these intricate aspects. By building upon the existing body of knowledge, this study seeks to contribute valuable insights into the complex dynamics at the intersection of water resources, sustainable development, and poverty alleviation, particularly in the context of climate change.

2.2 Definition of Concepts

2.2.1 Semi-arid Rural Area

A semi-arid rural area is a region characterized by generally dry conditions and limited rainfall between 450 and 600mm per annum (Mugambiwa & Rukema, 2020). Consequently, these regions always have limited water availability. This causes water scarcity that affects various aspects of life, including agriculture, livestock rearing, and access to clean drinking water. Droughts are common in semi-arid areas, which can have

significant impacts on the local economy (Odusola & Abidoye, 2015), food production (Mazvimavi et al, 2017), and the livelihoods of the residents.

Agriculture in semi-arid areas often relies on drought-resistant crops and where there are some water sources available, farmers also irrigate horticultural crops using various methods including the use of buckets. Livestock rearing, such as goats and sheep, is common in semi-arid rural areas due to their ability to graze on drought-tolerant vegetation (Koluman, 2023). Livestock can provide a source of income and food security for rural communities. However, limited access to markets is a challenge in semi-arid rural areas (Rapsomanikis, 2015), hindering economic development and employment opportunities. Being geographically isolated results in higher transportation costs and difficulties in accessing these markets.

Communities in semi-arid rural areas often develop resilience strategies to manage the difficulties caused by the climate. This may include traditional knowledge, social networks, and cooperative efforts to manage resources, deal with droughts, and support each other during difficult times.

Semi-arid regions are often home to unique flora and fauna adapted to dry conditions. Conservation efforts are, therefore, important in protecting biodiversity and preserving the ecological balance in these fragile ecosystems.

2.2.2 Climate Change-induced Poverty

Climate change-induced poverty occurs when the impacts of climate change lead to higher levels of poverty or greater vulnerability to poverty for individuals or communities (Hallegatte et al, 2014; Adeniyi, 2016). This type of poverty is brought on or made worse by modifications to the climate system, including elevated temperatures, altered precipitation patterns, a rise in the frequency and power of extreme weather events, and an increase in sea level.

Poverty may be influenced by climate change in various ways, both directly and indirectly, particularly in vulnerable regions and among populations with limited adaptive capacity (Penning-Rowsell, 2013). Climate change can disrupt traditional livelihoods dependent on agriculture, forestry, fishing, and other climate-sensitive sectors. Changes in rainfall patterns, prolonged droughts, floods, or heatwaves can lead to crop failures, loss of

livestock, reduced yields, and reduced income-generating opportunities. Climate change impacts on agricultural productivity, such as decreased crop yields or changes in pests and diseases, can contribute to food insecurity (Nelson et al, 2014). This can lead to a lack of access to nutritious food, malnutrition, and an increased risk of hunger and poverty.

Climate change can worsen health risks, especially in impoverished communities with inadequate healthcare and infrastructure. Heatwaves, extreme weather events, changing disease patterns, and water-related illnesses (Ebi, 2021) can further strain limited resources and increase healthcare costs (Kabir, et al, 2016) pushing individuals and households into poverty.

Marginalized groups, such as women, children, indigenous communities, and individuals residing in remote or underserved regions, are frequently subject to a disproportionate burden of the impacts resulting from climate change. These groups may already face social, economic, or political disadvantages, and climate change can exacerbate their vulnerability to poverty.

2.2.3 Alluvial Aquifer

An alluvial aquifer is a type of aquifer formed by the deposition of sediment carried by rivers, streams, or other water bodies. These aquifers are typically found in river valleys or floodplains where sediment has accumulated over time. Alluvial aquifers are often composed of sand, gravel, silt, and clay, which can store and transmit groundwater. They are often quite productive and are vital sources of water for industrial, agricultural, and drinking purposes in many parts of the world. However, their vulnerability to contamination and depletion due to human activities and changes in hydrological conditions highlights the need for careful management and conservation measures.

2.2.4 Sand River Water Abstraction

The term "sand river water abstraction" describes the procedure used to remove water from sand rivers or riverbeds that are mainly made of sand (Clanahan & Jonck, 2004). In this study, sand rivers are also called ephemeral rivers or intermittent rivers. The permeable sandy substrate of sand rivers enables water to seep through the riverbed and

create subterranean aquifers. To access the subsurface water sources, wells or boreholes sunk into the riverbed are usually used in the abstraction of water from sand rivers.

Where surface water sources are few or unstable, water abstraction from sand rivers is a widespread activity. It offers an alternate way to get water for a range of uses, including industrial use, domestic use, livestock watering, and irrigation (Clanahan & Jonck, 2004).

2.2.5 Adaptation

Adaptation is the process of changing or adjusting to climate change to reduce its adverse effects and amplify its positive impacts (UNDP, 2007; UNFCCC, 2010; OECD, 2012; IPCC, 2014; World Bank, 2016).

2.2.6 Reliable Water Supply

A dependable water supply is one that is steady and sustainable that provides enough clean water to suit the demands of many users, such as homes, companies, farms, and ecosystems (Dinka, 2018). The idea has several essential elements:

Continuity: Water must always be available on a regular and predictable basis for there to be a reliable supply. It entails supplying people with water in a steady flow or without noticeable hiccups or variations.

Adequacy: The water supply should be sufficient to meet the demands of the users. An adequate water supply ensures that there is enough water to fulfil the needs of households, support agricultural activities, sustain industrial processes, and maintain ecosystem health.

Quality: Reliability is not only about quantity but also about the quality of water provided. A reliable water supply ensures that the water meets acceptable standards for drinking, irrigation, industrial processes, and environmental preservation. Water quality is crucial for protecting public health and the environment.

Accessibility: A reliable water supply system ensures that people have equitable access to clean, safe water without facing any forms of discrimination.

Sustainability: Sustainable water supply practices guarantee that future generations will have sufficient water resources to meet their needs without depleting or compromising

those resources. It entails managing water resources in a manner that prevents degradation while considering ecological and environmental factors.

Resilience: A reliable water supply system should be resilient to external shocks and uncertainties, such as changes in climate, extreme weather events, and other potential disruptions. Infrastructure and management practices should be designed to withstand and recover from disturbances to ensure continuous water availability.

Equity: Reliability also involves addressing issues of equity in water distribution. It requires ensuring that vulnerable or marginalized communities have access to a fair share of the water resources and that water allocation is not disproportionately skewed toward specific groups.

2.2.7 Governance Structures

In the context of managing water resources in rural regions, governance structures are the institutional frameworks, rules, and processes (Durant et al., 2004; Gudaga et al., 2018) that control the allocation, consumption, and protection of water resources. These institutions involve a wide range of stakeholders, such as associations of water users, local communities, governmental and non-governmental organizations (NGOs), and other relevant parties (Jung et al., 2015; Kelliher et al., 2014; Hanida et al., 2017; Soetriono et al., 2019). The goal of governance frameworks is to ensure equitable and sustainable management of water resources while attending to the particular needs and difficulties faced by rural communities

Governance systems define the official and informal organizations responsible for overseeing water resources in rural areas (Ozdemir et al., 2019). These could include user associations, community-based organizations, water management boards, and government departments or agencies. To promote efficient water governance, distinct roles, duties, and coordination mechanisms are established.

Governance structures provide the policy and legal frameworks that guide water resources management in rural areas. This includes laws, regulations, and guidelines related to water allocation, water rights, water quality, and environmental protection. These frameworks set the principles, standards, and procedures for managing water resources sustainably and address issues such as water scarcity, pollution, and competing water uses.

Robust governance structures are instrumental in fostering dynamic participation and engagement among diverse stakeholders, with a specific emphasis on the inclusion of women. As asserted by Eaton et al. (2021), an imperative aspect of achieving this inclusivity lies in the transformation of prevailing social gender norms. Eaton and colleagues (2021) argue that altering established gendered norms is crucial to facilitating the active participation of women in decision-making processes, especially when it comes to tackling issues related to water availability. This proposition aligns with the acknowledgment that women, as a demographic, bear a more direct impact from such issues (Haule & Massawe, 2020). The scholarly perspective presented by Eaton et al. thus advocates for a fundamental restructuring of gender norms to create an environment that not only acknowledges the specific challenges faced by women but also actively encourages their meaningful participation in managing water resources.

Governance frameworks (Grigg, 2016) promote the use of an integrated and comprehensive approach known as Integrated Water Resources Management (IWRM) in rural water resource management. Integrated water resource management (IWRM) places a strong emphasis on the sectors and stakeholders involved in water management, including agriculture, industry, the environment, and social sectors. It recognizes the interdependencies between water supply, human welfare, and ecosystems. Information management, data collecting, and water monitoring are facilitated by governance structures. This includes putting up monitoring networks, obtaining data on the amount and quality of water, updating databases, and notifying the appropriate parties. To make educated decisions, planning, and put water management policies into practice in rural regions, accurate and current information is essential.

Water resource management decision-making procedures and dispute resolution procedures are part of governance frameworks. This entails putting in place open and inclusive procedures for settling disputes between water users, handling conflicting requests for water, and deciding how to distribute water, build infrastructure, and formulate policy on water (Lebek, 2021).

By implementing effective governance structures, rural areas can ensure fair and sustainable management of their water resources, promote stakeholder participation, and address the particular needs and challenges of their communities.

2.3 Water Supply in Semi-Arid Rural Areas

2.3.1 Typology of Water Resources

The main source of safe drinking water in many rural areas of Zimbabwe is groundwater drawn from shallow wells and boreholes (Nilsson & Hammar, 1996; Manyakaidze et al., 2024). But as Manyani (2017) pointed out, these significant water sources are now experiencing changes in their water tables due to climate change. In other rural areas, there are different water sources, including rivers, springs, and sand aquifers. Piped water sources are, however, not common in rural Zimbabwe due to inadequate finance, poor maintenance, and inadequate infrastructure (Dhoba, 2020; Manyakaidze et al., 2024).

Of particular interest is the eastern part of Mutoko District in Zimbabwe, where there is a lack of information regarding groundwater aquifers. This knowledge gap suggests that there is untapped potential for groundwater resources within the catchment areas of rivers in this region. Further exploration and investigation of these groundwater sources could provide valuable insights into expanding the available water resources in the area.

2.3.2 Drivers of Water Demand in Semi-Arid Rural Areas

In semi-arid rural areas, population growth, as identified by Zhu and Chang (2020), compound the demand for water, exacerbating scarcity and hindering sustainable development. As the rural population grows, the need for water for drinking, sanitation, agriculture, and livestock also increases. Furthermore, Fan et al. (2013) stated that a larger household lowers the individual quantity of water that each member receives from the same water source.. The capacity of existing water resources to cope with increased demand is limited and development of additional water resources is also constrained by weak institutional capacity (Kashaigili et al, 2003), lack of financial resources and environmental limitations. An examination of the sufficiency of water resources in relation to demand in semi-arid rural areas is vital in the context of population dynamics influenced by socio-economic forces and climate change.

Many smallholder farmers and their livestock in semi-arid rural settings face a critical shortage of water, which is exacerbated by the varying availability of water during different seasons (Sileshi et al., 2003). Mfinanga et al, (2023) further affirm that access to water for livestock is an even bigger challenge for rural villagers. Other scholars like Clanet et al., (2009) report that water shortages often result in conflicts between farmers

and cattle herders. In extreme cases, humans share water points with animals, resulting in transmission of zoonotic diseases like Leptospirosis from animals to people (Narkkul et al, 2021).

Closeness to water sources has an inverse relationship with water demand; that is, individuals who have convenient access to clean drinking water at home tend to use a greater quantity of water for different purposes within their households. According to Adamu (2019), Ogunbode (2023) and Fu & Wu (2014), when a water source is situated less than 500 meters from a house, or when the time taken to walk to the water source is less than 30 minutes, it is considered to be close.

2.3.3 Water Quality

According to Diawara & Loua (2024), rural water sources are mostly of poor quality due to various forms of contamination that also include pollution from fertilizer residues (Singh, 2024) from gardens. While water quality monitoring in rural areas of Zimbabwe relies mostly on indigenous knowledge systems (IKS) (Nare, Love, & Hoko, 2006), another monitoring system, the Rural Wash Information Management System (RWIMS) in Zimbabwe's rural provinces (UNICEF, 2018), has been implemented to help achieve universal access to quality water and sanitation. Even though the IKS lean more on the physical characteristics of water than bacteriological parameters (Nare, Love & Hoko, 2006), they are a critical source of input into the RWIMS.

2.3.4 Climate Change Impacts on Water Availability in Sand Rivers

Recent scholarly inquiries have highlighted the complex interplay between climate change and future patterns of water availability in sand rivers (Chattopadhyay, et al, 2017; Zhu & Ringler, 2012). The focal point of this discussion revolves around the alterations in precipitation patterns, elucidating the potential ramifications on water resources (Dahal et al, 2020) Specifically, researchers posit that shifts in precipitation, marked by reduced rainfall or heightened variability, are poised to engender discernible impacts on sand rivers. These alterations are anticipated to yield diminished river flows and truncated intervals of water abundance, posing formidable challenges to water abstraction endeavours (Omer et al, 2020), particularly during arid or semi-arid seasons or prolonged drought episodes when these rivers might desiccate entirely.

Climate change can also disrupt the natural flow regime of sand rivers. As outlined by Siddha and Sahu in their 2022 study, the flow rate of a river exhibits variability, with fluctuations in mean precipitation serving as a key determinant. Their study suggests that variations in rainfall patterns can lead to both an increase and a decrease in the river's flow rate, illustrating the dynamic interplay between hydrological processes and meteorological factors (Nkhonjera, 2017; Siddha & Sahu, 2022; Park, 2023). This can affect the predictability and consistency of water abstraction, complicating efforts to plan and effectively regulate water from sand rivers.

A nuanced perspective also draws attention to the escalating global temperatures as a catalyst for augmented water evaporation from sand rivers. This facet adds another layer of complexity to the overarching discourse on climate-induced changes in water availability. In their 2023 study, Whitney and colleagues investigated the impact of climate change on the flow of the Colorado River Basin. Their findings provide compelling evidence that the warming trend is intensifying the decline in streamflow. The intensification of evaporation processes, linked to rising temperatures, amplifies the strain on water resources within sand river ecosystems. Consequently, the confluence of reduced precipitation and heightened evaporation serves as a multifaceted driver of the impending challenges in securing water from these vital river systems and other aquifers.

The forthcoming influence of climate change on water quality in sand rivers is of utmost significance. Anticipated shifts in temperature, precipitation, and runoff patterns are poised to exert substantial influence on critical hydrological parameters, including sedimentation rates, nutrient levels, and pollutant concentrations within river ecosystems (Gyawali et al., 2013; Ostad-Ali-Askari et al., 2017; Santy et al., 2020; Shayannejad et al., 2022). The consequences of these changes also encompass the possible decline in water quality, posing significant challenges for water abstraction methods.

In semi-arid locations where the consequences of climate change are visible, the considerations presented above imply a sense of uncertainty about the dependence on water from ephemeral rivers to meet future demands. But according to another perspective, strategic water collecting projects can provide a workable way to improve and preserve water supply in semi-arid regions (Lasage & Verburg, 2015).

Contrary to the notion of inherent unreliability, proponents of water harvesting contend that it holds the potential to be a transformative solution. By implementing systematic approaches to capture and store ephemeral river water communities in semi-arid regions can mitigate the impacts of unreliable water sources (Wekesa, 2020). This perspective underscores the dynamic nature of water resource management and presents an optimistic view of the potential for sustainability even in the face of climate-induced challenges.

The imperative for assessing the reliability of future water supply from sand rivers necessitates robust hydrological studies capable of offering insightful projections, especially considering the influence of climate change. As underscored by Wekesa et al. (2020), the discussion regarding the hydrological dynamics of alluvial corridors associated with ephemeral rivers, recognized for their role as water buffers, requires greater attention. This is particularly crucial in regions where water scarcity is a persistent challenge. Despite the well-established significance of these alluvial corridors, a notable research gap exists in Sub-Saharan Africa. Specifically, there is a lack of investigation into their hydrological variability and their potential as alternative water sources for adjacent communities. Addressing the research void is essential, as such studies would establish a foundation upon which comprehensive planning and utilization strategies for sand rivers can be effectively anchored.

2.4 Socio- Economic Benefits from Sand Rivers

2.4.1 Introduction

Not only has water abstraction from sand rivers attracted scholarly attention, but it has also had an enormous effect on the lives of rural residents in dry regions. It has transformed subsistence agriculture into profitable commercial ventures through partnerships with established businesses, generating income and employment opportunities. The availability of water from sand rivers has also encouraged entrepreneurship and potential revenue from community-based tourism. Additionally, it has contributed to improvements in education, healthcare, and social cohesion within the communities. Moreover, the accessibility of water from sand rivers has alleviated the burden of fetching water from long distances. Overall, water abstraction from sand rivers has brought about notable socio-economic and social benefits, enhancing the livelihoods of individuals and resilience to climate change in arid regions.

