THE PERCEPTIONS OF THE COMMUNITY IN WATER, ENERGY, FOOD, AND ECOSYSTEM NEXUS (WEFE NEXUS) A CASE STUDY AT HA SEEISO METOLONG, MASERU

BY

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ABSTRACT

Water, energy, food, and ecosystems, as the essential resources underpinning human existence, are critical to the sustainable development of humanity. The local community exerts a significant influence in fostering the sustainable development of these resources. There exists a limited information regarding the effectiveness of nexus resource management in facilitating livelihoods and ensuring resource security. These challenges are associated with the insufficient knowledge within local communities concerning the utilization and exploitation of water, energy, and food resources; this lack of awareness lead to trade-offs, particularly in local and marginalized regions.

Through the analysis of data collected from a local community through a questionnaire approach, this research endeavors to investigate the perceptions of the local community regarding WEFE nexus. The findings suggest that community perceptions of nexus resources are comprehensible through the lenses of social, natural, economic, human, physical, and environmental indicators. The results indicate that people's perceptions of nexus resources are based more on the advantages of individual resources than on how they are related to one another. This might be the outcome of how the community views a certain nexus resource; that is food and water, from the four nexus sectors. The community's primary nexus resources in the study region are food and water. This indicates, that there is a missing link between cross-sectorial resource utilization and management, and full-scale adoption of the WEFE nexus to enhance living conditions.

Our results indicate that the livelihood advantage of individual nexus resources is the main focus in the community under study, and that there is a lack of knowledge regarding the usage and management of WEFE nexus resources. Based on these findings, we recommend the government and other interested stakeholders to take further steps to enhance the local community's awareness of nexus resources so that they may better comprehend the connections between WEFE sectors.

KEY WORDS: WEFE Nexus, Community perceptions, Community participation, Resources security, Ecosystem integrity

DECLARATION

The work contained in this dissertation was carried out and completed by KAMOHELO JEANETT MAHLOANE, 201502146 at the National University of Lesotho Water Institute, National University of Lesotho. I hereby declare that this study constitutes my original work and has never been submitted for the award of a degree or diploma to any University. To the best of my knowledge this dissertation contains no material written by another person except where due reference is made in the dissertation itself.

Signature…  **……. Date…18/07/2025**

As the candidate's supervisor, I certify the above statement to be correct to my knowledge and have recommended this dissertation for submission.

Dr Name and Surname Dr. Pulane Nkhabutlane Date 09/10/2025 

Dr Co supervisor ……Date……

IF any other supervisor…….Date……

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DIFINATION OF TERMS

Community participation: the active involvement of residents in decision-making, planning, and implementation of water resource management.

Ecosystem: a community of living organisms interacting with their physical environment.

Nexus approach: an approach that integrates management and governance across sectors and scales

Water tower: a region that serves as a major source of water for surrounding areas due to its high altitude and rainfall.

WEFE Nexus: interlinkages, tradeoffs, and synergies that exist among water, energy, food and ecosystem sectors.

LIST OF ACRONYMS

E-FLOW……...Environmental flow

ICM…. Integrated Catchment Management

NRM……... Natural Resources Management

WEFE……. Water, Energy, Food and Ecosystem

WE……... Water and Energy

CHAPTER 1

This chapter presents the contextual framework for the study, with particular emphasis on community perspectives concerning the interrelationships within the Water, Energy, Food and Ecosystem nexus. It also encompasses essential elements, including the articulation of the problem statement, the significance of the study, the formulation of research questions, and the parameters delineating the scope of the research.

1.1 Introduction

The Kingdom of Lesotho is characterized as a mountainous nation situated in Southern Africa, possessing a distinctive geographical configuration as it is completely encircled by South Africa (Rousselot, 2015). Approximately 80% of Lesotho's territory is situated at altitudes exceeding 1,800 meters above sea level, with a mean elevation of 2,161 meters. Lesotho is categorised as a "Lower Middle Income" nation, with a per capita Gross Domestic Product (GDP) estimated at USD 2,300 in the year 2021 (World Bank Lesotho overview, 2024). This nation is relatively small and predominantly rural, with a population approximating 2.3 million individuals. Although the majority of the population resides in rural regions, there has been a significant increase in the proportion of urban inhabitants, thereby imposing additional pressures on water and sanitation infrastructure (World Bank, 2010 and Nyaka, 2021).

Water is among the most essential natural resources in Lesotho, playing a critical role across multiple dimensions, including societal well-being, economic development, and environmental sustainability. The distinctive geographical setting, elevated topography, and unspoiled natural attributes of the mountainous regions position Lesotho as the "water tower" of Southern Africa (ReNoka Overall Report, 2021).

Lesotho has made significant efforts to incorporate the WEF nexus into its policy framework. The term nexus is used to describe the relationships and trade-offs between WEF sectors driven by growing population, an expanded middle class, food price volatility, increasing energy demand, and competition for natural resources (Javan et al., 2024). The search for linkages between these drivers and the trends, they generate in the pursuit of understanding and managing these interdependencies, driven by the question of how we can better manage,

protect, and ensure resilient access to natural resources into the future (Lucca et al., 2023). Lesotho's approach to managing its water resources is central to this integration, as water is recognized as a critical component for both energy generation and food security (Nhamo et al., 2018).

The Lesotho Water Act of 2008, establishes a legislative framework for the management, protection, conservation, development, and sustainable use of water resources, which includes their application for agricultural purposes such as irrigation, a critical component for ensuring food security.

1.2.1 Water and Food security

Water significantly impacts the availability of food in Lesotho, a country that faces significant challenges due to its geographical and climatic conditions. Lesotho's dependence on rain-fed agriculture renders it especially susceptible to variations in water availability, intensified by climate change and extreme weather occurrences (Climate Risk Profile: Lesotho (2021). Recent droughts have severely impacted crop yields, leading to persistent food insecurity among rural households (IPC Report, 2023). This situation is further compounded by the El Niño phenomenon, which disrupts seasonal rainfall patterns and leads to crop failures (IFRC Report, 2024). In addition to direct impacts on agriculture, water shortages have detrimental effects on livestock health and productivity. Insufficient water availability leads to the decline of livestock conditions, hence diminishing income for farmers dependent on animal husbandry for their livelihood (IPC Report, 2023).

1.2.2 Water and Energy

Lesotho lacks indigenous supplies petroleum, coal, or natural gas, importing roughly 2,000 barrels of oil daily. Due to the absence of domestic oil refineries, all petroleum products, including as kerosene, jet fuel, and gasoline, are imported (LMS, 2013). Lesotho's energy security is closely linked to its water resources, as the country relies heavily on Muela Hydropower station for electricity generation. Approximately 72 MW of electricity is produced from hydropower, yet demand often exceeds supply, necessitating imports from neighbouring country (LHDA Report, 2019/2020). Climate change also remains a critical threat, with low dam levels jeopardizing energy production. Electricity constitutes only approximately 3% of

Lesotho's total energy consumption. An estimated 60% of households rely on biomass sources such as wood, shrubs, animal dung, and agricultural residues for cooking and heating, while about 95% of households depend on paraffin or candles for lighting (Mothala, 2020). Biomass alone contributes roughly 72% to the national energy mix, indicating that nearly three-quarters of the nation's energy requirements are met using traditional biomass fuels (Biomass Burning in Lesotho, 2020). This heavy reliance on biomass is largely attributed to limited access to electricity, which is predominantly concentrated in the Maseru District, where the capital is located. National electricity accessibility stands at approximately 38%, with urban and peri-urban areas recording about 60% coverage, in contrast to only 18% in rural regions. Generally, electricity availability is higher in the lowland regions than in the highlands (Tsoeu-Ntokoane et al., 2022).

1.2.3 Water and Ecosystem

Water is essential to the ecosystem of Lesotho, significantly impacting both the environment and the economy. The country is endowed with abundant water resources, primarily from its three major catchment areas: Senqu, Mohokare, and Makhaleng. These catchments support diverse ecosystems, including wetlands that provide essential habitat for various species and contribute to water purification processes. However, the control of this water related resources has been hindered by human activities including overgrazing, cultivation, and infrastructure development, leading to habitat degradation and reduced biodiversity (Renoka, 2020).

Climate change further complicates the situation by modifying rainfall patterns and escalating the incident of harsh weather occurrences such as prolonged dry periods and wet seasons, these climatic changes cause major risks to agricultural production and food security, as Lesotho's agriculture heavily relies on rain-fed system (Climate Risk, 2021). These environmental pressures have exacerbated the degradation of natural ecosystems, including soil erosion across the country.

The Lesotho Water and Sanitation Policy (2007) emphasizes the proper handling of water resources to maximize socio-economic benefits while ensuring sustainability. It also highlights the relevance of IWRM to synergize water and food security. The Lesotho Food Security Policy

(2005) delineates the framework for food safety, encompassing institutional frameworks to tackle food safety challenges.

Globally, the WEFE nexus is among the most prominent ideas that seek to integrate multiple policy domains around environmental and water management. The Zambezi Basin is an example of a focus for WEFE Nexus assessments, with ongoing projects related to water transmission and management across several countries (Farinosi et al., 2021).

The WEF nexus model had been applied in Lesotho, with various initiatives aimed at integrating these sectors for sustainable development. Integrated Catchment Management (ICM) Program, this program, supported by the European Union, concentrates on sustainability and the strategic oversight and use of water and land resources. Its goal is to rehabilitate degraded catchments, which are crucial for WEF security. The program is part of broader efforts to align with the WEF nexus approach, ensuring that water resources support both energy generation and agricultural activities. For instance, The ReNoka program which is part of the ICM initiative is an example of successful WEF nexus application. It aims to rehabilitate catchments, ensuring sustainable water resources that can support both hydroelectric power generation and agricultural activities, thus aligning with the WEF nexus principles (ICM, ReNOKA programme reports, 2022).

1.2 The Conceptual Framework

A framework to define and strengthen WEF nexus security is adopted from Wolde et al., (2020), following the literature review of this study. It primarily concentrates on the interconnections among the resources of WEF, alongside the perceptions of the local residents regarding these interconnections. The study demonstrates how the community is strongly related to all four nexus resources. The framework in fig.1 illustrates the interrelationship among water security, energy security, food security, and ecosystem integrity, demonstrating their potential impact on the local residents as outlined by (Wolde et al., 2020). This framework highlights the WEFE Nexus which shows an interaction of WEF security and the entire ecosystem.

It facilitates a more precise identification and examination of the residents' understanding regarding interconnections among four sectors. This framework is particularly applicable to

community contexts where food security concerns are equally significant as water-related issues, thereby enabling the nexus to capture challenges pertaining to energy security. According to the framework, the livelihoods of community members are impacted by the access and availability of the WEF resources.

The framework holds relevance in scenarios where the correlation between resources within the WEFE nexus and local perceptions can contribute to comprehensive WEFE nexus security for all stakeholders (Wolde et al., 2020).

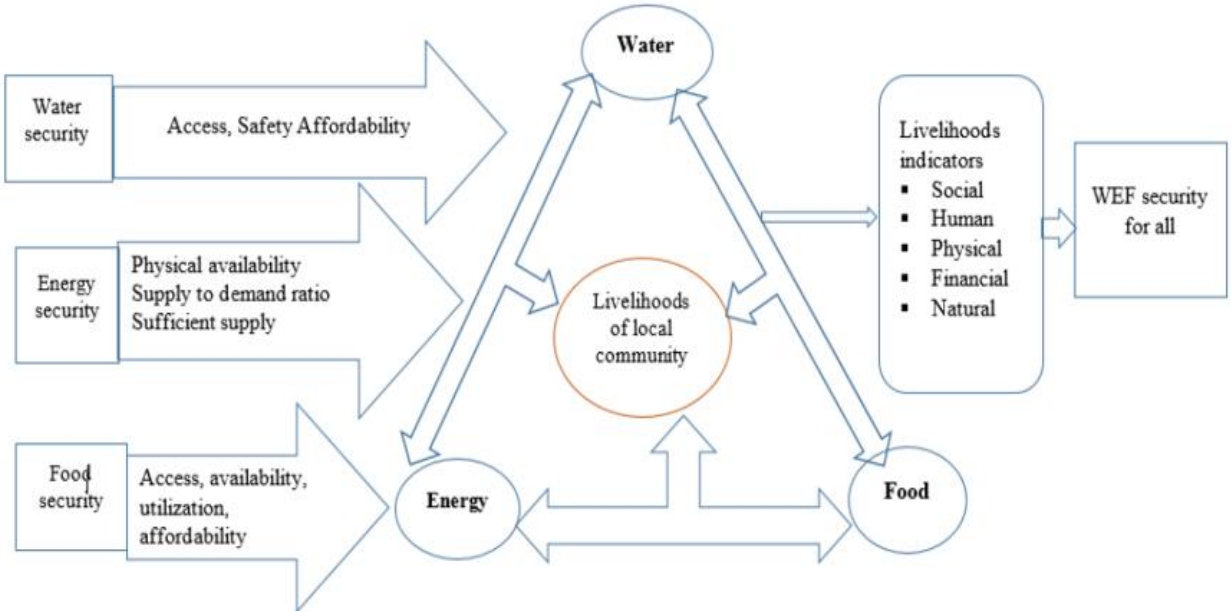

Fig 1. Conceptual framework for the WEF nexus adopted from (Wolde et al., 2020).

In Metolong (Ha-Seeiso), the WEFE framework can be contextualized to capture the challenges and opportunities resulting from the Metolong Dam. Water security is shaped by the reservoir's role in supplying urban areas, while relocated households struggle to access water for irrigation and livestock. Food security has been undermined by resettlement, which reduced access to fertile land for subsistence farming. Energy insecurity persists as residents depend largely on biomass, directly contributing to ecosystem degradation. Ecosystem integrity is further threatened by land-use change, soil erosion, and pressure on natural resources. Centering community perceptions, the framework highlights resource interconnections, trade-offs, and potential synergies, thereby offering a holistic understanding of local nexus dynamics.

The framework comprises four core components: water security, food security, energy security, and ecosystem integrity, with community perceptions positioned at the center. It hypothesises

that changes in one sector directly influence the others, creating both trade-offs and synergies that shape local livelihoods. This model guides the research by structuring inquiry around these interconnections, ensuring that both resource availability and residents' perceptions are captured. Data collection will focus on household surveys to assess access, availability, and use of WEF resources. Specific variables to be measured include water access for domestic and agricultural use, land availability for farming, energy sources and reliability, and indicators of ecosystem health such as land degradation. The framework will thus organize analysis around identifying interdependencies (e.g., water for energy, energy for food processing, food for livelihoods), and their implications for resource security in Metolong which will guide cross-variable analysis. Quantitative data is analyzed to test correlations and associations across the WEF nexus and livelihoods while qualitative data is coded along the framework's dimensions to capture perceptions and lived experiences.

