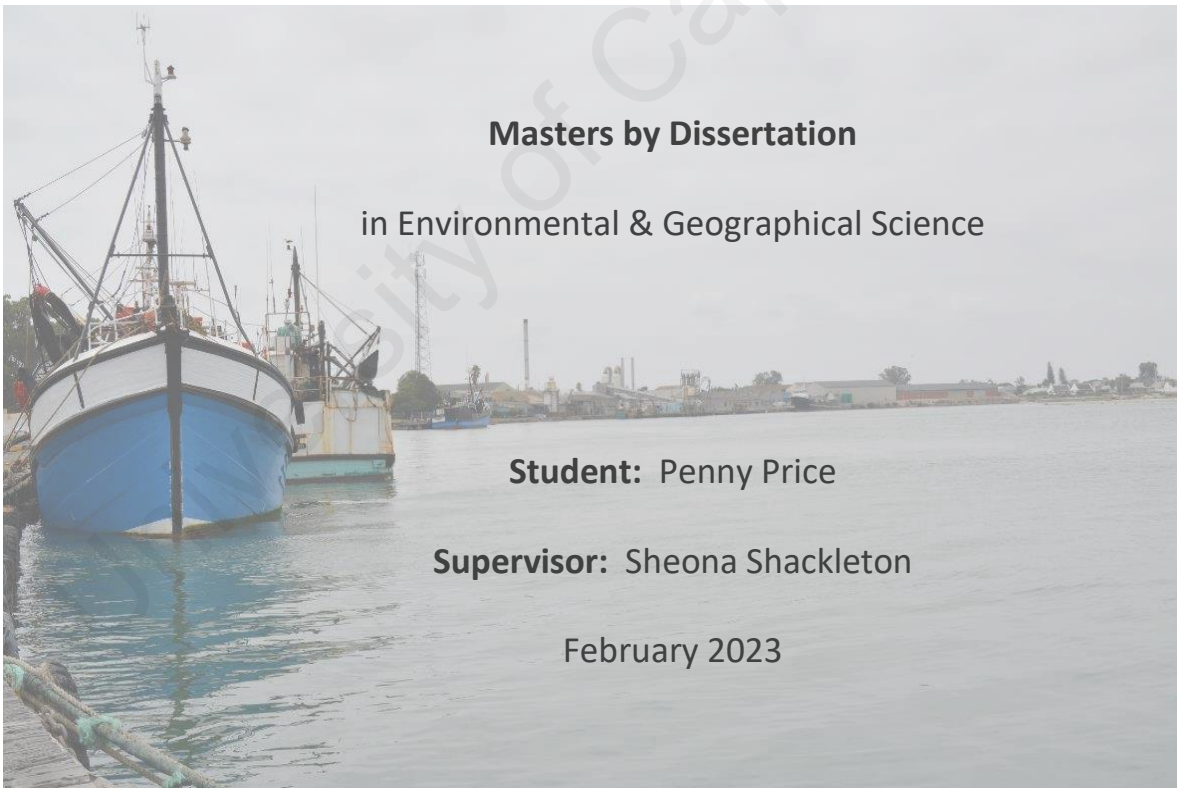
EXPLORING THE RELATIONSHIP BETWEEN THE WATER-ENERGY-FOOD NEXUS AND LIVELIHOODS AT THE LOCAL SCALE

A case study focussed on a low-income residential area in Velddrif, South Africa



Masters by Dissertation

in Environmental & Geographical Science

Student: Penny Price

Supervisor: Sheona Shackleton

February 2023

Declaration

I know that plagiarism is wrong. Plagiarism is to use another's work and pretend that it is one's own.

I have used the APA 7th edition reference style for citation and referencing. Each contribution to, and quotation in, this dissertation from the work(s) of other people has been attributed, and has been cited and referenced.

This dissertation is my own work.

I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as their own work.

Signature: Signed by candidate

Date: 15th January 2024

Abstract

The water-energy-food nexus (WEF nexus) has primarily been applied to addressing WEF security at large spatial scales in response to resource scarcity concerns. In contrast, WEF security at local levels, particularly amongst the poor, has received little attention. This thesis addresses this gap by exploring the application of the WEF nexus at the local level through a case study of a low-income residential area in the small urban fishing town of Velddrif on the west coast of South Africa. The primary empirical focus of the study is the household where availability, access, and affordability of WEF resources, as well as the linkages to livelihood options, are explored through a household survey. This is complemented by the gathering of contextual qualitative data on service delivery, livelihood opportunities, and the WEF nexus at the town and municipal scales.

The results indicated a low-income settlement with a high degree of water and electricity service delivery, which is rare in the South African context. They also revealed a concentration of employment in the fisheries sector, but very little fishing as a means of household food provision. Households typically relied on supermarkets and corner shops for food provision, indicating a reliance on income or financial capital as opposed to other livelihood capitals. All households reported some form of income, with a low percentage relying solely on social grant income. In line with the provisions of *The Constitution*, households that register as indigent are supported by the municipality in terms of receiving a minimum allocation of free basic water and electricity. The local municipality ensured their financial viability through imposing mechanisms to collect municipal rates debt before they escalated, thus enabling continued provision of basic services to all residents and free basic services to indigent households.

The availability of water has been at risk due to recent drought conditions, and this highlighted the significant consumption of the town's largest employer - the large-scale fish processing factory, which through the industrial production of food is also the town's largest electricity consumer. Urgent scaling back of their water consumption was achieved through the installation of a desalination plant, thus averting employment losses through an alternative solution of reducing or stopping factory production. It did however realise other trade-offs, such as an increase in their electricity consumption. The fish factory therefore

emerged as a significant actor in the WEF nexus / livelihoods intersection in this case study. Similarly, the local municipality plays a pivotal role in balancing trade-offs between availability and affordability of water and electricity in seeking to foster employment through economic development, as well as the sustainability of basic service provision. The WEF nexus at this level is therefore very useful in highlighting issues of equity, resource status and governance.

Acknowledgements

To my family my deepest thanks for their support and enduring patience during this protracted process of being 'almost there' for a number of years! To my friends and neighbours who encouraged me along, then politely stopped asking me if I was finished yet, whilst patiently keeping the champagne on chill.

Thank you to my supervisor, Sheona Shackleton, for her patience and support in helping me pare this down from its huge and messy beginnings into something both presentable and finished.

Thank you to Nadine Methner and Stephanie Midgely for inviting me into the overarching project and to the Water Research Commission for funding the overarching project and therefore the field work for this thesis. Thank you to the other students of the 'WEF Nexus and Local Livelihoods' project and ACDI staff who helped with field work, logistics, and some rich discussion.

Thanks to the Mfecane NPO who ran the Youth Café in Noordhoek that acted as our 'base camp' and helped me recruit and manage community research assistants. Thank you to Nico Pampier, the Velddrif youth team leader, who was magnificent in their 'can do' approach, enthusiasm and keenness to learn, as well as being a great source of local information.

Central to this thesis are the people who so generously and trustingly shared their lived experiences of the WEF nexus with me. Thank you to the household respondents who sat through an hour-long questionnaire, and public and private sector respondents who graciously gave of their time for lengthy interviews.

And finally, to the staff at Bergrivier Municipality who continue to be a shining example of public service – thank you.

Table of Contents

Chapter 1: Declaration II

Abstract III

Acknowledgements V

Table of Contents VI

List of Figures IX

List of Tables XI

ABBREVIATIONS AND ACRONYMS XII

CHAPTER 1 INTRODUCTION 1

1.1. Why the Water, Energy, Food Nexus at the Household Level 1

1.2. Aims and Objectives 4

1.3. Organisation of the Thesis 4

CHAPTER 2 THEORETICAL AND CONCEPTUAL FRAMING 6

2.1. Emergence of the WEF Nexus Concept 6

2.2. Ongoing Development and Application of the WEF Nexus 9

2.2.1. Extending the WEF nexus 9

2.2.2. Critiques and challenges in operationalising the nexus 11

2.3. Meeting Basic Needs - Livelihoods and Household WEF Security 12

2.3.1. Livelihoods and the WEF nexus 13

2.3.2. Local-level quantitative approaches 15

2.3.3. Mixed methods and qualitative approaches 17

2.4. Framework Developed for this Thesis 20

2.4.1. Household WEF status 20

2.4.2. Livelihoods and the household WEF nexus 20

2.4.3. Poverty and its relevance to the research 22

2.4.4. Availability, access, and affordability 23

2.4.4.1. Availability 24

2.4.4.2. Access and affordability 25

2.5. WEF Resource Context in South Africa 25

2.5.1. National water context 25

2.5.2. National energy context 28

2.5.3. National food context 30

CHAPTER 3 STUDY AREA AND METHODOLOGY 32

3.1. Embedded in an Overarching Project 32

3.2. Study Area 33

3.2.1. Case study location and site overview *34*
3.2.2. Demographics and socio-economic context *36*
3.2.3. Local municipal representation *37*
3.2.4. Local service delivery *37*
3.2.4.1. Water 37
3.2.4.2. Electricity 39
3.2.5. Local food context *41*
3.3. METHODOLOGICAL OVERVIEW 42
3.3.1. Case study approach *42*
3.3.2. Mixed methods research *44*
3.3.3. Transdisciplinary research *44*
3.4. METHODS 47
3.4.1. Scoping *47*
3.4.2. Household questionnaire *47*
3.4.2.1. Sampling 47
3.4.2.2. Data collection 51
3.4.2.3. Data capture and analysis 55
3.4.3. Key informant interviews and site visits *56*
3.4.3.1. Selection of Key Informants 57
3.4.3.2. Data Collection 58
3.4.3.3. Analysis 62
3.5. LIMITATIONS AND ASSUMPTIONS 62
3.6. ETHICAL CONSIDERATIONS 63
CHAPTER 4 RESULTS - HOUSEHOLD WEF STATUS AND LIVELIHOOD OPTIONS **64**
4.1. INTRODUCTION 64
4.2. HOUSEHOLD LIVELIHOOD CAPITALS 64
4.2.1. Human Capital *64*
4.2.2. Natural Capital *65*
4.2.2.1. Water 65
4.2.2.2. Energy 66
4.2.2.3. Food 67
4.2.3. Financial Capital *68*
4.2.4. Physical Capital *69*
4.2.5. Social Capital *71*
4.3. STATUS OF HOUSEHOLD WEF RESOURCES 71
4.3.1. Water *72*
4.3.2. Energy *76*
4.3.3. Food *78*

4.4. DISCUSSION 80

CHAPTER 5 RESULTS - THE LOCAL LIVELIHOODS AND WEF RESOURCE CONTEXT 87

5.1. INTRODUCTION 87

5.2. LOCAL CONTEXT RELATING TO WEF RESOURCES 87

5.2.1. Water *87*

5.2.1.1. Water Availability - Infrastructure 87

5.2.1.2. Water Availability - Drought 88

5.2.1.3. Water access and affordability 92

5.2.2. Energy *93*

5.2.2.1. Energy availability - infrastructure 93

5.2.2.2. Energy access and affordability 94

5.2.3. Food *96*

5.2.3.1. Food availability 96

5.2.3.2. Food access and affordability 97

5.2.4. Loss of Municipal Income *98*

5.3. LOCAL LIVELIHOOD OPPORTUNITIES 100

5.3.1. The fisheries sector *101*

5.3.2. Other employment sectors *104*

5.4. DISCUSSION 106

CHAPTER 6 INTEGRATING LIVELIHOODS AND THE WEF NEXUS 110

6.1. WATER-ENERGY-FOOD-LIVELIHOOD NEXUS IN VELDDRIF 110

6.2. REFLECTION ON THE APPLICATION OF THE WEF-LIVELIHOODS NEXUS AT THE LOCAL SCALE 114

6.3. CONCLUSION 115

6.4. RECOMMENDATIONS 116

REFERENCES 118

List of Figures

FIGURE 1: WATER-ENERGY-FOOD NEXUS SHOWING SOME OF THE INTERCONNECTIONS AND INTERDEPENDENCIES BETWEEN THE THREE RESOURCES (SOURCE: AUTHOR'S OWN) 2

FIGURE 2: SYSTEM DIAGRAM FOR RISKS ASSOCIATED WITH THE WATER-ENERGY-FOOD NEXUS AS DEPICTED IN THE WORLD ECONOMIC FORUM'S 2011 GLOBAL RISK REPORT (P. 29) 7

FIGURE 3: WEF NEXUS FRAMEWORK PRESENTED BY HOFF (2011) DEPICTING THE AVAILABILITY OF WATER AS THE CENTRAL PIVOT TO THE NEXUS FRAMEWORK 8

FIGURE 4: SUSTAINABLE LIVELIHOODS APPROACH (SOURCE: DFID, 1999) 14

FIGURE 5: THE ENVIRONMENTAL LIVELIHOOD SECURITY FRAMEWORK DEVELOPED BY BIGGS ET AL. (2014, P. 61) DEPICTING THE COMBINATION OF THE 'ENVIRONMENTAL NEXUS' WITH 'SUSTAINABLE LIVELIHOODS' 15

FIGURE 6: CONCEPTUAL OUTLINE USED BY NHAMO, MABHAUDHI, ET AL. (2020, P. 20) TO DEVELOP THE WEF NEXUS ANALYTICAL MODEL. 16

FIGURE 7: FRAMEWORK DEVELOPED BY WOLDE ET AL (2020, P.2) FOR ASSESSING THE IMPACT OF THE WEF NEXUS ON COMMUNITY-SCALE LIVELIHOODS 18

FIGURE 8: FRAMEWORK SHOWING THE LIVELIHOOD CAPITALS EXPLORED WITH REFERENCE TO HOW HOUSEHOLDS MEET THEIR WEF NEEDS. (SOURCE: AUTHOR'S OWN) 22

FIGURE 9: HOUSEHOLD WEF STATUS EXAMINED IN TERMS OF AVAILABILITY, ACCESS, AND AFFORDABILITY. 23

FIGURE 10: MEAN ANNUAL RAINFALL ACROSS SOUTH AFRICA PER WATER MANAGEMENT AREA. THE LOCATION OF THE CASE STUDY (VELDDRIF) IS SHOWN ON THE WEST COAST OF THE COUNTRY. SOURCE (COLE ET AL., 2018) 26

FIGURE 11: LEGISLATIVE FRAMEWORK OF THE REGULATION AND OPERATION OF WATER IN SOUTH AFRICA... **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 12: ILLUSTRATION OF THIS VELDDRIF CASE STUDY AS PART OF A COLLECTIVE CASE STUDY ADOPTED IN THE OVERARCHING PROJECT DESIGN (SOURCE: AUTHOR'S OWN) 32

FIGURE 13: MAP OF SOUTH AFRICA SHOWING THE LOCATION OF THE OVERARCHING PROJECT CASE STUDY SITES WITHIN THE THREE CATCHMENTS. SOURCE: (METHNER ET AL., 2021). 33

FIGURE 14: MAP INDICATING THE LOCATION OF THE TOWN OF VELDDRIF WITHIN THE WESTERN CAPE PROVINCE OF SOUTH AFRICA. THE TOWN IS OUTLINED IN RED, AND THE AREA OF NOORDHOEK OUTLINED IN ORANGE. 34

FIGURE 15: VIEW FROM THE RIVER MOUTH UP THE BERG RIVER ESTUARY SHOWING THE FISHING HARBOUR ADJACENT TO THE FISH PROCESSING FACTORY. (SOURCE: AUTHOR'S OWN) 35

FIGURE 16: WATER SUPPLY TO VELDDRIF SHOWING THE DIFFERENT ROLES AND RESPONSIBILITIES WITHIN THE SUPPLY CHAIN. (SOURCE: AUTHOR'S OWN) 38

FIGURE 17: DETAIL OF THE WATER SUPPLY SYSTEM TO HOUSEHOLDS IN NOORDHOEK. 39

FIGURE 18: ELECTRICITY SUPPLY SYSTEM FROM NATIONAL TO HOUSEHOLD LEVEL IN THE CASE OF VELDDRIF. 40

FIGURE 19: DETAIL OF THE ELECTRICITY SUPPLY SYSTEM TO HOUSEHOLDS IN NOORDHOEK. 41

FIGURE 20: SPATIAL BOUNDING OF THE CASE STUDY, SHOWING THE SPATIAL FOCUS ON THE SETTLEMENT OF NOORDHOEK, BUT RECOGNISING THE INFLUENCE OF EXTERNAL FACTORS ON THE HOUSEHOLD WEF STATUS. (SOURCE: AUTHOR'S OWN) 43

FIGURE 21: RESEARCH PROCESS FLOW, SHOWING THE RELATIONSHIP TO THE OVERARCHING PROJECT AND THE SEQUENTIAL DESIGN. (SOURCE: AUTHOR'S OWN) 46
FIGURE 22: CADASTRAL MAP OF NOORDHOEK DEPICTING THE FIVE SUB-AREAS. 49
FIGURE 23: THE OLDEST HOUSES IN NOORDHOEK IN THE SUB-AREA KNOWN AS 'OUBLOK'. 50
FIGURE 24: A TYPICAL SCENE IN THE SUB-AREA OF 'GAUTENG' SHOWING THE MIXTURE OF FORMAL BRICK AND MORTAR DWELLINGS AND INFORMAL STRUCTURES CONSTRUCTED FROM WOOD AND OR ZINC SHEETING ADDED ON 51
FIGURE 25: IN CONTRAST TO THE STRUCTURED DATA COLLECTION OF THE HOUSEHOLD QUESTIONNAIRE, THE MORE EXPLORATORY INDUCTIVE SEMI-STRUCTURED APPROACH SUITED THE GATHERING OF CONTEXTUAL DATA AT THE TOWN AND MUNICIPAL SCALES. (SOURCE: AUTHOR'S OWN) 57
FIGURE 26: SITE VISIT WITH CRAS AND MUNICIPAL REPRESENTATIVE EXPLORING NOORDHOEK'S ELECTRICITY SYSTEM (SOURCE: AUTHOR'S OWN) 61
FIGURE 27: SITE VISIT WITH CRAS AND MUNICIPAL REPRESENTATIVE EXPLORING NOORDHOEK'S WATER SYSTEM. (SOURCE: AUTHOR'S OWN) 61
FIGURE 28: CHART SHOWING THE FREQUENCY OF DURATION OF RESIDENCE PER SUB-AREA. 69
FIGURE 29: HOUSEHOLD AGE DEPENDENCY AND EMPLOYMENT STATUS 83
FIGURE 30: THE FISH FACTORY LETTING OFF STEAM, TAKEN FROM AN ADJACENT RESIDENTIAL AREA. 97
FIGURE 31: WOMEN MANUALLY FIXING FISHING NETS ON AN OPEN FIELD WITH THE CHIMNEYS OF THE FISH PROCESSING FACTORY VISIBLE IN THE BACKGROUND. (SOURCE: AUTHOR'S OWN) 101
FIGURE 32: ILLUSTRATED SYNTHESIS OF THE WATER-ENERGY-FOOD-LIVELIHOOD NEXUS PERTAINING TO HOUSEHOLDS IN NOORDHOEK, VELDDRIF. (SOURCE: AUTHOR'S OWN) 113