2.4.2 Creation of Commercial Opportunities

Sand river water abstraction has the potential to stimulate economic development and foster commercial opportunities in riparian areas. Academic research indicates that access to water resources from sand rivers can support a variety of economic activities, including agriculture, livestock farming, and local industries (Mugabe et al., 2003; Love et al., 2005; Senzanje et al., 2008; Mpala et al., 2016). For instance, water abstraction for irrigation purposes enables farmers to cultivate crops year-round, thereby boosting agricultural productivity and improving food security (Duke et al., 2020; Jambo et al., 2021). Furthermore, sand river water abstraction can catalyse the growth of agribusinesses and value chains, facilitating the transition from subsistence farming to commercial enterprise through private-public community partnerships and technological advancements (Latham et al., 2015).

Empirical evidence from studies conducted on initiatives such as the Shashe Irrigation Scheme in Beitbridge validates the effectiveness of this multifaceted approach, particularly within the complex dynamics of semi-arid rural settings (Latham et al., 2015). Moreover, the adoption of efficient irrigation technology in arid to semi-arid regions becomes more feasible for economically disadvantaged farmers when supported by financial resources derived from collaborative efforts such as private-public community partnerships (PPCPs). As suggested by Dittoh et al. (2010), the support of these partnerships has been instrumental in alleviating poverty in the Sahel region, emphasizing the significant role that financial capital, directed through strategic collaborations, can play in advancing agricultural practices in water-scarce environments.

Conversely, several factors contribute to the lack of success in agricultural partnerships. According to Karimba et al. (2022), the dissolution of partnerships can be attributed to various issues, including the unreliability of partners, the volatility of markets, and the escalation of irrigation expenses, all of which frequently lead to financial losses for farmers. Duker et al. (2020) emphasize the detrimental impact of partner non-compliance with agreements, particularly concerning the timely supply of essential resources like chemicals and fertilizers, resulting in diminished crop yields and economic losses.

Market price fluctuations represent another significant challenge, as noted by Van Campenhout et al. (2015), which often dissuade farmers from sustaining their production

efforts within partnerships due to financial uncertainty. Furthermore, Frija et al. (2011) shed light on the tendency of farmers to adjust their crop selections in response to shifts in water prices. This adaptive behaviour may result in the exclusion of crops included in partnership agreements, as they could lead to financial losses for the farmer.

Thus, the intricate interplay of factors such as partner reliability, market volatility, rising input costs, and changing crop preferences underscores the complexities inherent in agricultural partnerships and their susceptibility to failure.

While smallholder irrigation farming presents an opportunity of income generation to rural communities within the watershed of sand rivers, the aspect of long-term sustainability of this strategy require further exploration. This study will, therefore, seek to assess changes in income levels, livelihood diversification, and community adaptability to climate change-induced shocks. Furthermore, determining whether partnerships are common in smallholder farming within sand river watersheds and if they offer reliable market opportunities to these settings is crucial.

2.4.3 Entrepreneurship and Employment

In semi-arid rural regions impacted by climate change, access to water resources among vulnerable communities offers a gateway to entrepreneurial opportunities. For instance, improved water availability can support the establishment of small-scale enterprises such as fish farming, water-based tourism, or water processing industries (Toerien & Seaman, 2011). These initiatives cannot only create employment opportunities but also catalyze national economic development (OECD, 2020; Defra, 2021; Phillipson et al., 2019)), consequently mitigating poverty levels within the community. Furthermore, the diversification of enterprises serves as a strategic buffer, diminishing the adverse impact of poverty induced by climate change on households (Etim & Edet, 2016).

Employment prospects being unveiled by water from sand rivers, can reverse the rural-to-urban migration, avail critical skills required for boosting rural economic activities, and promote family unity. According to Suckall et al. (2015), a discernible trend is observed where young Malawians are opting to return to rural environments from urban centres. This migration is driven by the pursuit of leveraging nascent agricultural opportunities, a

decision influenced by the challenges encountered in securing gainful employment within urban settings (Suckall et al., 2015).

These arguments emphasize the possibility for water-driven enterprises to create employment opportunities and boost rural economic activities. However, there is limited discussion on the barriers that may hinder enterprise development, such as access to financing, technical skills, market access, and regulatory constraints. This research will identify these barriers and make recommendations which will facilitate the successful establishment and growth of small-scale enterprises within the watershed of sand rivers.

2.4.4 Potential Earnings from Community-based Tourism

Residents of semi-arid rural areas, contending with poverty exacerbated by climate change, have the potential to enhance their livelihoods through engagement in Community-Based Tourism (CBT). By being within the vicinity of ephemeral rivers or sand rivers, which possess unique natural landscapes, diverse wildlife and cultural heritage, communities can benefit from income from visitors (Gohori, & van der Merwe, 2020). A study conducted by Juma, et al. (2019) sheds light on the pivotal role of Community-Based Tourism as a catalyst for enhancing the sustainability in both the socio-economic and physical environments within rural areas. Snyman (2016) even suggests that for tourism to be sustainable, it should bring both direct and indirect benefits to the community. CBT, characterized by its reliance on resources owned or controlled by the community, emerges as a nuanced approach that involves active participation from community members or communal stakeholders in tourism activities (Gohori & van der Merwe, 2020). This reciprocal relationship ensures that the community receives equitable returns for granting access to and utilizing its resources.

On the other hand, a critical discourse within academic circles has raised questions regarding the purported benefits of tourism, emphasizing the prevalence of higher leakages and diminished multiplier effects. Goodwin (2002) contends that the traditional theory of economic growth "trickling down" does not materialize in a way that materially helps the most vulnerable members of society. Jamal & Dredge. (2014) further collaborate this claim by attesting that proceeds from tourism are never evenly distributed over space and time (Uslu, 2020; Muresan , 2021; Celik, et al, 2023).

The critique of the conventional tourism model has prompted a quest for alternative paradigms that prioritize sustainability and local empowerment. Recognizing the shortcomings of the prevalent tourism practices, scholars advocate for the exploration of alternative tourism models characterized by small-scale, locally owned, and locally controlled enterprises. In response to the negative repercussions associated with mass tourism, various alternative tourism models have emerged, each presenting distinctive characteristics. These models encompass ecotourism, responsible tourism, green tourism, sustainable tourism, community-based tourism, and other frameworks characterized by the operation of small-scale businesses owned and managed by local communities. In this scholarly discourse, the exploration and promotion of alternative tourism models emerge as crucial avenues for mitigating the adverse effects of conventional tourism and fostering a more sustainable and inclusive approach to tourism development.

Although the concept of sustainable livelihoods through recreational activities in ephemeral river basins is usually viewed positively as a potential source of income, there is always debate over a couple of points. A few points that may be disputed or discussed include the impact on the environment, social inclusivity, cultural preservation, economic value, and climate resilience.

Llanos-Paez and Acuna (2022) underscored the limited acknowledgment of the recreational economic value associated with temporary river flows in comparison to their perennial counterparts. This observation gains significance in light of Sterner et al.'s (2020) proposition that recreation constitutes a pivotal Cultural Ecosystem Service (CES), playing an important role in augmenting the general well-being and generating value for both the ecosystem and tourism. Consequently, a critical imperative emerges to systematically evaluate the prospective economic benefits that may emanate from the CES within communities situated in the catchment areas of ephemeral sand rivers.

The arguments emphasize the the significance of involving the community in tourism activities as well as the preservation of cultural heritage. However, there is absence of empirical evidence on how much CBT initiatives promote social inclusivity, empower marginalized groups, and safeguard cultural traditions. There is also limited analysis of the economic value generated by tourism activities and their distribution among local stakeholders. Research could explore the socio-cultural dynamics of CBT, including issues of representation, equity, and cultural authenticity, to guarantee that tourism benefits are fairly shared among local communities.

2.4.5 Interplay of Water Availability, Health and Education

Access to water resources from sand rivers bears both direct and indirect implications for education in semi-arid rural areas (Amahmid et al., 2018). The consequential enhancement of water availability fosters improved sanitation and hygiene practices, thereby mitigating water-borne diseases and uplifting the overall health of rural scholars (Hutton & Chase, 2017). Subsequently, this improvement resonates in heightened school attendance rates, as evidenced by research from UNICEF (2019), Asaba (2013), and Afullo and Danga (2013), concurrently alleviating absenteeism due to illness. Such a positive ripple effect allows individuals, both children and adults, to dedicate more time and energy to educational pursuits and skill-building activities. Consequently, easy access to water from sand rivers emerges as a catalyst for rural residents' empowerment through education, acting as a buffer against the adversities brought on by poverty, particularly those exacerbated by climate change.

Aligned with the Human Capital Theory, which emphasizes the pivotal role of health in economic development (Lawanson, 2017; Grossman, 2017), access to safe water from sand rivers emerges as a cornerstone for community health improvement (Quinn et al., 2018). This improvement not only leads to reduced healthcare costs but also translates into heightened productivity. Supplying clean water for drinking and sanitation is essential for preventing waterborne diseases and promoting overall health and well-being. Consequently, individuals enjoying good health are not only more likely to be productive but also tend to achieve better economic outcomes, thus contributing to poverty alleviation (Abanyie et al., 2023).

2.4.6 Social Cohesion

Water availability exerts a substantial impact on social cohesion within rural areas. In regions grappling with water scarcity or limited access due to climate change, communities face multifaceted challenges that strain social bonds. Water scarcity often sparks competition and conflicts among community members, leading to tensions, divisions, and, at times, violence (McGuirk & Nunn, 2020). Notably, pastoralists in the Sahel region engage in occasional violence during migrations with livestock in search of water. Agricultural activities, often the primary income source in rural communities, are

impeded by water shortages, resulting in crop failures and decreased output. The subsequent financial strain and hardships give rise to social inequality and divisions, straining relationships within society. Moreover, water scarcity increases the occurrence of diseases, contributing to the burden of illness and resultant healthcare costs, thereby further weakening social cohesion by placing additional stress on individuals and families.

Despite these challenges, concerted efforts by governments and non-governmental organizations to enhance water availability in rural areas have yielded positive results. Construction of dams and drilling boreholes in areas lacking natural water resources has significantly alleviated water shortages, contributing to improved social cohesion in rural settings. However, there remains a gap in research regarding the specific effects of water abstraction from sand rivers on social cohesion. Addressing this gap, this research endeavours to explore the attribution of water abstraction from sand rivers to social cohesion in Nyamuzizi Village.

2.5 Changes in Land use/Land Cover Patterns within Riparian Zones

2.5.1 Introduction

The escalating water demand resulting from population growth within riparian areas has spurred intense discourse regarding the viability of relying on water abstraction from sand rivers as a sustainable adaptive strategy in the face of climate change-induced poverty. The main focus of this discussion has been how human activity and climate change affect sand river base flow, which is thought to be a crucial sign of how long-term water abstraction can be. While some arguments posit that increasing population sizes correlate with significant changes in land use, ultimately impacting underground water quantities, others situate their arguments on the attribution of climate variability to the state of base flows within ephemeral rivers.

2.5.2 Effect of Land Use Changes on Base Flow in Sand Rivers

Many studies contend that the swelling population inhabiting riparian zones has significant repercussions on the base flow of water in sand rivers, primarily stemming from resultant alterations in land use practices. Basset et al (2023) posit that the conversion of forested land to cultivation through tillage practices and the trampling of the ground by grazing

animals typically induces alterations in soil structure. Franzluebbers (2003), Yimer et al, (2008) further affirm that the diminishing levels of soil organic carbon also contribute to the deterioration of the soil structure, resulting in decreased groundwater recharge because of changes in surface permeability (Muñoz et al, 2017). Alterations in land utilization, illustrated by the transformation of natural vegetation into agricultural areas, result in a reduction in infiltration capacity and soil moisture content crucial for sustaining base flow in sand river systems (Batlle-Aguilar and Cook, 2012; Chen et al., 2013). The decline in infiltration resulting from these alterations consequently yield decreased base flow levels during periods of aridity, potentially culminating in a partial or complete cessation of flow (Schilling et al, 2021). Therefore, the sustainability of base flow in sand rivers hinges upon the preservation and conservation of natural vegetation (Taylor et al., 2012; Chen & Wang, 2015). Natural vegetation typically facilitates groundwater recharge by promoting infiltration of precipitation into the soil, allowing water to percolate downward and replenish aquifers. On the contrary, replacing natural vegetation with impermeable surfaces or agricultural practices disrupts this process. As a result, the reduced base flow in sand rivers brought about by changes in land use may imperil the capacity to supply an increasing number of people with water.

Indeed, alternative perspectives in the scientific literature suggest that the alteration in soil infiltration capacity resulting from land use changes is not solely determined by removing natural vegetation, but also by the type of vegetation utilized as a replacement. Sun et al. (2018) reported that infiltration rates increased when grasslands were transformed into forests, as opposed to decreasing when the land was used for crops. Additionally, Bargués Tobella et al. (2014) contend that agroforestry systems may offer superior potential for enhancing soil infiltration rates compared to monoculture crops or trees alone. He argues that agroforestry, through the integration of perennial vegetation such as trees and shrubs, facilitates the accumulation of organic matter in the soil, thus improving soil structure by enhancing aggregation and stability. This, in turn, increases soil porosity and fosters better water infiltration, as supported by Anderson et al. (2009). Consequently, activities such as agroforestry may contribute to promoting base flow in sand rivers, irrespective of changes in population density.

On the other hand, some critics, attribute changes in base flow dynamics to broader climatic factors, like precipitation, temperature, and a rise in frequency of severe weather events, rather than solely to local land use practices. It has been observed that the

reduction in precipitation patterns attributed to climate change (Hughes et al., 2021) directly impacts groundwater recharge within sand river basins. As highlighted by Pokhrel et al. (2019), this diminished recharge diminishes base flow levels within these hydrological systems. However, Cuthbert et al (2019) affirm that despite changes in precipitation rates, groundwater systems may exhibit a degree of resilience that allows them to buffer against some of the impacts of climate variability. This resilience, deduced from observed connections between precipitation and groundwater recharge, is vital for informing forecasts of how groundwater systems might react to future climate change scenarios and for formulating efficient adaptation strategies to address the resulting impacts on base flow. Furthermore, as highlighted by Hongbin et al. (2021), rising temperatures play a pivotal role in shaping variations in base flow. The escalation in temperature exacerbates water dissipation, leading to a reduction in base flow levels. This decline in groundwater quantities can be attributed to heightened evaporation rates induced by elevated surface temperatures, along with other key factors including humidity, wind speed, and available soil moisture (Savva & Frenken, 2002). Changes in evapotranspiration depend on humidity, solar radiation, wind speed and air temperature.

While conventional arguments attribute changes in base flow to either land use changes or climate change in isolation, emerging scholarly perspectives underscore the intricate interplay between these two factors. Majaliwa (2013), Talib (2015), and Kirby et al. (2016) argue that changes in land use and climate significantly affect key hydrological processes such as evapotranspiration, infiltration, surface runoff, groundwater flow, and stream discharge regimes, a view also supported by Natkhin et al. (2015). Moreover, the future trajectory of land use and land cover changes is anticipated to intersect with projected temperature increases, culminating in a reduction in water availability (Hyandye et al., 2018). This trajectory is further propelled by escalating deforestation rates driven by agricultural expansion, compounded by the overarching influence of global warming trends, as elucidated by Fischer (2013). Therefore, to effectively forecast and mitigate impacts on base flow dynamics in riverine ecosystems, it is crucial to understand the synergistic effects of changes in land use and climate.

The presented arguments primarily draw upon general trends and findings from various studies on the relationships between land use changes, vegetation, climate change, and base flow dynamics. But further study is required to comprehend how different land use and land cover patterns relate to water shortages in semi-arid rural environments with

unique meteorological, hydrological, biological, and socioeconomic circumstances, such as the Nyamuzizi watershed.

2.5.3 Sand River Water Conflicts

An escalation of human population density in the riparian zones of sand rivers drives competition for water, which often creates social tensions that can degenerate into conflicts (Michel, 2020). as demand outstrips supply. Such conflicts lead to sustainability challenges of water abstraction from intermittent rivers, thus limiting the reliance on these rivers as a mitigating measure of climate change-induced poverty. According to Malthus (1798), the imbalance between population growth and resource availability would inevitably lead to scarcity, poverty, and social strife unless population growth was checked by preventive or positive checks such as famine, disease, war, or moral restraint. Consequently, the heightened competition often results in conflicts among users with divergent interests, stemming from varying demands for water for household domestic needs, agricultural practices for crop cultivation, and livestock husbandry activities within the communities. In the Sahel region, for example, conflicts occasionally arise from encroachments by livestock onto cultivated lands. Such encroachments precipitate deleterious consequences, including the destruction of agricultural yields and consequent economic repercussions for rural communities. As the conflicts intensify, they tend to spill over into other social spheres beyond the immediate issue of water access (Seter et al 2018).

Some critics argue that water conflicts are not solely caused by water scarcity but rather by longstanding disputes in villages, stemming from social, ethnic, and political dimensions. Fröhlich (2012) and Seter et al (2018) underscored that water disputes can become intertwined with broader social, economic, and political dynamics within the village or region. They argue that issues such as unequal access to resources, historical land tenure arrangements, and governance failures play a significant role in driving tensions over water and land use. As a consequence, tensions between different ethnic or social groups, economic hardships, displacement of communities, or even violence explode.