The conceptual framework underpins this hypothesis by emphasizing the interconnections among water, energy, food, and ecosystem resources, Since the framework highlights how local residents understand and experience trade-offs and synergies across these sectors, it directly supports the view that greater community participation in conservation can strengthen awareness and foster positive attitudes toward sustainable resource use. situating perceptions as a key variable, the framework provides the basis for testing whether active involvement in managing water resources translates into improved understanding and acceptance of integrated resource management within the nexus.

1.3 Hypothesis

Enhanced engagement of the community in the conservation of water related resources exerts beneficial impact on the perceptions regarding the sustainability and efficiency of the utilization of resources within the WEFE Nexus framework.

1.4 Research Problem Statement

Lesotho faces several challenges related to the WEF Nexus and ecosystem resilience. Despite being endowed with abundance of water resources, Lesotho struggles with providing access to potable water for its population. This is largely due to technological and distribution challenges

rather than a lack of water itself. Over half of the inhabitants of Lesotho lives below the national poverty line, primarily in rural areas where most resources are located (Long-Term Water and Sanitation Strategy Volume II Water Sector Programme, 2014), inadequate infrastructure and uneven distribution of water exacerbates poverty in rural areas where agriculture is the main source of living.

Limited access to clean water affects farming, reducing food production and income opportunities. The persistent struggles in effectively implementing WEFE nexus strategies are the limited incorporation of community participation. Despite the recognition that local communities are often the primary stakeholders and direct beneficiaries of these resources, their involvement in decision-making processes remains inadequate (Franks, S. K. 2021).

Community engagement and participation is essential for the effectiveness of WEFE initiatives because it ensures that the strategies are contextually relevant, socially acceptable, and sustainable. It also fosters local ownership and stewardship which are essential for ensuring the long-term sustainability of natural resources. Nevertheless, there is a vital gap in understanding how community participation can be systematically integrated into WEFE nexus management. Existing models often overlook the socio-cultural dynamics and the indigenous knowledge that local communities bring to resource management (UNU-FLORES & INWREAM. 2017).

The primary research problem is the inadequate community participation in consultation, cocreation and shared decision-making processes in implementing WEFE Nexus.

1.5 Research Questions

Main Research Question:

How do community members at Ha-Seeiso perceive the concept of the WEFE nexus, including their awareness, beliefs, and its effectiveness?

Specific Research Questions:

- How do community members utilize water, energy, food, and ecosystem resources in their daily lives? In what ways do changes in one WEFE component affect the others in Ha-Seeiso?

- What is the level of awareness among Ha-Seeiso residents regarding the interconnection between WEFE nexus?
- What are the socio-economic challenges faced by the community due to fluctuations in WEFE resources?
- How can community participation be systematically integrated into water-energy-food-ecosystems (WEFE) nexus management through an analysis of existing framework and identification of gaps?

1.6 Research Objectives

Main Objective

To explore community perceptions of the WEFE nexus at Metolong Ha-Seeiso, focusing on their level of awareness, underlying beliefs, and views on its effectiveness.

Specific Objectives

- To examine the impact of WEFE nexus resources on residents' livelihoods and the social system (socio-cultural dynamics and the indigenous knowledge).
- To assess the current knowledge and awareness of WEFE nexus amongst residents at Metolong Ha-Seeiso village.
- To propose how community participation can be integrated into water-energy-food-ecosystems (WEFE) nexus management by analyzing existing frameworks and identifying gaps.

1.7 Significance of the Study

The research explores how community participation impacts water resource management and production at Ha Seeiso, Metolong catchment, providing valuable insights for designing effective community-based programs. It aims to address shortcomings identified in the existing literature, about the role of community in WEFE nexus sectors especially in Lesotho to different stakeholders such as the government institutions, students and researchers while also responding to challenges of limited community involvement in decision-making and the

fragmented management of interconnected resource faced by the community in Metolong Ha Seeiso.

The accessibility of this research will provide significant insights into local perspectives regarding resource management. This research will be particularly advantageous for scholars and researchers engaged in similar studies, as it will enhance their understanding of how communities perceive and interact with interconnected resources such as WEF resources. This research will underscore the relevance of inclusive decision-making processes that encompass local stakeholders. Effective resource management requires cooperation among policymakers, community members, and specialists to guarantee the efficient utilization of natural resources. The outcomes will emphasize the necessity for participatory methodologies in decision-making, which can facilitate equitable and efficient allocation of resources.

This research will also serve as a valuable reference for various projects such as ReNoka and ROLL as well as for governmental departments, particularly the Department of Environment, which plays a critical role in policy implementation and community engagement. The findings of the study can be utilized to inform and design outreach programs aimed at educating communities on sustainable practices. Through execution workshops, training sessions, and awareness campaigns, agencies can disseminate knowledge on the interdependencies within the WEFE Nexus, fostering a more informed and proactive community.

Moreover, the study will contribute to the broader discourse on environmental sustainability as it provides empirical evidence on local perceptions and practices. Understanding how communities perceive and manage their resources will assist policymakers in developing context-specific strategies that address socio-economic and environmental concerns. Lastly, this research is expected to make a dual contribution by enriching academic literature and informing practical interventions to enhance sustainable resource management in Ha Seeiso, Metolong Village and beyond.

1.8 Research Limitations

The study emphasizes the interactions among WEF resources but may not fully account for other critical factors affecting rural household security, such as socio-economic conditions, governance, and climate change impacts. This narrow focus could overlook important variables that influence household resilience. Collecting data in rural areas can be challenging due to logistical issues, limited access to respondents. These challenges may affect the reliability and validity of the findings. This limitation suggests that the results may not be applicable in the long term. The study is limited to Ha Seeiso, Metolong village and can therefore not be generalized. The study is conducted within a short period of time with limited finances.

1.9 Chapter Summary

This chapter introduced the groundwork for the study by introducing and contextualizing the issue being studied. The research questions that the study aims to answer have been clarified.

CHAPTER 2

2.1 Literature Review

In this chapter the literature review is organized according to objectives of the study and the conceptual framework. It starts with definition of the WEFE nexus indicating the importance of each of these resources in the community. In this chapter, the perceptions of community members on WEFE Nexus have also been discussed. It also provides an extensive review of literature pertinent to the present study. It also examines prior research to identify existing gaps within the body of knowledge. Furthermore, it explores the relationships associated with community perceptions examined in this study. Notably, this section serves as a critical component by providing the theoretical underpinning that shaped the understanding of community perceptions within WEFE nexus.

2.2 The WEFE Nexus and Explanation of Its Interconnections.

The WEFE nexus is defined by (Lucca et al., 2023) as the approach that incorporates governance and management across the various sectors of WEFE as being deeply interconnected, shifting away from a traditional focus on distinct entities. The WEFE Nexus indicates the strong interdependencies between WEF and natural ecosystems. Water is often central due to its scarcity and essential role in food and energy production (Global Water Partnership, 2023).

Under the Nexus framework, the interconnections, synergies, and trade-offs are examined, with the objective of identifying viable solutions, promoting water, food and energy security and operational efficiency, and mitigating impacts and risks on water-dependent ecosystems (Global Water Partnership, 2023).

As articulated in the UNESCO Report of 2021, the WEFE Nexus is delineated as an approach that diverges from the conventional emphasis on isolated entities, instead advocating for the integration of management and governance across the multifaceted sectors of food, energy, water, and ecosystems, recognizing their complexity and inextricable interrelation. There is a

burgeoning recognition, both globally and locally, of the intricate interconnectedness that exists between WEFE sectors.

2.2.1 Water for Energy

Water and energy (WE) nexus constitute indispensable resource inputs for the sustenance of food security and the promotion of economic development. Substantial yet underexploited WE resources are prevalent in Southern Africa. Nonetheless, a significant proportion of the population in this region remains deprived of accessibility to both energy and consistent, clean water (Nhamo et al., 2018). Within the majority of energy production methodologies, water functions as an essential resource, playing a vital role in various energy-related processes. It is required for the extraction, transportation, and processing of fossil fuels, and is also extensively used for cooling in thermoelectric power generation, particularly in systems dependent on nuclear energy and fossil fuel sources (Al-Zubari et al., 2021). Considerable energy is requisite for rendering water resources accessible for human utilization and consumption, including irrigation, through the operations of pumping, transportation, treatment, and desalination (Sunil, Sharma, & Kumar, 2023).

The conceptualization of the WE nexus is of paramount importance as it underpins various life forms on the planet, and its comprehension can facilitate the attainment of sustainable development goals. In contemporary contexts, water and energy are intricately linked, mutually supporting and depending on one another to foster sustainable development across agricultural, urban, and industrial domains (European Commission, 2018).

2.2.2 Energy for Agriculture

The complex interrelationship between energy and agriculture, characterized by their mutual dependence and significant influence on one another, is herein termed the energy and agriculture nexus (Kabir and Ekici, 2024). Energy is indispensable in agricultural practices to facilitate various operations, encompassing the entire spectrum from land preparation to the food value chain, as well as in contemporary agricultural methodologies such as greenhouse cultivation and technologically enhanced livestock propagation (Majeed et al., 2023). The agricultural sector is a major consumer of energy resources. Approximately 30% of global energy consumption is attributed to agri-food systems, predominantly during post-harvest

phases (Vourdoubas, John & Dubois, Olivier, 2022). In contrast, since the sources of biofuels and biogas are derived from crops and livestock, energy production is inherently dependent on agricultural outputs (Mahapatra et al., 2021).

Globally, an estimated 30% of energy is utilized in agriculture and the food sector, and this is anticipated to rise due to increased food demand. Southern Africa lacks sufficient energy resources, and more than 60% of its residents do not have electricity accessibility so they must use biomass energy for cooking, heating, and lighting instead. The area struggles with significant energy poverty, impeding economic development because of low energy services (Mabhaudhi et al., 2018). The use of biomass for bioenergy, while a renewable energy source, presents significant environmental and social challenges beyond its potential as a substitute for fossil fuels, particularly concerning its close association with food production and resource competition (Popp et al., 2014). The use of different types of biomasses and their production locations and methods will result in varying effects on ground, water bodies, biodiversity, ecological health, and neighborhood residents. The magnitude of these effects is also influenced by uncertainties related to both the biological factors (Sieber et al., 2015).

2.2.3 Water for Agriculture

Water is a vital resource in agriculture, playing essential role in food production and security worldwide (Ringler et al., 2022). As the primary input in crop cultivation and livestock rearing, water availability and quality directly influence agricultural productivity and sustainability. In recent years, the escalating challenges of water scarcity and climate change have underscored the urgent need for optimizing water use in agriculture (Ingrao et al., 2023).

Climate change phenomena, including drought and flooding, exert detrimental effects on food security across the African continent. Drought represents a significant environmental challenge within African nations (Alfiado, 2024). The agricultural sector is disproportionately impacted relative to other sectors due to its inherent vulnerability to climate variability and changes, which manifest as harsh weather events such as droughts and floods, erratic rainfall patterns, and rising temperatures. Drought conditions result in diminished water availability for irrigation, consequently leading to reduced agricultural yields, exacerbating food insecurity, and increasing the demand for irrigation water. Water required at different stages of food

production, with rain-fed agriculture being particularly affected by the climate change (Kanda et al., 2023).

The escalating challenges caused by climate change, compounded by urbanization, population growth, and industrial pressures, necessitate strategic interventions aimed at enhancing water utilization within agriculture through the improvement of crop water productivity to ensure resource sustainability. Among the techniques to enhance crop water productivity, efficient irrigation technologies and agronomic practices such as deficit irrigation and soil moisture conservation can be adopted (Kanda et al., 2021).

2.2.4 Water – Energy – Food – Ecosystems (WEFE) Nexus

An ecosystem is delineated as a collective of living organisms engaging with the abiotic components of their environment, operating as a cohesive system (Lartey & Solomon, 2024). These biotic and abiotic constituents are intricately linked through nutrient cycles and energy exchanges (Kafle, 2023). Ecosystems are pivotal in the dynamics within the nexus, as the services they provide constitute fundamental elements that sustain biodiversity and enhance the availability of essential resources such as food, water, land, and energy, which are critical for fulfilling the foundational requirements for human well-being (Shi et al., 2022). These services may be classified into four distinct categories: provisioning, regulating, cultural and supporting (Pu et al., 2023).

However, provision of these services can lead to environmental degradation when one or more of the following occurs: excessive water is consumed or diverted, untreated solid or liquid waste is discharged into ecosystems, biodiversity is compromised, and deforestation takes place (Choudhary et al.,2015). Currently, approximately 3 billion individuals inhabit regions that are identified as hotspots for land degradation, thus threatening food and water security (Ratner, 2018). Climate change adversely affects the sustainability of ecosystems and intensifies the pressure on these ecosystem services (Qinqin Liu, 2016).

The forecasted changes in thermal conditions, rainfall patterns, sea levels, and the incidence of dry periods and floods will interact with existing ecological and social and economic stresses, specifically factors such as population growth, conflict, and water contamination may result in

profound implications for water and food security, the integrity of ecosystems, and lastly, human security (Teku and Eshetu, 2024).

2.3 Global Perspective on Integrated Resource Management

The WEFE Nexus has been identified as an instrumental framework for quantifying and analyzing the interrelations among various sectors, as well as for analyzing and understanding intricate political agendas, to enhance the formulation of policies, governmental initiatives, and sectoral strategies. This, consequently, facilitates the resolution of challenges associated with the achievement of integrative governance, the provision of institutional incentives, and the establishment of norms conducive to intersectoral collaboration (Lazaro LLB et al., 2022). The rationale underlying the WEFE nexus is that it shifts focus from a singular sector perspective to a more holistic and coordinated approach (Bazilian et al., 2011; Al-Saidi and Elagib, 2017; Zarei, 2020).

The conflict surrounding water resources in the context of food and energy generation has emerged as a central issue in the ongoing discourse surrounding the WEFE nexus, as the expanding urban population necessitates increased quantities of food, energy, and water drawn from finite freshwater supplies, which is projected to become progressively limited in the context of climatic variability (Khofi et al., 2025).

Moreover, the Food and Agriculture Organization of the United Nations (FAO) has posited that the WEF nexus framework possesses the capacity to ensure food security while promoting sustainable agricultural development (FAO, 2014). The IRENA has underscored that the adoption of renewable energy technologies can effectively alleviate certain trade-offs within the WEF sectors, thereby generating substantial benefits for all three domains. Moreover, renewable energy sources have the capacity to alleviate competition through the provision of energy services through methodologies and technologies that are less resource-demanding (IRENA, 2015).