List of Tables

TABLE 1: RATIONALE FOR USING THE FIVE SLA CAPITALS FOR FRAMING HOW HOUSEHOLDS MEET THEIR BASIC WEF NEEDS. 20

TABLE 2: DEMOGRAPHIC AND SOCIO-ECONOMIC STATISTICS FOR NOORDHOEK (SOURCE: STATISTICS SOUTH AFRICA, 2011) 36

TABLE 3: AREAS FORMING SAMPLING SUB-SET OF NOORDHOEK. 49

TABLE 4: OUTLINE OF CONTENT COVERED IN THE HOUSEHOLD QUESTIONNAIRE 53

TABLE 5: DESCRIPTION AND MOTIVATION FOR SELECTION OF IN-DEPTH INTERVIEWS (N=12). 57

TABLE 6: KEY INFORMANT INTERVIEW GUIDELINES FOR THE DIFFERENT GROUPS OF ACTORS. 59

TABLE 7: EXCERPT FROM THE HOUSEHOLD QUESTIONNAIRE SHOWING THE AGE BANDS USED IN COLLECTING HOUSEHOLD MEMBERS' AGE. 64

TABLE 8: CHARACTERISTICS OF HOUSEHOLD OCCUPANTS. 65

TABLE 9: RESULTS SHOWING PROPORTION OF HOUSEHOLDS DRAWING DIRECTLY ON NATURAL CAPITAL TO MEET HOUSEHOLD WATER NEEDS. 66

TABLE 10: RESULTS SHOWING PROPORTION OF HOUSEHOLDS DRAWING DIRECTLY ON NATURAL CAPITAL TO MEET HOUSEHOLD ENERGY NEEDS. 66

TABLE 11: RESULTS SHOWING PROPORTION OF HOUSEHOLDS DRAWING DIRECTLY ON NATURAL CAPITAL TO MEET HOUSEHOLD FOOD NEEDS. 67

TABLE 12: HOUSEHOLD INCOME GENERATION PROFILE. 68

TABLE 13: CHARACTERISTICS OF HOMESTEADS SAMPLED. 70

TABLE 14: DESCRIPTIVE STATISTICS OF VARIABLES RELATED TO HOUSEHOLD WATER STATUS. 73

TABLE 15: DESCRIPTIVE STATISTICS OF VARIABLES RELATED TO HOUSEHOLD ENERGY STATUS. 77

TABLE 16: DESCRIPTIVE STATISTICS OF VARIABLES RELATED TO HOUSEHOLD FOOD STATUS 79

Abbreviations and Acronyms

ACDI	African Climate and Development Initiative
BRM	Bergrivier Municipality
CAS	Complex Adaptive Systems
CCT	City of Cape Town
CDW	Community Development Worker
CRA	Community Research Assistant
DBE	Department of Basic Education
DoH	Department of Health
DORA	Division of Revenue Act
DWS	Department of Water and Sanitation
EPWP	Extended Public Works Programme
IDP	Integrated Development Plan
IDZ	Industrial Development Zone
IWRM	Integrated Water Resource Management
LBPL	Lower-bound Poverty Level
MIIF	Municipal Infrastructure Investment Framework
MMR	Mixed Methods Research
NDP	National Development Plan
RGDP	Regional Gross National Product
SAMPI	South African Multidimensional Poverty Index
SASSA	South Africa Social Security Agency
SDG	Sustainable Development Goal
SES	Socio-ecological Systems
SLA	Sustainable Livelihoods Approach
SOE	State Owned Entity
UCT	University of Cape Town
WCDM	West Coast District Municipality
WCG	Western Cape Government
WEF	Water-Energy-Food
WIQI	Water Infrastructure Quality Index
WRC	Water Research Commission

Chapter 1 Introduction

1.1. Why the Water, Energy, Food Nexus at the Household Level

Life depends on water and food, and socio-economic development depends on energy (Rasul, 2014). As such there is an urgent need to sustainably manage these critical resources for present and future generations as articulated in the following Sustainable Development Goals, 2: Zero Hunger, 6: Clean Water and Sanitation, and 7: Affordable and Clean Energy (UNGA, 2015, p. 2). This is particularly pertinent given the current rapid changes taking place in the human-nature system driven by, amongst others, climate change, a burgeoning human population increasingly concentrated in urban settlements, changes in land use, and changing resource consumption and demand patterns (Future Earth, 2018; IPBES, 2018; IPCC, 2021; UNDESA, 2019). These changes and associated future uncertainties are not only placing pressure on the availability of water, energy, and food resources, but are also compounding social justice issues such as inequalities in access and affordability (Bazilian et al., 2011; Terrapon-Pfaff et al., 2018).

Furthermore, the water, energy, and food systems are highly interlinked and therefore need to be managed in an integrated manner in order to reduce trade-offs, optimise synergies and thus maximise efficiencies (Hoff, 2011). Numerous integrating approaches have emerged as a result (Benson et al., 2015), including the water-energy-food nexus (WEF nexus) which focusses on the connection points, or 'nexus' between all three resource systems, seeking to "… integrate management and governance across sectors and scales …" (Hoff, 2011, p. 7) , and thus introduce efficiency and reduce negative externalities. Figure 1 illustrates my understanding of the connectivity and interdependence of these three resources, for example, the use of water to generate electricity, and the use of energy to pump water required for producing food, or the need for energy to manage and transport agricultural produce.

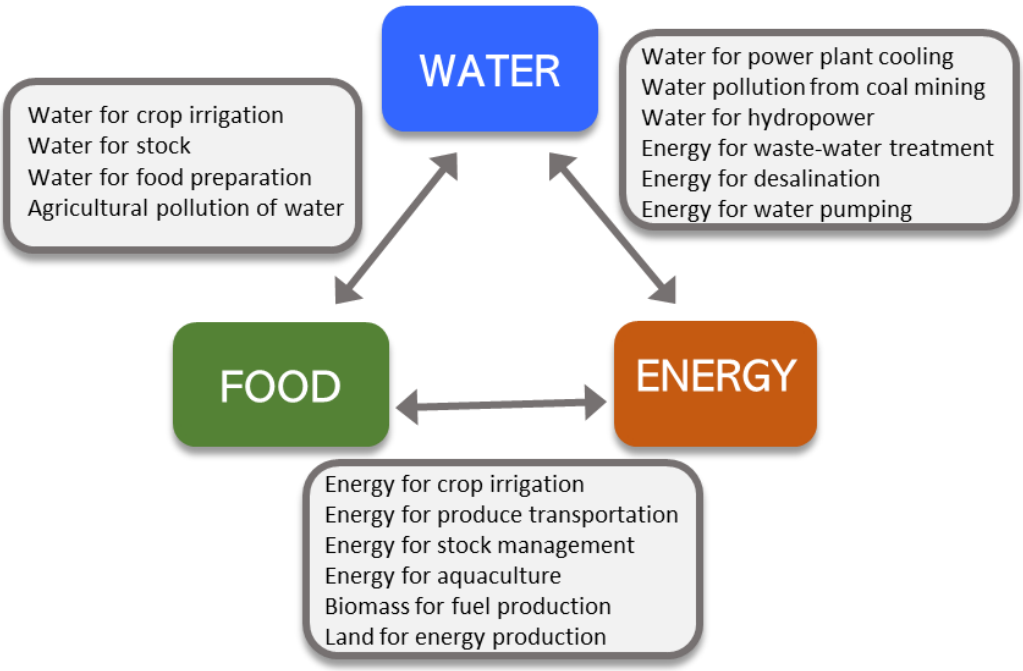


Figure 1: Water-energy-food nexus showing some of the interconnections and interdependencies between the three resources (Source: Author's own)

While the WEF nexus has proved useful as evidenced by ongoing contributions to its conceptual and methodological development (Albrecht et al., 2018; Bazilian et al., 2011; Biggs et al., 2015; Bizikova et al., 2013; Chirisa & Bandauko, 2015; Daher & Mohtar, 2015; Halbe et al., 2015; Huntington et al., 2021; Kurian et al., 2019; Mabhaudhi et al., 2019; Mcgrane et al., 2019; Mguni et al., 2020; Midgley et al., 2014; Miller-Robbie et al., 2017; Naidoo et al., 2021; Nhamo, Ndlela, et al., 2020; Seeliger et al., 2018; Simpson et al., 2019; Spiegelberg et al., 2017; Sušnik et al., 2018), it has largely been applied to addressing WEF security at a catchment, national and regional scale in response to current or anticipated resource scarcity concerns (Allouche et al., 2015; Biggs et al., 2015; Leese & Meisch, 2015; Terrapon-Pfaff et al., 2018) . Large capital investments are inherent in the water, energy, and food supply infrastructure at this scale, and approaches have thus not only been driven by those with access to sufficient capital and power to negotiate or influence across the nexus, but have also been largely technical-managerial in approach (Allouche et al., 2015; Terrapon-Pfaff et al., 2018; Wiegleb & Bruns, 2018).

In contrast, WEF security at the local and household scales, particularly amongst the poor, has received little attention (Endo et al., 2017; Hussien et al., 2017; Jaka, 2019; Mguni et al.,

2020; Terrapon-Pfaff et al., 2018; Villamor et al., 2018). The household as a unit of analysis provides insight into how people meet their basic water, energy, and food needs, thus bringing the relationship with livelihoods into focus. As a result, several studies have emerged that address this gap (Biggs et al., 2015; Hussien et al., 2017; Mabhaudhi et al., 2019; Nhamo, Ndlela, et al., 2020; Spiegelberg et al., 2017; Wolde et al., 2020). Exploring the interplay between the household WEF nexus and livelihoods surfaces issues of equity, particularly around access, affordability, and quality of WEF resources that are easily overlooked at a courser spatial scale, particularly when adopting technical-managerial approaches. However, research at the local scale has followed the approaches adopted at the larger scale and has similarly been dominated by quantitative approaches such as the use of models, indicators, and matrices that seek to quantify interdependencies, and identify trade-offs and synergies across the nexus (Hussien et al., 2017; Mabhaudhi et al., 2019; Nhamo, Mabhaudhi, et al., 2020; Nhamo, Ndlela, et al., 2020).

There is, however, an emerging body of literature applying mixed methods and transdisciplinary approaches to this scale, which are able to discern and differentiate contextual issues such as power relations, economic circumstances, and community dynamics, the likes of which can have a profound influence on local level WEF security (Givens et al., 2018; Huntington et al., 2021; Mguni et al., 2020).

These approaches are well-suited to this research, which seeks to gain an understanding of low-income urban households' lived experience of the WEF nexus and how this intersects with their livelihoods. Drawing on this body of work, I have selected a case study approach which focusses on the community of Noordhoek, located within the fishing town of Velddrif at the mouth of the Berg River on the West Coast of South Africa. Through the application of mixed methods, I have explored the biophysical availability of WEF resources at the local scale and the accessibility to and affordability of these resources at the household level, taking into account the livelihood and service delivery context.

Given the constitutional right to sufficient water and food, and the right to basic services in South Africa, I hope that an exploration of the potential impact on households of the intersection of livelihoods and the nexus can inform policies and decision making that can alleviate the levels of deprivation currently experienced by the poor.

1.2. Aims and Objectives

The aim of the case study is to understand the status of WEF resources in low-income households within the town of Velddrif and explore the role local livelihood opportunities play in this.

The objectives include to:

1. Determine the availability of, access to, and affordability of WEF resources amongst Noordhoek households, and the role livelihood activities play in this.
2. Examine the local context with regards to livelihood opportunities, and the WEF nexus.
3. Integrate the findings from objective one and two, exploring any interlinkages between the WEF nexus and livelihoods across the nested scales.

1.3. Organisation of the Thesis

I have organised this thesis into six chapters. Chapter one consists of this introduction wherein I motivate for the application of the WEF nexus at the household level and introduce the aims and objectives of this research.

In chapter two, I delve into the peer-reviewed literature to explore the emergence and conceptual development of the WEF nexus, the range of applications, and the intersection between the nexus and livelihoods at the local scale. Drawing on this literature, I then present the framework I have developed for this research. I conclude the chapter with a section on the WEF resource context in South Africa drawn from the literature.

In chapter three I introduce the study area, followed by a methodological overview of the approach taken and the methods used. I close the chapter by stating the limits and assumptions made during the research, as well as the ethical considerations.

In chapter four, the first of the results chapters, I present results from the household survey. Responding to objective one, I initially present descriptive statistics of the physical dwelling, the composition of the household and basic livelihood activities to provide a profile of respondents. This is followed by a statistical description of household WEF status, primarily in terms of available WEF sources and households' access to and affordability of these.

In chapter five, the second results chapter, I present the results from the key informant interviews, site visits and personal observations. Responding to objective two, I examine the local context with regards to the WEF nexus and livelihood opportunities. Here I describe the status of WEF resources at this expanded spatial scale, drawing on the availability, access and affordability framing, as well as how the nexus plays out at this scale. I also explore local livelihood opportunities with reference to the Noordhoek households.

Chapter six is a synthesis and conclusion chapter wherein I combine the results from chapters four and five, weaving them together across the nested scales, from the household to the town and municipality, through the lens of the WEF nexus and livelihoods. This highlights trade-offs and synergies resulting from the complex interactions between these variables and scales.

Chapter 2 Theoretical and Conceptual Framing

2.1. Emergence of the WEF Nexus Concept

In the midst of the 2008/09 global recession, the World Economic Forum identified water, energy, food and climate change as a nexus of issues posing a serious threat to the economy, society, as well as the environment (Allan et al., 2015). This is illustrated in the then United Nations Secretary General, Ban Ki-Moon's opening remarks at the January 2009 session of the World Economic Forum's Water Initiative, where they stated that:

> "I have taken to saying that the past year was one of multiple crises. We have the economic crisis, the food crisis, the energy crisis. To these we can add climate change. All of these crises are still very much with us. They illustrate our world's vulnerability to the shock of diminishing resources. And as you all know only too well, water is very much near the top of the list … Over the past year you have come together – academics, business people, government leaders – and put this issue on the global agenda. People are beginning to realise how connected it is to so many challenges – development, peace and security, economic growth." (World Economic Forum, 2011b, p. xix).

The Water Initiative Group they were addressing subsequently published their collaborative findings entitled 'Water Security: The Water-Food-Energy-Climate Nexus' in 2011, in which they presented the case of the centrality of water to a nexus of "…food, energy, trade, economic growth, climate change, and other issues." (p.6). Although the nexus concept had been foregrounded in this publication, the framing remained water-centric, similar to integrated resource approaches popular at the time, such as Integrated Water Resource Management (IWRM) (Benson et al., 2015; Seeliger et al., 2018).

The World Economic Forum published another perspective on the water-energy-food (WEF) nexus that year in the form of their annual Global Risks report (2011). Here the nexus was presented as one of three global cross cutting 'risks in focus' for 2011, where it was recognised as having the potential for major disruption within macro-level global systems (World Economic Forum, 2011a). As illustrated in Figure 2, the WEF nexus in this publication was plotted according to economic, geopolitical, environmental, social, and technological risks.

Key drivers of risk were portrayed as population and economic growth related to burgeoning consumption patterns associated with emerging economies, as well as environmental pressures such as climate change (ibid.). Governance failures in the management of shared resources, and economic disparity were identified as compounding existing risks that could lead to conflict and drive ongoing unsustainable practices (ibid.).

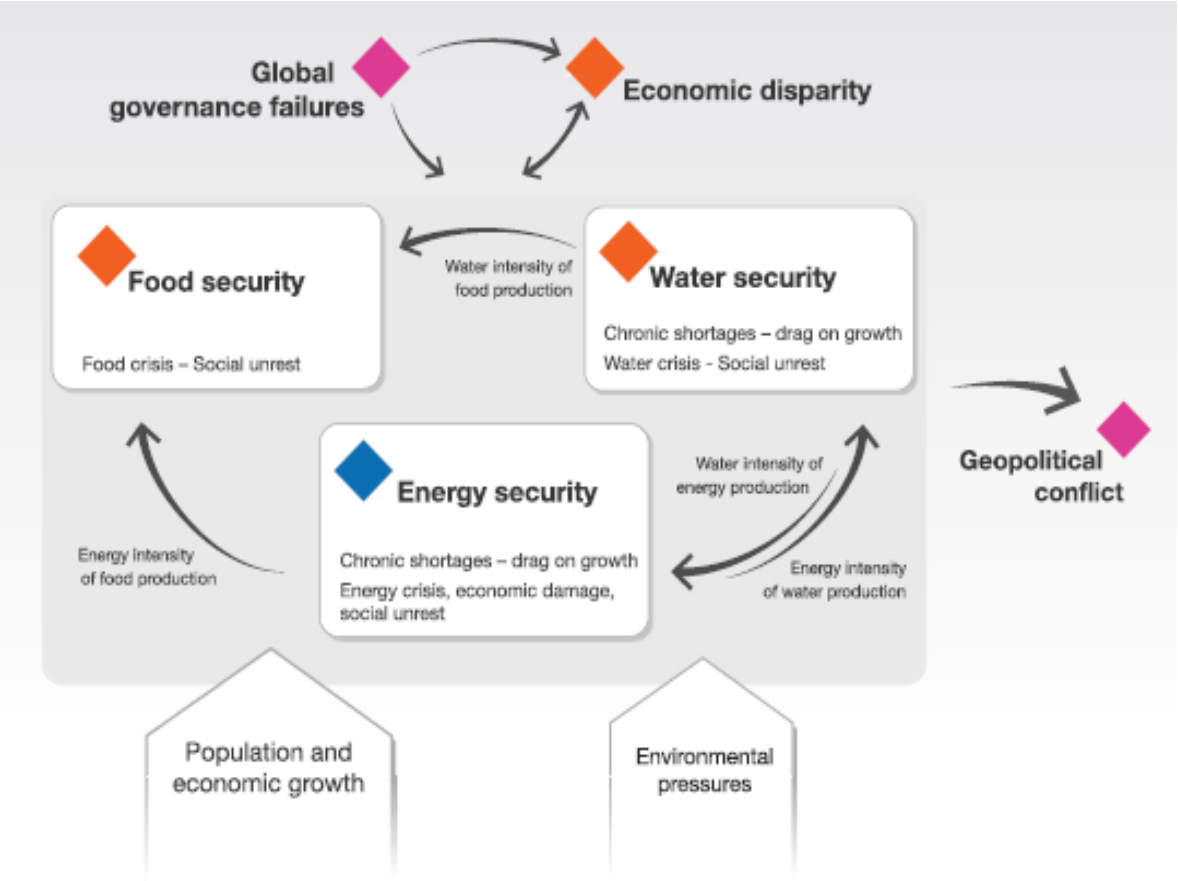


Figure 2: System diagram for risks associated with the water-energy-food nexus as depicted in the World Economic Forum's 2011 Global Risk Report (p. 29)

These early nexus publications emerging from global economic interests thus reflected a scarcity narrative associated with increasing demand alongside resource degradation which threatened to undermine the economic status quo (Allouche et al., 2015; Leese & Meisch, 2015; Mdee, 2017).