Overall, while there may be broad agreement on the importance of addressing conflicts over water resources, there are diverse perspectives on the underlying causes and the most effective strategies for resolution. These differences underscore the complexity of the

issue and the need for interdisciplinary dialogue and collaboration in finding sustainable solutions.

It is, thus, imperative to explore the conflict resolution mechanisms in existence in riparian areas of sand rivers in semi-arid rural regions. An in-depth research is essential to identify the root causes and potential solutions to this problem. This study will explore existing legal frameworks, customary practices, and institutional arrangements to determine the most effective and sustainable conflict resolution mechanisms. Ultimately, addressing this research gap can promote better resource management and improve the livelihoods of those living in these areas

2.6 Role of Governance Frameworks on Water Abstraction

2.6.1 Introduction

Governance frameworks play a pivotal role in overseeing water abstraction from sand rivers by communities residing within the watershed, ensuring the sustainable utilization of this vital natural resource amidst the challenges posed by climate change. Additionally, these governance structures are essential for fostering the health and resilience of sand river watersheds, thereby safeguarding the well-being of both current and future generations. By establishing enforcement mechanisms, governance structures contribute to the prevention of water conflicts and promote social equity in access to water resources, particularly among disadvantaged community members. Moreover, effective governance frameworks facilitate the meaningful participation of residents and various parties involved in making decisions related to water management. Ultimately, these frameworks are, thus, instrumental in providing regulatory mechanisms to address critical issues such as regulation of water abstraction from sand rivers, decision-making authority and conservation of the environment.

2.6.2 Regulation of Water Abstraction

It is critical to have social and governance frameworks in place to enable the sustainable extraction of water from ephemeral rivers to ameliorate poverty from climate change. Social frameworks reflect how stakeholders, users of water resources, and local communities are involved and participate in decision-making processes (Chirenje et al., 2013). Governance frameworks, on the other hand, refer to the policies, rules, and

regulations that govern the extraction of water and ensure its sustainability (Jiménez et al, 2020). Establishing effective mechanisms for the sustainable management and regulation of water extraction is imperative. This is because drawing water from ephemeral rivers can exert notable effects on both the environment and the communities reliant on these vital water resources. It is therefore important to assess the effectiveness of governance frameworks in the extraction of water from sand rivers, which will be a major source of water in a rural setting.

2.6.3 Decision-Making Authority

Sustainable water abstraction from sand rivers is recognized as pivotal in effective water resources management, especially considering the increasing influence of climate change on water availability (Hussey, 2007; Pahl-Wostl, 2020). The decision-making authority over the sustainable use of water from ephemeral rivers holds significant importance, as evidenced by studies such as Berggren (2018). While some advocate for decentralized decision-making power, as demonstrated by Berggren (2018) and Dani (2014), contrasting arguments emphasize the benefits of retaining centralized authority over water resources.

The trend towards decentralization in river basin water resources management has been observed in various international agreements, highlighting the importance of aligning institutional systems with the resources they manage (Herrfahrdt-Pähle, 2014). For example, the SADC Revised Protocol on Shared Watercourses emphasizes effective governance at the basin level and local stakeholder involvement while offering a framework for decentralized river basin water resources management within the SADC area (Dani, 2014). As a result, initiatives for river basin management have been put in place in various SADC nations. However, scholars like Mody (2004) caution against the challenges posed by decentralization, suggesting that it may hinder coordinated efforts and the implementation of integrated strategies for managing river basins. Poorly coordinated abstraction can adversely impact local communities, in-stream habitats, water quality, and the hydrological regime of rivers and streams (Arroita et al., 2017). The complexities of differing stakeholder interests, accountability requirements, and basin-related aspects further compound the challenges of decentralized river basin management (Mody, 2004; Meijerink & Huitema, 2015). Blomquist (2004) argues that administering water resources at the most localized level may encounter feasibility constraints due to these difficulties,

emphasizing the need for long-term commitment, talent development, financial sufficiency, and accountability to achieve productive decentralization.

As the discourse on the ideal governance framework for water resources management continues, it becomes imperative to extend this discussion to the specific context of water abstraction from sand rivers. A comprehensive evaluation of governance frameworks in this context is vital, particularly concerning poverty mitigation and climate change. Future studies should concentrate on methodically evaluating the efficacy of implementing particular governance models in order to offer important insights into the sustainable management of water abstraction from sand rivers in the face of changing environmental concerns.

2.6.4 Preservation of Intermittent River Environments

The burgeoning populace inhabiting riparian zones poses a formidable challenge to the preservation of sand rivers. With population growth exerting unprecedented pressure on environmental resources, the safeguarding of sand rivers from pollution emerges as a paramount concern. Scholars contend that the enactment of robust governance frameworks constitutes an indispensable measure to avert contamination originating from diverse sources, including overstretched sanitation infrastructure, agricultural activities, and inadequate waste management practices.

Existing scholarly literature underscores the escalating anthropogenic pressures on riparian environments, attributing the degradation of water quality and ecosystem health to burgeoning populations and associated changes in land use (Vörösmarty et al., 2000; Wang et al., 2019). The vulnerability of sand rivers, characterized by their porous substrates and intricate hydrological dynamics, to pollution from various anthropogenic activities has been extensively documented (Mutuku et al., 2017; Kashaigili et al., 2018). Furthermore, studies elucidate the role of governance frameworks in mitigating pollution in riparian zones, emphasizing the need for integrated management approaches that encompass regulatory interventions, community engagement, and technological innovations (Allan, 2004; Wei et al., 2020). Building upon this scholarly foundation, the present discourse endeavors to delineate the imperative for governance frameworks tailored to the unique challenges posed by sand rivers within riparian landscapes.

The role of governance in conserving environments surrounding sand rivers plays a pivotal role in protecting the biodiversity within these ecosystems. As evidenced by Sánchez-Montoya et al. (2022), sand rivers harbour a richer diversity of flora and fauna compared to perennial rivers. Moreover, their study revealed that terrestrial animals exhibit a propensity to utilize sand river channels more frequently than river banks in their quest for sustenance. Complementing this perspective, Bonada et al. (2020) underscore the significance of sand rivers in sustaining aquatic ecosystems, particularly during periods of no-flow. Building upon these findings, Fovet et al. (2020) advocate for an enriched role of governance, emphasizing the need for a transdisciplinary approach to gain comprehensive insights into the ecological dynamics and human interactions within sand river environments.

The integration of governance mechanisms, such as the establishment of protected areas and conservation zones, emerges as a crucial strategy in conserving sand river ecosystems. By safeguarding critical habitats and species, these initiatives contribute to the enrichment of biodiversity and reinforce the overarching goals of environmental stewardship. Therefore, governance assumes a central position as an indispensable tool in the management and preservation of sand river ecosystems, facilitating the sustainable coexistence of human activities and ecological integrity.

While governance frameworks often focus on regulating the exploitation of water resources, the assessment of their effectiveness in the management of sand river water resources in the context of climate change, and in the preservation of the surrounding environments, is not specifically explored in the literature. This study will, thus, seek to examine the effect of the local governance framework on water abstraction from the Nyamuzizi River.

2.7 Conceptual and theoretical frameworks

2.7.1 Introduction

In the context of reducing climate-induced poverty in Nyamuzizi Village, conceptual and theoretical frameworks offer analytical lenses through which to view the economic, social, and environmental benefits of water abstraction from sand rivers. Depending on the precise focus and extent of the analysis, these frameworks make it easier to evaluate the implications of sustainable development in a thorough manner.

2.7.2 Human Capital Theory

The human capital theory was principally developed in the 1950s and early 1960s by Gary Becker and Theodore Schultz. It states that poverty reduction and economic growth are correlated with skills, education, and health. The sand river's water supply can enhance health outcomes and make investments in human capital—such as education and career training—possible, which will raise output and generate more revenue.

By applying Human Capital Theory to the evaluation of the economic benefits of water abstraction from the Sand River in Nyamuzizi Village, one can assess how improved water access influences education, productivity, income generation, entrepreneurship, and community resilience. This analysis highlights how water resources can contribute to human capital development, ultimately leading to poverty reduction and improved economic well-being.

2.7.3 Sustainable Livelihoods Framework

The framework for sustainable livelihoods looks at the various resources, skills, and methods that people and communities use to make ends meet. The availability of water from the sand river is a valuable natural resource that helps diversify sources of income and livelihoods, increase resilience to shocks brought on by climate change, and lessen poverty in Nyamuzizi Village.

2.7.4 Resilience Theory

Resilience theory aims to improve individuals and communities' capacity to deal with social and environmental problems and adapt to changing conditions. To evaluate the social advantages of water abstraction, one must look at how it strengthens community resistance to poverty brought on by climate change. This entails assessing how increased water availability promotes agricultural productivity, diversity of sources of income, and resilience to shocks linked to climate change.

2.7.5 Social Capital Theory

Social capital theory highlights the significance of social connections and community cohesion in fostering development and reducing poverty. Water abstraction from the Nyamuzizi River can foster social capital by providing a shared resource that brings

communities together, encourages cooperation, and facilitates collective action. This can lead to community resilience, improved social support, and enhanced capacity for addressing climate change-induced poverty.

2.7.6 Governance Theory

Governance theory on water abstraction focuses on the various mechanisms and structures in place to manage and regulate the use of water resources. This includes policies, laws, institutions, and decision-making processes that govern water abstraction practices to ensure sustainability, equity, and efficiency

2.8 Literature Review Summary

The research places significant emphasis on five central concepts: semi-arid rural areas, climate change-induced poverty, sand river water abstraction, land use and land cover patterns, and governance structures. These interconnected concepts form the foundation of the study, illustrating the complex web of challenges and opportunities in managing water resources, addressing climate-induced vulnerabilities, promoting sustainable development, and establishing effective governance in rural settings. The incorporation of these fundamental components displays a comprehensive methodology, acknowledging the mutual influence of environmental, social, and economic elements in moulding the resilience and well-being of societies in semi-arid areas.

Several studies underscore the crucial role of water from sand rivers in agricultural production within semi-arid rural areas, particularly when efficient irrigation methods are employed. This water source not only holds the potential to create employment opportunities but also offers a promising avenue to counter rural-to-urban migration. To enhance income levels, collaborative efforts with private companies through joint ventures are proposed as a means to achieve economies of scale. The prospect of sand river water goes beyond agriculture, as it presents opportunities for diversifying livelihoods in rural communities, with Community-based Tourism (CBT) emerging as a potential economic boon for households.

However, there are debates regarding the equitable distribution of benefits. Some argue that despite the potential economic advantages, benefits from activities like CBT might not effectively reach the targeted families, but instead benefit external entities. Additional

research is required to thoroughly assess the real impact of CBT in providing benefits to communities located within sand river basins. In addition to economic considerations, studies suggest potential social benefits linked to water from sand rivers, encompassing improved health, education, and social cohesion. Yet, the sustainability of these social benefits in the face of climate change remains a subject warranting further investigation.

In addition, scholars contend that realizing socio-economic benefits from water extracted from sand rivers can effectively alleviate climate change-induced poverty. However, this hinges on two critical factors: the assurance of sustainability of water supply from these rivers and the presence of social and governance structures that facilitate decentralized decision-making. The reliability of water supply is paramount for ensuring the success of sustainable development initiatives, while decentralized decision-making processes within social and governance frameworks are seen as instrumental in optimizing the positive impact of these benefits on poverty alleviation in the context of climate change.

Chapter 3

RESEARCH METHODOLOGY

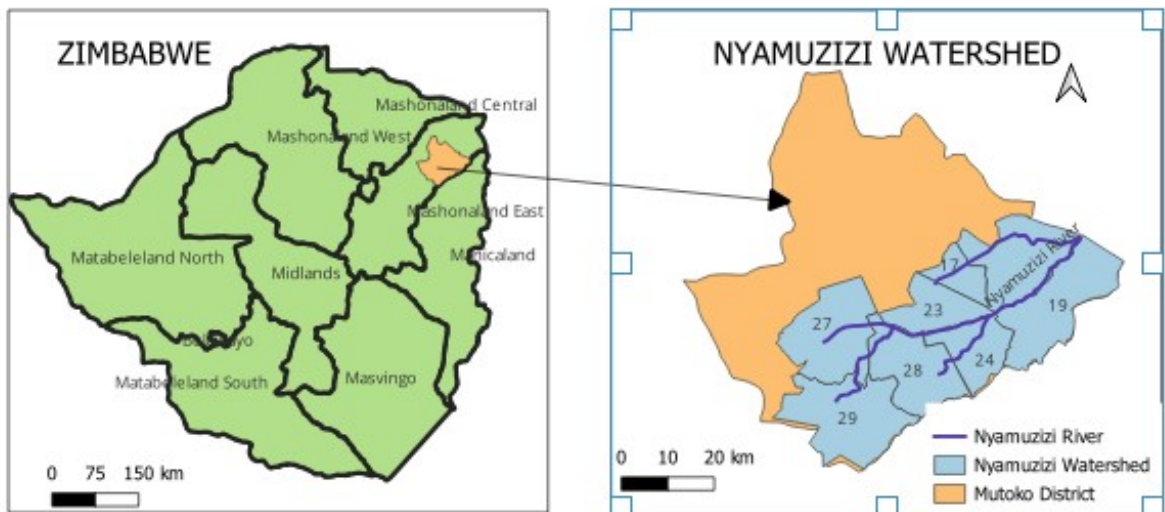
3.1 Introduction

This section delineates the methodological framework employed to address the overarching research question concerning the sustainability of water abstraction from sand rivers in mitigating climate change-induced poverty within semi-arid rural areas. The chosen research approaches, data collection techniques, and analysis methods are explicitly elucidated in alignment with each distinct research objective.

3.2 Study Area

3.2.1 Geographical location

LOCATION OF STUDY AREA



Prepared by: Chidza P.
April 2024

Figure 3.1: Location of Nyamuzizi Watershed

The Nyamuzizi watershed is located on the eastern side of Mutoko District in the Mashonaland East Province of Zimbabwe, situated at geographical coordinates 17°30'10.16"S and 32°20'9.63"E. Access to the study area involves driving approximately 150 kilometres along the Harare-Nyamapanda road until reaching Mutoko Centre. From there, one should turn right into the shopping centre and proceed in the eastern direction towards the Nyamuzizi River, passing through Mudzi and Nyabini rivers along the way.

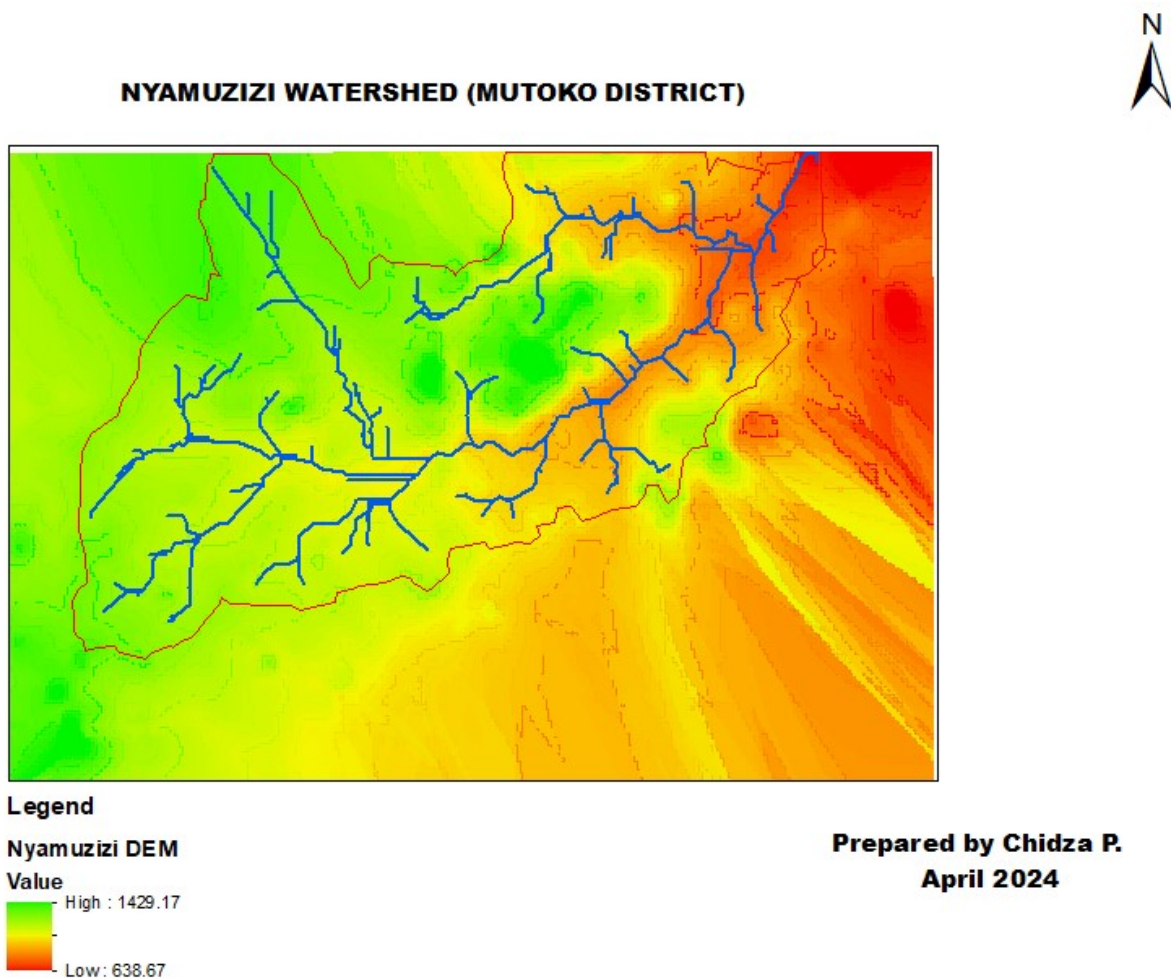


Figure 3.2: Nyamuzizi river and network of it's tributaries

3.2.1.1 Study Area Delineation

The delineation of the Nyamuzizi Watershed, shown in fig.3.2, was carried out using ArcGIS. The process involved a number of steps which are described below.