2.3.1 Community Perceptions and Stakeholder Engagement in Natural Resource Management

A community consists of individuals who engage with one another and possess shared characteristics, geographic location, interest, or identity, and frequently exhibit a sense of ownership and interpersonal connection, often reinforced by near physical location. A community comprises a collective group of individuals and cannot be constituted by a single person alone (Cobigo et al., 2016).

Community perception refers to the collective understanding, attitudes, and beliefs held by members of a community regarding specific issues, events, or entities. This perception is shaped by various factors, including cultural norms, education levels, personal experiences, and the flow of information within the community (Maruapula et al., 2023).

2.3.2 Community Perceptions in WEFE Nexus

Community perceptions concerning the WEFE nexus are fundamental for comprehending resource management and enhancing food security. Research indicates that local populations frequently evaluate these resources primarily through the lens of individual advantages instead of recognizing their intricate interconnections, with food commonly serving as the predominant emphasis. This signifies a deficiency in comprehending the integrated utilization and governance of these resources (Wolde et al., 2020).

Food is perceived as the centre of nexus resources for the residents, indicating a strong understanding of food production's importance. However, without efficient water and energy use, meeting food demands becomes challenging. The local community generally perceives water as the second most readily available and significant component of the nexus resources, ranking it just after food in terms of importance (Wolde et al., 2020). However, their comprehension of energy sources is very limited, which can impact the management of water for hydropower potential. Water accessibility is generally better than access to energy and food resources. The energy sector in many rural areas is predominantly biomass-based, with a considerable segment of the population experiencing limited electricity accessibility and relying on biomass for cooking. This restricts the role of electrification in enhancing quality of life and stimulating the economy (Wolde et al., 2020).

2.4 Metolong Community

The Metolong Dam site is situated at an altitude of about 1,670 meters above sea level in the foothills of Lesotho. Near the village of Ha Seeiso, on the South Phuthiatsana River, the river channel is deeply carved out of the surrounding narrow river valley. The region is geologically stable and primarily composed of the Clarens Sandstone Formation, which is layered with Lesotho formation basaltic lavas. The South Phuthiatsana River (Little Calendon), which traverses central western Lesotho is 35km kilometres from Maseru and the construction of the dam commenced in 2013.

Raselimo (2010) notes that Metolong is characterized by a temperate continental climate, featuring summers with temperatures reaching approximately 28 °C and very cold winters with temperatures dropping to around -2 °C. The winter season is typically dry with reduced evaporation rates, whereas summer is marked by higher precipitation and elevated evaporation levels. The nation receives roughly 700mm of rainfall annually, primarily from thunderstorms. Winters used to have more snow but they no longer do. The Phuthiatsana (where the Metolong Dam is located), the Senqu, and the Orange are the three perennial rivers that dominate the region. Ha Seeiso village is unique when compared to other villages in Lesotho because it is located adjacent to the Metolong Dam.

The community in Metolong Ha Seeiso is comprised of 134 households with 251 males and 256 females (Bureau of Statistics, 2016). Residences in the vicinity of the Metolong Reservoir predominantly comprise traditional dwellings, with modern houses being evident in the larger settlements such as Ha Seeiso (Sekamane, 2018). The patterns of settlement within the Metolong Reservoir area reflect the historically rural character of the region, characterized by dispersed villages surrounded by rangelands and agricultural fields (Metolong dam ESIA, 2008).

Most of the population (approximately 75%) resides in rural areas, where they rely predominantly on subsistence agriculture (Sekamane et al., 2023). Subsistence agriculture plays an important role in sustaining the livelihoods of nearly 80% of households within the country, this phenomenon is evident in ownership of agricultural lands within the Metolong Reservoir area, wherein over 80% of households have reported that they had fields.

These fields are primarily located in the plateau regions adjacent to the villages. However, the construction of the dam has compelled certain residents to sell their livestock due to the reduction of available grazing land. This dispossession of land has severely constrained agricultural activities, resulting in diminished productivity and heightened food insecurity (Sekamane et al., 2023).

Other identified sources of income frequently included wages, remittances from South Africa, proceeds from the sale of beer, income from the sale of homegrown vegetables, remittances from workers based in Lesotho, and pensions. More than half of the households reported monthly incomes of M300 or less. Approximately 70% indicated that their monthly household incomes did not exceed M500. Merely 1.6% of households reported monthly incomes surpassing M1,100. The income levels of households led by women consistently fell short compared to those led by men (Metolong dam ESIA, 2008).

Notwithstanding the observable disparities in the means by which both genders within the village sustain themselves, the dependence on pensions, welfare grants, or remittances serves as a significant indicator that, despite the enhancements in their quality of life due to their proximity to the dam manifested through improved infrastructure such as roads, electricity, pit toilets, running water, educational institutions, and healthcare facilities, it has not substantially improved their prospects of securing paid employment or launching income-generating enterprises (Majoro, 2023).

The evaluation of water sources utilized by residents in the Metolong Reservoir region reveals that more than two-thirds of the population collected the water from the village standpipes. The other notable sources of water included springs, with 17.8% accessing unprotected springs and 10.4% utilizing protected springs. Sanitation conditions are generally inadequate, as slightly more than half of the population resorts to using the bush or open fields, the remainder either possesses their own pit latrines or relies on access to latrines owned by others (Majoro, 2023).

Educational institutions, such as schools, are predominantly situated in the larger villages within the Metolong Reservoir area, such as Ha Seeiso, resulting in only a limited number of villages having access to educational institutions. Primary school students primarily attend schools located within villages, although some do cross the river for to attend schools.

Conversely, a significant number of secondary school students attend schools located in peri-urban and urban settings.

The construction of this dam has undoubtedly yielded positive outcomes. Often, the establishment of large dams triggers the development of essential infrastructure such as roads, power lines, clinics, police stations, and schools. Such infrastructural advancements providing enduring benefits upon local communities (Hitchcock, 2015).

The standard of living for certain segments of the resettled population has been enhanced. The establishment of hospitals, the construction of connected roads and bridges (for instance, over the Phuthiatsana River), the implementation of piped water systems, improvements in sanitation facilities (latrines), and the provision of electricity have all contributed to this enhancement. Ha Seeiso and neighbouring settlements have derived benefits from the recently constructed infrastructure (Sekamane et al., 2023).

The dam has also resulted in adverse effects, notably an influx of migrant workers who have significantly disrupted prevailing social norms. This migration has led to increased school dropouts among young girls, along with instances of teenage pregnancies and HIV infections as a result of interactions with these new community members. The dispossession of land has undermined their ways of living and created intergenerational poverty, given that lost lands and livestock are incapable of being inherited by offspring. In addition to the depletion of trees, land, and livestock, some individuals have lost access to sacred ancestral territories located in the same area. Certain resettled individuals have experienced a disconnection from their ancestral sense of place when the inundation caused by the Metolong Reservoir Storage submerged seven graves.

The establishment of the Metolong Dam has altered local climatic conditions and biodiversity, specifically concerning flora and fauna, within the study region. Degu et al., (2020) have documented that the construction of large dams significantly impacts local climates, particularly in Mediterranean and semi-arid regions, whereas such influences are less pronounced in humid climates. A frequently neglected dimension of dam construction is that it triggers regional systematic alterations in large-scale land use and land cover, attributable to the multifaceted objectives they serve. Consequently, systematic modifications in land use and land cover have the potential to indeed transform regional hydro climatology. Additionally,

there have been fluctuations in temperature, with cooler conditions that were typically experienced from May to July now extending from April to August. There has been an arrival of foggy days, which they had never experienced before, and that was due to the construction of the dam (Sekamane et al., 2023).

The community of Metolong has experienced considerable transformations owing to the implementation of the Metolong Dam and Water Supply Program (MDWSP) (Sekamane, 2015). While the dam facilitates the provision of potable water to urban and peri-urban locales, including Maseru and its adjacent towns, several rural communities situated in proximity to the dam, such as Ha Seeiso, continue to lack access to clean water (LENA report, 2024), causing discontent among local residents. The development of the dam has resulted in the displacement of communities, leading to the loss of agricultural land and essential natural resources necessary for sustaining livelihoods, such as building sand and rangelands (Sekamane, 2015).

2.5 Local Community Engagement in WEFE Nexus

The WEFE nexus literature, according to Biggs et al. (2015), mostly concentrates on metropolitan regions, middle classes, global expansion, and world population. This generates a narrow emphasis on the main nexus difficulties encountered by low-income local communities and households, but it also offers a way to link nexus resources from the standpoint of socio-economic and environmental concerns on a larger scale. Water and food security can be enhanced by better understanding nexus resource management, which is facilitated by researching local community perspectives on WEFE nexus resources.

The community's benefits will increase, which can have a good economic impact, and high agricultural output and biodiversity conservation depend on the water, energy, food, and ecological nexus. This knowledge is essential for guiding the creation of successful investments, policies, and initiatives that improve the well-being of regional communities (Olsson, 2013).

According to (Canessa et al., 2022) Stakeholder engagement across all levels, including at the community level, remains limited within the Nexus research agenda, although the anticipated advantages of interdisciplinary research are widely recognized, many scholars agree that the

integration of participatory approaches, convergence thinking, and interdisciplinary methods can offer fresh insights to the discourse by enabling the exchange of knowledge and supporting evidence-based decision-making (Baratella et al., 2023).

Policy innovations may not have a significant impact locally since they are frequently formulated at high government sector levels without considering local values and concerns. Nexus research typically ignores local stakeholders, which highlights the need for more efforts to guarantee that nexus evaluation takes into account their actual requirements (Brouwer et al., 2024). By including local stakeholders at every stage of the WEFE nexus process, policymakers and researchers may better bridge the gap between the creation and application of scientific results, allowing them to customize policies to the needs of local stakeholders and particular regions.

Ultimately, incorporating local stakeholders' values and concerns improves WEFE nexus research's sustainability, relevance, quality, and efficacy. Although the relevance of incorporating stakeholders in WEFE nexus research is becoming more widely recognized, most of the examples that are currently available concentrate on adding stakeholders just as end users of technical data from models, as opposed to involving them throughout the whole process of creating indicators and tools (Schlemm et al., 2024).

Social dynamics should be connected to the nexus in meaningful ways to enable a collaborative management approach, building trust and empowering communities to contribute to nexus governance. Community or citizen contributions to nexus problems, solutions, and interventions are underexplored. (Lotz-Sisitka et al., 2024) emphasize the importance of adaptive governance frameworks that facilitate stakeholder engagement and knowledge co-production, which are crucial for navigating resource conflicts and fostering resilience.

According to (Johnson and Karlberg, 2017), the WEFE nexus approach explains the strong interdependence among these critical sectors and the need for integrated, cross-sectoral management to achieve sustainability and security. Community participation is important to the success of the WEFE nexus approach. Participatory scenario-building processes provide a valuable space for dialogue among diverse stakeholders with different knowledge, priorities, and perspectives. This allows for a better understanding of the interlinkages between the WEFE

sectors and the identification of mutually beneficial solutions that manage trade-offs (Global Water Partnership, 2023).

Through acquisition, processing, transportation, and end usage, water and energy are utilized and lost. Since these lost amounts of energy and water are essentially undetectable, they are rarely taken into account when calculating resource usage. These resource flows are made more complex by the realization that water and energy are interdependent, or have a nexus. Throughout the life cycle of an energy source, water is extracted, used, and energy is used in the extraction, distribution, and final use of water resources (Perrone et al., 2011). There is a rising recognition of the interdependence of WEF security and ecosystems on a local and global scale. We already know that the production of food and energy requires direct inputs of water, and that the extraction, transportation, and purification of water as well as the storage and distribution of food require energy (Global Water Partnership, 2023).

2.6 Culture and Indigenous Knowledge Nexus

Culture encompasses the shared experiences, knowledge, beliefs, values, norms, and attitudes developed and sustained by a specific social group through routine practices. Indigenous knowledge refers to traditional forms of understanding, interpretation, and reasoning that are passed down orally from one generation to the next. This body of knowledge reflects continuous adaptation and innovation across multiple sectors, such as agriculture, livestock management, child-rearing, education, healthcare, and the stewardship of natural resources (Malapane et al., 2024).

Both culture and indigenous knowledge play a critical role in enhancing community well-being and fostering development. Consequently, it is necessary to establish mechanisms for the safeguarding of culture and indigenous knowledge. Protection encompasses the strategies aimed at preserving, promoting, regulating the utilization, and ensuring equitable benefit-sharing with the knowledge custodians (Kebede and Belay, 2017). Culture as one of the determinant factors for development has given less emphasis for long times (Sani et al., 2012).

2.7 Water Resources and Community Access in the WEFE Nexus

2.7.1 The Significance of Water Resources for Food Production, Energy Generation, and Ecosystem Health

The rapid expansion in the global population, coupled with rising demands for WEF and ecosystem services, has placed considerable pressure on conventional resource management systems, pushing them to their operational limits (Tariq and Willis, 2024). This phenomenon has intensified food insecurity, exacerbated water scarcity, and accelerated ecological deterioration, thereby necessitating the implementation of innovative resource management strategies. The WEFE nexus has surfaced as a critical framework for comprehending the synergies and trade-offs associated with managing these essential resources (Chaher et al., 2024).

Food security is fundamental to human life, societal stability, and economic development. In light of the expanding global population and evolving dietary preferences, the demand for food continues to increase (Kang et al., 2023). Significant water resources are required for food production, and agriculture accounts for the majority of the world's water consumption (about 70%) (Kang et al., 2023). However, on a global level, climate change is making the existing unequal allocation of water resources worse and increasing the strain on them (The Effect of Climate Change on Water Resources, 2022). The tension between the limited supply of water resources and the increasing demand for food is getting worse (Li et al., 2020) and therefore the necessity for efficient method of managing agricultural water is required in order to improve water efficiency in food production while preserving crop production and food security (Ingrao et al., 2023).

WE resources are not just the only the foundational elements of modern production systems and human existence but also strategic resources that are essential for sustaining ongoing social advancement and economic development (Lu et al., 2023). The interrelationship between energy and water is profound: energy is needed for water management, and water is indispensable for energy production. Water is necessary for the extraction and refinement of fuels, irrigation of energy crops, generation of hydroelectric power, and cooling processes in thermoelectric power facilities. Conversely, the acquisition, processing, distribution, and thermal enhancement of water for municipal, industrial, and agricultural purposes require significant energy resources. Furthermore, a substantial quantity of energy is essential for the collection, treatment, discharge, and subsequent reuse of wastewater. This inherent

interdependence is frequently referred to as the energy and water nexus (Silva-Afonso and Pimentel-Rodrigues, 2024).

Ecosystems represent a critical component in the achievement of the Sustainable Development Goals (SDG) (UN, 2015), which encompass water security, energy security, and food security (Sánchez-Zarco and Ponce-Ortega, 2023). The advantages of well-functioning freshwater ecosystems extend from promoting ecological health and supporting human livelihoods to the provision of intangible cultural and aesthetic benefits (Liu et al., 2018).