Picking up on this momentum in the development of a nexus approach, the German government hosted the 'Bonn2011 Nexus Conference on the Water, Energy and Food Security Nexus: Solutions for the Green Economy', which sought to prepare nexus inputs for the upcoming United Nations Rio + 20 Sustainable Development Summit (Hoff, 2011). A

background paper prepared for the conference indicated confidence in the nexus approach to improve water, energy, and food security, describing the nexus as "… an approach that integrates management and governance across sectors and scales." (Hoff, 2011, p. 7). Embracing the ethos of sustainable development, the publication presented the view that "… a reduction of negative economic, social and environmental externalities can increase overall resource use efficiency, provide additional benefits and secure the human rights to water and food" (Hoff, 2011, p. 7). This approach as illustrated in Figure 3, expanded beyond the initial political economy scarcity framing, to one embracing elements of equity, social justice, ecosystem services, resilience, and sustainable growth. Although the central part of the figure depicts the 'nexus perspective' as being an interplay between water supply security, energy security, and food security, like IWRM and the World Economic Forum's Water Security report (World Economic Forum, 2011b), it locates 'available water resources' as a central pivot. It does, however, represent complex interlinkages across not only sectoral interests, but also introduces process considerations akin to a theory of change, moving from action fields, through the current situation of global trends, looking towards governance, finance, and innovation, for drivers towards the desired outcomes.

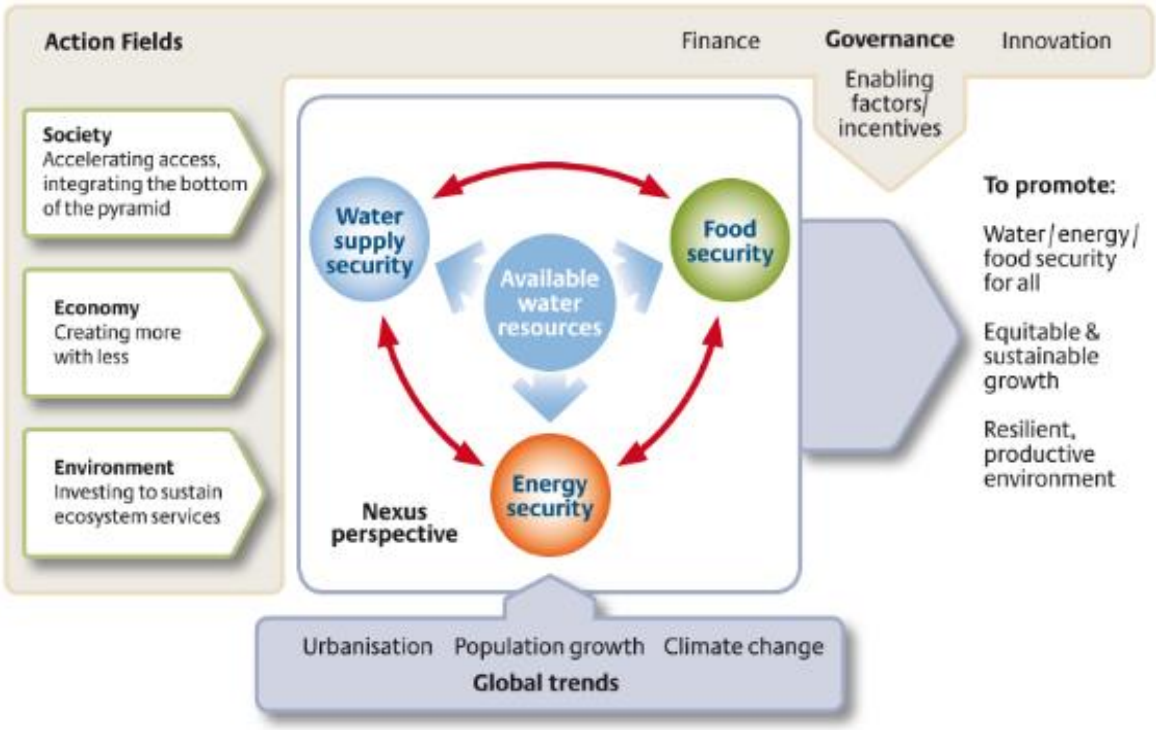


Figure 3: WEF nexus framework presented by Hoff (2011) depicting the availability of water as the central pivot to the nexus framework.

These early nexus framings therefore provided a transition from existing integrated resource management approaches that were utilising cross-sectoral participation to secure sectorally driven outcomes, to an approach that sought to optimise synergies and reduce trade-offs across all participating sectors. This 'paradigm shift' (Smajgl et al., 2016) was achieved by "… shift[ing] the emphasis onto relationships and feedbacks between sectors …" (Pahl-Wostl, 2019b, p. 365) as opposed to on narrow sectoral interests.

2.2. Ongoing Development and Application of the WEF Nexus

The increased popularity of nexus thinking (Fernandes Torres et al., 2019) supports the growing need for integrating approaches that can address the complex challenges facing decision makers, researchers, and practitioners. The WEF nexus has thus been widely applied, giving rise to a wealth of literature covering conceptualisations, tools, critiques, reviews, and case studies. This section provides a broad overview of this literature before leading into a more in-depth exploration of literature directly relevant to this thesis.

2.2.1. Extending the WEF nexus

As the nexus concept surfaces the implications and dependencies between elements of choice within a system, it has been widely applied to complex system challenges beyond the water-energy-food system. As a result, there has been an expansion of the WEF nexus to include additional and / or substitute elements. Examples include the nexus of water-energy-food-health (Miller-Robbie et al., 2017; Slorach et al., 2020), water-waste-energy-food (Caiado Couto et al., 2021), water-energy-land-food (Ringler et al., 2013), water-energy-food-land-biodiversity (Hulley, 2015; Midgley et al., 2014), water-energy-food-land-climate (Sušnik et al., 2018), climate-energy-water-land use (Welsch et al., 2014); water-energy-food-forests (Melo et al., 2020), and water-energy-food-climate (Chirisa & Bandauko, 2015; Howells et al., 2013; Ramos, 2021; Sušnik et al., 2018; World Economic Forum, 2011b). This broad application of the nexus highlights the value of the concept as a systems-based approach that integrates across social-ecological systems seeking increased efficiency of the system as a whole, as opposed to that of individual resources.

The nexus has also been applied in combination with other frameworks and approaches, such as the research conducted by (Weitz et al., 2014) and (Fader et al., 2018), both of which explored the value of the WEF nexus as an integrating framework in the implementation of

the Sustainable Development Goals (SDG). These authors highlighted the use of the nexus in identifying trade-offs and synergies implicit in the goals and targets related to SDG 2 (food), SDG 6 (water), and SDG 7 (energy). Similarly, Olawuyi (2020) examined the legal and governance challenges related to the use of the WEF nexus as an integrating framework in the implementation of the SDGs.

Another framework that has been explored in combination with the nexus is the sustainable livelihooods approach (SLA). This will be addressed in detail in section 2.3.3.

The nexus has also been applied to urban studies, such as that by Chirisa and Bandauko (2015). These authors argued for the incorporation of the water-food-climate-energy nexus into the sustainability and resilience agenda for African cities. In addition, Gragg et al. (2018) applied the WEF nexus to "... the rapidly urbanizing agricultural food systems ..." (p.1), modelling the interactions across the social-ecological system (SES) at various scales. Moreover, the *Journal of Integrative Environmental Sciences* published a special issue in 2020, covering the results from a three-country study seeking to deepen the "... social science understanding of the urban nexus in developing and transitional cities ..." (Mguni & Van Vliet, 2020, p. i). In a similar vein, seeking to utilise the nexus in a SES framing centred on social justice, Stringer et al. (2018) combine resilience and nexus approaches for application to risk-based decision making.

In contrast, Yuan et al. (2021) developed a system of indicators to measure the sustainability of the WEF nexus applied to mainly infrastructure and technological solutions at the city level.

The complexity of the nexus has lent itself to the development of tools and models, such as the Nexus Simulation Model developed by Afshar et al. (2021), and the WEF Nexus Tool 2.0 developed by Daher and Mohtar (2015), both of which are designed to aid in the implementation of the nexus. Similarly, Harwood (2018) applies Cybernetic Methdology, designed for complex 'wicked problems' such as presented by the nexus, to guide practical implementation including addressing governance issues through the use of a Variable System Model. In addition, Dargin et al. (2019) reviewed existing nexus tools against a 'complexity index', providing a practical guide to help implementers select the most relevant tools.

Seeking to contribute to sustainable household WEF supply, Hussien et al. (2017) developed an integrated model of the nexus at the houseehold scale, modelling household WEF demand and waste generation. (Givens et al., 2018) take the integrated modelling approach further by seeking to incorporate social and equity dynamics as well, and explore what data needs would be required to achieve this.

2.2.2. Critiques and challenges in operationalising the nexus

Although the nexus offers conceptual and theoretical 'solutions' to sustainable and integrated resource management, one of the biggest challenges noted in nexus literature is operationalising the nexus (Allan et al., 2015; Bizikova et al., 2013; Dargin et al., 2019; Leck et al., 2015; Liu et al., 2017; Mcgrane et al., 2019; Naidoo et al., 2021; Simpson & Jewitt, 2019; Srivastava & Mehta, 2014; Stein et al., 2014). Stein et al. capture the challenge succinctly in their 2014 publication by stating that,

> "[A]acknowledging interdependencies and complexity is a necessary first step, but not enough to address nexus challenges. What is generally missing is practical guidance on how to move from abstract concepts to practical action, i.e. how to identify the multiple and sometimes conflicting issues that should be integrated and how integration should happen in practice." (p. 4).

Indeed, operationalising the nexus is not simple, requiring a high degree of cross-sectoral multi-level and -scalar communication, coordination, cooperation, and planning (Bizikova et al., 2013; Liu et al., 2017; Naidoo et al., 2021; Pahl-Wostl, 2019b; Simpson & Jewitt, 2019). Unfortunately, most of the prevailing regulatory frameworks and governance structures are organised into jurisdictional scales according to well-established sectors, with separate budgets, implementation plans, and reporting lines in the case of the public sector, and well-established company-owned supply chains in the case of the private sector (Mabhaudhi et al., 2019; Mohtar et al., 2020). In both the public and private sector these compete for budget allocation or market share, which can introduce an element of disincentive for co-operation. In other words, as noted by Allouche et al. (2015, p. 611), "…the 'nexus' bureaucracy has[ve] not been constructed and enforced yet." Furthermore, temporal scales associated with planning horizons differ across sectors, as do organisational structures which are often compartmentalised according to differing spatial scales (Liu et al., 2017). Despite numerous attempts to tackle the challenges associated with operationalising the nexus, largely through

the development of analytical frameworks and models (Bazilian et al., 2011; Daher & Mohtar, 2015; Hussien et al., 2017; Mabhaudhi et al., 2019; Nhamo, Mabhaudhi, et al., 2020), Naidoo et al. (2021, p. 2) note that "… operationalising the WEF nexus remains elusive due to the inability of current models to move the theoretical model approach into a practical decision-support tool."

These challenges in operationalising the nexus are further compounded by what Foran (2014, p. 655) describes as an "… immature concept…" that requires "… more critical conceptualisation." particularly referring to the "… social dimensions of resource linkages [that] remain thinly described and under-theorized.". Taking this line of critique further, the nexus has even been termed a 'buzzword' (Srivastava & Mehta, 2014; Stein et al., 2014; Terrapon-Pfaff et al., 2018), and Cairns and Krzywoszynska (2016, p. 165) state that as such it is "… used in fragmentary, multiple and ambiguous ways …". Keskinen et al. (2016, p. 13) add that despite a wide diversity of nexus publications, "… there is still little practical evidence on the nexus and that there is not even a commonly agreed definition for the nexus.", a view that is mirrored by Endo et al. (2017); Wichelns (2017), Harwood (2018), Cairns and Krzywoszynska (2016), and Muller (2015). Allouche et al. (2015) take a more positive note on the diversity in nexus framings and definitions, arguing that as the "… complex food-water-energy nexus security problems are so-called wicked problems to which there is no easy definition and no easy solution …" (p. 621), there is value in pursuing multiple approaches that will all contribute "… many ten percent solutions…" (p. 622). This is supported by Mabhaudhi et al. (2021, p. 421), who state that,

> "[N]o one approach is applicable to all situations and the suitability of a given framework or methodology will vary in response to the aims, priorities, and scale of application, from global to local."

2.3. Meeting Basic Needs - Livelihoods and Household WEF Security

As stated in section 2.1, the nexus emerged in response to global concerns around WEF resource insecurity, with particular concern for the implications on economic growth and related negative impacts. Since initial efforts to secure these vital resources were largely made by multi-lateral global organisations, large transnational corporations, and global finance institutions (Hoff, 2011; World Wildlife Fund and SAB Miller, 2014) the scale of

application of WEF thinking has typically been on large transboundary technical-managerial interventions aimed at establishing WEF security for ongoing economic activity (Allouche et al., 2015; Middleton, 2015; Stevens & Gallagher, 2015; Terrapon-Pfaff et al., 2018; Wiegleb & Bruns, 2018). As noted by Mguni et al. (2020, p. 2),

> "This has apparently led to the dominance of top-down, big-framing of the nexus as a meta-narrative of scarcity which disempowers local voices and blurs place-specific needs in ways that could inadvertently reinforce existing inequalities and dominant pathways."

In contrast, this study seeks a bottom-up approach which can explore household WEF security in terms of issues of equity around access and the intersection with livelihoods - which determines how households meet their basic needs. However the paucity of nexus publications documenting research into livelihoods and / or the local level has been noted by many authors (Biggs et al., 2015; Endo et al., 2017; Hussien et al., 2017; Leck et al., 2015; Mabhaudhi et al., 2019; Stevens & Gallagher, 2015; Terrapon-Pfaff et al., 2018; Weitz et al., 2014; Wolde et al., 2020). Furthermore, attempts at addressing this gap have largely shied away from locally-grounded empirical applications which explore social aspects (Mguni et al., 2020; Terrapon-Pfaff et al., 2018). The following section therefore explores the existing literature in this regard, documenting the conceptual framings and methods where relevant.

2.3.1. Livelihoods and the WEF nexus

As illustrated in Figure 4, one of the seminal concepts in livelihood research is the Sustainable Livelihoods Approach (SLA) initially developed and applied in the context of rural households (Chambers & Conway, 1992). Situating the household within a dipole of vulnerability context and transforming processes and structures, it describes how households draw on a number of assets or capitals to form livelihood strategies which achieve livelihood outcomes (Ashley & Carney, 1999; Biggs et al., 2015; DFID, 1999; Scoones, 1998). Although SLA does not speak directly to the WEF nexus, it is a significant livelihood framework drawn on by a number of authors seeking to explore how households meet their basic needs.

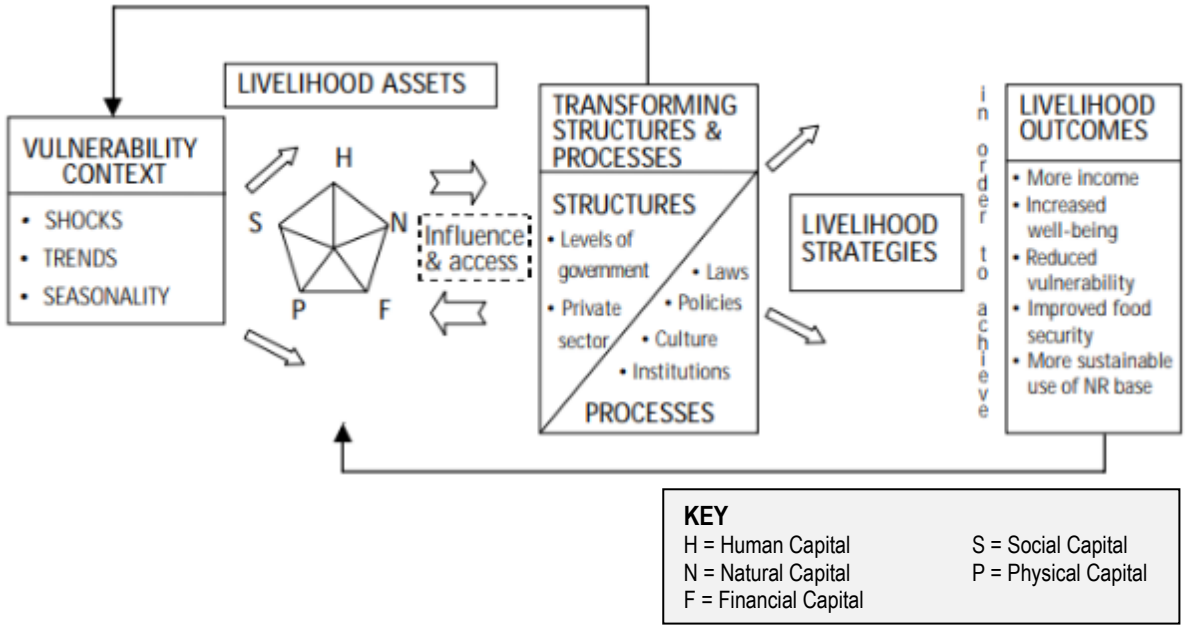


Figure 4: Sustainable Livelihoods Approach (Source: DFID, 1999)

One of the first publications to address the livelihoods-WEF nexus gap was Biggs et al. (2015) who developed a framework termed Environmental Livelihood Security (ELS) which combined elements of SLA with the WEF nexus through a central pivot that sews them together in terms of achieving sustainability between human demand and natural supply. The conceptual ELS framework, drawn from the authors' 2014 publication (p. 61) shown in Figure 5, explores the tension between the security of supply of WEF resources in terms of the constraints placed on the natural system, and the growing human demand for these resources. The framework combines the 'Environmental Nexus' comprising the WEF nexus and climate, with 'Sustainable Livelihoods' which is centred on the five assets of the SLA linking vulnerability and livelihood outcomes through 'transforming processes'. Although ELS provides a useful framing, this case study seeks a more locally-grounded exploration of household experiences and perceptions of the WEF nexus, in relation to their livelihood opportunities and local-scale WEF resource status.