The first step involved the acquisition of relevant spatial datasets which included digital elevation model (DEM), hydrological data, and land cover data. The DEM was prepared from Google Earth and ArcGIS tools.

Using the hydrological analysis tools, the watershed boundary of the Nyamuzizi Watershed was delineated by identifying the drainage area that contributes runoff to a common outlet point, typically a river mouth or confluence. The DEM served as the primary input for this process, allowing the software to calculate flow direction and accumulation to determine watershed boundaries.

Once the watershed boundary was delineated, the next step involved extracting the river network within the watershed. ArcGIS offers tools for stream network extraction, which utilize flow direction and accumulation algorithms to identify continuous flow paths within the watershed. This process resulted in the creation of a river network dataset representing the major rivers and streams within the Nyamuzizi Watershed.

3.2.2 Rationale for Selection

The Nyamuzizi Watershed has emerged as a critical site where local communities heavily rely on water sourced from sand aquifers to sustain agricultural production and other water-dependent activities. In the face of escalating climate change impacts, such as increasing temperatures and fluctuating rainfall patterns, villagers have resorted to the extraction of water from the intermittent river as an adaptive measure. This practice not only aids in mitigating the adverse effects of harsh climatic conditions but also serves as a coping mechanism for ensuring the continuity of various livelihood practices.

Moreover, the evolving demographics within the Nyamuzizi watershed, characterized by an influx of families seeking access to water from the sand river, have resulted in notable changes in land use and land cover patterns. Consequently, the study area presents an ideal context for investigating the implications of sand river water abstraction on riparian ecosystems, the overall water quality and, ultimately, the sustainability of the practice.

3.3 Research Philosophy

This research adopted a pragmatist philosophy as the overarching framework to investigate the social, economic and environmental aspects of water abstraction from sand rivers as an adaptation measure against climate change-induced poverty in semi-arid rural

areas. A pragmatist research approach is a methodology that emphasizes practicality and utility in research design and implementation (Allemang et al, 2022). It draws from the philosophical tradition of pragmatism, which asserts that the value of ideas and theories should be measured by their practical consequences and usefulness in solving real-world problems. In pragmatist research, the focus is on selecting methods and techniques that are most suitable for addressing the research question at hand, rather than adhering strictly to a particular theoretical framework or methodology. This approach often involves a flexible combination of qualitative and quantitative methods, depending on what will yield the most meaningful insights. The pragmatic approach is chosen to ensure a comprehensive and flexible exploration. By prioritizing the application of findings to address immediate challenges, the study aims to provide actionable insights for sustainable development and poverty alleviation in the targeted regions

3.4 Research Approach

This research employed a mixed methods approach to comprehensively investigate the factors that influence the sustainability of water abstraction from sand rivers in adapting to climate change-induced poverty in semi-arid rural areas. These methods included focus group interviews, open-ended interviews, field observations and documentary research.

3.5 Research Design

3.5.1 Introduction

In this research design section, the methodology employed is delineated according to the research questions. The section begins by elucidating the research methods utilized, notably employing focus group interviews with villagers and open-ended interviews with pertinent officials. These methods were chosen for their efficacy in capturing diverse perspectives and generating rich qualitative data, essential for exploring complex topics such as water resource management. The sampling strategy employed, namely convenience sampling emphasized the selection of participants possessing relevant knowledge and experiences within the study area. The subsequent subsections detail the meticulous data collection and analysis processes, elucidating the role of the researcher as a moderator guiding discussions and the utilization of thematic analysis to discern patterns and themes from the qualitative data. Moreover, the integration of photographs and

interview guides in the appendices underscores the comprehensive approach adopted to ensure the robustness and reliability of the research findings.

3.5.2 Examination of Adequateness of Water Sources

3.5.2.1 Research Method

The primary research method utilized for this assessment involved conducting a focus group interview. A focus group interview is a qualitative research approach that proves particularly valuable when investigating intricate subjects, gathering a wide range of perspectives, and generating in-depth qualitative data (Dilshad & Latif, 2013).

A field research was carried out to observe the types of water resources that are available in Nyahondo-Marira Ward. According to Soukop et al (2017), field research has an advantage of the researcher being involved in the observations.

Open-ended discussions were additionally held with representatives from various organizations including the Department of Water Resources Management, Supply and Sanitation, ZINWA Mutoko Rural District Council, and Lower Rwenya Sub-Catchment Council. These conversations aimed to gather valuable perspectives on water resources management, with a specific focus on the management of sand river water resources.

3.5.2.2 Study Population

The villagers within the wards in the Nyamuzizi Catchment formed the study population. This is a finite population since the total number of villager's resident in this area is known after having been established by the Population Census of August 2022 (refer to table 4.1). The total size of the population was 18 328.

3.5.2.3 Sampling Strategy

A sample of participants for the focus group interview was drawn from the target population using the purposive sampling technique. Purposive sampling involves deliberately selecting participants based on specific characteristics, expertise, background, or other defined criteria. According to Creswell (2014), being purposeful involves selecting participants who can offer valuable insights relevant to your research inquiry. This approach, thus, allowed for the selection of participants who possess

relevant knowledge and experiences related to water availability and accessibility within the Nyahondo-Marira Ward. Participants were drawn from various demographic groups, including community members, local leaders, and experts in water resource management and environment management.

3.5.2.4 Data Collection and Analysis

Data collection was conducted through a focus group interview held within the Nyahondo-Marira Ward. In the interview I was the moderator who guided the discussion and prompted participants to share their insights, experiences, and perspectives on water availability and accessibility. A focus group interview guide was used. It was a semi-structured interview, allowing for both predetermined questions and open-ended discussions to emerge organically.

Interview guides with open-ended questions were used during the interviews with water authorities.

Following data collection, the research findings were analysed using a qualitative thematic analysis method. Thematic analysis involves identifying patterns, themes, and recurring ideas within the data set. This process entailed transcribing the interview, coding the data into meaningful categories, and identifying key themes related to water demand, availability, accessibility, challenges, and potential solutions.

3.5.3 Evaluation of Socio-economic Benefits from Sand River Water Abstraction

3.5.3.1 Research Method

The qualitative research used in the study, involved conducting interviews and personal communications with villagers, an agricultural extension officer, and the Ward councillor to gather rich, contextualized data on the socio-economic dynamics within the community. These interviews provided insights into the lived experiences, perceptions, and challenges faced by community members, allowing for a nuanced understanding of the interplay between water scarcity and various socio-economic factors. Additionally, qualitative methods were employed to capture narratives and testimonies, such as the emotional accounts provided by villagers regarding the impact of declining water availability on agricultural productivity and household income.

3.5.3.2 Population

The same population used in sub-section 3.5.22 was also used for the objective of examining how the socio-economic benefits from abstracting water from Nyamuzizi River contributed to the alleviation of poverty.

3.5.3.3 Sampling Strategy

Convenience sampling was employed to select a sample from the Nyamuzizi watershed, a choice influenced by constraints of time and resources. Specifically, Ward 23, also referred to as Nyahondo-Marira Ward, was chosen due to its greater accessibility compared to other wards within the watershed. As articulated by Obilor (2023), convenience sampling entails the selection of participants based on their proximity to the researcher. Consequently, other wards necessitated greater fuel resources, and the vehicle utilized was unsuitable for the rugged terrain of access roads.

The ward councillor played a pivotal role in facilitating the mobilization of villagers hailing from both Nyahondo and Marira settlements. Notably, Nyahondo villagers originated from settlements situated at a greater distance from the Nyamuzizi riparian zones, while Marira villagers resided in closer proximity to the Nyamuzizi River basin. This deliberate inclusion of residents from these two distinct localities aimed to enhance the comprehensiveness of the coverage of various water resources within the ward. The villagers (shown in photographs in the Appendix H), constituted the sample population and actively participated in the focus group interviews. Noteworthy from the same photographs is the representation of both genders among the participants.

3.5.3.4 Data Collection and Analysis

A focus group interview guide (Appendix C) was used as a data collection tool. This instrument was designed to gather qualitative data on the water demand and the capacity of the available water resources in satisfying this demand, income generated, employment opportunities created, agricultural productivity, household income levels, access to education indicators, health status, and food sufficiency.

In-depth interviews were conducted with members of the youth and Munjoma garden co-operatives, local councillor and the agricultural extension officer in the field. These

interviews explored perceptions, experiences, and cultural aspects related to the use of river water, providing qualitative insights into the socio-economic landscape.

Qualitative data analysis techniques such as thematic coding and content analysis were employed to identify recurrent themes, patterns, and narratives within the interview transcripts and qualitative data sources.

3.5.4 Assessment of the Water Scarcity Impact On LULC Patterns

3.5.4.1 Research Method

Geospatial Information Systems (GIS) and Remote Sensing were used in analysing the changes in the land use and land cover (LULC) patterns in the study area. GIS is a tool that allows users to create, manage, analyze, and visualize various types of geographical data, such as maps, satellite images, terrain models, and more, while Remote Sensing refers to the process of gathering information about the Earth's surface without being in direct physical contact with it. The choice of this research method was based on the need to provide a spatial and temporal understanding of the LULC changes that have occurred over a big area at a very minimum cost.

3.5.4.2 Area of Study of the LULC Changes

The analysis was carried out over the wards within the watershed of Nyamuzizi River. This area of study was chosen in order to show how the effect of climate change on water available in other water resources in these wards, could influence the land use and land cover changes in the riparian areas of the river. The inclusion of the population statistics, presented in Table 4.1, of these wards was a meant to show whether population changes had a significant impact on the LULC changes, other than the effect of changes in water quantity in the river.

3.5.4.3 Data Collection and Analysis

Land use/land cover classification for the Nyamuzizi Watershed utilized remote sensing and GIS techniques. Landsat 8 satellite images for 2013 and 2023 were acquired from the USGS Earth Explorer, providing spatial resolutions of 30 meters. These images encompassed spectral bands 1 to 7 and were processed into composite bands within ArcGIS software.

To focus the analysis, shapefiles delineating ward boundaries were sourced from Diva-GIS and used to clip the images to the areas of interest. False-colour images were generated by combining bands 5, 4, and 3, aiding in visual interpretation of land cover features.

Supervised classification techniques were employed, utilizing training samples to guide the classification process. The maximum likelihood algorithm was applied to classify the imagery, assigning pixels to specific land cover categories based on spectral characteristics.

Quantitative analysis involved measuring the extent and magnitude of LULC changes. This included calculating the area of land converted from one land cover type to another, quantifying the rate of change over the period from 2013 to 2023, and analyzing spatial patterns of change across the watershed.

In calculating the areas of each class in the land use/land cover (LULC) map using ArcGIS, several steps were undertaken:

Firstly, the LULC map was prepared ensuring proper formatting and georeferencing within ArcGIS. This map ideally was in raster format, with each cell representing a specific land cover class.

The attribute table of the LULC raster layer was accessed. This table contained information about the attributes of each cell in the raster, including the land cover class codes. The "Summary Statistics" tool in ArcGIS was utilized to calculate statistics for the LULC raster layer. The LULC raster layer was selected as the input, and the field containing the land cover class codes was specified as the "Case field". The statistic type chosen was "Area" to calculate the total area of each land cover class.

3.5.5 Effectiveness of the Water Governance Framework on Nyamuzizi River

The research aimed to assess the impact of social and governance frameworks on water resources management within the Nyamuzizi Watershed. A mixed-methods research design incorporating interviews and documentary analysis was employed to thoroughly investigate how the decentralization of decision-making processes influences water extraction from sand rivers in semi-arid rural regions.

3.5.5.1 Target Population

The study concentrated on the Nyamuzizi Catchment, specifically examining the communities and stakeholders impacted by water extraction from the sand river. This encompassed a diverse array of individuals, including residents, community leaders, water management authorities, and pertinent decision-makers engaged in water usage practices. The heterogeneous makeup of this target population aligns with the principles of Integrated Water Resource Management (IWRM), advocating for a comprehensive approach and inclusivity in addressing water management issues.

3.5.5.2 Sampling Strategy

Utilizing a purposive sampling method, the sample was selected to represent significant entities within the catchment area, such as the Lower Rwenya sub-Catchment Council, Environmental Management Agency, Mutoko Rural District Council, Nyamuzizi Ward 23 councillor, and local villagers.

3.5.5.3 Data Collection and Analysis

During the data collection phase, interview guides, conveniently placed in the appendices section, served as structured tools for conducting interviews. The participants in these interviews included the ARDAS Extension Officer, Lower Rwenya Sub-Catchment Officer, RDC Councillor, and an Environmental Management Officer; these guides facilitated comprehensive discussions on pertinent topics related to water governance within the Nyamuzizi Catchment.

Simultaneously, various documents, including but not limited to the Water Act, EMA Act, Rural District Councils Act, and relevant publications, underwent thorough examination during documentary research. These documents provided invaluable insights into the legal and regulatory frameworks governing water resources management in the study area.

Subsequently, to analyze the collected data effectively, a thematic content analysis approach was adopted. This methodology enabled the identification and exploration of recurrent themes and patterns concerning water governance, particularly focusing on the unique challenges posed by intermittent rivers like the Nyamuzizi River. Through this systematic analysis, a nuanced understanding of the complexities surrounding water management practices in semi-arid rural regions was attained.

Chapter 4

FINDINGS AND DISCUSSION

4.1 Introduction

This chapter elucidates the findings derived from a comprehensive investigation addressing pivotal research questions pertinent to water resource management and climate change adaptation in the Nyamuzizi Watershed of Mutoko District. The overarching aim of this inquiry is to evaluate the sustainability of water abstraction from sand rivers as a strategic response to climate change-induced poverty within the region.

The research questions guiding this study are as follows:

1. How is the adequacy of the sources of water available in selected Ward within the Nyamuzizi Watershed in Mutoko District in the face of climate change?
2. How are the socio-economic benefits derived from water abstraction from the sand river, alleviating climate change-induced poverty in a selected ward within the Nyamuzizi Watershed in Mutoko District?
3. How has water scarcity impacted on the land use/land cover patterns in the Nyamuzizi Watershed?
4. How effective is the governance framework in managing water from Nyamuzizi River in the face of climate change-induced scarcity?

These research inquiries serve as the cornerstone for assessing the intricate interplay between water resource management, climate change adaptation, and socio-economic development in the study area. The ensuing findings are of paramount importance to policymakers, implementers, donors, practitioners, and communities alike, providing crucial insights to inform decision-making processes regarding adaptation and resilience initiatives amidst the changing climate landscape.

In addressing the research questions, qualitative methods were predominantly employed, encompassing focus group interviews, observation and documentary research. This methodological approach facilitated a nuanced exploration of the multifaceted issues

surrounding water scarcity, climate change impacts, and poverty alleviation strategies within the Nyamuzizi Watershed.

The subsequent sections of this chapter are structured in alignment with the study objectives, presenting a systematic exposition of the findings followed by a rigorous analysis and interpretation thereof.

4.2 Adequacy of Water Resources within the Watershed

4.2.1 Introduction

Water, as a fundamental element for sustaining life, livelihoods, and ecosystems, plays a pivotal role in fostering sustainable development within communities. It serves as a cornerstone for various activities and is crucial for the overall well-being of individuals. This section presents the findings of the research study conducted to assess the adequacy of water resources within the Nyamuzizi Watershed. Specifically, the study, carried out through a focus group interview and observation methods, explored the factors that influence water demand and supply within the Nyahondo-Marira Ward, which is situated in this catchment area. An analysis of these factors is subsequently done in order to establish the current state of the adequacy of water resources in the context of climate change.

4.2.2 Factors Influencing Water Demand

The demand for water within the Nyahondo-Marira Ward is multifaceted, propelled by a combination of domestic, agricultural, and non-agricultural imperatives. Domestic water requirements, constituting a significant portion of overall demand, are notably influenced by the prevailing family structures within the community. Particularly, the adherence to polygamous practices within the Johanne Marange Apostolic sect, alongside a general aversion to family planning methods, results in sizable household populations. Responding to the question on what the average family size per household is in the ward, Participant 1 said:

“On average each homestead could have as much as 16 to 40 family members who need water for drinking, cooking, bathing and laundry. This imposes substantial demands on the few water resources that we have in the community and each family member fails to get sufficient quantities as an individual.”