Environmental flows (e-flows) constitute the segment of natural hydrological dynamics within freshwater ecosystems that is requisite for the sustenance of these ecosystems. Although e-flows encapsulate the ecological requirements for ongoing viability, they typically address the fundamental human necessities for water, which encompass drinking, culinary preparation, and personal hygiene, thereby taking precedence prior to the allocation of water from natural sources for alternative utilizations. E-flows comprise the quantitative volume or levels of water, alongside the frequency, timing, and duration of hydrological events in a river, estuary, or wetland that are essential for the maintenance of the ecosystem (Arthington, 2012; Whitney et al., 2025).

2.7.2 Challenges of Water Governance and Community Participation in Decision-Making

The water governance framework is practical and grounded in place-specific cultural principles that legitimize effective social norms for the protection and sustainable management of current and future water resources within Indigenous territories (Kehinde et al., 2025). This indicates that Indigenous practices of water governance provide a sustainable approach to water management capable of mitigating exploitative human actions while accommodating various human interests and perspectives in the responsible utilization of water resources (Kehinde et al., 2025). Nevertheless, in numerous countries worldwide, the foundational concepts underlying water governance frameworks are frequently perceived as culturally influenced and, at times, dismissed as mere myths or traditional beliefs, thereby undermining their validity in decision-making processes.

Within the domain of water supply, international organizations and government agencies work jointly to promote the provision of safe and clean drinking water for populations in both urban and rural areas. While a variety of strategies are utilized, community engagement is identified as a fundamental element, enabling stakeholder engagement through influence, shared responsibility, resource allocation, and the empowerment of less privileged groups (Rasool et al., 2024). Community involvement serves as a cohesive force, harmonizing actions for the collective benefit and integrating with broader themes of rural development, natural resource stewardship, and management of water resources (Rasool et al., 2024).

Community engagement in the preservation of water resources presents numerous benefits, including enhanced decision-making processes, enhanced accountability, and improved social and environmental outcomes (Boakye & Akpor, 2012). The inclusion of relevant groups, in planning and implementation efforts ensures that water management initiatives more accurately reflect the needs and desired outcomes of the community (Michael Osinakachukwu Ezeh et al., 2024). Moreover, community participation ensures a sense of ownership and stewardship regarding water resources, fostering more sustainable practices and behaviors (Syamsiyah et al., 2025).

Research suggests that community involvement in water management generates a diverse array of advantages, including enhanced governance of resources facilitated by the engagement of local communities in decision-making processes which enhances the transparency, accountability, and perceived legitimacy of water governance initiatives (Ananga et al., 2021).

Moreover, the meaningful involvement of communities in participatory processes promotes social equity by ensuring the inclusion of marginalized and needy groups in both planning and implementation efforts, this, in turn, helps reduce inequalities in access to groundwater resources (The Role of Community Participation in Sustainable Integrated Water Resources Management, 2024). Additionally, this phenomenon yields enhanced environmental results, as community-driven monitoring and conservation initiatives play a pivotal role in the protection and restoration of ecosystems reliant on water resources (Danielsen et al., 2022).

Communities that are actively involved in groundwater management demonstrate heightened resilience, being more equipped at adapting to fluctuating environmental conditions and alleviating risks associated with water scarcity and contamination (Armitage et al., 2022).

Despite the numerous advantages associated with community participation in water management, various challenges and limitations persist. These constraints include the scarcity of resources, as numerous communities are deficient in the financial, technical, and institutional capacities requisite for effective engagement in water management endeavors (Sustainable Groundwater Management Under Global Climate Change, 2023).

2.8 Energy Production and Its Linkages to Water, Food, and Ecosystems

Global goals, particularly SDG 7, underscore the necessity of ensuring universal access to modern, affordable, reliable, and sustainable energy by the year by 2030 (Minas et al., 2024). The International Energy Agency defines energy access as the availability of reliable and affordable electricity alongside clean cooking facilities for households, initially sufficient to support basic needs and progressively improving to align with regional standards. Furthermore, electricity is vital for businesses, driving economic growth through industrialization, while also supporting agricultural productivity by supporting irrigation systems and modernizing machinery. In addition, electricity significantly contributes to the services sector, enhances social well-being, provides environmental benefits, and facilitates research related to the operation of essential household appliances (Shi et al., 2025).

Lesotho's energy sector is largely dominated by the use of biomass fuels such as wood, shrubs, and animal dung, supplemented by imports of coal, petroleum, and paraffin (Department of Energy, 2017). Only 47% of the population has electricity accessibility, with rates varying significantly between rural areas (38%) and urban centers (71%) (World Bank, 2018a). This situation exists alongside a total electricity generation capacity of 77 MW, 75.8 MW is met by hydropower and 1.2 by diesel. Main power generation is concentrated at the 72 MW 'Muela hydropower plant, commissioned in 1999 and constructed as a part of the Lesotho Highlands Water Project (LHDA, 2021). With a peak demand of 140 MW, deficits are met by imports from South Africa and Mozambique (Liu et al., 2019). In addition to the Muela hydropower plant, there are five small-scale hydropower plants in Lesotho with capacity ranges from 180 kW to 2 MW. Due to technical and operational problems, only two out of these plants are currently operational (Lesotho Electricity Company, 2025).

2.9 Community Perspectives on Energy Access and Affordability.

Electricity is one of the key drivers of economic development; it influences various aspects of the economy's production and consumption of goods and services. The demand for energy consumption is rising due to people's rising living standards, increase in population and rapid economic growth. The nexus between electricity availability and economic opportunities has garnered attention, particularly in developing regions, where access to reliable and affordable electricity remains a formidable challenge (Lee et al., 2016).

Electricity access is also connected to poverty reduction. Reliable and affordable electricity can reduce energy poverty, a barrier to economic participation, especially in developing countries. Improved electricity access in these regions promotes local economic development and mitigates rural-urban migration by creating sustainable livelihood opportunities (Asaleye et al., 2025).

Energy systems face increasing pressure to function without failure. Yet power outages are common in energy networks, becoming more erratic and widespread in extremely complex situations while exacerbated by combined impacts of rising demands, aging and inadequately maintained infrastructure, system shocks from extreme events and long-term weather trends shaped by anthropogenic climate change. Power outages are defined by the United States (US) Department of Homeland Security (DHS) as a disruption in electrical supply, often unexpectedly (US Department of Homeland Security; 2024). Disruptions impact communications, transportation, water and other critical services, businesses, food safety, and medical equipment.

According to DHS, energy dependence increases the threat of a severe power failure given that even temporary or minor failures interrupt critical economic, communication, and security systems. When outages occur, the specific consequences unfold throughout diverse infrastructures and socio-technical networks, exposing critical interdependencies of the many systems maintaining livelihood activities and social safety (Ptak et al., 2025). Power outages occur for a variety of reasons including natural causes, human error and overload factors. Examples of natural causes include weather, trees, animals and lightning strikes (Marcotullio et al., 2023).

2.10 Food Security and Agricultural Practices Within the WEFE Nexus

2.11 The Impact of Water and Energy Availability on Agricultural Productivity.

Agricultural production, both livestock and crops, provide a lifeline for the rural population of Lesotho. Lesotho does not have any significant commercial agriculture and very little crop irrigation compared to other countries in the Orange-River basin. Both South Africa and Namibia have a strong commercial agricultural sector with large-scale crop irrigation. The agricultural production in Lesotho for the growing of crops is almost exclusively rainfed (World Bank, 2016). The principal crops reported for the study area is maize, sorghum, and wheat (Bureau of Statistics, 2019). Arable land is estimated at 429 300 ha (FAO, 2018). The agricultural sector is reported with a contribution of 5 percent to gross domestic product (Bureau of Statistics, n.d.). The existing area currently under irrigation in Lesotho is found to be approximately 1000 ha, of which 703 ha of these are confirmed located within five existing irrigation schemes (World Bank, 2016).

Large-scale agriculture and energy production consumes more than 85 % of the regional water consumption (National Bureau of Statistics of China, 2021). With decades of intensive development of agriculture and energy industry, there are many important problems such as ecological degradation, fragile ecological environment, low-resilience natural environment, and water shortage in the study area (Huang et al., 2025).

There is an increasing demand for freshwater to produce foods and feeds, and a wide range of other commodities, to support industrial processes, and to sustain urban and rural populations' needs. The growing global need for freshwater is leading to the depletion of groundwater resources, particularly in areas facing limited surface water availability (Ingrao et al., 2023b).

With the intensification of water scarcity, especially in Mediterranean countries, shift in climatic conditions is expected to further aggravate limitations in agricultural water availability, power generation, and domestic along with industrial use. One of the most significant impacts of water shortages is observed in agricultural crop yields, which are anticipated to decline by 12–20% by the end of the century if no adaptive strategies are adopted (Bellvert et al., 2025). While considerable reductions in crop yields are more likely to occur in

rain-fed agricultural systems compared to irrigated modalities (Ishaque et al., 2023), irrigated agriculture is projected to play fundamental role in the preservation of global food security. In the near future, numerous regions have faced significant challenges regarding water security and shortages due to diminishing reservoir levels, resulting in constraints on available irrigation water and, consequently, pronounced decreases in agricultural output (Bellvert et al., 2025).

2.11.1 Sustainable Farming Practices and Ecosystem Conservation.

Agriculture constitutes a pivotal element within national economies, yielding substantial contributions to income generation, employment opportunities, and food security (Kharel et al., 2022). The health of soil is an essential determinant in the facilitation of sustainable farming practices and the assurance of food safety, particularly in the context of the expanding global population and the escalating demand for agricultural commodities (Kour et al., 2020). However, in response to the rising demand for food, a significant number of farmers have increasingly adopted industrial agricultural methodologies. Traditional approaches are marked by a strong reliance on synthetic inputs, including chemical fertilizers and pesticides. Currently, more than 300 hazardous substances are employed worldwide to enhance soil fertility and control pest populations. While these intensive agricultural practices have contributed to heightened levels of productivity, they have concurrently engendered considerable environmental and health-related challenges (Nuruzzaman et al., 2025). The excessive application of synthetic agrochemicals has resulted in the accumulation of toxic agents within soil, groundwater, crops, and the atmosphere, thus posing threats to both ecological systems and human health (Ahmad et al., 2024).

Furthermore, the prolonged reliance on industrial agricultural methodologies has precipitated the degradation of soil quality, thereby impairing its capacity to fulfill essential ecological functions and deliver ecosystem services. Consequently, the loss of biodiversity, excess soil loss, and diminishing crop yields have emerged as urgent global issues (Nthebere et al., 2025). A principal factor contributing to soil degradation is intensive tillage, which disturbs the structural integrity of soil, accelerates the depletion of vital natural resources, and undermines agricultural sustainability (Valizadeh et al., 2024). Unsustainable farming methodologies, including excessive chemical applications and continuous soil disruption, have exacerbated

these environmental challenges, adversely affecting biodiversity and the resilience of ecosystems (Mng'ong'o et al., 2024).

In light of these pressing challenges, sustainable agricultural practices such as Conservation Agriculture (CA) have emerged as a crucial strategy within contemporary agriculture, significantly impacting ecosystem health and sustainability (Farooq et al., 2024). Conservation Agriculture (CA) is delineated as an agricultural approach that minimizes soil disturbances, preserves soil moisture, and promotes soil health through three fundamental principles: minimal tillage or no-till methodologies, the establishment of enduring soil cover utilizing organic substances, and the implementation of crop rotations and intercropping systems to enhance soil biodiversity and fertility (Farooq et al., 2024).

2.12 Chapter Summary

WEFE has been explained as the approach that incorporates governance and management across the various WEFE as being deeply interconnected, shifting away from a traditional focus on distinct entities. The strong interdependencies between water, energy, agriculture, and natural ecosystems have been highlighted. The chapter also emphasised the community perceptions concerning the WEF nexus as they are fundamental for comprehending resource management and enhancing food security.

CHAPTER 3

3.1 Methodology

This chapter details the research methodology employed in the study, describing the design, methods, and procedures utilized to accomplish the aim and objectives of the study. The study area and how the study population was identified are well explained. Furthermore, the quantitative instrument and strategies to ensure reliability and validity are well explained. A summary of ethical clearance is given and methods for data analysis are addressed.

3.2 Research Design

Descriptive survey was used to investigate the interplay of WEFE nexus resources with socioeconomic and environmental aspects in the Ha Seeiso village. Data was collected using the questionnaires from heads of households residing within the Ha Seeiso village, with a dataset constructed from sampled households obtained through systematic random sampling. The study population was comprised of community members who mostly depend on agriculture for their livelihood. There are 134 households in Ha Seeiso village (Bureau of Statistics, 2016). A sample of 40 respondents was gathered from a population of 134 households in the village, using a sampling interval (k) = N/n. With 134 households, the study population is relatively small. A sample of 40 represents nearly 30% of the entire population**,** which provides adequate representation of community characteristics while maintaining feasibility in terms of time and resources. Sampling theory suggests that for populations under 200, a sample of 30–50 respondents is often sufficient to capture variation and provide reliable estimates of proportions and associations (Creswell, 2014; Israel, 1992). A sample size of 40 exceeds the minimum recommended threshold of 30, which is generally considered adequate. The WEFE nexus study requires household-level data on water use, energy access, food security, and livelihood activities. Collecting in-depth information from all 134 households would be resource-intensive. A sample of 40 balances the need for robust data collection with the practical constraints of time, logistics**,** and financial resources**.**

3.3 Description of the Study Area

Ha Seeiso Metolong is situated approximately 35 kilometers from Maseru along the south Phuthiatsana River (referred to as Little Caledon), which traverses central-western Lesotho as shown in Fig 2. The climatic conditions prevalent in Ha Seeiso Metolong are categorized as temperate continental, characterized by warm summers with temperatures averaging around 28 ºC and exceedingly cold winters where temperatures may plummet to 5 ºC (Weather and Climate data, 2020). The village chiefs exert significant influence and are esteemed as the custodians of the land. A substantial portion of the population (75%) resides in rural areas and relies on subsistence agriculture for their livelihoods (Sekamane et al., 2023). The primary type of land use in the study area comprises settlements with residential structures dispersed throughout, followed closely by the cultivation of field crops. Agricultural activities within the village encompass the production of field crops, livestock husbandry, aquaculture, and arboriculture. The focus of the field crop production system is predominantly on the cultivation of cereals and pulses.