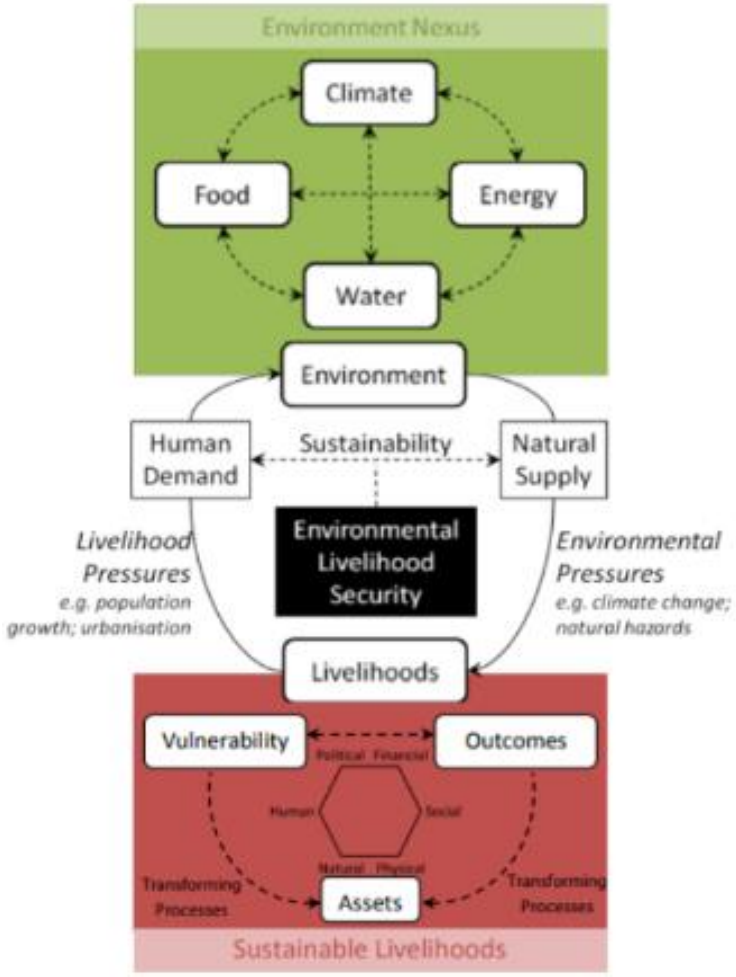


Figure 5: The Environmental Livelihood Security framework developed by Biggs et al. (2014, p. 61) depicting the combination of the 'Environmental Nexus' with 'Sustainable Livelihoods'.

2.3.2. Local-level quantitative approaches

Mabhaudhi et al. (2019) used a modelling approach to assess the cause and effect of climate change on regional-level human health and livelihoods through the development of a WEF nexus analytical livelihoods framework (ALF). This comprised of a causal loop diagram modelling the cause and effect of climate change on WEF resources, livelihoods, and human health. This set the context within which derived composite WEF nexus indicators were assessed, in terms of sustainability of the resources, using the analytical hierarchy process. The study focussed on the regional level of southern Africa due to a lack of household level data (Mabhaudhi et al., 2019). Although this approach holds promise for decision-support modelling at a regional scale and includes elements related to human health and wellbeing,

it remains technically focussed and high-level and thus not best suited to the household level that this thesis seeks to address.

Nhamo, Mabhaudhi, et al. (2020) developed an integrative analytical model for the WEF nexus as depicted in Figure 6. The figure shows two WEF nexus sustainability indices per resource in the second block, which are also related to the relevant SDGs, followed by the component of WEF security the indices speak to in the third block. A multi-criteria decision-making method is then applied (fourth block) which produces composite indices for the scale of the data applied. Designed to be applied at any scale, the model "… define[s] sustainability indicators for each WEF sector … in a way that reflects the securities of water, energy, and food from a nexus perspective". The model was subsequently expanded to include a climate adaptation component and applied to a local municipality in South Africa (Nhamo, Ndlela, et al., 2020).

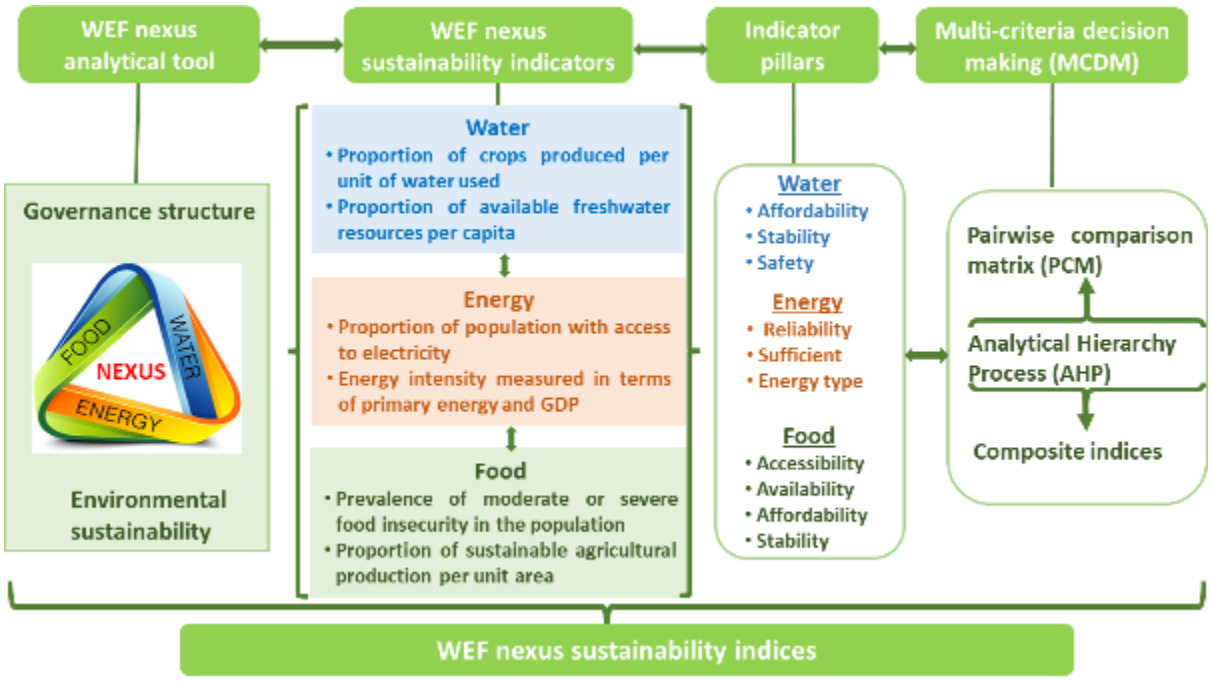


Figure 6: Conceptual outline used by Nhamo, Mabhaudhi, et al. (2020, p. 20) to develop the WEF nexus analytical model.

Applying variable-oriented quantitative research at the household level, Hussien et al. (2017) gathered empirical data from households[1] in order to develop a system dynamics model that

[1] Household data collected for a previous publication by the same authors (Hussien et al, 2016)

captured household WEF interactions. The output from the model provides stocks and flows associated with detailed household WEF consumption patterns and choices as well as responses to variables such as family size, family income, seasonal duration, amongst others. Although household size and income are included, no other social dimensions, such as livelihood options, or differences in availability or access to the WEF resources, are included. This model therefore assumes that WEF resources are available to all households in the study, and that they are all serviced comparably, as well as all households having equal access to these services. Although useful in terms of modelling household stocks and flows and the interaction between these, issues of equity are not adequately reflected in this approach.

In summation, quantitative models are typically data intensive, which makes them challenging to apply at the local level due to the difficulties in securing sufficiently detailed data to represent the locally-specific conditions (Foden et al., 2019; Huntington et al., 2021; Mguni et al., 2020; Terrapon-Pfaff et al., 2018). This is not just the case in the global south, where data is often lacking and lived experience can vary greatly, but also applies to the global north as noted by Huntington et al. (2021), who state that,

> "This paper is concerned primarily with the FEW framework, community-level data and the attempt to create an overall synthesis model. We were able to identify important couplings and influences within the FEW nexus but the creation of a systematic synthesis model was elusive because conditions varied greatly from one community to the next and over time, even within Alaska where many features of the political-economic system are consistent statewide." (MicroFEWs Project section, para.1).

2.3.3. Mixed methods and qualitative approaches

Like Hussien et al. (2017), both Spiegelberg (2017) and Wolde (2020) used primary household data to assess the WEF nexus, and like Biggs et al. (2015), they included livelihoods in their assessments. Both publications applied a mixed methods approach as well as categorising their indices according to the five capitals (assets) of the SLA (DFID, 1999), then into sub-indices relevant to their research needs. Spiegelberg (2017) used a socio-ecological network (SEN) model to analyse the indices populated by data collected through a household survey of fishers and farmers in a watershed in the Philippines. Although an innovative and thorough

methodological approach, the focus was on establishing the level of connectedness, via WEF nexus elements, between two user groups in a catchment, which is not relevant to my study.

Similarly, working with rural communities in an Ethiopian sub-basin, Wolde et al (2020) used a household survey to gather data to populate variables related to the impact of the WEF nexus on community-scale livelihoods, with the aim of increasing food security. These were weighted and ranked in relation to the WEF nexus through participatory engagements with local stakeholders. As illustrated in Figure 7, their conceptual framework shows the interconnectedness of the WEF resources and their ability to affect the centrally located community livelihoods. Inputs to the framing include the variables associated with WEF security, which when combined with the livelihoods indicators, result in 'WEF security for all'. This study is primarily concerned with the rural communities' perceptions of the interlinkage between WEF resources and how their livelihood actions impact food security. Although conceptually useful, the research in question is quite different to that of this research in that it is focussed on rural communities and primarily concerned with food security.

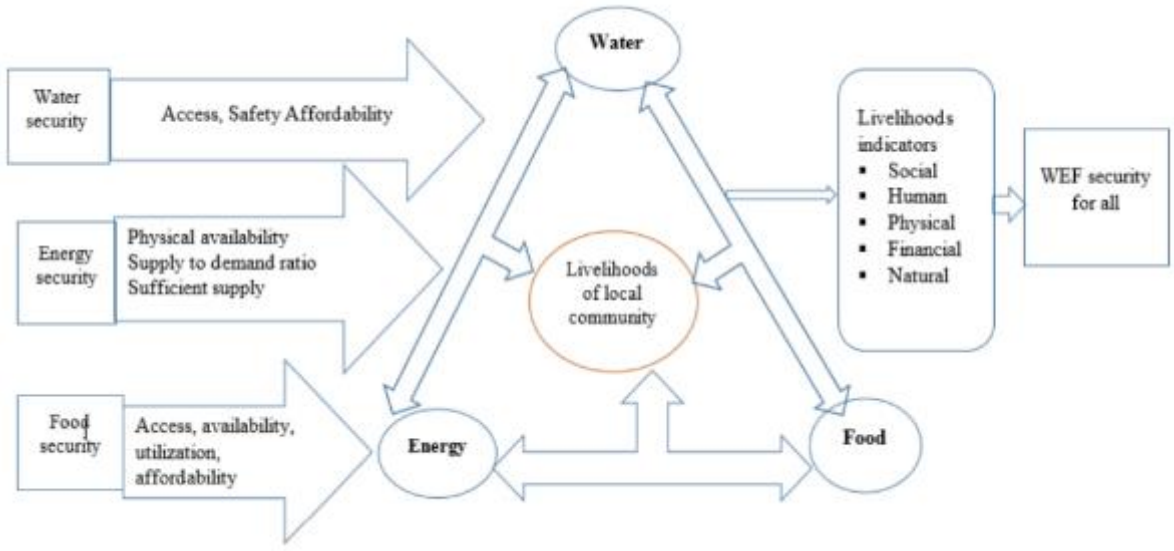


Figure 7: Framework developed by Wolde et al (2020, p.2) for assessing the impact of the WEF nexus on community-scale livelihoods.

Other publications that have adopted either qualitative and / or mixed method approaches to WEF nexus studies at the local level include Foden et al. (2019); Huntington et al. (2021);

Mguni et al. (2020); and Villamor et al. (2018). However, unlike Spiegelberg et al. (2017); and Wolde et al. (2020), they did not employ a household questionnaire to collect primary data but used participatory methods such as focus groups and expert interviews for this purpose.

Albrecht et al. (2018, p. 20) suggest that "[I]interdisciplinary and mixed method approaches that combine quantitative and qualitative methods from multiple disciplines are needed to address the physical and social aspects of water, energy, and food systems.". This is particularly relevant to nexus studies at the local level (Albrecht et al., 2018; Mguni et al., 2020; Stringer et al., 2018).

Furthermore, the use of social science-based methods is supported by Givens et al. (2018, p. 15) who examined the WEF nexus through a resilience lens and found that historical applications based on nexus management that did not include "… insights from the social sciences may unintentionally privilege a status quo created by those in power" and thus lead to unequal outcomes. Similarly, the approach adopted by Mguni et al. (2020, p. 2), who use the activity of cooking to unpack how household "… vulnerabilities emerge at the intersection of water, energy and food[?]", claiming that "… such everyday abstractions of the nexus ideally emphasise the impact that availability, access to, distribution and consumption of WEF resources have on human well-being".

Dalla Fontana et al. (2021), in exploring the five 'W' questions relating to the nexus of why, what, where, when, and who, note that "… research in the dominant technical discourse tends to answer mainly what questions, while researchers who advocate more social approaches delve more frequently into who and why questions.". They conclude that the complexity and interdependencies inherent within the nexus necessitates "… bringing together different perspectives and expertise …". As my research is concerned with understanding the WEF nexus and livelihood relationship amongst low-income urban households, these approaches have relevance.

2.4. Framework Developed for this Thesis

2.4.1. Household WEF status

Authors typically break WEF security down into its component parts of water security, energy security, and food security at their chosen scale(s) when seeking to define the term (Bizikova et al., 2013; Leck et al., 2015; Wolde et al., 2020). These definitions are based on accepted definitions from the literature and are mostly framed around balancing supply and demand. The supply side is typically phrased in terms of availability, and the demand side in terms of access and affordability, with other dimensions specific to the individual resource included, such as safety in the case of water, and utilization in the case of food. As a full analysis of all dimensions of the individual WEF securities was not the purpose of this research, I have replaced the phrase 'WEF security' with 'household WEF status', which refers to the availability, access, and affordability of water, energy, and food to the household.

2.4.2. Livelihoods and the household WEF nexus

As stated in section 2.3.1, livelihoods are understood to be the means through which a household meets its basic needs. In this research I am interested in how households meet their basic needs of water, energy, and food, and have drawn on the five capitals of the SLA to understand how they do this (DFID, 1999). These include i) human capital (household members); ii) financial capital (income); iii) natural capital (natural resource base); iv) physical capital (infrastructure); and v) social capital (social networks). The rationale behind this selection is outlined in Table 1. The framing of how this has been applied is illustrated in Figure 8, which follows the table.

Table 1: Rationale for using the five SLA capitals for framing how households meet their basic WEF needs.

Livelihood Capital	**Framing Rationale**
Human	The number of household members and the dependency ratio will have a bearing on its ability to ensure sufficient water, energy and food to meet its needs. Replace with: The number of household members contributing towards securing water, energy, food resources as a proportion of

	household members drawing on these resources will have a bearing on the household's ability to meet its needs.
Financial	Noordhoek is located in an urban setting (Velddrif) offering employment opportunities. South Africa also has a system of social support grants for pensioners, child support, disability grant, etcetera. It is therefore expected that Noordhoek households will at least in part draw on financial capital to service their WEF needs.
Natural	Located on the estuary of the Berg River and the shores of St Helena Bay – an area renowned as a rich fishing ground - it is expected that the natural capital associated with this setting will offer livelihood opportunities to at least some Noordhoek households.
Physical	Physical infrastructure is a key component of how households meet their basic WEF needs – for example household rainwater tanks and solar water heaters, as well as infrastructure associated with municipal water and energy supply.
Social	Households may occassionally not be able to meet one or more of their WEF needs sufficiently and may turn to drawing on their social capital in these instances, such as sharing or borrowing from friends, family or neighbours.