The sentiments by Participant 1 supports similar findings by Fan, et al (2013), who established that larger households tend to consume less water on an individual basis, potentially due to shared water usage practices or more efficient water management within the household.

Beyond the sect's adherents, other villagers, although not necessarily affiliated with the sect, similarly rely on communal water sources for these primary needs. According to data from the 2022 Population Census (ZIMSTATS, 2022), the ward comprises a population of 1,048 individuals (Table 4.1), further accentuating the magnitude of domestic water demand.

Agricultural pursuits represent another significant driver of water demand within the ward, serving as vital sources of livelihood for the majority of households. Farming activities encompass both garden cultivation and animal husbandry.

On being asked what the average size of a garden plot was for each family, Participant 2 elaborated:

“The average plot size for each household range from 0.25 to 1 hectare. But we also have cooperative initiatives such as the Munjoma gardens, spanning a 10-hectare area. These plot are irrigated with water from deep wells as well as shallow wells dug in Nyamuzizi River.”

Participant 3 further expanded:

“We keep all types of livestock which include cattle, goats, sheep, chickens and ducks. Despite the cattle herd being reduced to an average of 5 per household by the January disease, some individual families still have as much as 60 cattle. Others rear 300 to 500 chickens at a given moment.”

These explanations by Participants 2 and 3 are in agreement with observations made by Sileshi et al. (2003) in a similar study carried out in Ethiopia. Some scholars suggest that the demand for water for agricultural purposes can be managed by adopting climate resilient farming practices (Ketiemi et al., 2015). In Zimbabwe, this being practised through conservation agriculture programmes like the Pfumvudza/Intwasa Programme and the promotion of small grains in the arid parts of the country.

Non-agricultural undertakings are also contributing to the water demand landscape as they are offering alternative sources of income for residents, including those without agricultural plots. On being asked if there are other activities that require water, Participant 4 responded,

“Brick moulding has gained prominence within the ward. It is a major source of income for those who cannot do farming because their plots are situated far away from any water source. However, there are conflicts that arise when the same water source used for brick-moulding is also used for irrigating garden plots”

The proliferation of such non-agricultural ventures underscores the diversification of livelihood strategies and the consequential implications for water utilization patterns. The conflicts highlighted by Participant 4 resonates with the findings made by Kativhu et al (2021) on their study on the influence of multiple uses of water on the sustainability of communally-managed rural water in Zimbabwe. However, the conflicts are not so common in the Watershed as villagers have a shared understanding of supporting each other’s source of livelihood.

4.2.3 Water Supply within the Watershed

4.2.3.1 Water Resources Available

Water sources available in all the villages in the ward are generally very few. Those that were observed during the field visit included water sources like deep wells and shallow sand aquifers as shown in photographs 42a, b, c, and d. Nyamuzizi river happens to be the major source of water for both primary use and agricultural needs for the majority of households within the watershed.

The ward councillor:

“We, unfortunately, have more open water sources than closed ones. There is only one borehole that is functioning and this was drilled through the efforts of our former councillor. It was drilled to a depth of 60 metres and is currently the only source of clean water since the other boreholes are broken down, while some are yet to be drilled at the pegged sites.”

4.2.3.2 Access to Water Sources

Only open water sources are within the proximity of homes or garden plots. The borehole was said to be too far away to be accessed by all the villagers. Participant 5, who was one of the elderly participants, in the focus group interview, lamented this,

“Imagine how difficult it is for us villagers, especially those who are physically impaired, to travel 6 to 7 kilometres in order to access this distant borehole. That is the reason we keep on drawing water from open sources like Nyamuzizi river”

Participant 6:

“Some of us who are privileged to still have cattle, after the demise of many cattle in the area due to January disease, are able to fetch water from the borehole with much ease using scotch carts. Otherwise the majority of the community members have to either endure the pain of walking for an average of 3 hours every day to the borehole or fetch water from the Nyamuzizi river which less than 30 minutes away”

This comment by Participant 6 is further substantiated in Photograph 4.1 which shows a man walking with 20 litre containers towards a shallow well dug in the sand bed of Nyamuzizi river.

Figure 4.1: Man heading to a well



Photo by Author

4.2.3.3 Challenges with Water Abstraction Methods

The methods used in drawing water from the water sources range from use of 20 litre buckets (Photograph 4.2c), treadle pumps (Photographs 4.2a), 5hp petrol pumps (Photograph 4.2b) and 50mm diameter siphons (Photograph 4.2d). These methods, have different challenges.

Participant 7:

“Buckets are sources of water contamination as people tend to step in the water in order to access it. So disease carrying germs can be transmitted from peoples ‘feet to the water.’”

Participant 8 complained about the cost of running petrol pumps:

“I use US\$8 every day to buy petrol to run the pump. This is a huge cost which result in me getting very low profits when I finally sell my produce.”

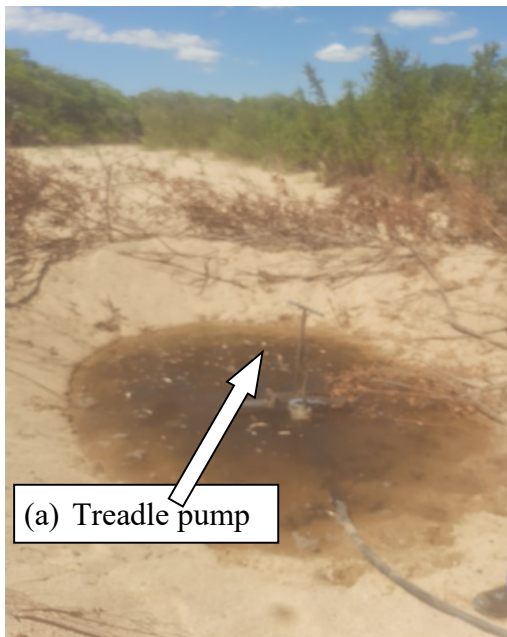
He further added:

“At the same time, a treadle pump is too hard to operate for the length of time required to irrigate to achieve field capacity. It is also limited to physically fit young people, though is less expensive in terms of running costs when compared to a petrol pimp.”

Participant 9:

“I am happy with the method of siphoning water from the well since I will be relying on the force of gravity to cause water to flow to my garden plots. Moreover, I have no operating costs that I incur. I only have to face the expense of buying the 50mm High Density Poly-Ethene (HDPE) pipes. However, the only problem I encounter these days is that of the water level declining excessively thereby making it difficult to siphon.”

Figure 4.2 : Abstraction Methods



Photos by Author

4.2.3.4 Impact of Climate Change on Water Supply

Besides being limited by challenges relating to typology of abstraction techniques, all villagers in the Watershed contend that climate change has emerged as a major constraint water supply.

Participant 10:

“Nyamuzizi river now flows for a shorter time period during the rainy season than before. It usually flowed for about a week just after a raining incident but these days it now flows for 4 days or less.

We are now able to fetch water from the deep wells up to August only during a normal rain season. Thereafter we have to either deepen our wells or we have to search for sites where the water table could be high. During drought water start to deplete as early as April.”

4.2.3.5 Quality of Water

The lack of nearby sources of clean water has left households exposed to water of poor quality. This has led to a range of health issues, including waterborne diseases and infections.

Participant 11:

“The quality of water that we use for cooking and drinking is contaminated with germs as evidenced by regular outbreaks of waterborne diseases like bilharzia and diarrhoea in the community.”

Participant 12:

“We also share water from open sources with both domestic and wild animals. There have been several incidences where wild animals have attacked villagers at these water points.”

Figure 4.3 Water point in the Sand River



Photo by author

Participants 11 and 12 highlights the common challenge of poor water quality which characterizes rural water resources. Their remarks resonate with similar observations made by Diawara & Loua, (2024) in rural Guinea. Ketiém et al (2015) recommends the establishment of separate water reservoirs for animals to eradicate human-animal interaction on water points meant for people.

4.3 Alleviation of Poverty through Sand Water Abstraction

4.3.1 Introduction

The socio-economic landscape of communities within the Nyamuzizi Watershed in Mutoko District is deeply intertwined with the availability and management of water resources, particularly evident in the Nyahondo-Marira Ward. This research delved into the intricate relationship between water abstraction from the sand river and its socio-economic ramifications, aiming to understand how these dynamics alleviate climate change-induced poverty. Through a multidimensional exploration, encompassing aspects of income generation, access to education, health, and social cohesion, this study sheds

light on the profound implications of water scarcity on rural livelihoods. By examining the challenges faced by villagers in sustaining their households through small-scale agriculture and other non-agricultural endeavours, as well as the repercussions on education, health, and community cohesion, this research elucidates the complexities of socio-economic resilience within the context of environmental change. Ultimately, it seeks to elucidate how the management of water resources plays a pivotal role in mitigating poverty and fostering sustainable development in the face of climate variability and change.

4.3.2 Income from Sand River Water Abstraction

4.3.2.1 Introduction

Ecosystem-based services encompass the range of benefits that human populations derive from natural ecosystems. Among these ecosystems, sand rivers, characterized by their courses through sandy substrates, assume pivotal roles in bolstering ecological integrity while furnishing tangible benefits to both human societies and environmental systems.

Within the context of the Nyamuzizi River watershed, situated within the Nyahondo-Marira Ward, the significance of water from the Nyamuzizi River is underscored by its substantial contribution to various economic activities supporting local households. While alternative water sources such as deep wells and shallow aquifers were observed during field investigations, it was apparent that water sourced from the Nyamuzizi River predominated in facilitating revenue generation endeavours within the region.

4.3.2.2 Findings

On being asked which income-generating activities depend on water from the Nyamuzizi River, villagers cited agriculture and brick moulding. Participant 13 explained,

“In this Ward we rely mostly on growing different types of crops that we sell in order to get money needed to support our family needs. We obtain water for irrigating in our gardens from the pits that we dig out in the base of the river.”

Participant 14 also added,

“Income from growing crops is also complimented by rearing of livestock which also drink water from Nyamuzizi River. However, the amount of water is not enough for both crops and livestock. So the amount of water available naturally limits the quantity of crops we can grow and the number of livestock we can rear, hence the income we get is also limited.”

Villagers were also asked if there are some non-agricultural activities which use water abstracted from the sand river and also produce incomes for the family. Participant 15 responded,

“Water extracted from Nyamuzizi is also used for brick moulding, which is also another source of livelihood for families without garden plots close to the river.”

Further discussions with the villagers revealed that the adequacy of the income from agricultural pursuits is contingent upon several factors, which include the availability of water resources, the spatial proximity of land plots to water reservoirs, accessibility to agricultural inputs, proximity to markets, and prevailing market prices.

The dwindling availability of water from traditional sources has become a source of distress among villagers, exacerbating the challenges they face in sustaining their livelihoods. Participant 6, speaking with palpable emotion, vividly described the repercussions of this decline on agricultural productivity and household income:

"The falling amounts of water available from the rivers have forced us to cut down the size of our gardens, thereby reducing potential income critical for supporting family needs."

This poignant testimony underscores the profound implications of climate change-induced water scarcity on the agricultural landscape and economic well-being of rural communities. As farmers grapple with diminishing water resources, their ability to cultivate crops and generate income is significantly compromised, perpetuating a cycle of poverty and vulnerability.

The adequacy of water resources, alongside the application of agricultural inputs such as fertilizers and chemicals, significantly influence both the quality and quantity of crop yields in the Ward. However, many farmers encounter difficulties in accessing these

inputs due to their prohibitive costs, which surpass their income capacities. As reported by the local ARDAS Extension Officer,

“Household incomes have dwindled from an average of US\$130 per month to approximately US\$50 per month over the past few years.” (ARDAS official, Personal Communication, April 16, 2024).

Consequently, farmers resort to utilizing cattle manure to a limited extent for their horticultural crops, albeit facing constraints due to the diminished cattle population resulting from the January disease outbreak.

The Nyahondo-Marira villagers also benefit from government input programs such as the Presidential Input Scheme and the Pfumvudza/Intwasa Programme, as confirmed by the Agricultural and Rural Development Advisory Services (ARDAS). However, the problem is that the inputs from these programmes are always availed late. While some villagers have not fully embraced the Pfumvudza/Intwasa Programme, those adhering rigorously to its technical recommendations have reported significant yield improvements. Notably, maize yields averaging approximately one ton per plot of 624 square meters underscore the efficacy of agricultural inputs in enhancing productivity alongside water availability.

The presence of accessible markets plays a pivotal role in crop production and livestock farming endeavours. Villagers naturally benefit from local market outlets, which are often established by communities inhabiting regions unsuitable for farming due to water scarcity or soil degradation. Farmers from Nyahondo-Marira transport their produce to nearby markets such as Mutoko Centre, and occasionally venture as far as Mbare Musika in Harare. Transportation logistics to these markets are typically organized collectively among farmers to mitigate costs and maximize efficiency.

However, farmers frequently find themselves at the mercy of market forces at Mbare Musika, with prices heavily influenced by supply and demand dynamics. Middlemen exert considerable control over market prices, compelling farmers to accept suboptimal rates to facilitate sales. This lack of bargaining power results in meagre profit margins for farmers, as eloquently expressed by Participant 20:

“We always end up adjusting to the market conditions so that we at least get money to go back home with. If I don’t accept where else am I going to get money to buy salt and cooking oil?”

Consequently, farmers often contend with unfavourable market conditions, further exacerbating their economic challenges.

Another source of income to the villagers are the annual congregational gatherings hosted by prominent religious groups in the ward. These create a huge market for their agricultural produce, generating substantial income for the local community.

Participant 4 elaborated,

“A notable example is the gathering organized by the Johanne Masowe ekwaMarange denomination, which consistently draws no fewer than 1,000 attendees per each annual event. This is an exciting event that earns us good money, though it happens once in a year”

In summary, the local inhabitants of Nyahondo-Marira Ward heavily depend on the abstraction of water from the Nyamuzizi River to support their various income-generating initiatives, predominantly in the realms of agriculture and brick-moulding. The financial returns derived from these endeavours are significantly influenced by two key factors: firstly, the accessibility of water resources from the river, and secondly, the prevailing market dynamics.

4.3.2.3 Analysis of Findings

The Sustainable Livelihood Framework (SLF) can be utilized to assess the extraction of water from sand rivers to generate income. It is a widely recognized approach that examines the various dimensions and interactions of livelihoods and provides a framework for understanding how individuals and communities can improve their well-being in a sustainable manner. In an analysis of sustainable livelihoods, sustainability is taken into account in terms of the capital that is available—natural, human, social, physical, and financial—as well as the vulnerability context, which is the trends, shocks, and stressors that these assets are subject to (Serrat, 2017; Morse et al., 2009).

In the context of Nyahondo-Marira Ward water abstraction from Nyamuzizi River represents a dimension of natural capital of the SLF. Its availability and quality act as a crucial natural asset for the villagers to generate income and sustain their livelihoods. The SLF emphasizes the livelihood strategies adopted by individuals and communities to generate income and improve well-being. Water abstraction from the Nyamuzizi River, thus, serves as a livelihood strategy for the villagers in Nyahondo-Marira Ward. By

utilizing the water resource, they diversify their livelihood options and enhance their income generation potential which is key to poverty alleviation.

The SLF considers external factors such as social, economic, and environmental dynamics, recognizing the vulnerable context in which livelihoods function. In this case, the villagers' water abstraction practices may be driven by the vulnerability of water scarcity or unreliable water sources in the region. By accessing water from the Nyamuzizi River, they mitigate the vulnerability of their livelihoods to water shortages and ensure a more reliable water supply for income generation.

4.3.3 Access to Education

4.3.3.1 Introduction

Empowering children with education has the ultimate benefit of eradicating poverty in a rural setting. Thus, the utilization of water from Nyamuzizi River has facilitated financial sustenance for educational endeavours within the ward. This water has enabled parents to partake agricultural activities in their plots whose proceeds have successfully financed their children's education

4.3.3.2 Findings

When asked how far they have managed to support their children's education through water abstraction from Nyamuzizi River, Participant 18 responded,

“We have always been able to support our children's education up to tertiary levels through proceeds derived from selling produce that we obtain from our garden plots along the Nyamuzizi River Basin.”

Another participant pointed out that the decline in water availability is now affecting their revenue streams and making it difficult to timeously and sufficiently honour their school fees obligations. Participant 21,

“These days we are no longer able to raise enough money to pay school fees in time because the available water quantities are becoming less and less because of changing rainfall patterns. As a result, a significant number of children have withdrawn from schools, resulting in declining enrolment rates in some institutions, and the closure of others, such as Kanyongoro Secondary

School. The declining attendance rates have also precipitated the departure of educators from these institutions. For instance, Hadya Primary School currently operates with only three teachers, catering to students from early childhood development (ECD) to grade seven.”

4.3.3.3 Analysis of Findings

The discussion with the villagers highlighted the importance of water availability in the semi-arid rural areas for the advancement of children’s education. This is in agreement with Amahmid et al. (2018), who assert that access to water from sand rivers has some educational implications that are quite significant. Its availability secures support for education, which is key to the eradication of poverty, particularly in semi-arid rural settings.