The Ha Seeiso village has been deliberately selected as a study site owing to its strategic proximity to the Ha Seeiso Metolong Dam as illustrated in Fig 3. Notwithstanding the initiatives undertaken to capture water through the Ha Seeiso Metolong Dam to reduce the persistent issue of water scarcity in the area, local communities continue to experience significant water shortages. The agricultural sector, which fundamentally relies on the availability and accessibility of water, constitutes a critical source of livelihood for the Basotho; consequently, the water scarcity indisputably inflicts detrimental effects on the livelihoods and overall well-being of the community (Nyaka, 2021). Furthermore, there exists a pressing challenge of land degradation in the region, primarily driven by soil erosion exacerbated by overgrazing and suboptimal farming practices. The predominant factors contributing to land degradation within the village are overgrazing and inadequate farming techniques, which have resulted in irreversible damage to the landscape, manifested in the formation of deep gullies, the deterioration of rangelands, and the degradation of plant cover attributed to drought conditions (Rampai, 2017).

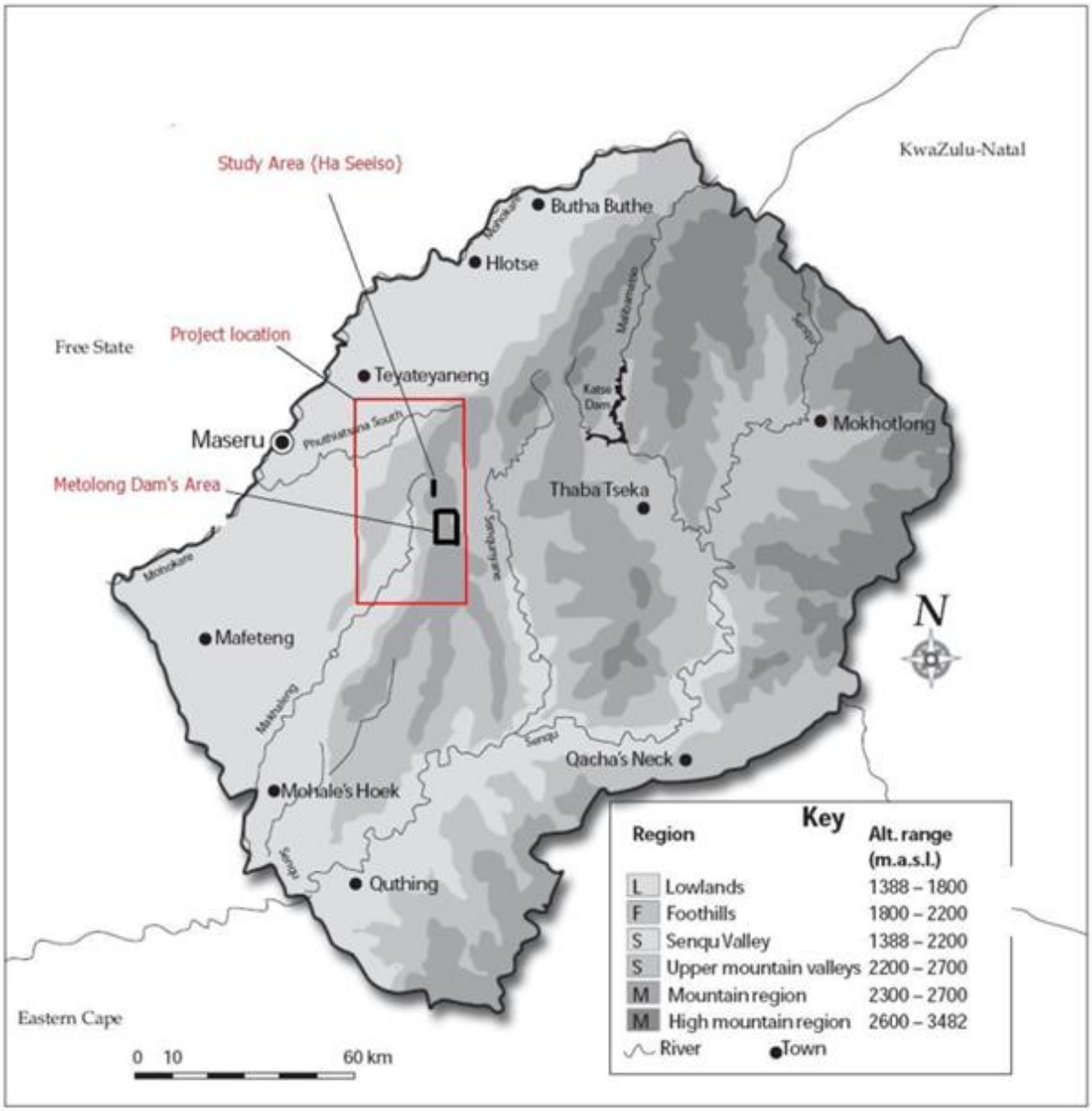

Fig. 2. Map of the study area

Source (Sekamane, 2023)

Fig. 3. Metolong Ha Seeiso village, Goggle Earth Image

3.4 Target population and sampling

The research utilized a systematic random sampling technique to select forty (40) household heads from the designated study area. In alignment with the research design, the sampling framework was predicated on the overall count of households within the village. Specifically, a total of 40 randomly selected self-identified household heads aged 18 years or older, who had resided in the area for no less than 5 years, were identified for the study. This diverse group encompasses various stakeholders, including men and women such as farmers, fishermen, local leaders, and residents, all of whom are directly impacted by concerns pertaining to WEFE security. Their involvement ensured that the scenarios developed was a reflective of the community's needs and perspectives with regard to WEFE.

3.5 Instrument

The questionnaire primarily consisted of closed-ended questions with predefined answer options for participants to choose from and one open-ended question included to allow to elicit more comprehensive responses. The questionnaire was developed using the insights from the literature review. It consisted of 3 main sections as follows:

Section A

i. Demographic data

Section B

This section covered the questions of objectives of the Study

i. Current knowledge and awareness of WEFE nexus
ii. Impacts of WEFE nexus resources on community livelihoods and the social system
iii. Community integration into WEFE Nexus

Section C

i. Open-ended question

3.6 Pilot Study

A pilot study constituted the preliminary phase of the research endeavor, aimed at evaluating the effectiveness of the data instruments within the research context. The instrument was pilot-tested utilizing a sample similar to the target population, specifically conducted at Ha Mafefooane in Roma, involving only 10 individuals from 10 different households. For example, some participants found certain technical terms unclear, prompting rephrasing into simpler language so the pilot study assisted in refining the questionnaire instrument and ensured clarity in the questions posed. It aimed to ascertain the duration of each interview, the clarity of questions, and how the respondents reacted to each question.

3.7 Reliability and Validity

The reliability was assessed by comparing responses from different research assistants to ensure consistency in interpreting and recording answers. The instrument was assessed by facts from the literature review and the questionnaire was given to experts from the water Institute of the NUL to check both content and face validity. Experts were to judge whether the

instrument was measuring what it was meant to measure or not, whether statements were not ambiguously stated and whether it was clear. Construct validity was prioritized by ensuring that the survey items accurately measure community perceptions, with expert reviews of the questionnaire prior to implementation. The criterion-related validity was considered by comparing the responses of local participants with existing research or expert opinions on the nexus. During data analysis, key themes such as water use priorities, resource allocation practices, and perceived management challenges were cross-referenced with the literature to identify consistencies and discrepancies.

The results for the pilot study and experts were used to modify the questionnaire and once the researchers were satisfied, the data collection process then commenced.

3.8 Ethical Considerations

Informed consent was secured from each participant before data collection commenced so as to ensure they understood the purpose of the study, how their data would be used and their right to withdraw at any time without consequences. It was made clear to participants that confidentiality is paramount, that personal details will be anonymised and the information provided by the participants will only be used for the intended research purposes. Participants were treated with respect and dignity and participation was voluntary. Cultural sensitivities of the community, tailoring questions were also considered and transparency was well maintained.

3.9 Data Collection

Methodology flow chart for data collection and data analysis

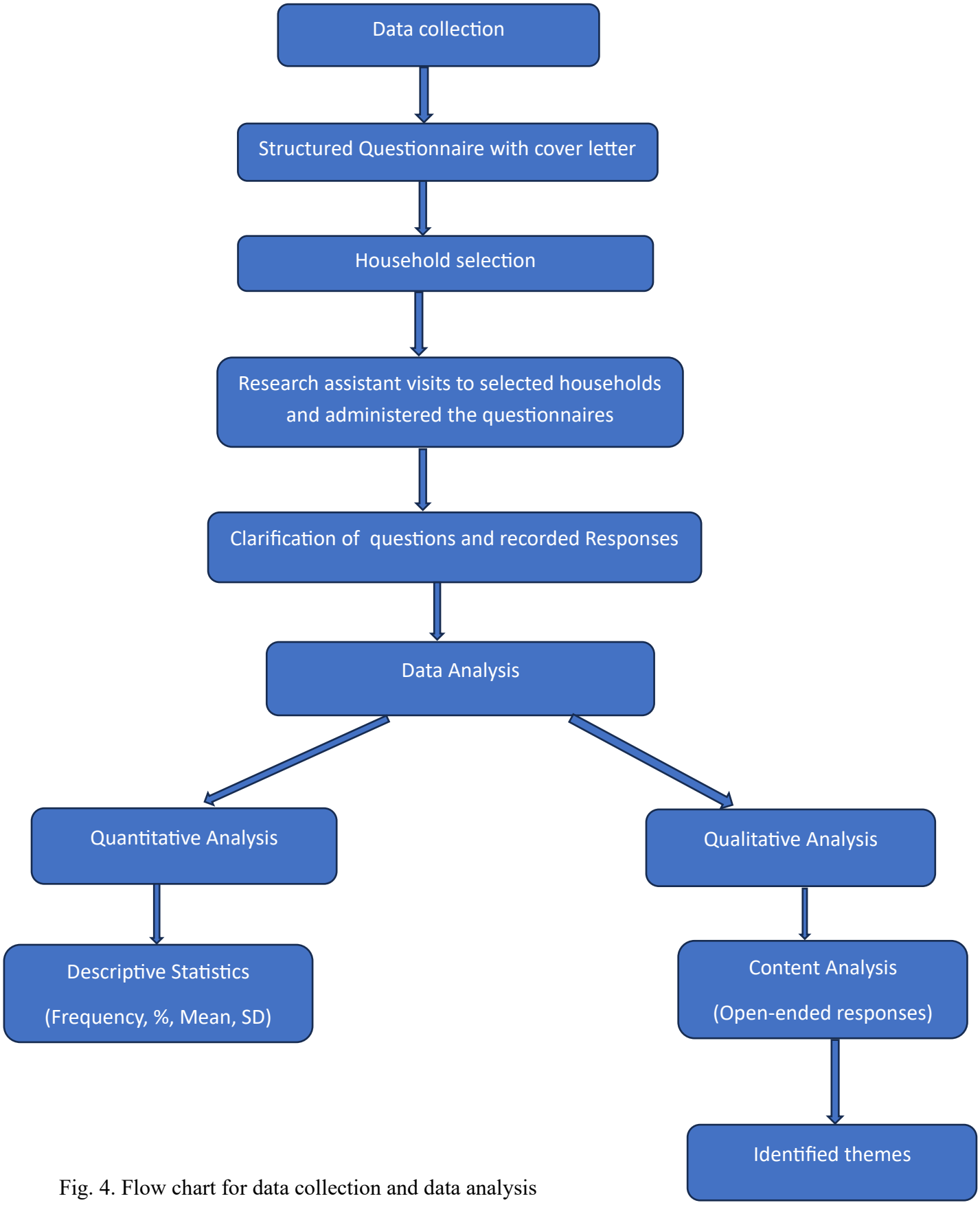

Fig. 4. Flow chart for data collection and data analysis

The data collection for this study was conducted using a structured questionnaire consisting of quantitative questions and one open ended question for qualitative data as show Fig 4. The questionnaire was distributed along with a cover letter that detailed the objectives of the research and asking for participants support in completing the questionnaire as well as assuring the respondents that their responses will be treated with highest confidentiality. The residents at Ha-Seeiso were informed through the chief and the office of the council about the study at least a week before data was collected so that they were aware that there would be people moving in the village and knocking at their doors for data collection. Research assistants visited randomly selected households to administer the questionnaire and record responses. The study was conducted by trained research assistants who are literate and fluent in both English and Sesotho. Research assistants facilitated the data collection process by clarifying any ambiguities in the questions and accurately recording responses on behalf of the participants to ensure data reliability and validity. Data collection took 5 days of the week from -18-24 march 2025.

3.10 Data Analysis

Quantitative analysis

The data obtained from the questionnaire has applied the quantitative approaches for data analysis. It was analyzed using descriptive statistics of frequency count, simple percentages, mean and standard deviation.

Qualitative Data Analysis

The open-ended question included in the questionnaire, generated in-depth information about the opinions of respondents and it was analyzed using content analysis to identify themes and meanings of data. Responses from open-ended questions were transcribed and organized into a database, each response was carefully read to gain familiarity with the data. Line-by-line coding was conducted to capture key words, phrases, and expressions relevant to the Water–Energy–Food–Environment (WEFE) nexus. Codes were both deductive (guided by the conceptual framework: water, energy, food, and livelihoods) and inductive (emerging from the

data, such as coping strategies or perceptions of scarcity). Themes were analyzed in relation to the research objectives and conceptual framework. For example, water-related responses were linked to both household consumption and agricultural production, highlighting the interdependence of water security with food production and livelihoods.

3.11 Research impact

This research examined the influence of community views on the management and production of water and related resources in the Ha Seeiso Metolong catchment, offering critical insights for the development of effective community-based programs. It addressed key limitations in the current literature regarding the relevance of local residents' engagement in water resource management, particularly in Lesotho. The study examined sustainability concerns related to water and ecological issues, emphasizing the importance of community involvement in addressing these challenges. It pointed out the significance of community participation in efficient water resource management and examined the methods by which community engagement may strengthen governance and accountability in the WEFE nexus. Involving communities in the WEFE nexus enhances individual empowerment and strengthens local capability. This empowerment promotes a sense of belonging and accountability, resulting in increased proactive and enduring community engagement and environmental sustainability.

3.12 Chapter Summary

This chapter outlined the methodological framework employed in the study, which utilized quantitative and qualitative approach for open-ended question. It detailed the instruments used for data collection and the measures implemented to guarantee the rigor of the results. In summary, this chapter served as a detailed blueprint for the entirety of the research, elucidating the methodological framework and procedures that substantiate the study.

CHAPTER 4

4.1 Results

This chapter outlines the results of data collection and analysis using the statistical package SPSS. Data is presented in 3 sections covering the 3 objectives of the study. The objectives addressed in this study were:

1.To examine the impacts of WEFE nexus resources on community livelihoods and the social system (socio-cultural dynamics and the indigenous knowledge).

2.To assess the current knowledge and awareness of WEFE nexus among residents at Metolong Ha-Seeiso village

3.To discuss how community participation can be integrated into water-energy-food-ecosystems (WEFE) nexus management by analyzing existing frameworks and identifying gaps.