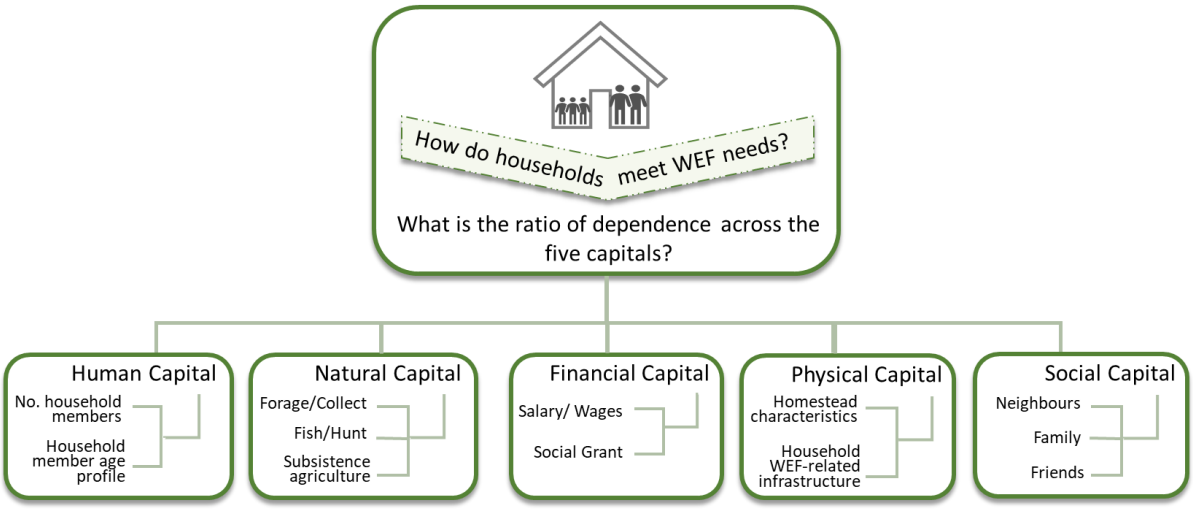


Figure 8: Framework showing the livelihood capitals explored with reference to how households meet their WEF needs. (Source: Author's own)

2.4.3. Poverty and its relevance to the research

Lack of access to sufficient resources to ensure human wellbeing is a defining element of poverty. As South Africa suffers extremely high levels of poverty, unemployment, and inequality, many households are vulnerable to water, energy, and food insecurity. Motivated by the need to support equitable sustainable development through an improved understanding of WEF nexus and livelihood interactions at the local level, I have selected to focus on low-income households as the unit of analysis.

Households too poor to access basic services have rights associated with basic needs enshrined in *The Bill of Rights* in the *Constitution of South Africa* (1996,s.27), which states that:

> (1) "Everyone has the right to have access to— (a) … (b) sufficient food and water; and (c) social security, including, if they are unable to support themselves and their dependants, appropriate social assistance. (2) The state must take reasonable legislative and other measures, within its available resources, to achieve the progressive realisation of each of these rights."

Furthermore, the *Constitution* mandates local government "… to ensure the provision of services to communities in a sustainable manner" (S.152, 1(b)). The *Municipal Systems Act* (32 of 2000) outlines the general duty of municipalities in this regard by stating that,

> "A municipality must give effect to the provisions of the Constitution and – … (c) ensure that all members of the local community have access to at least the minimum level of basic municipal services." (s73(1)).

Mandated to deliver basic services, local municipalities classify households that fall below a monthly income threshold as 'indigent' which entitles the household to some level of free basic services, such as water and electricity. The cost of providing these free basic services to indigent households is largely subsidised by national government through the equitable share granted to municipalities in terms of the *Division of Revenue Act* (DORA), Republic of South Africa (2019).

2.4.4. Availability, access, and affordability

As stated in section 2.4.1, I have examined the household WEF status in terms of availability, access, and affordability. Figure 9 presents the framing I have developed around these three dimensions. As the household is the unit of analysis, I have used it as a reference point in considering what factors determine the availability of, access to, and affordability of household WEF resources. I have also included the livelihood capitals, as illustrated in Figure 8, as key factors determining the affordability of household WEF resources.

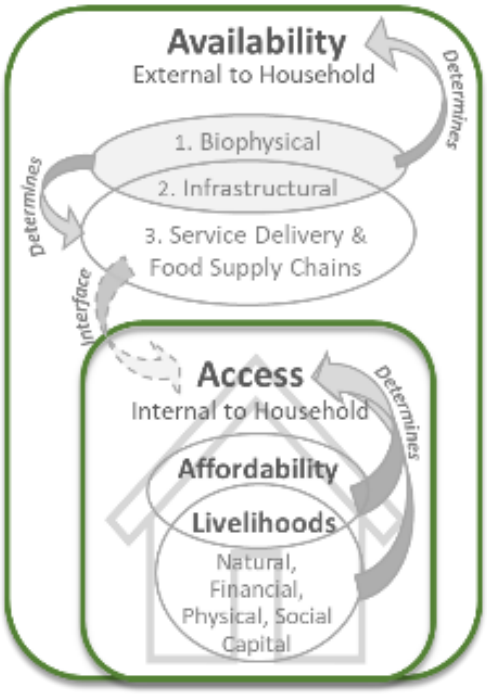


Figure 9: Household WEF status examined in terms of availability, access, and affordability. (Source: Author's own).

2.4.4.1. Availability

As illustrated in Figure 9, I have framed the availability of WEF resources as being determined by factors external to the household, namely biophysical, and infrastructural. Biophysical availability is a first order determinant of household WEF resource availability, which answers to the question of whether the resource is physically available. For example, in a drought situation water may either be in short supply or in extreme cases, not available at all. Similarly, naturally occurring food sources and food production may be negatively impacted by a drought or floods, with the result that less food would be available to households reliant on subsistence, as well as reduced inputs to food supply chains. Energy supply may also be affected by drought if generated by hydropower.

The second order determinant of household WEF availability is the physical infrastructure required to interface between the natural resource and the household. For example, there may be sufficient rain, but households may lack adequate water storage capacity; or a dam may have ample store of water, but the bulk water provider or the water supply authority may have problems with their infrastructure such as a pump breakdowns or pipe breakages, or lack of electricity to power their infrastructure, which compromise household water supply. In terms of energy this includes factors that limit the generating capacity of the national fleet which results in loadshedding which will compromise the availability of electricity to households. Additional breakdowns in the local municipal transmission infrastructure can also compromise household electricity availability. Food supply can be interrupted by damage to physical infrastructure such as roads by floods or political unrest, for example.

I recognise that governance may also play a role in determining availability of WEF resources to households, for example if a local municipality has sound governance over their financial and infrastructure maintenance systems, there is a high likelihood that these will be functional in delivering water and energy services to the household but have selected to not include this due to efforts to constrain the scope of this research.

As depicted in Figure 9, both service delivery and food supply chains are reliant on the biophysical, and infrastructural elements of availability being in place, before they can make WEF resources available to households. These two elements are therefore depicted in Figure 9 as essential connectors between the availability of WEF resources to the household and

household access in areas where municipal services are available, and households do not rely on subsistence for food supply.

2.4.4.2. Access and affordability

As opposed to availability, I have framed household access to WEF resources as being determined by factors internal to the household. As described in section 2.4.2, availability of livelihood options, that households may take up as their livelihood activities,essentially determine how households meet their basic WEF needs, and therefore determine access, as depicted in Figure 9. Affordability is closely linked to the livelihood capitals, not just the direct link to financial capital, but it may also drive increased reliance on other capitals such as natural or social capital, as well as introducing an element of trade-offs across the capitals. An example of households shifting reliance onto other capitals can be found in the response to increasing food prices where households may supplement household food provisions through food gardening activities (natural capital). However, this in turn will require additional water (natural capital), which, depending on the source, may also incur additional expenses, i.e. if municipal. In the case of a drought, the availability of water would be limited, which would restrict this supplemental activity.

2.5. WEF Resource Context in South Africa

The WEF resource context in South Africa is described here through an overview of biophysical availability and the governance and legislative frameworks. These describe mandated responsibilities, as well as contextual factors feeding into the household WEF status in terms of availability and access as outlined in section 2.4.3.

2.5.1. National water context

Regarding the availability of water from a biophysical perspective, South Africa is a water-scarce country with a mean annual rainfall of 464 mm (World Bank Group, 2021). Relying primarily on surface water resources, it experiences low and highly irregular rainfall, combined with high rates of evaporation (Department of Water Affairs, 2013). Figure 10, depicting mean annual rainfall per water management area, illustrates the decreasing precipitation from the predominantly summer rainfall eastern part of the country to the western part which receives predominantly winter rainfall (Brandt et al., 2013). As depicted, this case study is located in the south-western quadrant of the country, falling into the 200 –

300mm mean annual rainfall range (Cole et al., 2018). Compounding this water scarcity is an observed and projected warming trend associated with climate change, with the strongest signal, showing warming in excess of 2°C per century which is double the mean global warming trend, coming from the western parts of the country (Department of Environmental Affairs, 2018).

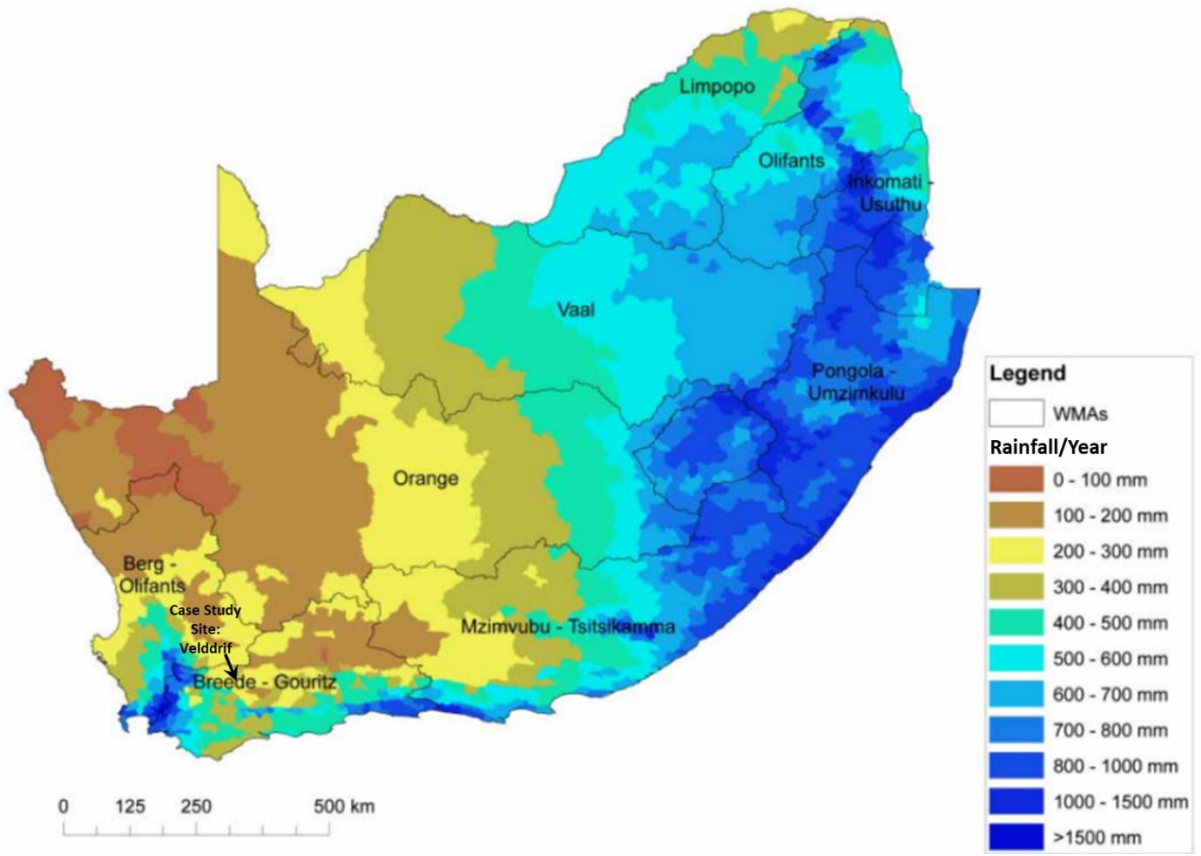


Figure 10: Mean annual rainfall across South Africa per water management area. The location of the case study (Velddrif) is shown on the west coast of the country. Source (Cole et al., 2018)

Figure 11 illustrates a broad outline of the legislation regarding governance of water in South Africa, which takes an integrated, rights-based approach. Enshrined in the *Bill of Rights* contained in the *Constitution of South Africa* (1996), is the right to access sufficient water. This is enacted through two pieces of complimentary legislation, namely the *National Water Act* (No 36 of 1998) and the *Water Services Act* (No 108 of 1997). The *National Water Act* sets out that National Government is "… the public trustee of the nation's water resources …" (p. 18) which is realised by the Minister of Water and Sanitation, who is therefore responsible for regulating the water resource in an equitable and environmentally sustainable manner.

In order to facilitate "…the proper management of water resources …" (p. 20), the Minister must ensure the development and regular review of a *National Water Resource Strategy* (NWRS) which sets out the institutional arrangements required to implement the legislation. The NWRS "… promote[s] the management of catchments within a water management area in a holistic and integrated manner" (p. 22) and also establishes the boundaries of water management areas (WMA) for which it must estimate water availability and requirements. South Africa is divided into nine WMAs, each of which should be governed by a Catchment Management Agency (CMA). At present only two of these CMAs are established (Department of Water Affairs, 2013).

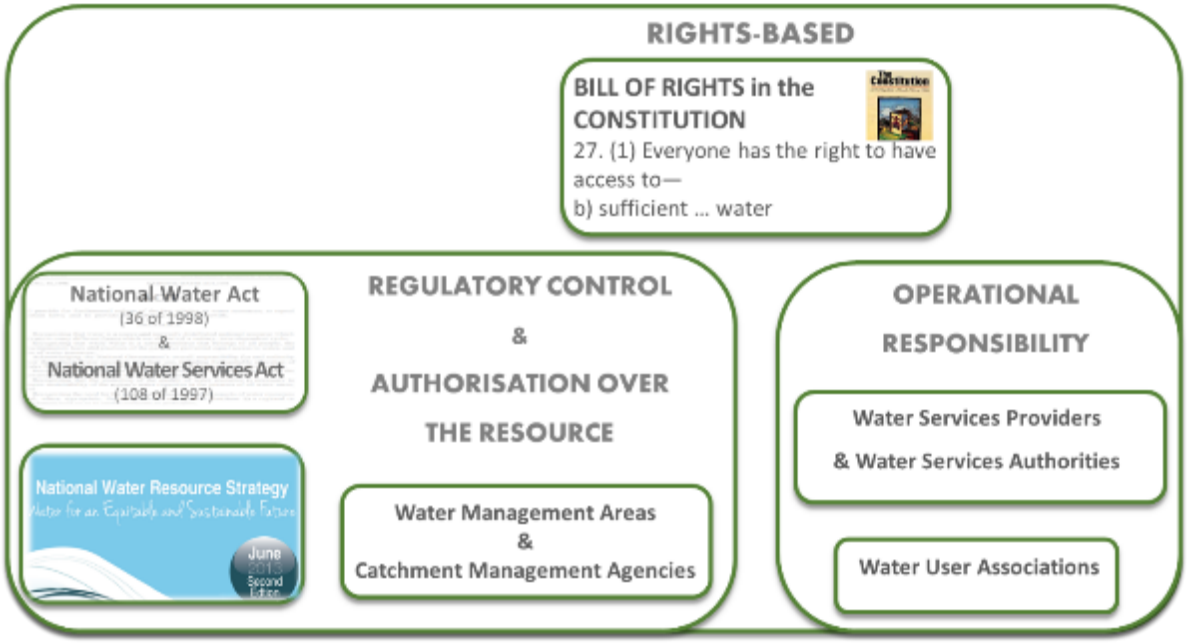


Figure 11: Legislative framework of the regulation and operation of water in South Africa. (Source: Author's own)

The Water Services Act (108 of 1997) provides for the realisation of the right of access to basic water and sanitation services through prescribing the institutional and regulatory requirements and duties that accompany this. Local government, as the water service authority (WSA), is required to ensure the delivery of "potable water supply systems and domestic waste-water and sewage disposal systems" and is thus responsible for basic water service delivery (Republic of South Africa, 1996, p. 137). The WSAs are typically supplied with bulk potable water by a larger utility-sized entity like a water board or in the case of some of the metro's and municipalities, their own facilities take on this role (Department of Water

Affairs, 2013). These bulk water suppliers, termed Water Service Providers (WSPs), do not have authority over the water resource, but are licenced to extract an allocated amount by a Catchment Management Agency, if they are in existence, or otherwise by the Minister. Similarly, Water User Associations (WUAs) are voluntary groupings of individual agricultural and or rural water users who collectively manage a common water resource according to duties and functions delegated to them by the Minister. Although recognised in the National Water Act (Republic of South Africa, 1998), WUAs and those old Irrigation Boards still in existence, are in the process of being dis-established, to be replaced by CMAs or a Regional Water Utility.

As illustrated in Figure 11, the level of responsibility therefore for ensuring the sustainable management of the resource rests at a catchment level or above, and the operational level rests with the WSP and the WSA. There is currently reform taking place in the enactment of the water legislation, as spelt out in the NWRS II and the National Water Framework, with regards to regional utilities, infrastructure ownership, and other related matters (Department of Water Affairs, 2013; Nepfumbada, 2020). This reform, if implemented will see a tidier and more consistent arrangement with regards to the national water supply chain.

The low levels of rainfall across the country are further compounded by a wide variation in water service delivery, with poor service delivery typically tracking high poverty headcounts across provincial, municipal, and urban-rural divides (Statistics South Africa, 2017). However, as mentioned in 2.4.3, poor households are entitled to free basic services in the form of a minimum water, energy, and sanitation allocation that are required to meet their basic needs. The local municipality determines the provision that registered indigent households will receive according to minimum standards set by national government. In the case of Bergrivier Municipality, all registered indigent households are entitled to 6 kl of free basic water (Bergrivier Municipality, 2020a).

2.5.2. National energy context

Energy availability at the national scale as applied to this thesis is confined to electricity generation, as transport is not included, and piped gas is not present in the area. As the case study is located in an urban environment on an arid coastal plain, fuel wood and animal dung are not viable energy sources either.

In terms of governance, electricity, piped-gas, and petroleum pipeline industries are regulated by the National Energy Regulator of South Africa (NERSA), which was set up in order to ensure that this monopoly-dominated industry remains competitive, efficient, and open to private sector participation (Republic of South Africa, 2004). Complementing this is the *Electricity Regulation Act* (4 of 2006) which regulates electricity supply through issuing of licences for the generation, transmission and distribution of electricity, regulating prices and tariffs, and enforcement of compliance, amongst other means (Republic of South Africa, 2006). Electricity generation and transmission is currently mainly the responsibility of the state owned entity (SOE), ESKOM (Treasury, 2011), however the Constitution places the responsibility for service delivery on local municipalities, and lists electricity reticulation as a local municipal function (Republic of South Africa, 1996). However, some end users are supplied directly by ESKOM resulting in a shared responsibility between local government and ESKOM (Treasury, 2011). Where local municipalities are the distributer, they purchase bulk electricity from ESKOM and resell it to their residents at a tariff rate set by NERSA.