The research findings on how water abstraction from the Nyamuzizi River benefits education of children in the Nyahondo-Marira Ward illustrate a bleak outlook. The problems of high numbers of school dropouts, closure of schools and unavailability of teachers highlighted by Participant 21 fly in the face of global efforts to achieve Universal Access to Education. While this goal is a human right, the effects of climate change on water availability in the sand river are becoming a hindrance to parental efforts to partake in this responsibility. The failure of children to continue attending school, especially at primary school level, because parents cannot afford to pay the school fees conflicts with the United Nations International Children’s Emergency Fund's (UNICEF) calls for Free Basic Education. It also reveals the government's noncompliance with the UNICEF agreement, which requires that 20% of the national budget go toward education.

The research has revealed the need for a consensus by all stakeholders on intervention modalities for rescuing the education of children from demise emanating from the impact of climate change on sources of educational support like sand river water abstraction.

4.3.4 Health and Family Well-being

4.3.4.1 Introduction

The health status of households in the Nyahondo-Marira Ward is significantly influenced by two principal determinants: access to potable water and the unavailability of sufficient and nutritious food resources.

4.3.4.2 Findings

The physical location of the borehole, which is the only source of clean water open to the community, is too far to be conveniently accessed by all the villagers. Hence there is heavy reliance on contaminated water from Nyamuzizi River perpetuating the prevalence of bilharzia in the ward. When asked what the source of water for animals is in the area, Participant 19, responded:

“We share sand wells excavated along the Nyamuzizi water course with livestock because there are no other sources of water for animals. We usually get sick but because we cannot find money to travel to a clinic we resort to traditional remedies.”

The dwindling availability of water from the river is inhibiting the production of sufficient food that meets the nutritional requirements of a good diet. In responding to the health status of children, Participant 13 said.

“Our children generally suffer from malnutrition because we cannot provide them with a balanced diet in their daily meals. In severe cases, school children attend classes after consuming only a 30g packet of Maputi (Shona vernacular).”

Participant 2 also reported some help they received in dealing with malnutrition,

“Local health authorities address this malnutrition through periodic home visits to distribute F75 and F100 milk supplements to affected children. Additionally, support also comes from organizations such as UNICEF and the Department of Social Welfare which distribute food to all households.”

The community also reported a high prevalence of diarrhoeal diseases, a common symptom of waterborne illnesses, with observed fatalities linked to diarrhoea-related complications. Limited transportation options in the region hinder access to medical facilities, with only one commuter omnibus servicing the route daily, impeding timely medical intervention when needed.

4.3.4.3 Analysis of Findings

The findings on the health implications of water abstracted from Nyamuzizi river divulge how poverty can be exacerbated in the rural areas through illnesses associated with either the quality of water from rivers or its inadequacy.

The reliance on the Nyamuzizi River for domestic water supply suggests a limited utilization of groundwater resources via borehole infrastructure in the region, a notion seemingly at odds with Manyakaidze et al.'s (2024) assertion that groundwater serves as the primary water source for rural areas. Consequently, the poor health of the community becomes a persistent constraint to attaining the Sustainable Development Goal 3 on good health and well-being of families within the watershed.

Moreover, the impact of food deprivation on children's health, exacerbated by water scarcity, reinforces the findings of multiple scholars indicating stunted natural growth. Emerging research suggests that household food insecurity hinders children from attaining their complete physical, cognitive, and psychosocial capacities (Gallegos et al., 2021). In numerous nations and global regions water scarcity has emerged as the primary limiting factor for augmenting food production (Seckler et al., 1998).

4.3.5 Social Cohesion

4.3.5.1 Introduction

In the Nyahondo-Marira Ward, characterized by small-scale farming, social cohesion manifests through communal efforts and shared resources, particularly concerning water accessibility from sand aquifers.

4.3.5.2 Findings

In order to access water from the sand rivers, villages always work together in digging up wells. This teamwork continues as new wells are dug after the drying up of others.

However, not everyone participates. Disputes erupt when these villagers want to also draw water from these wells when they never participated in the digging process.

Participant 22 angrily lambasted such attitude,

“Why does someone want to benefit from something that one never worked for? The fact that one excludes himself or herself from collective efforts means that you have your own source of water. So stay away from our wells.”

The community have its own dispute resolution mechanism. Unlike communal setups with designated village heads overseeing social disputes, this ward relies on internal mechanisms for conflict resolution, minimizing the need for external mediation. The presence of village heads within the community further reinforces this decentralized approach to dispute resolution. While criminal cases are directed to the police, disputes arising from water scarcity or over-abstraction are predominantly managed within the community.

During periods of water scarcity, villagers unite to share the limited available resources, fostering a sense of collective responsibility and solidarity. However, challenges arise when individuals over-abstract water thereby straining community cohesion. Participant 7 complained about the self-centred attitude amongst some individuals in the community,

“It is very sad to note that we have some people in our community who only think about themselves even during difficult times like these when water quantities are so little. How can someone think about herself or himself only by emptying wells at night without considering that others also need water the following morning?”

4.3.5.3 Analysis of findings

The research findings disclosed the importance of community cohesion and collective action in managing water resources. Despite challenges such as disputes over water abstraction, the shared dependence on water fosters unity and a collective sense of responsibility within the community. Water scarcity underscores the necessity for cooperation and equitable distribution, reinforcing bonds within the community. Additionally, the absence of centralized authority encourages self-governance and communal problem-solving, enhancing social cohesion. This highlights the resilience of rural communities in the face of adversity and the significance of community-based approaches to resource management and conflict resolution.

In summary, the issue of social cohesion in the Nyahondo-Marira Ward revolves around the shared utilization of water resources from sand aquifers. While disputes are primarily resolved internally, criminal cases are referred to external authorities. Despite challenges such as over-abstraction, the community's reliance on shared resources fosters unity and a collective sense of purpose, contributing to social cohesion within the ward.

4.4 Impact of Water Scarcity on Land Use/Land Cover Patterns

4.4.1 Introduction

The previous section revealed how climate change is impacting water resources critical in sustaining the socio-economic fabric of villagers in the Nyamuzizi Watershed. It is also important to bring to the fore how the water scarcity is affecting the land use/land cover patterns in the Watershed, while assessing the attribution of population dynamics as well. As highlighted in chapter 2, changes in population within the river basin are also linked to the levels of water abstraction from the existing water resources.

4.4.2 Population Changes within Nyamuzizi Watershed

Table 4.1: Population changes in Nyamuzizi Wards

WARD	POPULATION STATISTICS		
	2012	2022	%age Population Change
18	8548	9704	13.5
23	958	1048	9.4
24	864	877	1.5
27	1572	1707	8.6
28	5389	4992	-7.4

Source: ZIMSTATS (2012,2022)

In the table, Ward 18 has the largest population in the Watershed and its population has increased relatively more than the other wards. Ward 24 has both the least population size and population change. Despite having the second largest population size in the Nyamuzizi Watershed, the population size of Ward 28 dropped over the ten-year period.

The location of Ward 18 is adjacent to Makaha village in Mudzi district where small scale mining of gold occurs. Since this activity provides an opportunity for deriving income, a large number of villagers are drawn to this area.

The bulky of land within Ward 24 is non-arable and is generally rocky. As such, the geographical status of the area naturally limits occupation and does not provide space for meaningful agricultural production.

Ward 28 is situated closer to Motoko town centre. The decline in population could possibly be as a result of rural to urban migration being propelled by the deteriorating economic environment facing the country.

Percentage Change in Nyamuzizi Watershed Population

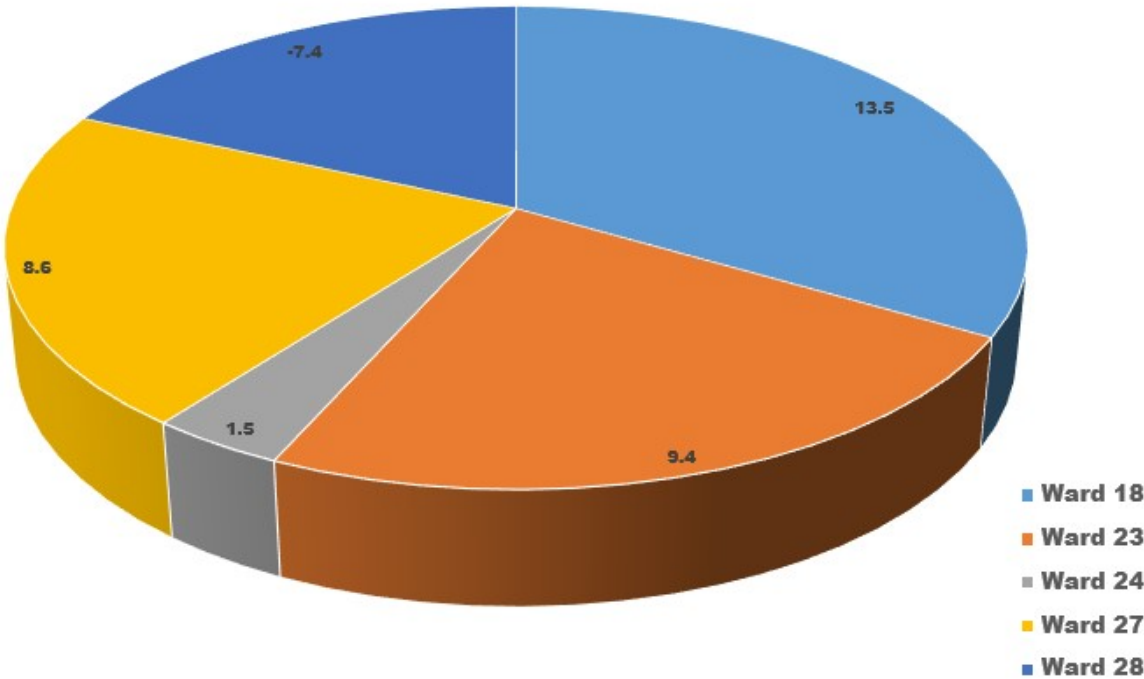


Figure 4.4 : Population Percentage change

4.4.3 Changes in Land use/Land cover in the Nyamuzizi Watershed

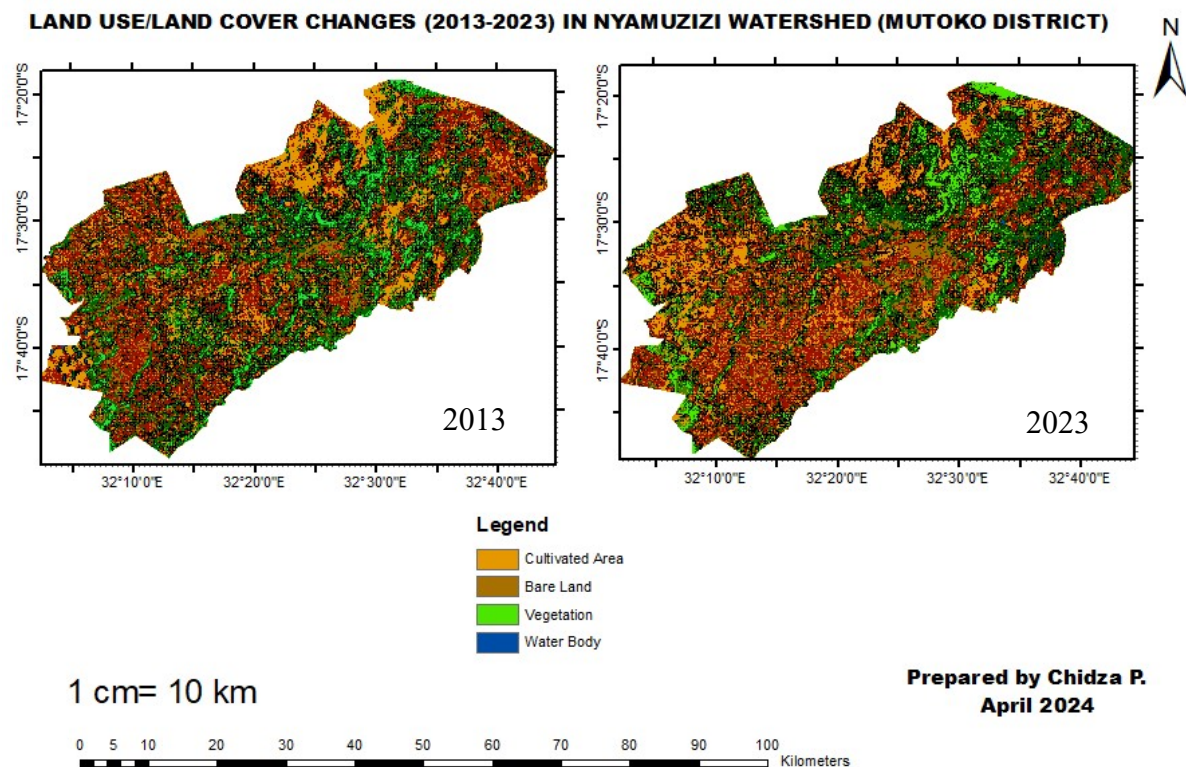


Figure 4.5: Changes in the LULC (2013-2023)

Table 4.2: Change in LULC from 2013 to 2023

CLASS	AREA (ha)-2013	AREA (ha)-2023	Percent Change
Cultivated Area	84882.69789	80090.50429	-2.36091908
Bare Land	71484.27631	70566.0718	-0.45428754
Vegetation	45885.83839	46711.06244	0.40444469
Water Body	967.5738871	5867.149351	2.41076193

Prepared by Author

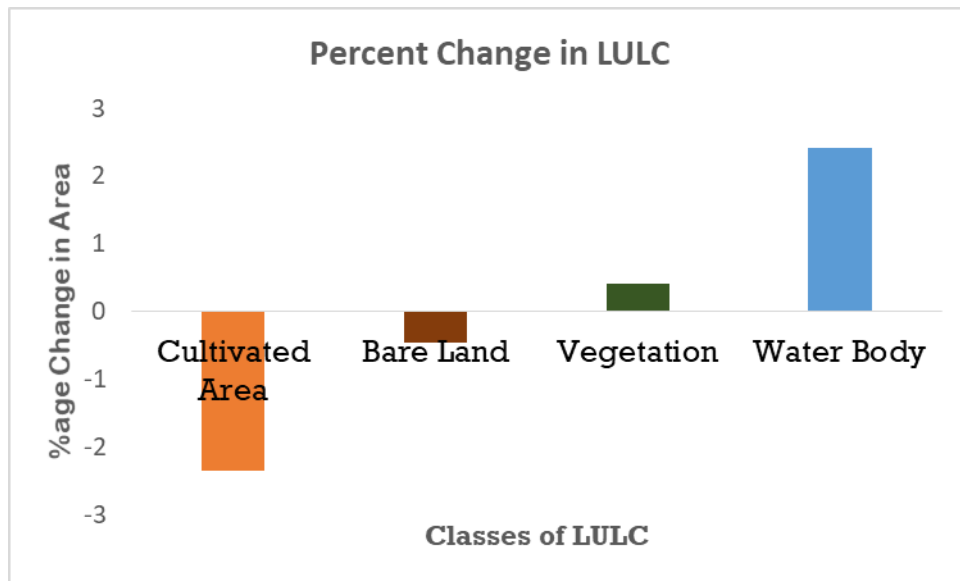


Figure 4.6: LULC percentage changes

Table 4.2 and Fig. 4.3 show that cultivated area and bare land have declined over the 10-year period in the Watershed area. The shift in the cultivated area can be attributed to the area's shifting patterns of rainfall as a result of climate change. As a consequence, villagers have reduced the area on which maize and other summer crops are grown. On the other hand, the decline in bare land is due to the increase in land use of the area close to shallow wells, sand aquifers and river banks. So, villagers are abandoning dryland areas opting to cultivate areas within the proximity of water sources.

The increase in vegetation is as a result of grasses and bushes that are now emerging in abandoned cultivated areas. It is also due to the increase in canopy cover from trees that have survived deforestation over the years.

The increase in water bodies, provides further evidence of the increasing exploitation of water resources for agricultural production. Villagers are excavating shallows wells in places where the water table is high and utilize the water found to irrigate gardens.

4.4.4 Conflict between Preservation of Riparian Zones and Poverty Mitigation

The quest to grow crops for sale has driven many villagers in the ward to site their gardens within the proximity of Nyamuzizi river basin and its tributaries where water can be conveniently accessed. Despite acknowledging the negative impact this practice inflicts to

both the river and the riparian environments and also being aware of environmental regulations, the garden farmers emphasize the need to derive income which is critical to their livelihoods as a prevailing factor. One garden farmer, defended the practice:

"We have no option but to use this water from these sites since we want to reduce suffering emanating from poverty." (Villager, Personal communication, April 10, 2023)

Another farmer, however, expressed worries over the decline in river discharge,

"We have since observed that stream bank cultivation has reduced the volume of water flowing in our rivers." (Farmer, personal communication, April 10, 2024).