The results are organized in alignment with the research objectives in which quantitative data is presented chiefly in bar charts, graphs, and tables. The results open with information on the demographic data of the respondents**.**

Section 1

Following the demographic information presented in this chapter the perception of the community on the impact of WEFE nexus resources on community livelihoods and the social system (socio-cultural dynamics and the indigenous knowledge) results are presented for objective
1: To examine the impacts of WEFE nexus resources on community livelihoods and the social system (socio-cultural dynamics and the indigenous knowledge).

4.2 Demographic Information of Participants

According to Bartschi (2020), the provision of comprehensive demographic profiles represents an ethical imperative, as it helps researchers in acknowledging diversity and inclusivity, thereby minimizing biases and enhancing the validity of the conclusions. Furthermore, demographic data contextualizes the generalizability of the findings. Tables 4.1.1 to 4.1.3 delineate the demographic characteristics of the participants in this investigation.

Table 1

Table 4.1.1: Proportion of respondents by gender

Gender	Frequency	Percentage %
Male	15	36.6
Female	26	63.4
Total	41	100.0

Field Survey: March, 2025 (n=41)

Table 4.1 above shows that 15 male respondents participated in the study and this accounts for 36.6% of the total sample used for the study. Similarly, 26 (63.4%) of the study sample were females.

Table 2

Table 4.1.2: Distribution of respondents by age

Age group (years)	Frequency	Percentage %
18-24	3	7.3
25-34	5	12.2
35-44	17	41.5
45 or Older	16	39.0
Total	41	100.0

Field Survey: March, 2025

Table 4.1.2 shows that 7.3% of the study participants were between the ages of 18 – 24 years old, 12.2% were between 25-34 years old, 41.5% were between 35-44 years old and 39.0%

were between 45 or older. The total respondents were 41. It shows that age group 35-44 contained more of the participants than other groups followed by those that are 45 or older, age group 18-24 and 25-34 has the least of the participants.

Table 3

Table 4.1.3: correlation of respondents by age and gender

	Gender			
	Male		Female	
Age group	Frequency	Percentage (%)	Frequency	Percentage (%)
18-24	1	2.4	2	4.9
25-34	2	4.9	3	7.3
35-44	7	17.1	10	24.4
45orOlder	5	12.2	11	26.8
Total	15	36.6	26	63.4

Field Survey: March, 2025

Table 4.1.3 relates to table 4.1 and 4.2, it shows that the respondents were mostly between 35-44 years of age and 45 or older and 17.1 % of age group 33-44 were males and 24.4 % were females whereas 45 or older age group also hold a higher number of females 26.8% compared to males 12.2%. In this study, females, 63.4% participation was higher than that of males 36.6%.

These results are presented in accordance with objective 1: To examine the impact of WEFE nexus resources on community livelihoods and the social system (socio-cultural dynamics and the indigenous knowledge).

4.3 Community Perceptions on WEFE Nexus Resources and Livelihoods

The respondents 100% revealed that they depend on water from springs, water taps and rain water harvesting as their main sources of water. Even though they are based next to the dam, they mentioned that they do not use the water from the dam.

Table 4

Table 4.2.1: The main sources of water for household and agricultural use

Response	Frequency	Percentages %	Mean	StD
Springs and wells and tap water	20	48.8	1.51	0.506
Tap water and rainwater harvesting	21	51.2	1.51	0.506

Field Survey: March, 2025

Table 4.2.2, presents respondents' perceptions of access to clean water. A majority (46.3%) rated access as good, while a comparable proportion (43.9%) reported poor access. Only a small fraction (9.3%) considered access to be moderate. This indicates significant inequality in water accessibility. The small percentage (9.3%) reporting moderate access suggests that most respondents have either clearly sufficient or clearly inadequate access to clean water, with little in-between.

Table 5

Table 4.2.2: Water accessibility

Themes		Frequency	Percentages %
Access to clean water	Good	19	46.3
	Moderate	4	9.3
	Poor	18	43.9

Field Survey: March, 2025

Table 4.2.3 indicates that the majority of respondents (22), representing 54%, perceived no improvement in their lives and livelihoods following the construction of the Metolong Dam, while 14 respondents (34%) expressed a contrary view, reporting positive impacts and 12% indicated that they are negative.

Table4.2.3: Impact of WEF resources on income generation activities by gender

Responses	Frequency	Percentages	Mean	Std
Positively improved income opportunities	14	34.1	1.78	0.652
No significant impact	22	53.7		
Negatively affected income opportunities	5	12.2		

Source: Field Survey: March, 2025

4.4 Socio-cultural dynamics and indigenous knowledge

The perspective of the respondents to socio-cultural dynamics and indigenous knowledge. Majority of the respondents **(90.2%)** believe IKS helps manage WEFE resources effectively and only few **(9.8%)** disagreed as shown in fig 5. The low **mean of 1.10 and very small standard deviation** of **0.300** reflect strong consensus and limited variation in opinions.

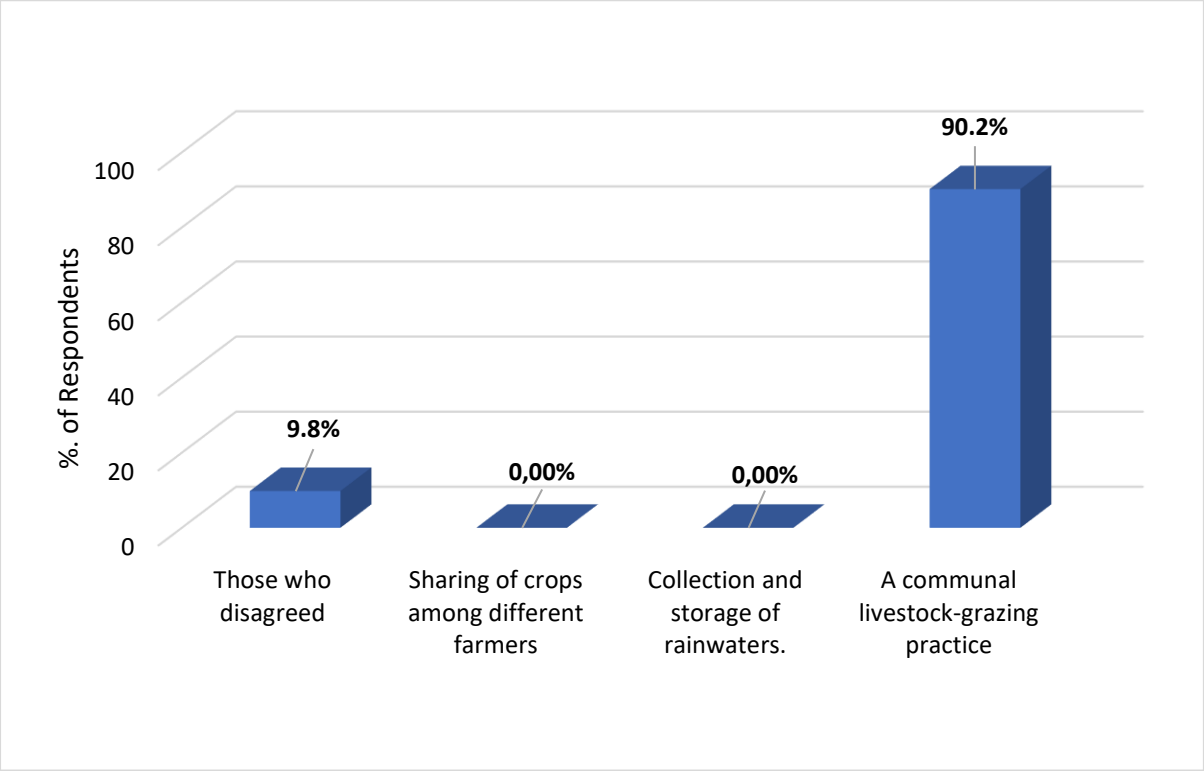

Fig. 5. Traditional practices or indigenous knowledge systems

Section 2

The findings presented in this section are in accordance with objective 2: To assess the current knowledge and awareness of WEFE nexus among residents at Metolong Ha-Seeiso village.

4.5 Awareness of the WEFE nexus

Findings in fig 5, show that awareness of the WEFE nexus remains limited. Only about half of the respondents 20, (48.8%), have heard of the concept, and the other half 21, (51.2%) are not

familiar with it. Among those aware, educational institutions 8 (19.5%) were most frequently cited as the primary source of information, followed by community meetings 6 (14.6%) and media 6 (14.6%). (Iqbal Mujtaba Freng, 2024) mentioned that scholars highlight that educational initiatives, academic research, and training programs are essential for building capacity and fostering cross-sectoral understanding necessary for implementing the nexus approach. Workshops, community engagement, and public communication are also increasingly recognized as vital channels for disseminating WEFE concepts, supporting the transition from theory to practical action.

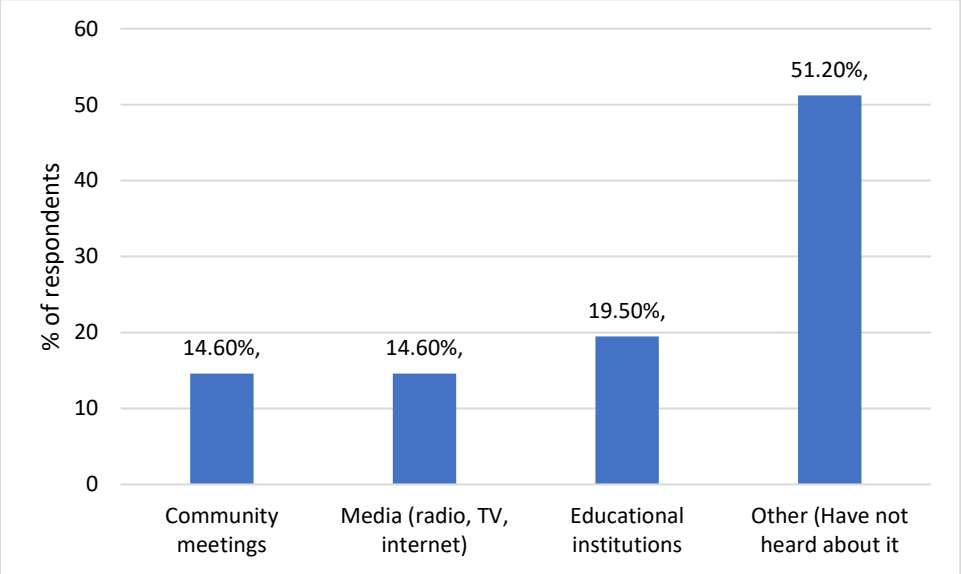

Fig. 5. Source of information on WEFE nexus according to the respondents

Standard deviation	
Low	- 0.400
Moderate	0.400 – 0.600
High	0.600 – 0.900

All respondents who were aware of the WEFE Nexus (48.8%) concurred with its definitions, which highlight the interdependence among the water, energy, food, and ecosystem sectors, as well as the importance of examining synergies, conflicts, and trade-offs in their integrated management (Simpson and Jewitt, 2019, Sánchez-Zarco and Ponce-Ortega, 2023). The

standard deviation is 0.229, indicating very low variability and suggesting strong consensus among those who answered.

4.6 Knowledge on WEFE Resources and How One Affect Other Sectors

Survey data table 4.5.1 indicates the perceptions of the community regarding the experienced resource-related challenges, with 95.1% facing water issues, despite abundant water resources.

Table 6

Table 4.5.1: Water challenges faced by the respondents at Ha Seeiso

THEMES		Frequency	Percentage (%)
Experienced challenges related to water, in your community	Yes	39	95.1
	No	2	4.9
water scarcity and contaminated sources		39	95.1

Source: field survey March 2025, (*n = 41*)

Energy challenges

All participants 100% reported experiencing significant energy challenges in Ha Seeiso, primarily due to frequent power outages attributed to adverse weather conditions (Muttaqee et al., 2025). These outages were unanimously identified as the sole energy-related problem affecting the community. Respondents further indicated that, aside from these disruptions, they did not encounter any financial barriers to installing and buying electricity in their homes and these power outages significantly disrupt their daily routines and activities. According to (Lipholo Makhetha, 2014), energy insecurity is compounded by Lesotho's reliance on imported electricity, making access both costly and unreliable for many households.

The table 4.5.3 indicates that nearly all households experienced food challenges, with 92.7% struggling with food supply whereas 9.8% had limited access to fresh produce and 7.3% did not have any challenges regarding food.

Table 7

Table 4.5.3: Food challenges faced by the respondents at Ha Seeiso

THEMES		Frequency	Percentage (%)
	Yes	38	92.7

Experienced any challenges related to food supply in your community	No	3	7.3
Limited access to fresh produce due to transportation issues.		4	9.8
Climate change reduces agricultural productivity, contributing to rising food prices		34	82.9

Source: Field Survey: March, 2025, (*n = 41*)

A substantial majority of respondents 97.6% in table 4.5.4, agreed that water availability directly affects food production while only 2.4% had a different view.

Table 8

Table 4.5.4: Impacts of water availability on food production

Statement		**Frequency**	**Percentages %**
Water availability directly impacts food production	Yes	40	97.6
	No	1	2.4
Sufficient water boosts agriculture, while water scarcity reduce yields and threatens food security		40	97.6

Source: Field Survey: March, 2025, (*n = 41*)

The fig. 6, indicates that the majority of respondents (75.6%) acknowledge energy's role in food and water systems, highlighting the critical interdependence of these sectors. Out of these 75.6%, 36.6% believes that water supply relies on energy whereas 22.0% reported that irrigations systems require electricity and 17% mentioned that energy powers machinery for harvesting and processing. However, the presence of dissenting opinions (24.4%) and a standard deviation of 0.435 suggest variability in understanding, particularly in rural contexts where energy access remains limited.