Regarding availability, electricity generation, transmission, and distribution is centralised in a state-owned entity (SOE) Eskom, which produces approximately 90% of the country's electricity, 83% of which is generated from coal-fired power stations (Bowman, 2020; Department of Energy, 2019; Department of Environmental Affairs, 2018; National Planning Commission, 2018). The balance is generated by a growing renewable energy sector, one nuclear power plant, gas, pumped storage and hydro-electric sources (Department of Energy, 2019). The utility is however prone to unplanned outages as supply fails to keep up with demand (Ateba et al., 2019). The underlying reasons for this are complex and beyond the scope of this thesis, however, attempts to address the electricity deficit have not yet resulted in a cessation of rolling blackouts, but have resulted in significant increases in the cost of electricity generation. This has been passed on to the consumer in the form of tariff hikes, which although regulated by NERSA have still been above the rate of inflation since 2009 (Comins, 2021; Ting & Byrne, 2020).

This sharp increase in price over the past decade has led to decreased affordability, particularly for poor households. However, as mentioned under section 2.4.2, households that are registered as indigent with their local municipality receive a minimum free basic service. In BRM this amounts to the same as that set as the national minimum, in other words,

50kWh per household per month (Bergrivier Municipality, 2020a; South African Government, 2022).

2.5.3. National food context

Food security in the South African context, as defined in the National Policy on Food and Nutrition Security (Department of Social Development, 2014, p. 8), means:

> "Access to and control over the physical, social and economic means to ensure sufficient, safe and nutritious food at all times, for all South Africans, in order to meet the dietary requirements for a healthy life".

This is broken down into the 'four pillars' of food security, namely adequate availability of food; physical, social and economic accessibility of food; utilisation, quality and storage of food; and stability of food supply (Department of Social Development, 2014; FAO, 2013; Statistics South Africa, 2019d).

Like water, "… the right to sufficient food…" is enshrined in section 27 (1)(b) of the *Bill of Rights* in the *Constitution* (Republic of South Africa, 1996). In addition, section 28 (1)(c) states that "… every child has the right to basic nutrition …" (Republic of South Africa, 1996). Statistics South Africa, in their 2019 publication on measuring the extent of food security in South Africa, describe the right to food as "… requiring that food be available, accessible, and adequate for everyone without discrimination" (p. 1). However, unlike the situation with the right to water, there is no one department responsible for ensuring this right is enacted. As a result, the responsibility is primarily shared by two departments, namely the Departments of Agriculture, Land Reform and Rural Development (DALRRD) which is responsible for the availability of food, and Social Development (DSD), which is responsible for ensuring that everyone has access to food. Additional departmental initiatives exist, such as the National School Nutrition Programme run by the Department of Basic Education (DBE), and interventions and programmes on food safety and nutrition run by the Department of Health (DoH) (Moyo, 2019).

Despite South Africa being a net exporter of food products, making it a food secure country, many households experience food insecurity (Sihlobo, 2021; Tawodzera, 2016; Vermeulen, 2020). This is largely due to high levels of poverty, unemployment and inequality in the

country (Tawodzera, 2016), resulting in 40% of the population living below the lower-bound poverty line[2] (Statistics South Africa, 2019). This places further emphasis on the importance of exploring questions of access when examining household food security in the South African context.

[2] Poverty headcount of the number people living below the Lower-bound Poverty Level (LBPL) - which represents the financial boundary below which people do not have sufficient resources to purchase or consume both food and non-food items and are therefore forced to sacrifice food to obtain essential non-food items.

Chapter 3 Study Area and Methodology

3.1. Embedded in an Overarching Project

This research is one of four case studies undertaken as part of an overarching project entitled '*Exploring the Evidence of Water-Energy-Food Nexus Linkages to Sustainable Local Livelihoods and Wellbeing in South Africa'* (Methner et al., 2021). As illustrated in Figures 12 and 13, this research forms one of four case studies spanning three catchments that comprise a collective case study (Crowe et al., 2011) at the project scale. The overarching approach and the empirical instruments were collectively developed at the project scale which included student inputs, however individual students took slightly different approaches and therefore applied minor adjustments to the empirical instruments in response to variation in research aim and objectives. For the purpose of this dissertation, I am presenting a singular case study, and in so doing am presenting my interpretation, adjustments, and application of the project research design and methodology. I have developed the figures and framing presented in this thesis as a means to help me unpack and understand the complex interlinkages presented in this study area. The conceptual framing presented in this section is therefore largely my own work, unless referenced otherwise.

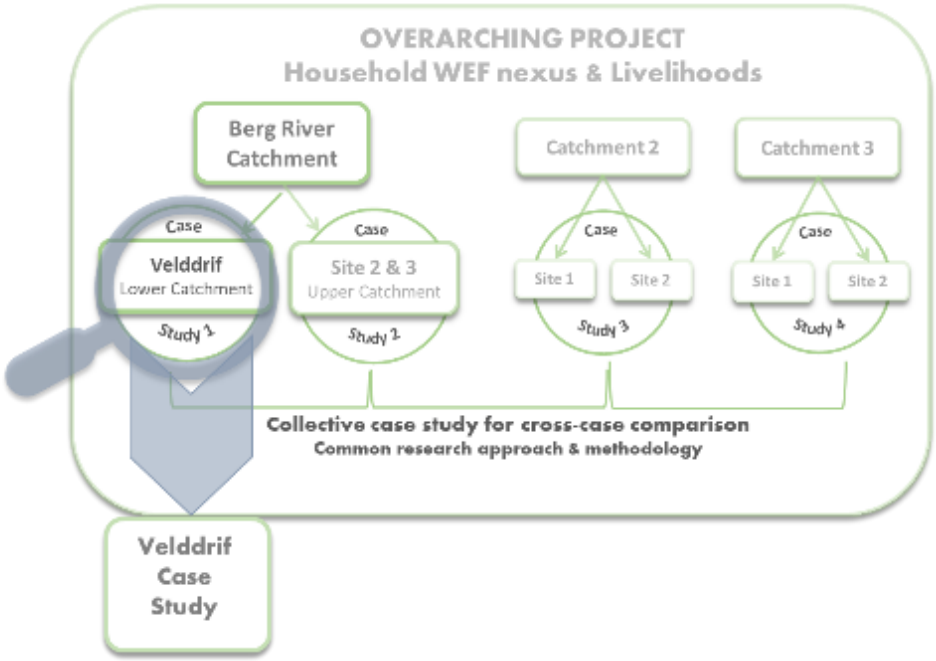


Figure 12: Illustration of this Velddrif case study as part of a collective case study adopted in the overarching project design. (Source: Author's own)

3.2. Study Area

As illustrated in Figure 13, the case studies included in the overarching project span three catchments, namely the uMngeni River, the Keiskamma River, and the Berg River. This case study, one of two in the Berg River catchment, is located at the mouth of the Berg River in a town called Velddrif.

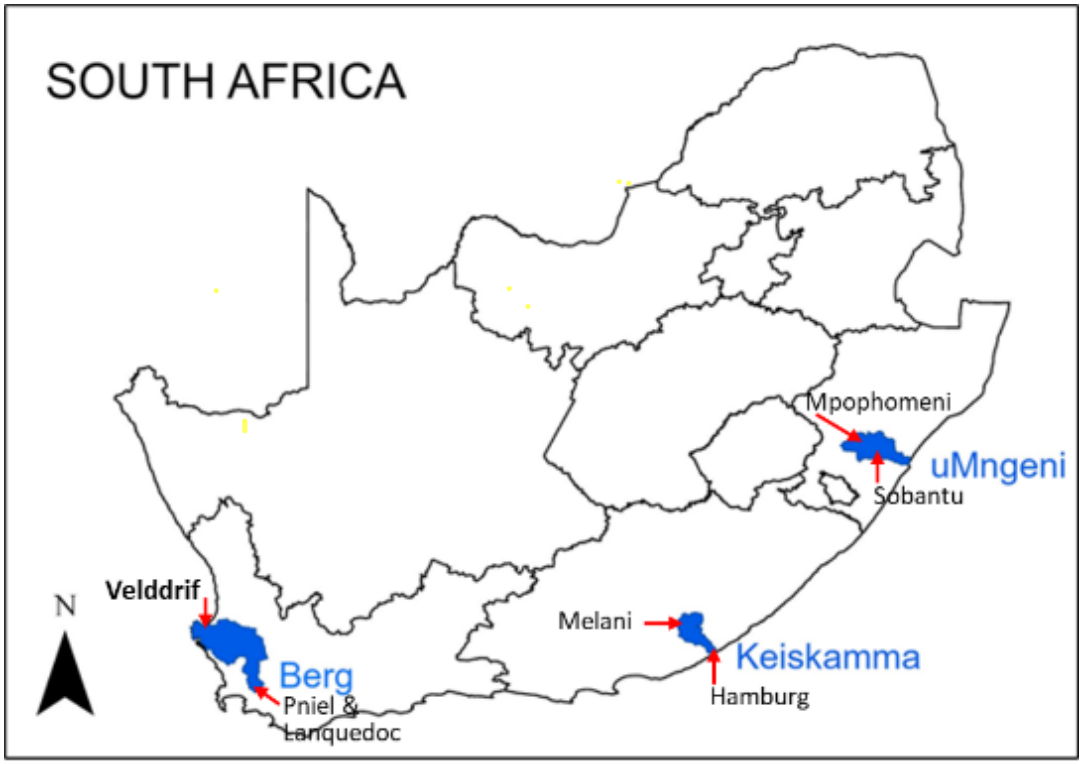


Figure 13: Map of South Africa showing the location of the overarching project case study sites within the three catchments. Source: (Methner et al., 2021).

The selection of the town of Velddrif as the research site was done at a project level and was based primarily on the consideration of spatial representation within the Berg River catchment in terms of upper and lower catchment. Velddrif, long known as a fishing town, is situated on the estuary and was thus an attractive choice in the lower catchment given the connection between water, food, and livelihoods the location offered.

3.2.1. Case study location and site overview

As depicted in Figure 14, the research site of Noordhoek is located within the town of Velddrif, which is the second largest town in Bergrivier Municipality (BRM), one of five local municipalities that make up the West Coast District Municipality (WCDM) in the Western Cape Province of South Africa (Bergrivier Municipality, 2017; West Coast District Municipality, 2020).

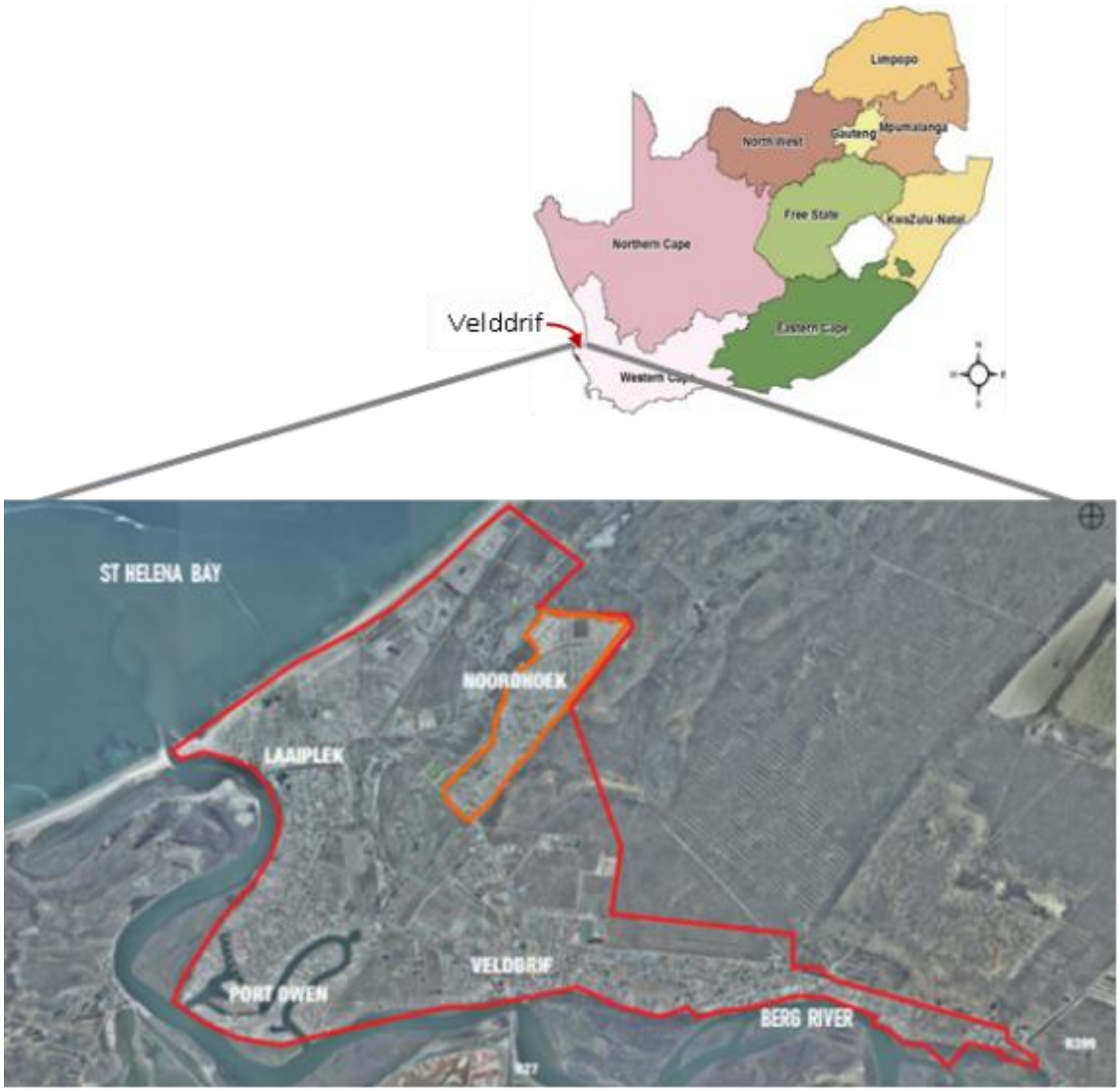


Figure 14: Map indicating the location of the town of Velddrif within the Western Cape Province of South Africa. The town is outlined in red, and the area of Noordhoek outlined in orange. (Source: Adapted by author from City ThinkSpace)

Situated 2 km upstream from the permanently open and navigable mouth of the Berg River, Velddrif serves as a harbour primarily for fishing vessels which offload directly to an industrial

scaled fish processing factory[3] adjacent to the quay as shown in Figure 15. It is not surprising therefore that Velddrif is described in the BRM Annual Report 2019/20 (p. 20) "… as a focal point for the fishing industry along the West Coast".

With an extensive floodplain reaching into the upper reaches of the Berg River estuary, it is one of the largest in South Africa (Western Cape Government, 2021). Partly due to this unique feature, the estuary has high conservation value, however at present does not have any formal protected area status (Western Cape Government, 2021). It is also home to a commercial salt works.

Figure 15: View from the river mouth up the Berg River estuary showing the fishing harbour adjacent to the fish processing factory. (Source: Author's own)

As depicted in Figure 14, the town is comprised of four parts, namely the primarily residential area of Velddrif stretching up the estuary; Port Owen which is an upmarket marina providing both permanent residence and upmarket tourism accommodation; Laaiplek consisting of a fishing harbour, light industrial activity (mostly manufacture and fish processing), commercial and some residential; and Noordhoek, the empirical hub of this case study, which is a residential area described in the Bergrivier 2017-2022 Integrated Development Plan (IDP) (p. 310) as "… a remnant of the apartheid dispensation and is also one of the poorest areas in Bergrivier municipal area.". The 2008 BRM Spatial Development Framework (SDF) described Noordhoek as:

> "[T]the low-cost housing segment of Velddrif … it is separated from all natural attributes, serves as a dormitory for a large portion of the community, has no direct connectors to the rest of the town other than physical infrastructure and subsequently reaffirms the apartheid town layout." (p. 61).

[3] From here on referred to as the fish factory

3.2.2. Demographics and socio-economic context

Table 2 provides demographic and socio-economic statistics for Noordhoek drawn from the last national census conducted in 2011 (Statistics South Africa, 2012), which although slightly outdated, provides a useful reference point. Analysis of the data showed the relative significance of the area of Noordhoek in that its population, although small (7 135 people), constituted over half (64.8%) of the population of Velddrif (11 017 people). Noordhoek's population was also considered youthful with 68% falling into the 'working age' category, of which 49.1% were employed. The unemployment rate in Noordhoek was 11.9%, which was significantly higher than the average recorded for the municipality, which was 6.8%, but significantly lower than the national average of 29.1% (Statistics South Africa, 2019c). Average Noordhoek household size was 3.5 with a dependency ratio of 47.1, both on par with the municipal average.

Table 2: Demographic and socio-economic statistics for Noordhoek (Source: Statistics South Africa, 2011)

Population of Noordhoek	7135
Population of Velddrif	11 017
Number of households	2057
Average household size	3.5
Percentage young (0-14)	27.8
Percentage working age (15-64yrs)	68
Percentage elderly (65+)	4.2
Dependency ratio	47.1
Percentage employed (absorption rate)	49.1
Percentage unemployed (unemployment rate)	11.9

According to the 2020 provincial Municipal Economic Review and Outlook (MERO) (Western Cape Government, 2020), the economy of the municipal area is dominated by the agriculture, forestry and fisheries, sector which in 2018 contributed 26.7% to municipal Gross Domestic Product (GDP), was responsible for 50.6% of the municipal area's employment, and 75.9% of exports from the municipal area (Western Cape Government, 2020). Employment in this sector is also dominated by low-skilled workers who made up 75.5% of this sector's workforce

in 2018 (ibid.). Other significant sectors included manufacture which contributed 23.2% to the municipal GDP, as well as wholesale and retail trade, catering and accommodation which contributed 13.3% to municipal GDP (ibid.).

3.2.3. Local municipal representation

Residents vote for their local ward councillors as well as local and district council proportional representation at local elections which are held across the country every five years (Independent Electoral Commission, 2022). The town of Velddrif is divided into two wards, namely Wards 6 and 7, with Noordhoek being located within Ward 6, along with the towns of Aurora and Dwarskerbos. The other three areas of Velddrif are united under Ward 7. The municipal seat is located in Piketberg, however Velddrif has representation of most municipal functions in a satellite municipal office located in the town.