The Environmental Management Agency (EMA) frequently visit the ward to discourage farmers from engaging in stream bank cultivation, but because farmers have no alternative source of livelihoods, they continue with their agricultural activities. An EMA Officer highlighted challenges in the enforcement of environmental regulations,

As authorities we, currently, resort to awareness campaigns rather than enforcement of regulations because of a number of constraints. Firstly, the riparian zones offer sources of livelihoods to a large number of villagers since there are no other alternative sources within the area. Secondly, as officers we are naturally constrained by the amount of resources required for enforcement that are at our disposal". (EMA officer, Personal Communication, April 2024)

However, despite the shortcomings experienced by EMA, the Motoko Rural District Council (RDC) also compliment EMA on raising awareness to villagers on the problems associated with streambank cultivation and the need to conserve water. Furthermore, the council intends to peg the distance from the course of Nyamuzizi river and other tributaries as an act of enforcement.

4.4.5 Analysis of LULC Changes in the Nyamuzizi Watershed'

Population censuses have revealed a modest average demographic shift of approximately 5%, which does not appear to exert a significant influence on land use and land cover changes within the area under examination. Instead, the primary drivers of these changes

predominantly stem from the adverse impacts of climate change, notably manifested through diminished water availability. This decline in water resources is notably observed in traditional sources such as the Nyamuzizi river. Concurrently, there is a discernible shift in land use patterns, characterized by an escalation in the creation of customized water bodies. Despite the decreasing water quantity in the Nyamuzizi river, there is a notable expansion of agricultural activities within its riparian zones.

4.5 Governance of Water Resources in Rural Zimbabwe

4.5.1 Introduction

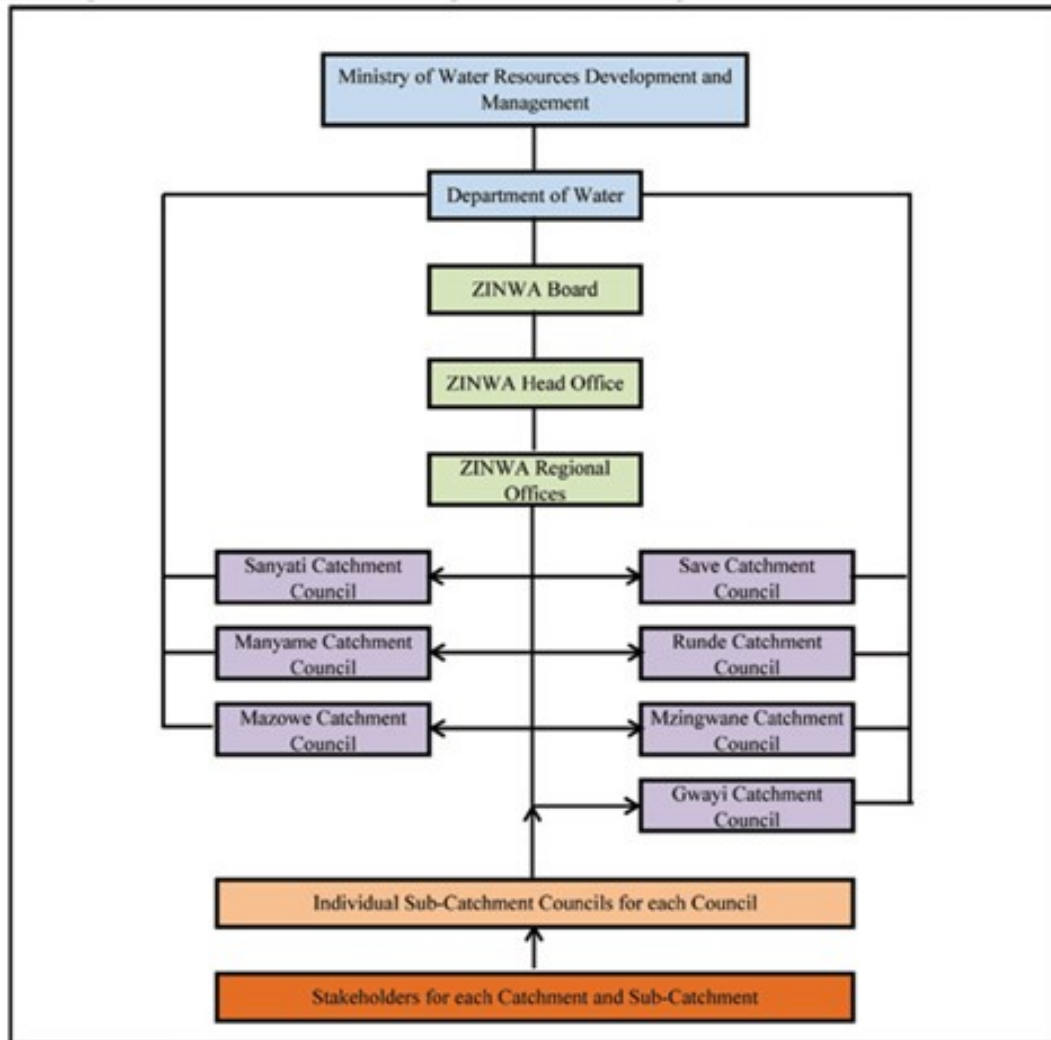
Effective governance frameworks for water resources hold equal significance in rural areas as they do in other contexts. Zimbabwe has an established comprehensive water governance framework that spans across all geographical locales, ensuring unified management of water resources. This section critically examines the governance structure governing water resource management in Zimbabwe, with a specific focus on the Nyamuzizi River and its associated tributaries. Through this investigation, the effectiveness of the governance mechanisms regulating this vital sand river is evaluated, shedding light on its efficacy in addressing contemporary water management challenges.

4.5.2 Overview of the Water Governance Framework in Zimbabwe

Water governance in Zimbabwe is governed by a comprehensive framework encompassing legal, institutional, and policy components. The Water Act serves as the cornerstone, delineating the rights and responsibilities of stakeholders including the government, communities, and water users.

Fig. 4.4 illustrates an organogram of the Water Authority from the national level to the local level.

Figure 4.4: The Water Authority Structure



Source: Ministry of Water Resources Development and Management.

An Integrated Water Resources Management (IWRM) approach is adopted, recognizing the interconnection of water, land, and ecosystems. As a consequence, water allocation is managed through a system of permits and licenses, which clearly outline the terms of usage for different purposes like irrigation, industrial processes, and domestic consumption. This aims for a balance between competing water demands while ensuring environmental sustainability and social equity.

In particular, rural water resources in Zimbabwe are governed through a multi-tiered approach that involves national policies, government institutions, local authorities,

community participation, and stakeholder engagement. This collaborative governance model aims to ensure equitable access to safe and reliable water supplies for rural populations while promoting sustainability and resilience in the face of challenges such as climate change and water scarcity.

4.5.3 Governance of Water Resources in the Nyamuzizi Watershed

The legislative framework defined in the Water Act facilitates the management of rural water resources at the local level, aligning with the tenets of Integrated Water Resources Management (IWRM). This legislative provision underscores a decentralized approach to water governance, emphasizing the involvement of local entities in decision-making processes pertaining to water resource management.

Sections 22 to 24 of the Water Act, Chapter 20:24 delineate provisions for decentralizing authority in water resource management. This is achieved through the establishment of catchment and sub-catchment councils, as stipulated within the legal framework. As an example, the Nyamuzizi River falls under the jurisdiction of the Mazowe Catchment and is locally administered by the Lower Rwenya Sub-Catchment Council. This institutional arrangement reflects a deliberate effort to devolve decision-making powers to regional entities, fostering localized governance and management of water resources. In that regard, the decentralized decision-making authority, allows for inclusion of other stakeholders with diverse interests. Stakeholder engagement plays a crucial role in the decision-making process regarding water management. As such, local communities, water user associations, NGOs, and other relevant parties are actively involved, fostering a collaborative approach to address water-related challenges and make informed decisions.

The principle of inclusivity in the governance of Nyamuzizi water resources is also reflected in the composition of the sub-catchment council. Councillors from the Nyamuzizi wards represent the Mutoko Rural District Council in the sub-catchment council. The Rural District Council is empowered by the Rural District Council Act, Chapter 29: 13, to administer by-laws that prohibit over-exploitation of natural water resources and protection of the environment. It complements the Zimbabwe Environmental Management Agency who, through the Environmental Management Act, Chapter 20: 26, enforce the conservation of the environment within the riparian zones of rivers.

Local community constitute a very significant component in the stakeholder portfolio. Their participation in the sub-catchment council meetings brings to the fore the concerns and suggestions from those at the grassroots. In the Nyahondo-Marira Ward, for example, there are some water users' groups, that cooperate in the excavation of sand wells in the Nyamuzizi water course, as well as develop some water management strategies that results in the optimum use of the limited water quantities.

One villager testifies this,

'We regularly meet as villagers to review the water situation in our local water sources. If water levels deplete, a resolution to stop garden farming is always adopted. In extreme cases, the volume of water a family is allowed to draw can be reduced to a single 20 litre bucket per day.'

(Villager, Personal Communication, April 2024.)".

Such decision-making elucidates the importance of social cohesion in response to a crisis of common cause in semi-arid rural areas in the face of climate change.

4.5.4 Effectiveness of Water Governance Framework in the Watershed

The water crisis, which is a natural phenomenon within the Watershed, is so acute. As such, the governance structures are more seized with the topical issue of water provision than regulation. The councillor of Ward 23 reported,

"ZINWA intends to drill more boreholes in the ward for the provision of cleaner water for primary use. Villagers are already contributing the fuel required for this operation." (Ward Councillor, Personal Communication, April 2024).

The lower level of the governance framework is more oriented towards resolution of social water conflicts than cooperation in the maintenance of broken down water infrastructure a development of new abstraction sites. A female member complained,

"Community members have failed to reach consensus on how to raise money to replace some worn-out rubbers for one of the well pumps. Others do not participate in digging new water wells when the old ones dry out. But these people wake at 12.00 mid night to go and poach water while most of us are

asleep. When we go to fetch water in the morning we find very little amounts left.” (Female villager, Personal Communication, April 2024).

4.5.5 Analysis and Interpretation of Findings

The scenarios outlined above underscore the nuanced challenges inherent in implementing governance best practices, particularly in the context of water scarcity exacerbated by climate change. Amidst these challenges, the paramount concern revolves around devising interventions capable of ameliorating the plight of communities within the watershed by enhancing water supply reliability. The effectiveness of governance frameworks, consequently, hinges largely on the tangible outcomes observed in the availability and accessibility of water resources. Presently, authorities encounter limitations in evaluating this effectiveness comprehensively, with the onus often falling on local villagers to spearhead decision-making processes, given their acute vulnerability to water scarcity. Thus, empowering local stakeholders to assume leadership roles in water resource management becomes imperative for ensuring sustainable solutions that address the pressing needs of affected communities.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the findings, the conclusions, limitations to the study and recommendations.

5.2 Summary of Findings

From a thorough analysis of the data collected through focus group interviews, open-ended interviews, field observations, documentary research and GIS and Remote Sensing, the following significant findings are summarized.

5.2.1 The Sufficiency of Water Resources in the Nyamuzizi Watershed

The research delved into the water dynamics within the Nyamuzizi Watershed, examining factors affecting demand and supply, alongside the impact of climate change.

Within the Nyahondo-Marira Ward, water demand is influenced by diverse factors. Large household sizes contribute significantly to domestic water needs. Agriculture constitutes another major demand driver, with crop farming and livestock rearing requiring substantial quantities of water. Additionally, non-agricultural activities such as brick moulding supplement income but also increase water demand, sometimes leading to conflicts over shared water sources.

However, there are challenges in ensuring adequate water supply. The watershed relies primarily on a few water sources like open wells and the Nyamuzizi River, with accessibility being an issue, especially for physically impaired individuals. Various methods of water abstraction pose their own challenges, including contamination risks, high operational costs, and physical limitations.

Moreover, climate change exacerbates these challenges. Reduced flow in the Nyamuzizi River and early depletion of wells during drought periods highlight the vulnerability of water resources to climatic shifts.

Poor water quality compounds these issues, leading to waterborne diseases and health concerns, exacerbated by contamination from human and animal use of open water sources.

5.2.2 Poverty Alleviation through Sand River Water Abstraction

The research investigated how water abstraction from the sand river in the Nyamuzizi Watershed, particularly within the Nyahondo-Marira Ward, impacts socio-economic factors. Drawing water from the Nyamuzizi River plays a crucial role in alleviating poverty among villagers in the Nyahondo-Marira Ward. The research highlights several socio-economic aspects, both at the household and community levels, that are supported by the utilization of water from the sand river. These aspects include income-generating activities, children's education, health and well-being, and social cohesion.

Agriculture emerges as a significant income-generating activity for most families in the ward. but declining water availability reduces the extent of crop cultivation, thus affecting household income. Brick moulding is another alternative source of income, mostly to those villagers without garden plots. Revenue is generated through the sale of produce within the community and at local markets, with some farmers even venturing to sell their goods as far as Mbare Musika in Harare. Access to distant markets like Mbare Musika is facilitated through collective transport arrangements. However, farmers often find themselves selling their produce at less-than-ideal prices due to market dynamics, thereby limiting their profit margins.

Historically, agricultural income used to sufficiently support children's education. However, the declining availability of water in the sand river due to climate change has severely disrupted this, leading to decreased enrolment rates and closures of schools due to financial constraints.

The problem of water scarcity causes villagers to rely on unsafe water sources, leading to waterborne diseases like bilharzia and diarrhoeal illnesses. Access to healthcare facilities is hampered by the absence of regular public transport.

The limited water available drives the community to unite and assume collective responsibility in the management of water abstraction from the sand river. However, challenges like over-abstraction strain community cohesion.

Overall, water scarcity significantly affects income generation, education, health, and social cohesion. Climate change exacerbates vulnerabilities, highlighting the need for sustainable water management and holistic development interventions tailored to rural communities' specific needs.

5.2.3 Impact of Water Scarcity on Land Use/Land Cover Patterns in the Watershed

The research investigated how water scarcity impacts land use and cover patterns in the Nyamuzizi Watershed, considering population dynamics and socio-economic factors.

Population changes vary across wards, with Ward 18 experiencing the largest increase due to nearby gold mining opportunities. Conversely, Ward 24 has the smallest population and limited agricultural potential, while Ward 28 sees a decline attributed to rural-to-urban migration.

In terms of land use and cover, cultivated and bare land areas decrease over time due to changing rainfall patterns and proximity to water sources. Vegetation increased as grass and bushes reclaim abandoned areas, while water bodies expand with the excavation of more wells for irrigation purposes.

Despite environmental concerns, farmers continue to cultivate within the riparian zones of Nyamuzizi River, highlighting the prioritization of economic welfare. Environmental agencies face challenges enforcing regulations due to limited capacity.

Analysis suggests that demographic shifts have minimal impact on land use compared to climate change-induced water scarcity. Despite diminishing water resources, agricultural activities expand near rivers, reflecting the complex interplay between socio-economic factors and environmental pressures.

In summary, climate change-induced water scarcity is driving changes in land use in the Watershed, while socio-economic factors are influencing agricultural practices near water sources. Efforts to prohibit cultivation of land close to the river encounter challenges because these sites offer a more immediate pathway to poverty alleviation.

5.2.4 Effectiveness of the Governance Framework for Nyamuzizi River

The research delved into the governance framework of Nyamuzizi River. The governance is decentralized, with catchment and sub-catchment councils overseeing water

management. Local entities, including the Mutoko Rural District Council and community water user associations, also play pivotal roles.

Despite these efforts, the effectiveness of the governance framework faces challenges. It mainly focuses more on water provision than regulation. Issues such as protection of the environments of the river and equitable water distribution are receiving little attention. The unequal access to water often leads to social disputes among community members.

5.3 CONCLUSIONS

5.3.1 Introduction

The study sought to determine whether it would be feasible to sustainably extract water from sand rivers in order to adapt to the effects of climate change and reduce poverty in the Nyamuzizi watershed. The central issue that emerged from the study is that climate change-induced decline in water availability is hindering the sustainability of water abstraction from sand rivers as an adaptation approach to poverty alleviation in semi-arid rural settings. Here's why:

5.3.2 Effect of Insufficient Alternative Water Sources on Nyamuzizi River

The inadequate supply of water from alternative sources has resulted in a heightened reliance and pressure on extracting water from the Nyamuzizi River. Consequently, the rate of abstraction from this river has increased significantly. This elevated rate of water withdrawal from the Nyamuzizi River raises concerns about the quality of the water and its long-term sustainability as a reliable water source for the local population.

The heightened abstraction has the potential to lead to the concentration of pollutants, increased turbidity, and a higher risk of saline intrusion, particularly during periods of low flow or drought. The overexploitation of the river can disrupt the natural hydrological processes and compromise the integrity of the aquatic ecosystem, further degrading the water quality and posing health risks to the community.

Moreover, the prolonged over-extraction from the Nyamuzizi River can have severe consequences for the local groundwater reserves and the river's overall resilience to climate variability and change. Depletion of groundwater resources, lowering of water tables, and reduced resilience to climate impacts can lead to more frequent and severe

water scarcity, jeopardizing the long-term sustainability of the water supply for the local population.