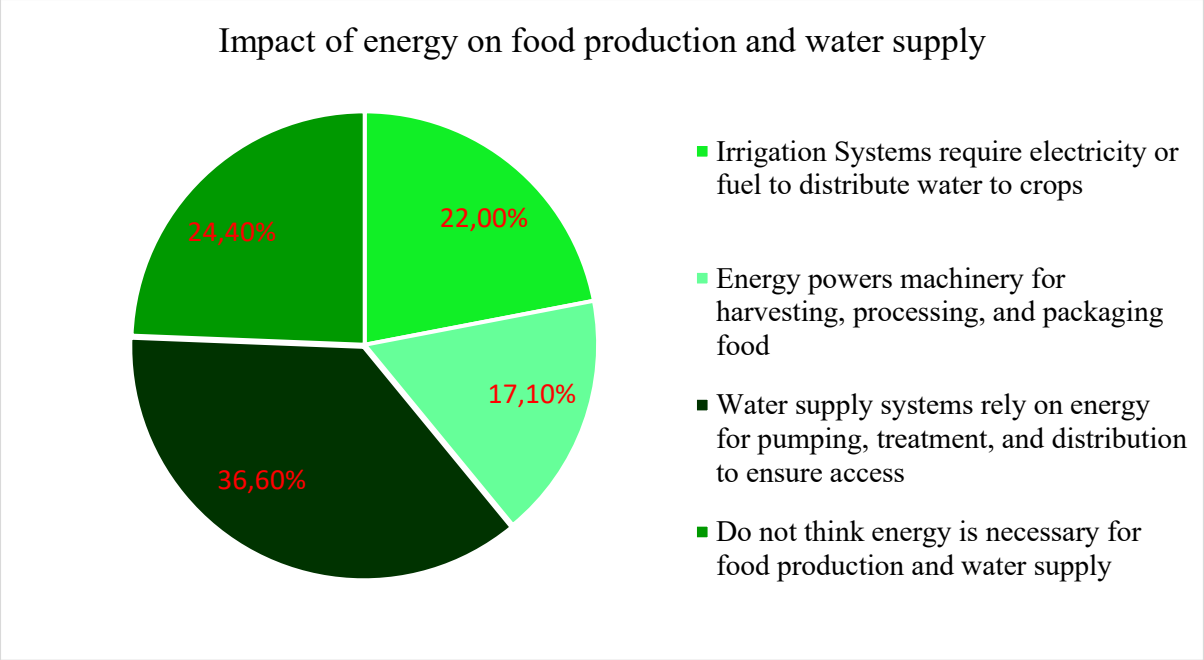

Fig. 6. The perspective of the respondents toward the impact of energy on water supply and food

The respondents (41) 100% agreed that environmental degradation affects water, food, and energy resources, indicating a strong shared perception. Environmental degradation in Lesotho significantly impacts water resources through several interrelated processes. The lack of adequate forest and vegetation cover has led to increased runoff and soil erosion, which reduce both water quality and availability by accelerating sedimentation and contaminant loads in water bodies. All the respondents reported that following the construction activities at Metolong Dam, a significant portion of their land was acquired by the Metolong Authority, resulting in a reduction of available pasture for livestock grazing. This loss of grazing land has intensified pressure on the remaining rangelands, leading to overgrazing.

Section 3

The findings presented in this section are in accordance with objective 3: To discuss how community participation can be integrated into water-energy-food-ecosystems (WEFE) nexus management by analyzing existing frameworks and identifying gaps.

4.7 Community Participation at Ha Seeiso

Table 4.6.1 shows that participation levels vary significantly across the community about 31.7% not involved at all, 29.3% are rarely involved, 24.4% are sometimes involved and only 14.6% are always involved at the mean of 2.78 and the standard deviation of 1.061 shows high variation in participation and in this study most of the participants are not involved in decision making processes.

Table 9

Table 4.6.1: Involvement of residents in decision-making processes about resource management

Participants' responses	Frequency	Percentage %	Mean	STD
Yes, always involved	6	14.6	2.78	1.061
Sometimes involved	10	24.4		
Rarely involved	12	29.3		
Not involved at all	13	31.7		

Source: Field Survey: March, 2025 (n=41)

4.8 Existing Frameworks for WEFE Nexus Management

The majority of respondents (78%) are aware of frameworks that integrate community participation in WEFE nexus management. Only 22% reported no awareness. Integrated Catchment Management (ICM) is recognized by all 32 aware respondents (100%) as a key framework. The low mean (1.22) and standard deviation (0.419) reflect high agreement on awareness.

Table 10

Table 4.7.1: Existing Frameworks at Ha Seeiso

Statement		Frequency	Percentages %	Mean	StD
Existing frameworks that integrate community participation in WEFE nexus management	Yes	32	78.0	1.22	0.419
	No	9	22.0		
Integrated Catchment Management (ICM		32	78.0	1.00	0.00

Source: Field Survey: March, 2025 (n=41)

4.9 Qualitative results for the open-ended question – Suggesting ways to involve community participation in WEFE Nexus at Metolong.

The table 4.8.1 indicates the respondent's perception on suggesting the ways to involve the community participation in the WEFE nexus, highlighting the importance of inclusive stakeholder engagement within governance frameworks. Respondents emphasized the importance of developing community-based and incentive-driven models to promote sustainability. They further highlighted the need for integrated policies and educational initiatives to raise awareness. Overall, empowering local residents through policy, participation models, and capacity-building efforts was considered essential.

Table 4.8.1 Ways to involve community participation in WEFE Nexus at Metolong.

Respondents' statements	Concept	Category
There is a need for frameworks that prioritize inclusive and continuous stakeholder engagement across all levels.	Inclusive participation	Governance/Policy Frameworks
Community-based and incentive-driven models must be developed to ensure long-term sustainability.	Incentive-based participation	Community Participation Models
Integrated policies and education programs should be designed to raise awareness and empower local residents.	Integrated policy & education	Capacity Building & Awareness

Source: Field Survey: March, 2025 (n=41)

CHAPTER 5

5.1 Discussion

Females are the ones that participated more in this study, this tendency may be ascribed to the high rate of male migration, particularly from rural areas, to South Africa in search of employment chances to support their families (IOM, 2024). (Bureau of statistics, 2016) also revealed that at Ha Seeiso the female population is higher than the male population. According to (ODI Insights, 2016), women are managing the complexities associated with securing water for domestic purposes while simultaneously safeguarding water availability for agricultural activities, with the pressure escalating during the seasonal peaks of water scarcity and agricultural labour demands. In contrast to men, women generally experience diminished access to and control over vital resources such as land, water, agricultural machinery, and inputs, which could potentially serve as a buffer against the adverse effects of rainfall variability (ODI Insights, Gender, agriculture and water insecurity, 2016). According to the Centers for Disease Control and Prevention (2016), an estimated 780 million people in developing countries face deficient access to safe water and sanitation services. Notably, women and girl children comprise approximately 65% of this affected population.

Extensive evidence substantiates that women predominantly bear the responsibility of ensuring the presence of water for domestic use such as sanitation, culinary activities, and personal hygiene; thus, the utilization of water is inherently gendered in this context (Galvin, 2011). The repercussions of inadequate access to water predominantly impact women and girls. For instance, in scenarios where water is unavailable from taps, women are compelled to spend considerable time walking longer distances to communal water sources or rivers for water collection. This renders women susceptible to various vulnerabilities, including violence, sexual harassment, and increased absenteeism of girls from educational institutions (Davies et al., 2023).

The community in Ha Seeiso reported that they access water through a piped system that directs spring water to village taps. However, they observed that the spring occasionally experiences depletion and fails to deliver water during dry periods. Moreover, the presence of piped or dug sources does not guarantee consistent water provision. Factors such as insufficient rainfall,

inadequate water management practices, or a lack of resources for infrastructure maintenance can result in irregular water supply. The absence of on-premises access to water may necessitate that certain family members, particularly women and girls, to spend many hours each day to fetch water, thereby detracting from time that could be allocated to income generation, educational pursuits, or leisure activities (Gomez et al., 2019).

Whitfield and Reed (2012) assert that within the context of a developing country context, the multifunctional utilization of WEF sectors derived from diverse sources is critically significant, however, policies, research, and developmental initiatives often give limited attention to methodologies for their synergistic management. A significant consequence of this oversight is the emergence of a knowledge gap regarding the interrelations between WEF production and consumption, and their impact on livelihoods, as well as the degradation of ecosystem services.

Lesotho's unique geographic position, characterized by its elevated altitude and pristine natural environment, position Lesotho as the "water tower" of Southern Africa (ReNoka, 2021), nevertheless, a substantial portion of the rural population continues to face ongoing difficulties in accessing clean water, adequate sanitation, and reliable irrigation water supply. These challenges are largely due to the lack of integrated resource management approaches necessary for ensuring the sustainable use and effective governance of existing resources (Emerton, 2001).

Despite abundant water resources, inadequate infrastructure means many Basotho struggle to access clean water, particularly in rural and mountainous districts (Lipholo Makhetha, 2014 and World Bank Report 2016). The majority of the population faces difficulties obtaining essential services such as piped water and electricity, with 79% of rural and 56% of urban residents reporting challenges (Lipholo Makhetha, 2014). Respondents in Metolong Ha Seeiso reported persistent challenges in accessing water, despite their proximity to the dam. They indicated that they do not benefit directly from the water supplied by the dam, as the infrastructure intended to connect their households, such as meter boxes and taps, remains incomplete, and the company responsible for installation did not complete the work. As a result, residents continue to rely on water sourced from a local spring, which is collected into a tank and distributed to the community through a piped system. However, this alternative water source is unreliable, as the spring sometimes runs dry, forcing residents to wait one or two days before water becomes available again. This situation has led to ongoing dissatisfaction, as the

community expected improved water access following the dam's construction, but instead continues to face water scarcity and service interruptions (LENA, 2024).

Household water insecurity around the Metolong Dam persists despite the presence of significant infrastructure, reflecting deeper systemic issues of governance and policy. Fragmented institutional mandates between national agencies, local councils, and project committees have created service delivery gaps that prevent equitable access to stored water. Furthermore, policy misalignment prioritizes large-scale infrastructure development over localized distribution and maintenance, thereby marginalizing peri-urban and rural communities situated closest to the resource. Failures in implementation, including inadequate financing for distribution networks, weak operation-and-maintenance systems, and minimal community engagement, further undermine the dam’s potential to address household needs.

Significant energy challenges in often faced by rural areas, primarily due to frequent power outages attributed to adverse weather conditions (Muttaqee et al., 2025). These outages were unanimously identified as the sole energy-related problem affecting the community. There are no financial barriers to installing and buying electricity in their homes and these power outages significantly disrupt their daily routines and activities. According to (Lipholo Makhetha, 2014), energy insecurity is compounded by Lesotho’s reliance on imported electricity, making access both costly and unreliable for many households.

(Larsen et al., 2020) concurred that power interruptions result from a multiple of factors, including meteorological influences, malfunctions or failures of electrical equipment, and indirectly, financial strategies pertaining to power system infrastructure, operations, and maintenance (Larsen et al., 2020). The U.S. Department of Energy reports that harsh weather events are the primary drivers of power outages, and their occurrence has risen markedly over the past twenty years. These disruptions have notable negative impacts on economic performance (Larsen et al., 2020).

Agricultural production, including both crop cultivation and livestock farming, plays a critical role in sustaining the livelihoods of Lesotho's rural population. In contrast to other countries within the Orange-River basin, Lesotho lacks substantial commercial agriculture and exhibits minimal crop irrigation. South Africa and Namibia boast a robust commercial agricultural

sector characterized by extensive crop irrigation (FAO, 2019/2020). The agricultural production within Lesotho is predominantly reliant on rainfall (World Bank, 2016).

The prolonged drought periods, resulting from climate change, have significantly impacts on food security, it has resulted in reduced crop yields and increased expenses when purchasing food. Droughts have become more frequent and severe, further undermining agricultural production and food security (World Vision, 2024).

The critical interdependence between WEF systems has been widely recognized forming the foundation of the WEF nexus approach. Food production is responsible for roughly 30% of global energy consumption, whereas energy generation frequently depends on substantial water resources, particularly for cooling and steam generation processes (Verma et al., 2024) This interconnectedness is noticeable in agriculture, which is the largest consumer of freshwater globally and heavily dependent on energy for irrigation, processing, and transportation. The respondents also mentioned that they rely on rain-fed agriculture since they don't have access to the Metolong dam water for irrigation.

As water scarcity intensifies, especially in Mediterranean regions, climate change is expected to further reduce the availability of water for irrigation, energy generation, and both domestic and industrial uses. The most significant impacts of water scarcity are often evident in agricultural crop production, which is projected to decrease by 12–20% by the end of the century in the absence of adaptive interventions (Bellvert et al., 2025a). While substantial losses in crop yield are more likely to manifest in rainfed agricultural systems compared to irrigated ones (Ishaque et al., 2023), irrigated agriculture is expected to play a pivotal role in safeguarding global food security.

The construction of the dam has reduced the availability of grazing land which contribute to the food security and this has led to reduction of livestock and even caused the livestock to graze at far rangelands. The construction has caused detrimental effects to the biodiversity of the area as some of the important trees such peach trees (Prunus persica), gum trees (Genuseucalyptus), pine trees (Genus pinus), apple trees (Malus pumila), willow trees (Genus Salix), apricot trees (Prunus armeniaca) and various types of poplar trees (Populus) were lost (Sekamane, 2021).

Through construction of large dams, people have been able to collect water and store it in reservoirs. Stored water in a reservoir is very important for areas experiencing drought, or in areas having rainfall that is seasonal. The Aswan Dam in Egypt is an example which experiences unreliable rainfall (Bashir et al., 2011). Construction of large dams and reservoirs help with water that is enclosed, which can be used for irrigation purposes. In many regions, especially during dry seasons, irrigation is required for growing crops as a way of increasing productivity. This view is supported by (Vorosmarty et al., 2005), who stated that out of 100%, 64% of the total population in Africa use water for different purposes.

Community or citizen contributions to nexus problems, solutions, and interventions are underexplored. (Lotz-Sisitka et al., 2024) emphasize the importance of adaptive governance frameworks that facilitate stakeholder involvement and knowledge co-production, which are crucial for navigating resource conflicts and fostering resilience.

According to (Johnson and Karlberg, 2017), the WEFE nexus approach explains the strong interdependence among these critical sectors and the need for integrated, cross-sectoral management to achieve sustainability and security. Community participation is important to the success of the WEFE nexus approach. Participatory scenario-building processes provide a valuable space for dialogue among diverse stakeholders with different knowledge, priorities, and perspectives. This allows for a better understanding of the interlinkages between the WEFE sectors and the identification of mutually beneficial solutions that manage trade-offs (Global Water Partnership, 2023).

The meaningful participation of communities in inclusive decision-making processes fosters social equity by incorporating vulnerable populations into planning and implementation efforts, thereby contributing to the reduction of inequalities in groundwater resource access (The Role of Community Participation in Sustainable Integrated Water Resources Management, 2024). Additionally, this phenomenon yields improved environmental results, as community-driven monitoring and conservation initiatives play a pivotal role in the protection and restoration of ecosystems reliant on water resources (Danielsen et al., 2022). Despite the many benefits of local people participation in water management, several issues and limitations remain. These challenges include resource constraints, as many residents lack the necessary financial, technical, and institutional capacities required for regular involvement in water management initiatives (Sustainable Groundwater Management Under Global Climate Change, 2023).