3.2.4. Local service delivery

As noted in section 2.4.2, local government is mandated by the *Constitution* as being responsible for the delivery of basic services (Republic of South Africa, 1996). The 2011 national census revealed that 87.9% of Noordhoek homesteads were formal, 98.9% received their water from a water services provider (BRM), 86% had a flush toilet connected to the sewerage system, 92% used an electric or gas stove for cooking, and 96% used electricity for lighting. This indicated a high level of dependence on municipal service delivery for household water and energy needs.

As also noted in section 2.4.2, indigent households are entitled to a level of free basic services granted by the local municipality and subsidised by the state. The Bergrivier Municipality definition of 'indigent' is "… households where the combined monthly income of the household is less than the equivalent of two state pensions plus 40%." (Bergrivier Municipality, 2020a, p. 26).

3.2.4.1. Water

Expanding on the national water context described in 2.5.1, and as illustrated in Figure 16, the West Coast District Municipality (WCDM) acts as the Water Service Provider (WSP) which is licenced by the national Department of Water and Sanitation (DWS) to draw an allocation from the natural resource at Misverstand Dam on the Berg River. Extraction is metered,

monitored, and charged for by DWS. Using their own infrastructure and reticulation system, the WCDM treats the water at Withoogte Water Treatment Plant and provides the Water Service Authority (WSA), in this case Bergrivier Municipality (BRM), with bulk potable water.

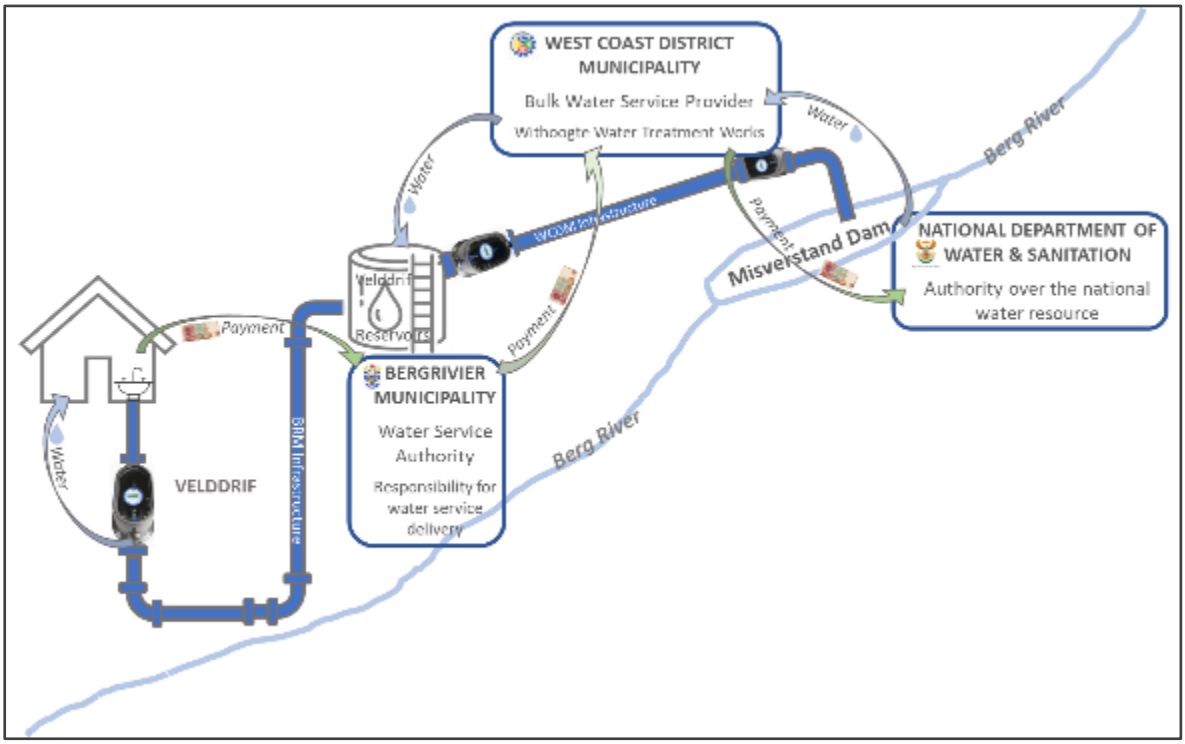


Figure 16: Water supply to Velddrif showing the different roles and responsibilities within the supply chain. (Source: Author's own)

As shown in the Figures 16 and 17, the transfer point in Velddrif from WCDM to BRM occurs at the town's reservoirs where the amount of water received is metered and BRM is charged accordingly. This water is delivered to end-users via the BRM reticulation system, as illustrated in Figure 17, and metered and charged for as part of the BRM rates and services billing. This point, where it reaches the household water meter, is the point where water availability becomes water access in terms of representing the point where there is a change of 'ownership' and the infrastructure becomes that of the household.

Figure 17: Detail of the water supply system to households in Noordhoek. (Source: Author's own on Google Earth base map)

In terms of water availability, there was a severe drought that affected the Western Cape Province between 2015 and 2018 (Theron et al., 2021), resulting in a provincial state of emergency being declared in 2017 which imposed water restrictions across the province. Level 5 and finally level 6 restrictions were imposed by BRM in 2017, which entailed a restriction of 50 litres per person per day (Bergrivier Municipality, 2020a). According to the BRM website, all water restrictions were finally lifted in October 2020 (Bergrivier Municipality, 2020b).

3.2.4.2. Electricity

The BRM also supplies the residents and businesses of Velddrif with electricity that is purchased directly from the national energy utility, Eskom, as outlined in section 2.5.2. and illustrated in Figure 18. The physical transfer point from the national utility to BRM occurs on the Velddrif side of the banks of the Berg River estuary, as depicted in Figure 18, where

the incoming electricity is received at the main Velddrif sub-station. This electricity is then distributed throughout Velddrif via the BRM electrical infrastructure. Residential end users are on a prepaid system which requires the purchase of electricity units from BRM which are then loaded into their meter for use. Bulk users pay on a post-use account basis.

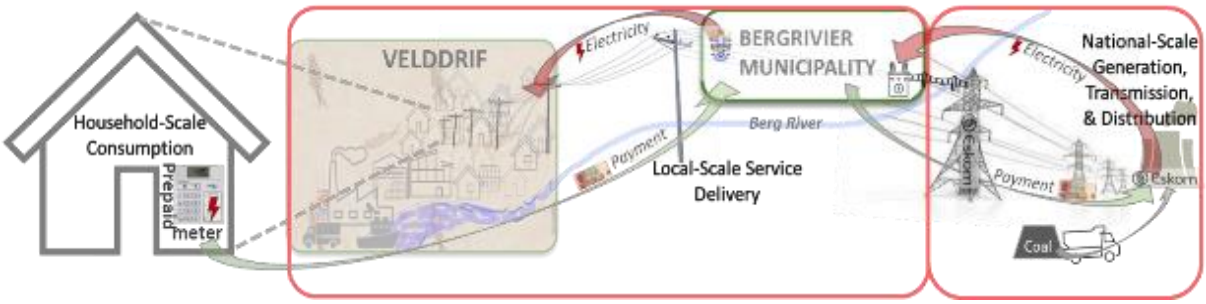


Figure 18: Electricity supply system from national to household level in the case of Velddrif. (Source: Author's own)

As depicted in Figure 19, electricity is available to the area of Noordhoek via two supply points, the first one as part of the main town supply and the second is a line taken off the supply line for Dwarskerbos, a town to the north of Velddrif.

Figure 19: Detail of the electricity supply system to households in Noordhoek.
(Source: Author's own on Google Earth base map)

3.2.5. Local food context

As stated in section 3.2.1, Velddrif has a long tradition of being a fishing village and continues to play an important role in this regard within the broader region. Fish, as a form of natural capital associated with such a rich estuary and coastline, has historically been a major food source in the area (Clark et al., 2009). Prior to 2003 when gillnet fishing was banned in the estuary, it was used by small-scale net fishers, primarily for catches of mullet *(Liza richardsonii)* that they would salt and dry. Known as 'bokkoms', this traditional small-scale fishery persists in Velddrif today, but fishers now net the mullet in the sea off Laaiplek (Department of Agriculture Forestry and Fisheries, 2015). 'Bokkom Laan' a dirt road adjacent to the estuary, provides a well-known tourist attraction where visitors can still buy these artisanal dried fish / 'bokkoms'. There are currently no permits available for commercial fishing in the estuary, only recreational fishing which includes limitations of species, size and number caught (Western Cape Government, 2021). Fishing as a source of food is therefore

largely industrialised today and the Berg River estuary provides a harbour for commercial fishing vessels, while Velddrif is home to a number of fish processing and packaging plants. There are also several fish and meat retail outlets related to the import, processing, and packaging of these products in the Laaiplek commercial and light manufacturing area (own observations).

Due to the extensive nature of the estuary having a tidal influence reaching approximately 65 km upstream (Hutchings, 2008), the agriculture around the town is limited to 'poor dry-land agricultural potential', suitable for wheat, potatoes, rooibos, sheep, and cattle (Bergrivier Municipality, 2019).

The town has numerous supermarket outlets, mostly clustered around Laaiplek. These are well-supported and residents of Noordhoek can be seen walking across open land to this area to do their shopping.

3.3. Methodological Overview

The purpose of this research was to establish the status of WEF resources in low-income households within the town of Velddrif and explore the role local livelihoods play in this. As livelihoods describe how households meet their basic needs, and water, energy and food are basic needs, there is an obvious linkage between the two concepts. The aim was not therefore to establish whether such a linkage exists – i.e. a deductive approach, but rather to apply an inductive approach by exploring how the WEF nexus and livelihoods play out at the local scale (Saunders et al., 2019). I created three objectives through which to fulfil the research aim. The first focussed on establishing the household WEF status (as conceptualised in section 2.4.1) and their livelihood options; the second on exploring the local context within which the households were located in terms of WEF resourcing and livelihood opportunities; and the third was to integrate the findings emerging from these nested scales into an understanding of the relationship between the WEF nexus and livelihoods at the local scale.

3.3.1. Case study approach

Foran (2014) noted that nexus interlinkages and livelihoods are site-specific, which points to the need for an approach that "… generate[s] an in-depth, multi-faceted understanding of a complex issue in its real-life context", which Crowe et al. (2011, p. 9) attribute to the case

study approach. Drawing on the seminal works of Stake (1995), Merriam (1998) and (Yin, 2002), a case study can be broadly defined as a bounded integrated system, focussing in on a single entity or phenomenon which is referred to as the case. In this instance as depicted in Figure 20, the case is spatially nested, with an initial and primary focus on low-income households in the settlement of Noordhoek in Velddrif. The influence of these larger spatial scales on the household WEF status have been introduced and discussed in detail in Sections 2.4.4.1 (Availability), 2.5 (WEF Resource Context in South Africa), 3.2.4 (Local Service Delivery), and 3.2.5 (Local Food Context).

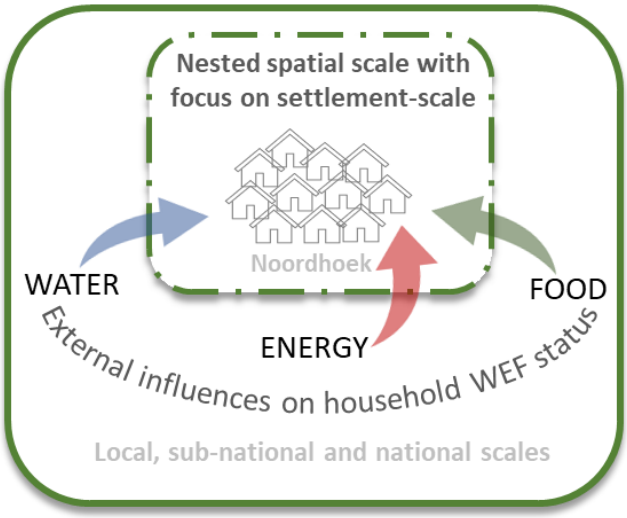


Figure 20: Spatial bounding of the case study, showing the spatial focus on the settlement of Noordhoek, but recognising the influence of external factors on the household WEF status. (Source: Author's own)

The phenomenon of interest includes the exploration of the relationship between the WEF nexus and livelihoods at the local scale as depicted in Figure 9.

This study is thus exploratory by nature (Crowe et al., 2011; Yin, 2009), seeking to make visible some of the complex interactions that characterise the WEF nexus and livelihoods in Velddrif, as opposed to a purely descriptive case study, or an explanatory case study which seeks direct causation or correlation (Ellinger & McWhorter, 2016; Yin, 2002).

3.3.2. Mixed methods research

As this research topic is comprised of complex phenomena across nested spatial scales, it required multiple sources of data to capture the different elements at play as well as their interlinkages (Crowe et al., 2011; Van Wynsberghe & Kahn, 2007; Yin, 2002; Yin, 2009). Mixed methods is well-suited to this need (Clark & Ivankova, 2016; Creswell & Plano Clark, 2007) , as reflected in Johnson et al. (2007), where it is defined as

> "… the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration" (p. 123).

The application of both methods in this research therefore not only accommodated the depth of understanding required of nexus interactions at the household level, but also the breadth across the nested scales and contextual elements (Endo et al., 2017).

In applying mixed methods, data was collected sequentially (Creswell & Creswell, 2018), starting at the household level and working out towards the town and municipal scales in a step-wise manner (Johnson et al., 2007). In this way, each step and method built on the previous and informed the next as illustrated in the research design depicted in Figure 21. This process allowed me to build a body of evidence anchored in the lived experience and perceptions of the household members regarding the interlinkages between the WEF nexus and livelihoods at the household scale, and then exploring the implications of selected contextual factors on the household WEF-livelihoods system. Although the main triangulation process occurred post analysis in the final chapter, the multi-scaled, step-wise and mixed methods approach facilitated a measure of emergence and snowballing as I worked through the research process (Clark & Ivankova, 2016).

3.3.3. Transdisciplinary research

This research, which includes elements of transdisciplinary practice, is embedded within a larger transdisciplinary research project. The overarching project, introduced in Section 3.1, adopted a transdisciplinary (TD) approach, which as defined by Lang et al. (2012), is:

> "… a reflexive, integrative, method driven scientific principle aiming at the solution or transition of societal problems and concurrently of related scientific problems by differentiating and integrating knowledge from various scientific and societal bodies of knowledge". (p.26).

The research design of the overarching project included a partnership component with local not for profit organisations (NPO) at each site. In this case study, the design involved the inclusion of a small group of local unemployed post-matric youth as community research assistants (CRAs). The aim was to provide opportunities for upskilling and training youth in data collection, while providing them with a stipend. It was hoped that this approach would encourage knowledge exchange across epistemologies as well as embedding the knowledge generated through the research process in the communities involved.

In this specific study, I conducted the household questionnaire and many of the key informant interviews accompanied by at least one CRA. We also discussed the how the data collection went after each data collection session. In this way, the youth could provide insight into any queries I had following data collection. They assisted in clarifying these queries with their local understanding and interpretation of a puzzling response, or a point of reference that I did not understand. Although the power dynamics in this situation were such that the youth were not consulted as experts, they add an enormous amount of value in terms of access to households, interpretation of results and guidance regarding the spread of households to target. Although this approach did not completely satisfy the definition of transdisciplinarity, having the CRAs so close to the data collection and interpretation did influence the research. Other learning opportunities were also made available to the youth such as visits to key points in the municipal water and electricity supply systems from the household outwards into the town.

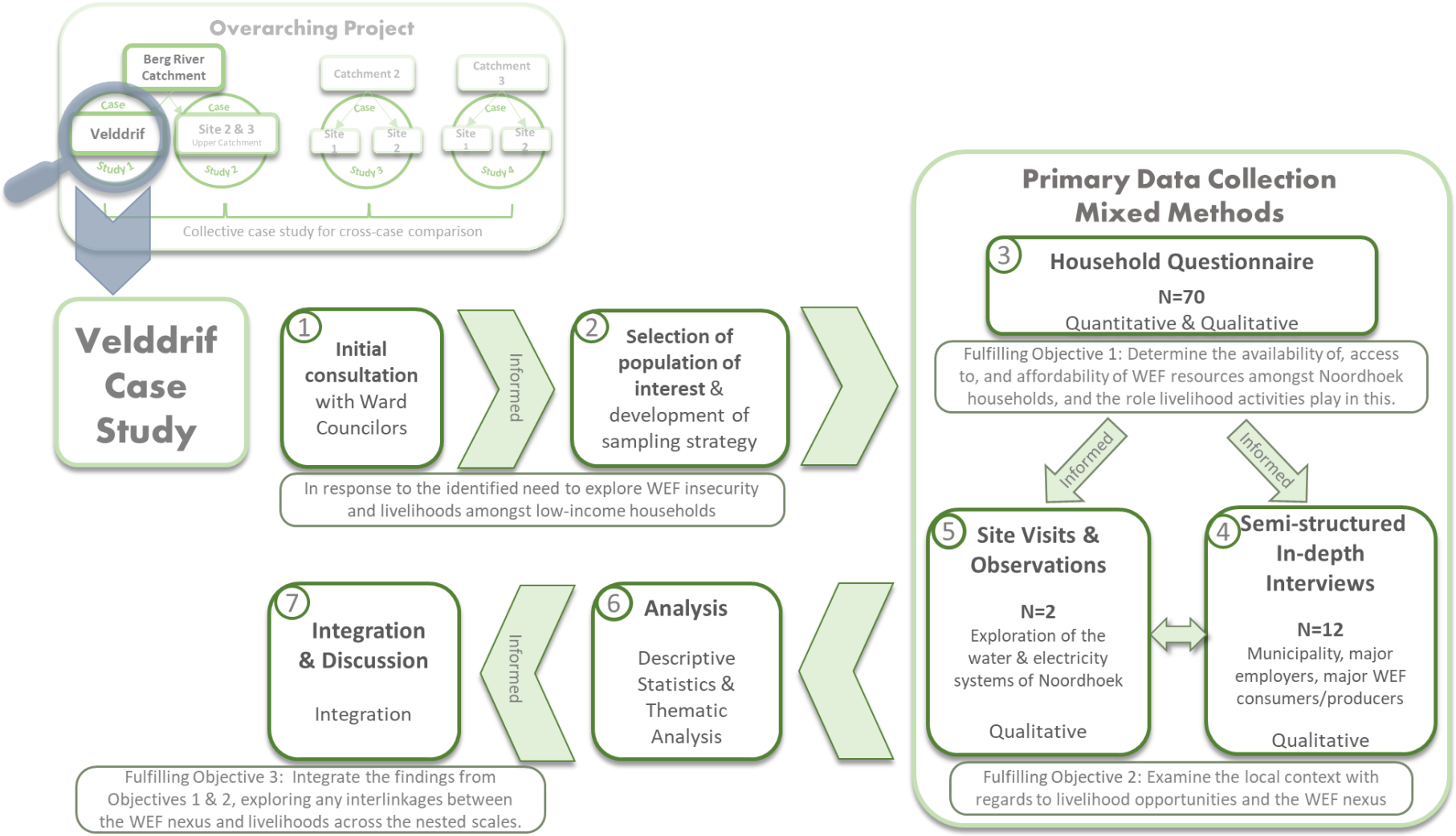


Figure 21: Research process flow, showing the relationship to the overarching project and the sequential design. *(Source: Author's own)*

3.4. Methods

3.4.1. Scoping

Step one of the research design, depicted in Figure 21, comprised a scoping and consultation component which involved a visit to the town and meeting with the ward councillors. They suggested the area of Noordhoek as the most suitable area in terms of meeting the research aim of establishing the status of WEF resources in low-income households within the town of Velddrif.