These findings raise doubts about the effectiveness and reliability of relying on water abstraction from the Nyamuzizi River sand as an adaptation approach to address climate change and poverty alleviation in the region. The potential risks to water quality, quantity, and long-term availability undermine the viability of this strategy in building the adaptive capacity and resilience of the local communities.

5.3.3 Diminishment of Socio-Economic Benefits Dependent on Water

As the impacts of climate change intensify, the reliability and availability of water from the Nyamuzizi River sand may become increasingly uncertain, potentially compromising the effectiveness and sustainability of any adaptation strategies that depend on it.

The decreasing water quantity have cascading effects on the ability of the water abstraction practices from the sand river in supporting poverty alleviation initiatives. As the reliability and availability of this water source diminish, the socio-economic benefits that were intended to be derived from it, such as increased income, improved access to education, good health and social cohesion will be in jeopardy. This undermines the effectiveness of water-dependent poverty alleviation strategies and leave the local population more vulnerable to the impacts of water scarcity.

5.3.4 Anthropogenically-Driven Siltation in Nyamuzizi River

The intensification of agricultural activities within the riparian zones of sand rivers has led to an exacerbation of siltation processes in the Nyamuzizi River. This anthropogenically-driven phenomenon of sediment deposition not only presents environmental challenges but also impedes the natural flow of water within the river system. The escalating rate at which this issue is progressing casts a shadow over the future sustainability of surface water flow, thereby endangering the viability of livelihoods reliant on this nature-based resource.

5.3.5 Ineffective Governance Framework for Sand River Water Management

The inadequacy of the governance framework for sand river water management is hindering the promotion of sustainable water abstraction practices in the Nyamuzizi Watershed. Periodic instances of water depletion exacerbate tensions within the Watershed community due to insufficient consideration of equitable access issues. Additionally, limited regulatory capacity among governing authorities prolongs existing water management challenges, perpetuating concerns well into the foreseeable future. Ultimately, this undermines the adaptive capacity of sand river water abstraction methods, jeopardizing their long-term viability as ecosystem-based poverty mitigation measures.

5.3.6 Conclusion

In summary, the study underscores the critical challenge posed by climate change-induced water scarcity to the sustainability of water abstraction from sand rivers as an adaptation strategy for poverty alleviation in semi-arid rural areas like the Nyamuzizi Watershed. The heightened reliance on extracting water from the Nyamuzizi River due to insufficient alternative water sources has led to increased abstraction rates, raising concerns about water quality and long-term sustainability. This overexploitation risks concentrating pollutants, increasing turbidity, and compromising the aquatic ecosystem's integrity, posing health risks to communities. Furthermore, prolonged over-extraction threatens local groundwater reserves, reducing resilience to climate impacts and exacerbating water scarcity. These findings question the effectiveness of relying solely on Nyamuzizi River sand abstraction for addressing climate change and poverty alleviation, highlighting the risks to water quality, quantity, and long-term availability. Ineffective governance frameworks exacerbate these challenges, hindering the promotion of sustainable water management practices and jeopardizing the adaptive capacity of sand river water abstraction methods as ecosystem-based poverty mitigation measures.

5.4 LIMITATIONS OF THE STUDY

5.4.1 Scope of the Study

The focus of the study on the Nyahondo-Marira Ward within the Nyamuzizi Watershed may restrict the generalizability of its findings to other areas within the watershed or similar semi-arid rural settings. Variations in socio-economic conditions, land use

practices, and water management strategies across different wards may influence water dynamics and present unique challenges not captured in the study's scope. A more comprehensive study would have been enabled by the availability of a longer time frame as well as adequate travel logistics.

5.4.2 Unknown Ground Water Resource Potential

The limitation presented in this section pertains to the lack of readily available data on the hydrogeological status, specifically regarding groundwater resources within the Nyamuzizi Watershed. This absence of data hampers the assessment of the potential of underground water resources to alleviate pressure on the Nyamuzizi River. Consequently, the study is unable to establish the capacity of groundwater sources to supplement existing water sources effectively. This gap in knowledge represents a significant limitation in the assessment of the sustainability of water abstraction practices within the area. Without a comprehensive understanding of groundwater availability and characteristics, it is challenging to develop informed strategies for water resource management and adaptation to changing environmental conditions. Therefore, addressing this data gap is crucial for enhancing the comprehensiveness and accuracy of assessments related to water resource sustainability and management within the Nyamuzizi Watershed.

5.5 RECOMMENDATIONS

It has emerged that the sustainability of water abstraction from Nyamuzizi River is as a result of climate change-induced water scarcity which has caused over-exploitation of water from the sand river. At the same time the use of underground water is limited only to a single borehole, which also discriminates users in terms of proximity to its location. It is, therefore, recommended that a detailed hydrogeological study be carried out through the Nyamuzizi Watershed. The results need to be followed up by development of the groundwater resources through installation of adequate boreholes in sites which enable access to fall under 30 minutes of walk.

Furthermore, garden plots should be replaced with plots located further from the river basins of the river but equipped with irrigation infrastructure and the means to convey water from either the sand river or boreholes. This measure will arrest environmental degradation in the riparian zones of the sand river, thereby ensuring its sustainability.

The capacity of water and environment authorities to monitor and manage sand rivers need to be enhanced by availing the adequate resources. At the same time, engagement of all stakeholders need to be strengthened. These recommendations will go further in boosting the effectiveness of governance frameworks of sand rivers.

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APPENDICES

APPENDIX A: INTRODUCTORY LETTER

DEPARTMENT OF GEOSCIENCES

BINDURA, Zimbabwe

Tel: 071 - 7531-6, 7621-4

Fax: 263 - 71 - 7534/6316



BINDURA UNIVERSITY OF SCIENCE EDUCATION

23 February 2024

To Whom It May Concern:

ASSISTANCE TO THE STUDENT WHO IS SEEKING INFORMATION FOR AN MSc in CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT RESEARCH PROJECT

This is to confirm that;

Full Name: Petros Chidza Registration number
B226712B, is a student doing a Master of Science Degree in Climate Change

and Sustainable Development programme at Bindura University of Science Education. The student is required to carry out a Research Project as part of his/her degree programme. The student is expected to gather data for the project from various sources including your institution.

This letter therefore serves to kindly request you to assist the above-mentioned student with information relating to his/her project on the

Title: *The Sustainability of Water Abstraction from Sand Rivers as an Adaptation Strategy to Climate Change-Induced Drought in the Nyanuzi Watershed in Musoro District*

.....

Thank you for the assistance.

A Manyani

.....
Dr. A. Manyani (Chairman) (0773099436)

APPENDIX B: LETTER OF INFORMED CONSENT



Promoting Science for Human Development
BINDURA UNIVERSITY OF SCIENCE EDUCATION

Faculty of Science and Engineering

Letter of Informed Consent

I am Petros Chidza, currently pursuing a Master of Science degree in Climate Change and Sustainable Development at Bindura University of Science Education. My research focuses on examining the sustainability of water abstraction from sand rivers as an adaptation strategy for climate change-induced poverty in the Nyamuzizi Watershed, situated within the Mutoko District.

This study aims to engage various stakeholders, including villagers from the study area, water authorities, environmental management authorities, agricultural extension workers, rural district councillors, and forest management authorities. Your valuable insights and information will significantly enhance the depth and breadth of this research endeavor. The findings from this study will complement ongoing efforts to develop adaptive response measures to mitigate the impacts of climate change, particularly among vulnerable populations in marginal areas.

Your participation in this research is highly appreciated. Rest assured, all contributions will be treated with the utmost confidentiality, and your identity will remain anonymous unless you explicitly grant permission for disclosure. I will document the information provided either through written notes or recorded interviews, and you will have the opportunity to

review these records at your convenience. Moreover, you reserve the right to withdraw your participation at any stage of the interview process.

For further inquiries or clarifications, please feel free to reach out to my supervisor, Dr. Albert Manyani, at 0773 099 436, or the course coordinator, Dr. Tawanda Manyangadze, at 0714 525 430.

Thank you sincerely for your time and willingness to participate in this interview.

APPENDIX C: FOCUS GROUP INTERVIEW

Focus Group Interview Guide: Ward 23 (Mutoko District)

Introduction

Thank you for participating in this interview. We are researching the impact of water from sand rivers on livelihoods in various communities. Your responses will provide valuable insights into the challenges and opportunities associated with water from sand rivers and help us understand its effects on agriculture, education, family dynamics, and overall well-being.

MAIN THEME		PROBE QUESTIONS
1.	Water Demand in the Villages	<ul style="list-style-type: none"> a. What are the primary uses of water in your household? b. What is the average family size per household? c. Which animals are kept in your rural village? d. If you have a garden or agricultural plot, what is its size?
2.	Water Supply Situation in Villages	<ul style="list-style-type: none"> a. What are the other water sources in your area? b. Who has the responsibility of fetching water in the family? c. How frequently do you access water from the sand river? d. How do you abstract water from the sand river? e. How much time does it take to collect water from the water source? f. What is the quality of water from a water source? g. How available is water from the water source throughout the whole

		<p>year?</p> <ul style="list-style-type: none"> h. Do you sometimes fall sick by using water from the sand river? i. How do you store water from the sand river? j. Have you noticed any changes in the water availability of the sand river over the years? k. What are the challenges you face in accessing water from the sand river? l. How often do you face water shortages or inadequate water supply? m. Do you have any systems in place for storing and conserving water?
3.	Livelihood Benefits from Sand Aquifers	<ul style="list-style-type: none"> a. Which crops do you grow in your plot? b. How much yield do you get from these crops? c. How do you sell these crops? d. Do the market prices meet your expectations? e. Do you also keep livestock for commercial purposes? f. What assets have you bought with money obtained from selling crops or livestock supported by water from the sand river? g. Has your crop and livestock been affected by either rising temperatures or changes in precipitation? h. Have you experienced crop or livestock losses due to drought, water scarcity or disease? i. Are you able to access agricultural

		<p>extension services or technical advice?</p> <p>j. Do you sometimes engage in contract farming?</p> <p>k. Besides farming, how else do you generate income?</p> <p>l. Are there some tourist or cultural events that occur in your area that brings income benefits to the community?</p> <p>m. Has anyone returned from the city or diaspora to do activities supported by water from sand aquifers?</p>
4.	Access to Education	<p>a. Are you able to pay school fees for your children's education?</p> <p>b. Do you have children who have dropped out of school? If so, why?</p> <p>c. What is the highest level of education achieved by your children generally?</p>
5.	Social Cohesion	<p>a. Are there some mechanisms of resolving water disputes in the village?</p> <p>b. How easy is it for residents to unite and work for a common purpose?</p>

Thank you for your participation in this interview. Your responses will contribute to our research on the impact of water from sand rivers on livelihoods.

APPENDIX D: RWENYA INTERVIEW GUIDE

Interview Guide for Lower Rwenya Sub Catchment Council: Sand river Water Management

Introduction:

Thank you for taking the time to participate in this interview. This interview aims to gather insights into the extent to which water abstraction from sand rivers enhances crop productivity in the garden plots. This information will contribute towards the assessment of the socio-economic benefits derived from the Nyamuzizi Watershed.

1. Can you please outline the functions of a sub-catchment council and how it links with ZINWA?
2. Are there laws, policies and regulations that govern the abstraction of water from sand rivers like Nyamuzizi River? If so can you give us examples?
3. Does the sub-catchment council issue out water permits for the abstraction of water from the Nyamuzizi sand river to villagers?
4. If so how much does such a permit cost?
5. Are there dams across Nyamuzizi River?
6. Are there any plans to construct such dams in future?
7. Have any hydrological studies been carried out in the Nyamuzizi Watershed?
8. In your opinion, is underground water in the Nyamuzizi watershed sufficient to irrigate large plot sizes in the area?
9. How do you ensure that the environment surrounding the rivers is protected from degradation?
10. From your observation, are there any changes in the flow of water in Nyamuzizi that is happening due to climate change and siltation?

APPENDIX E: ZINWA INTERVIEW GUIDE

Interview Guide Ministry of Water Resources & ZINWA: Role of Governance in Water Abstraction from Sand Rivers in Light of Climate Change

Introduction:

Thank you for taking the time to participate in this interview. This survey aims to gather insights into the role of governance in water abstraction from sand rivers or intermittent rivers, focusing on various aspects such as sustainability of water abstraction, decision-making authority, stakeholder engagement, equity, partnerships, and monitoring of water abstraction activities around intermittent river environments.

1. In your opinion, are there challenges with water abstraction from sand rivers given climate change??
2. How would you define sustainable water abstraction from sand rivers, especially considering the challenges posed by climate change?
3. Can you describe the current governance framework in place for managing and ensuring sustainable water abstraction from intermittent rivers, taking into account the impacts of climate change?
4. Are there any specific policies, regulations, or practices within the governance framework that have been successful in promoting sustainable water abstraction in the context of climate change?
5. How are stakeholders, such as local communities, water users, and other relevant parties, involved in the governance and decision-making processes related to water abstraction from intermittent rivers given climate change?
6. In your experience, how effective is stakeholder engagement in addressing the challenges posed by climate change and ensuring sustainable water abstraction?

7. How effective is the governance framework in addressing issues of equity amongst various stakeholders and good water management practices?
8. Are there any collaborations or partnerships between the water authority, government agencies, research institutions, or other stakeholders to enhance governance and ensure sustainable water abstraction from intermittent rivers given climate change?
9. In your opinion, how important are these collaborations and partnerships in addressing the challenges of climate change and promoting sustainable water abstraction?
10. How does the governance framework address climate change adaptation measures in the context of water abstraction from intermittent rivers?
11. Are there any specific strategies or initiatives in place to mitigate the impacts of climate change on water abstraction and ensure its long-term sustainability?
12. What mechanisms are in place to monitor and assess the impacts of climate change on water abstraction from intermittent rivers?
13. How are these monitoring and assessment results utilized in decision-making processes and adaptive management strategies?
14. Are there any specific strategies or initiatives that would be beneficial in enhancing the governance of water abstraction and adapting to climate change impacts?
15. Based on your expertise and experience, what recommendations would you provide to improve governance strategies for ensuring sustainable water abstraction from intermittent rivers in the context of climate change?

APPENDIX F: EMA INTERVIEW GUIDE

Interview Guide for EMA: The Role of Governance in the Preservation of the Environment during Water Abstraction from Sand Rivers

Introduction:

Thank you for taking the time to participate in this interview. This interview aims to gather insights into the role of governance in the preservation of the environment during water abstraction from sand rivers.

1. What do you do as environmental authorities to take care of areas surrounding sand rivers, which are rivers that flow only once during the rainy season but continue to flow through the sand media throughout the year?
2. Are there laws, policies, and regulations that govern the abstraction of water from sand rivers that are meant to protect the environments surrounding sand rivers?
3. How are stakeholders, including local communities, involved in the governance and management of riparian areas (i.e. areas close to rivers) during water abstraction?
4. Climate change is causing a reduction in the amount of water in most water bodies in rural areas, villagers have shifted their gardens close to the rivers, as authorities how are you dealing with this development?
5. Most villagers in attempting to mitigate climate change-induced poverty, are clearing land for agricultural purposes and this triggers land degradation, how do you respond to the issue of environmental protection versus poverty eradication?
6. What do you suggest should be done to prohibit stream bank cultivation, while proffering alternative sources of livelihoods to rural communities?

APPENDIX G: ARDAS INTERVIEW GUIDE

Interview Guide for ARDAS (formerly Agritex): Impact of Water Abstraction from Sand Rivers on Crop Productivity

Introduction:

Thank you for taking the time to participate in this interview. This interview aims to gather insights into the extent to which water abstraction from sand rivers enhances crop productivity in the garden plots. This information will contribute towards the assessment of the socio-economic benefits derived from the Nyamuzizi Watershed.

1. In your view, is water from sand aquifers able to sustain crops from planting to maturity?
2. Are villagers benefitting from government programmes like the Presidential Input Scheme and Pfimvudza/Intwasa Programme?
3. Do farmers deliver maize to the Grain Marketing Board (GMB)?
4. What are the average quantities that an individual farmer can deliver to GMB?
5. How do you compare the current yield levels from the garden plots and those from the past periods?
6. From your experience, what is current the average household income and how does it compare with the income earned before the manifestation of climate change intensified?
7. As an institution, how are you assisting villagers to cope with the effect of climate change?
8. How well do farmers follow technical advice from extension officers?
9. Has any Non-Governmental Organization or development partners provided some interventions to alleviate household poverty in the area?
10. To what extent has the problem of streambank cultivation gone and role does ARDAS play in mitigating the problem?

APPENDIX H: NYAHONDO-MARIRA VILLAGERS

Pictures of Nyahondo & Marira Villagers who attended Focus Group Interviews



Ward 23: Nyahondo villagers

Photo by Author



Ward 23: Marira villagers

Photo by Author

APPENDIX I: PLAGIARISM CHECK REPORT

CHIDZA PETROS B226712B

Title: The Sustainability of Water Abstraction from Sand Rivers as an Adaptive Strategy for Climate Change-Induced Poverty in the Nyamuzizi Watershed in Mutoko District

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