Community participation within the Ha Seeiso area of the Metolong catchment demonstrates both considerable potential and significant constraints. While local communities acknowledge the importance of engaging in Water, Energy, Food, and Ecosystem (WEFE) management, their involvement is limited by several structural barriers. A key challenge is the lack of sustained institutional support, where consultations often occur without meaningful incorporation of community perspectives into decision-making. Financial constraints further hinder participation, as households and community groups lack adequate resources to maintain conservation practices or invest in local infrastructure. In addition, the absence of continuous and inclusive platforms for dialogue reduces opportunities for constructive engagement between communities and policymakers. Nevertheless, opportunities exist to strengthen participation through established frameworks such as Integrated Catchment Management, particularly the ReNoka programme, which offers organized entry points for community involvement. Traditional leadership structures, notably chiefs and village councils, continue to serve as trusted mechanisms for mobilization and collective action.

Local communities, particularly the rural poor within developing nations, rely significantly on various nexus resources for their means of subsistence (Mohtar & Lawford, 2016). Consequently, the comprehension and establishment of consensus regarding the nexus resource approach are critically important. The local residents view the availability and allocation of nexus resources as intrinsically linked to their diverse uses for sustaining livelihoods (Wolde et al., 2020). The demand for food production is consistently escalating alongside population growth, while millions of individuals persist in lacking access to nutritious food essential for a healthy and active lifestyle. This situation is associated with inadequate access to WEF nexus resources (Javan et al., 2024).

Decentralizing the management of nexus resources to local people enhances both household-level access to these resources and their governance (Granit et al., 2012). Therefore, upholding the WEFE nexus serves as a strategy to enhance resource security and resilience, ultimately contributing to the sustainability of livelihoods and the preservation of the ecosystem. Natural resources particularly WEF, (land), represent the essential resource base from which households generate income, fulfil basic needs, mitigate risks, and adapt to stresses and shock (Rakodi, 2014).

Energy plays a crucial role in strengthing household quality of life and driving broader economic activities. Access to education and skills development, healthcare, sanitation facilities, clean water, and sufficient nutritious food are critical determinants influencing individuals' perceptions of their livelihoods (Wolde et al., 2020). Likewise, the ecological dimension encompasses the natural environment and the available resource base that households can access and manage to enhance their livelihood outcomes (Rakodi, 2014).

The livelihood of the local residents is predominantly reliant on rain-dependent farming and the husbandry of domesticated animals as their primary food sources. Consequently, food production exerts a profound influence on the sustenance of the residents from the perspectives of environmental variability, natural resources, and economic conditions (Wolde et al., 2020).

This indicates that the challenges associated with food security are contingent upon unforeseen alterations in the physical environment and natural resources, which consequently impact social and economic conditions (Wolde et al., 2020). The interrelationship between resources and livelihoods necessitates a strategy that addresses the highlighted issues to livelihoods, as management of individual nexus resources independently does not lead to improvements in the human environment interactions (Bizikova, Roy, Swanson, Venema, & McCandless, 2013).
Soil erosion and soil degradation in Lesotho dates back to the late 1800s when early missionaries reported the development of gullies (Couzens, 2003). Today, the state of land is described as critical and the country is known for its prominent soil erosion. Soil erosion is a major threat to the dependency of the Basotho on the land resources. (Leduka et al., 2015) state that, 85% of the population derive their livelihood from agriculture and livestock rely heavily on rangelands for fodder.

The WEF nexus model has indeed been implemented in Lesotho, with various initiatives aimed at integrating these sectors for sustainable development. The study has revealed that there is an introduction of Integrated Catchment Management (ICM) Program, this program, supported by the European Union, focuses on sustainability and management of water and land resources. It aims to rehabilitate degraded catchments, which are crucial for WEF security. The program is part of broader efforts to align with the WEF nexus approach, ensuring that water resources support both energy generation and agricultural activities. For instance, The ReNoka program which is part of the ICM initiative, is an example of successful WEF nexus application. It aims to rehabilitate catchments, ensuring sustainable water resources that can support both

hydroelectric power generation and agricultural activities, thus aligning with the WEF nexus principles (ICM, ReNOKA programme reports, 2022).

CHAPTER 6

6.1 Conclusion and Recommendations

6.2 Conclusion

This study demonstrates that WEFE nexus resources play a critical role in shaping residents' livelihoods and the social system within Ha-Seeiso village. Beyond providing material sustenance, these resources influence socio-cultural dynamics and the preservation of indigenous knowledge, underscoring their centrality to both economic and cultural resilience.

The research also revealed that community knowledge and awareness of the WEFE nexus remain limited, with residents predominantly focusing on water and food while giving less attention to energy and ecosystem considerations. This finding highlights the need for targeted education and outreach programs to enhance holistic understanding of resource interconnections and promote informed decision-making at the local level.

Finally, the study identifies the importance of integrating community participation into WEFE nexus management. Analysis of existing frameworks indicates that current approaches are often sector-specific and insufficiently inclusive at the grassroots level. Enhancing local engagement through collaborative, context-sensitive strategies can strengthen sustainable resource management, support livelihoods, and provide critical insights for policy development at local, national, and regional scales.

6.3 Recommendations

- It is recommended that participatory surveys, focus group discussions, and community dialogues be conducted to systematically capture residents' perceptions of their livelihoods, resource utilization, and indigenous knowledge within the context of WEFE nexus management.

- Targeted educational and outreach interventions should be implemented to improve community understanding of the WEFE nexus, fostering informed engagement and sustainable resource use.

- Participatory frameworks should be established that incorporate local socio-cultural practices and traditional knowledge, thereby empowering communities to actively participate in decision-making and policy development for sustainable management of WEFE resources as a long-term goal.

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Appendix A: Questions for participants at Metolong Ha Seeiso village

Please tick the most appropriate (boxes) response or fill in the blanks

SECTION A

Demographics

Name (optional): _____

1. **In which of the following age group do you fall?**

☐ 18-24

☐ 25-34

☐ 35-44

☐ 45 or older

2. **What is your gender?**

☐ Male

☐ Female

3. **What is your occupation:**

☐ Farmer

☐ Business Owner

☐ Government Employee

Other (please specify) _____

4. **What is your main source of income?**

☐ Farming

☐ Employment (formal/informal)

☐ Children

Other (specify) _____

5. **What is your highest formal education?**

☐ Primary education

☐ Secondary education

☐ Tertiary education

☐ None of the above

6. What is your approximate monthly household income?

☐ Less than 1,000 Maloti

☐ 1,000-3,000 Maloti

☐ 3,001-5,000 Maloti

☐ More than 5,000 Maloti

SECTION B

AWARENESS OF THE WEFE NEXUS

7. Have you ever heard of the term "WEFE Nexus" (Water, Energy, Food and Ecosystem)?

☐ Yes

☐ No

8. If yes, where did you hear about it?

☐ Community meetings

☐ Media (radio, TV, internet)

☐ Educational institutions

☐ Other (specify):

9. If yes, what have you heard about it, (tick all that apply)

☐ It is the interconnected relationship between water, energy, food, and ecosystems,

☐ It is a framework for managing resources sustainably by considering the trade-offs and synergies between water, energy, food, and ecosystems.

☐ It is an integrated approach to address competing demands for water, energy, and food while ensuring ecosystem integrity and sustainability

☐ Other (specify): _____

KNOWLEDGE OF WATER, ENERGY, FOOD, AND ECOSYSTEM INTERACTIONS

10. Do you believe that water availability affects food production?

☐ Yes

☐ No

11. If yes, how does water availability affects food production?

☐ Sufficient water for irrigation expands agriculture

☐ Water scarcity reduces crop yields and threatens food security

☐ Droughts severely impact food availability and prices, leading to malnutrition in affected regions

☐ Other

12. Do you think energy (electricity, fuel, etc.) is necessary for food production and water supply?

☐ Yes

☐ No

13. If yes, how is it necessary for food production and water supply? (tick all that apply)

☐ Irrigation Systems require electricity or fuel to distribute water to crops.

☐ Energy powers machinery for harvesting, processing, and packaging food

☐ Water supply systems rely on energy for pumping, treatment, and distribution to ensure access.

Other (your opinion): _____

_____

14. Do you think environmental degradation (e.g., deforestation, pollution) affects water, food, and energy resources?

☐ Yes

☐ No

15. If yes how does it affects water, food, and energy resources? (tick all that apply)

☐ Increased soil erosion and pollution can diminish water quality and availability

☐ The loss of vegetation and soil fertility due to deforestation and erosion can hinder agricultural productivity.

☐ Deforestation reduces biomass availability

Other (please specify) _____

16. Have you experienced any challenges related to water, in your community?

☐ Yes

☐ No

17. If yes, which of the following challenges have you faced? (Select all that apply)

☐ Water scarcity due to prolonged droughts

☐ Contaminated water sources leading to health issues

☐ Inadequate infrastructure and water supply

Other (specify): _____

_____

18. Have you experienced any challenges related to energy in your community?

☐ Yes

☐ No

19. If yes, which of the following challenges have you faced? (Select all that apply)

☐ Frequent power outages disrupting daily life and business operations.

☐ High energy costs making it difficult for families to afford electricity.

☐ Limited access to renewable energy sources

Other (specify)**:** _____

_____

20. Have you experienced any challenges related to food supply in your community?

☐ Yes

☐ No

21. If yes, which of the following challenges have you faced? (Select all that apply)

☐ Limited access to fresh produce due to transportation issues.

☐ Rising food prices making healthy options unaffordable.

☐ Limited agricultural productivity due to climate change

Other (specify) _____

WATER-ENERGY-FOOD-ECOSYSTEM (WEFE) NEXUS AND LIVELIHOODS

22. **What are the main sources of water for your household and agricultural use**? (Tick all that apply)

☐ River

☐ Springs and wells

☐ Tap water

☐ Rainwater harvesting

23. **How would you rate your access to clean water for household and agricultural use?**

☐ Very good

☐ Good

☐ Moderate

☐ Poor

24. **Do you have reliable access to energy (electricity, fuel, etc.) for daily needs?**

☐ Yes, always

☐ Sometimes

☐ Rarely

☐ No, never

25. **How would you describe the availability of food resources in your community?**

☐ Abundant and accessible

☐ Sufficient

☐ Moderate but limited at times

☐ Scarce and difficult to access

26. **Are natural ecosystems (forests, rivers, etc.) in your area preserved and utilized sustainably?**

☐ Yes, completely preserved

☐ Partially preserved

☐ No, heavily degraded

☐ Completely degraded

27. Has the availability of water, energy, and food resources affected your income generation activities?

☐ Positively improved income opportunities

☐ No significant impact

☐ Negatively affected income opportunities

Other (specify): _____

28. To what extent has resource scarcity (water, energy, food) impacted your household's economic stability?

☐ Not at all

☐ Slightly

☐ Moderately

☐ Severely

SOCIO-CULTURAL DYNAMICS AND INDIGENOUS KNOWLEDGE

29. Do traditional practices or indigenous knowledge systems in your community help manage water, energy, or food resources effectively?

☐ Yes, very effectively

☐ Not effectively

30. If yes, how does traditional practices or indigenous knowledge systems in your community help manage water, energy, or food resources effectively?

☐ Sharing of crops among different farmers for food security.

☐ A communal livestock-grazing practice that ensures sustainable land use.

☐ Collection and storage of rainwater for irrigation and household use in traditional dams.

Other (specify) _____

31. Are community members actively involved in decision-making processes about resource management

☐ Yes, always involved

☐ Sometimes involved

☐ Rarely involved

☐ Not involved at all

EXISTING FRAMEWORKS FOR WEFE NEXUS MANAGEMENT

32. Are you aware of any existing frameworks that integrate community participation in WEFE nexus management?

☐ Yes

☐ No

33. If yes, which of the following frameworks have you encountered? (Select all that apply)

☐ Integrated Catchment Management (ICM)

☐ Sustainable Development Goals (SDGs) framework

Other (specify)

34. Do you think the existing frameworks effectively address community participation in decision-making processes?

☐ Strongly disagree

☐ Disagree

☐ Neutral

☐ Agree

35. Which aspects of WEFE management would benefit most from increased community participation? (Select all that apply)

☐ Policy development

☐ Resource allocation

☐ Implementation of projects

☐ Monitoring and evaluation

36. What are the main barriers to community participation in WEFE nexus management? (Select all that apply)

☐ Lack of awareness

☐ Insufficient funding

☐ Weak governance structures

Other (please specify) _____

IDENTIFYING GAPS

37. Do you think there is a need for new frameworks to enhance community participation in WEFE nexus management?

☐ Yes

☐ No

38. Which framework would you recommend? (tick all that apply)

☐ Community-Based Resource Governance

☐ Incentive-Based Participation Models

☐ Integrated Policy and Education Frameworks

Other (specify): _____

39. What is the best method to ensure long-term community involvement in WEFE nexus management?

☐ Capacity-building programs

☐ Incentive-based participation

☐ Formalized stakeholder engagement platforms

☐ Government-led initiatives

SECTION C

40. What recommendations would you give to improve awareness and implementation of the WEFE nexus in your community?

_____

_____

_____

_____

Appendix B: Information Sheet and consent Form

Title: The perceptions of the community in Water, Energy, Food and Ecosystem Nexus (WEFE Nexus)

Student research project

My name is Kamohelo Mahloane and I am doing research with Dr Nkhabutlane in the Faculty of Agriculture towards the Master's degree at the National University of Lesotho. We are inviting you to participate in the study entitled 'The perceptions of the community in Water, Energy, Food and Ecosystem Nexus (WEFE NEXUS)

The purpose of the study

The purpose of this study is to find out the perceptions of the community in Water, Energy, Food and Ecosystem Nexus (WEFE NEXUS) in Metolong Ha Seeiso village.

Invitation to the participants

The research would like to have your perceptions in Water, Energy, Food and Ecosystem Nexus (WEFE NEXUS) because you are adjacent to the Metolong dam therefore, the researcher thought it will be essential to have your opinion in this regard. Permission to collect data was obtained from the Chief of Ha Seeiso prior to this meeting, and forty-one participants will be part of the interviews in this study.

Nature of participants in this study

The participants are expected to give out the perceptions, without any coercion put on them. This study involves closed ended questions and one open ended question.

Withdrawal clause

Participating in this study is voluntary, and you are under no obligation to consent to participate. If you do decide to take part, you will be given the information sheet to keep, and be asked to sign a written consent form. You are free to withdraw at any time, without giving a reason.

Information obtained will be kept confidential

Participants' perceptions will be viewed as strictly confidential, and only the researcher's team will have access to the information. No data publication in this research will contain any information through which participants in the interviews will be identified. Participants' answers will be given a code number, and will be referred to in this way in the data. Participants' anonymity is therefore ensured.

Thank you for taking time to read this information sheet and for participating in this study.

Thank You

Kamohelo Mahloane-A researcher