Once the research site had been established, I visited the town as part of an initial scoping exercise to familiarise myself with the physical geography of the town and to meet the local ward councillors to discuss conducting the research in the area. The ward councillors were enthusiastic about the research taking place in Velddrif and agreed that a suitable population of interest within the town would be the area known as Noordhoek which has a relatively high concentration of economically vulnerable households. I accompanied the ward councillor representing Noordhoek on a site visit to the area where they introduced me to a local not-for-profit organisation (NPO) working with unemployed youth. Following confirmation of Noordhoek as the research site, I held discussions with the NPO who agreed to become a project partner in terms of assisting to recruit and manage a cohort of unemployed youth in the area that could act as community research assistants (CRAs). This arrangement, in fulfilment of the overarching project trans-disciplinary design, aimed at facilitating knowledge exchange between residents and researchers, building elementary skills in local youth, and providing them with some work experience.

3.4.2. Household questionnaire

3.4.2.1. Sampling

As can be seen in Figure 21, the identification of the population of interest and the development of the sampling strategy occurred at step two of the research process. All the case studies under the overarching project agreed upon a minimum sample size target of fifty households, with the understanding that up to one hundred would be done if possible. As an initial means of getting my bearings on the area, I met with the municipal planner to obtain a detailed map of the erven and households in order to establish the layout of the area. This

map was utilised as a basis for determining the sampling. The planner pointed out the presence of distinct sub-areas within Noordhoek, which were confirmed by the CRAs. The historical development of the area took the form of visually distinct sub-areas being built at specific periods, with the result that the residents divided the area up into commonly referred to sub-areas which cover a range of housing types, from older single stand or carriage houses with well-established gardens to recently built serviced sites with an outside toilet in a sandy yard, and smaller less well-developed brick and mortar, or fibrecrete-slab houses in between. A map of the sub-areas is shown in Figure 22, which is accompanied by Table 3 providing details of the sub-areas.

I divided the sample area according to these sub-areas in order to ensure representation across what appeared to be areas of varying socio-economic circumstances; differences in age of basic infrastructure; differences in levels of formality; and potentially difference in livelihood opportunities. These factors appeared to constitute a valuable distinction in the household questionnaire sampling strategy. Sampling according to these sub-areas therefore introduced an element of stratification (Collins, 2010).

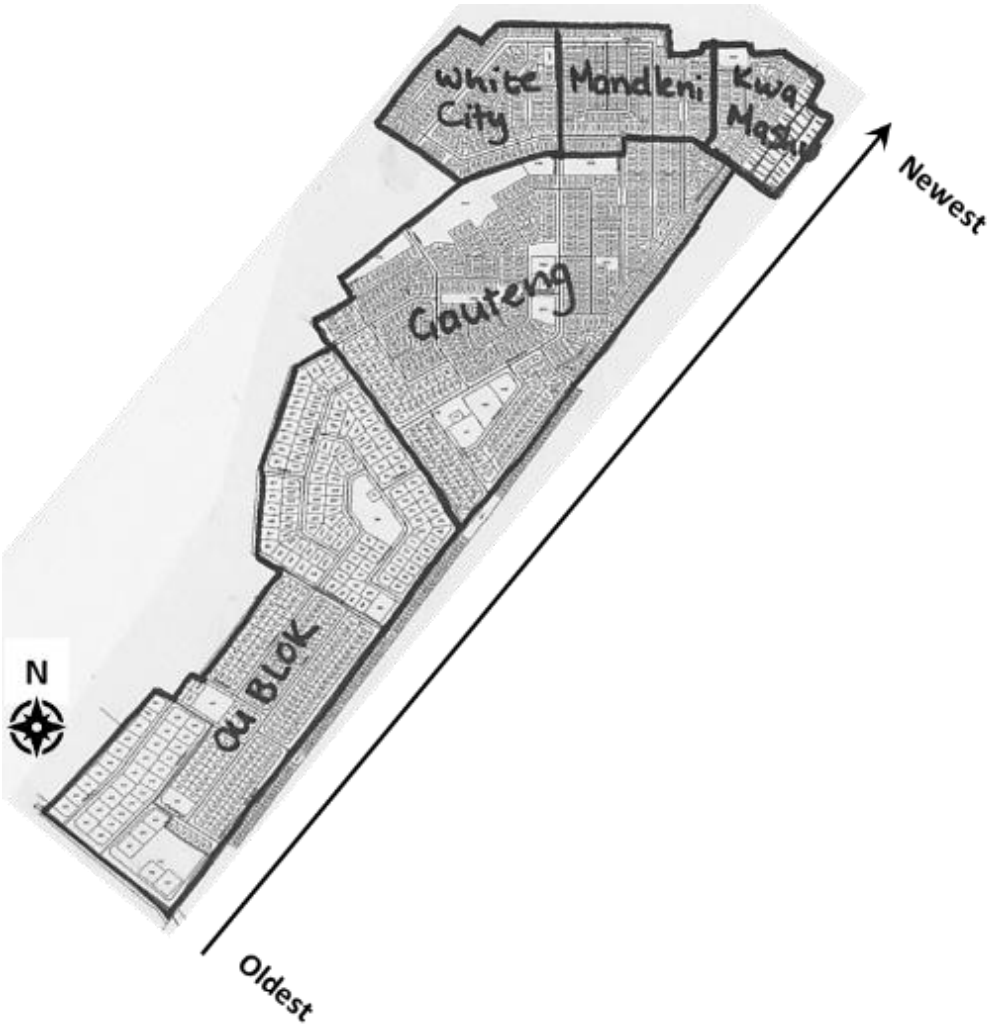


Figure 22: Cadastral map of Noordhoek depicting the five sub-areas.
(Source of base map: Planning Department, Bergrivier Municipality; Sub-areas: Author's own)

Table 3 gives a breakdown of the physical characteristics of the sub-areas, arranged from oldest to newest.

Table 3: Areas forming sampling sub-set of Noordhoek.

Area Name	***Description***
Ou Blok	The oldest residential block in Velddrif and the closest to the town centre. This area contains many single storey 'hop-huise' (carriage houses) and semi-detached houses as illustrated in Figure 23, as well as a visually distinct medium density area characterised by relatively large erven with medium to large sized free-standing houses that appear to be more up-market.

Gauteng	Like Ou Blok, Gauteng is a well-established area characterised by high-density, mostly single storey, small formal dwellings situated on small erven, many with an informal dwelling known as a 'backyarder' on the same erf as shown in Figure 24.
White City	This area is characterised by a distinct architectural style typical of the RDP housing schemes of the early years of democracy in South Africa. All the houses were initially painted white (and many still are), thus the name.
Crème City / Mandleni	Like White City, this area also has a characteristic architectural style as a result of being built all together as a housing scheme. All the houses are cream coloured, thus the name.
KwaMashu	This is the latest housing development comprising small, serviced plots mostly with zinc houses and outside toilets supplied by the municipality.

Figure 23: The oldest houses in Noordhoek in the sub-area known as 'Oublok'.
(Source: Author's own)

Figure 24: A typical scene in the sub-area of 'Gauteng' showing the mixture of formal brick and mortar dwellings and informal structures constructed from wood and or zinc sheeting added on. (Source: Author's own)

Once the sub-areas had been established, I selected households within each sub-area using the map indicated in Figure 22. I selected households based on attaining a balanced visual presence across the map. I started by selecting an initial ten houses in each of the five sub-areas in order to make up the minimum fifty households as required by the overarching project. Once the survey was completed in these households, additional households were allocated in areas which were visually under-represented, in other words where there were gaps on the map. This was repeated until the map was visually balanced with regards to data points. Consideration was given to differing erven densities across the whole area. When selected householders were not available or not willing to participate in the research, the next-door house was selected. There were also instances when the CRAs did not wish to go to a selected house as they indicated that they did not feel safe to do so, and then the same method applied where the adjacent house was selected.

3.4.2.2. Data collection

The household is the unit of analysis of this research, serving as the empirical entry point to the study. As indicated in Figure 21, this took the form of a household questionnaire (step 3), which I used to gather household-level data primarily in pursuit of answering objective one, which focussed on establishing the household WEF status and their livelihood options. As noted by (Creswell & Creswell, 2018), using a deductive structured method such as a questionnaire suits the need to establish a body of evidence covering a complex topic (phenomenon) across many households (n=95). Through a mixture of open-ended and closed questions, the questionnaire gathered both qualitative and quantitative data on basic

attributes of the household and dwelling; the status of Noordhoek households' availability of, and access to water, energy and food; perceptions of affordability of the water, energy, and food resources; as well as livelihood sources / activities, as detailed in Table 4.

A copy of the questionnaire is included as Appendix A.

Table 4: Outline of content covered in the household questionnaire.

Section	Question area	Detail	Link to SLA capitals
1 - General	Dwelling	Location; structure; period of residence.	Physical capital
	Household profile	Size. Age profile. Source and nature of income.	Human capital Financial capital Social capital
	Household WEF availability	Availability and reliability of municipal services. Use of natural resources for servicing WEF needs.	Physical capital Natural capital
2 - Water	Household access	Source(s) and quality of water. WEF and / or livelihood linkages. Ease of access. Access impacted by environmental issues and / or service delivery problems. Coping strategies if / when access is a problem. Frequency of problems with access. Changes in access over time.	Natural capital Financial capital Physical capital Social capital
	Household affordability	Ability to meet water demands. Alternative arrangements when not. Changes in affordability over time.	Financial capital Social capital Natural capital
3 - Energy	Household access	Source(s) of energy. WEF and / or livelihood linkages. Ease of access.	Natural capital Financial capital Physical capital

		Access impacted by service delivery problems. Coping strategies if / when access is a problem. Frequency of problems with access. Changes in access over time.	Social capital
	Household affordability	Ability to meet energy demands. Alternative arrangements when not. Changes in affordability over time.	Financial capital Social capital Natural capital
4 - Food	Household access	Source(s) of food. WEF and / or livelihood linkages.	Natural capital Financial capital
	Household affordability	Affordability of food. Trade-offs. Changes in affordability over time.	Financial capital Social capital

I collected the data, accompanied by students from the University of Cape Town (UCT) and local unemployed youth who I trained as CRAs, as mentioned in section 3.3.3. Questionnaires, which were available in English, Afrikaans, and isiXhosa, were conducted in pairs consisting of one UCT student and one CRA, with one person asking the questions and the other scribing the responses. Senior members of the households were targeted and where possible the questions were asked in the respondent's first language. Consisting of four sections, as indicated in Table 4, the questionnaire took approximately fifty minutes to complete. Participation in the research was done according to the ethics clearance received for the research, which is detailed in section 3.6.

3.4.2.3. Data capture and analysis

Data capture and analysis are illustrated in Figure 21 as step six of the research design. As the questionnaire was the common research instrument across all sites in the overarching project, I coded the common variables according to agreed coding parameters and manually entered the data into Microsoft Excel, a spreadsheet software programme. I then coded the remaining variables that were particular to my study, as well as recoding some of the common variables if I felt that the coding parameters did not give me sufficient detail, for example if I had collected higher resolution data than the lowest common denominator adopted across all project site data sets. I used IBM SPSS, a social science statistical software package, for this purpose, transferring any unchanged variables from the project database and manually entering the rest. I then cleaned the data using the following criteria:

- Eleven questionnaires were removed as they were conducted in Laaiplek, outside of Noordhoek which had been selected as the population of interest. These were conducted out of interest for the broader project, as Laaiplek traditionally had a very strong connection with the fishing industry and was an older settlement than Noordhoek. This was valuable for the overarching project.
- Six questionnaires were removed as they were either incomplete, duplicated (2 different pairs had sampled the different people in the same house), or improbable outliers. Although every effort was made to ensure that a UCT representative accompanied and supported the young CRAs in the pairwise teams, this was not always possible. There were therefore some questionnaires that were conducted by

the CRAs that did not meet the minimum requirements / standards set for the data collection.

- Eight questionnaires were removed as they targeted backyard informal dwellings. This was done once the data collection was complete. Although the initial data collection included some backyarders, it was determined that an additional focussed snapshot on backyarders may be useful to the overarching project in terms of cross case comparison as the other site on the Berg River included a focus on backyarders. However, the inclusion of this focussed sampling would have skewed my data and were therefore removed. The data collected on backyard dwellings in the main body of data collection however were retained.

Once the data was cleaned, the remaining seventy cases were analysed using IBM SPSS. Simple statistics and frequency of responses were generated for different variables.

3.4.3. Key informant interviews and site visits

Building on the body of evidence obtained through the household questionnaire, I used semi-structured key informant interviews and site visits as an inductive method to explore the context within which the household data could be interpreted. This choice is supported by Shackleton et al. (2021) who note in a publication on research methods in social-ecological systems, that "… the main application [of qualitative methods] being to gain 'understanding' of context-dependent variables and realities." (p. 109). Figure 25 illustrates the nested scale, showing the household at the empirical centre where structured, deductive methods of data collection were well-suited to creating a body of comparable data across households. This is contrasted with the town and municipal scales which serve as the context within which the household is nested, and where semi-structured data collection was more applicable as it enabled the exploration of emergent issues (Ponelis, 2015).

As depicted in Figure 21, this stage in the research design corresponds to steps four and five, and answers to the second objective of the research, namely to examine the local context with regards to the WEF nexus and livelihood opportunities.

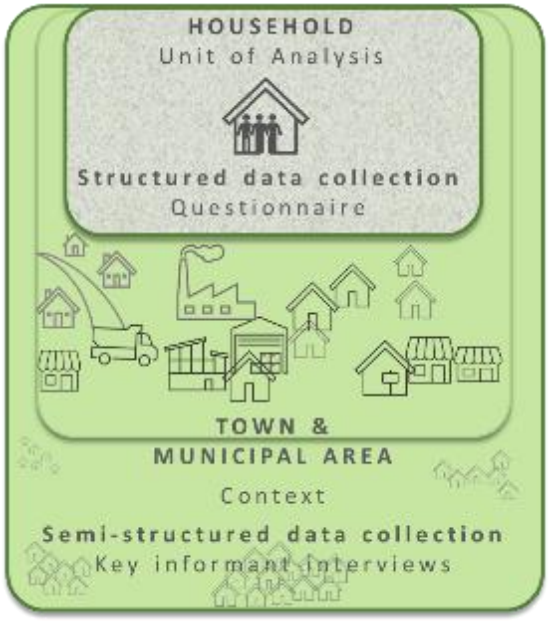


Figure 25: In contrast to the structured data collection of the household questionnaire, the more exploratory inductive semi-structured approach suited the gathering of contextual data at the town and municipal scales. (Source: Author's own)

3.4.3.1. Selection of Key Informants

Following the rationale of the step-wise design, where each step is informed by the previous, insights and initial results from the household questionnaire pointed to key actors at the town and municipal scales that a) were significant actors in terms of provision of local livelihood opportunities; b) were responsible for delivery of water and energy services or were food suppliers/vendors; c) were major consumers of one or more WEF resources; and d) exhibited linkages between any of the previously mentioned criteria. Table 5 provides a description and motivation for the selection of the twelve participants for in-depth interviews.

Data was sought about local water and energy supply systems and large consumers, as well as how these interacted with the local food supply resources, provided local livelihood opportunities, and service delivery related to water and electricity.

Table 5: Description and motivation for selection of in-depth interviews (n=12).

Interviewee Code	**Inputs sought**
BM01	Technical input on Velddrif water system
BM02	Technical input on Velddrif energy system

BM03	BRM water and energy tariff structure; indigent policy and application; cost recovery in terms of water and electricity supply to Noordhoek
BM04	BRM strategic planning regarding local economic development that may have a link to the municipal provision of water and / or electricity, or that may affect livelihood opportunities for Noordhoek residents
BM05	BRM spatial planning
BM06	BRM Council member
VE1	Large employer in Velddrif; member of the fisheries sector; significant bulk water and electricity user; food producer, management
VE2	Large employer in Velddrif; member of the fisheries sector; significant bulk water and electricity user; food producer, sustainability
VE3	Large employer in Velddrif; member of the retail sector; significant bulk electricity user, significant source of food in Velddrif
WM01	Technical input on WCDM and BRM water system
WM02	Environmental management regarding potential trade-offs and synergies between WEF resources from an environmental perspective
WM03	Disaster management regarding impact of drought

3.4.3.2. Data Collection

I collected data through semi-structured in-depth interviews (Jamshed, 2014), either by myself or with a fellow UCT student conducting research into the drought and the WEF nexus. The research was explained to potential interviewees who were invited to participate, including details of how the data would be captured, choices around anonymity, and how the data would be used. A signed consent form indicated agreement to participate prior to the interview. All interviews were audio recorded where possible, and detailed notes were taken where not possible. Table 6 documents the interview guideline used for the key informant interviews. These were clustered into three groups according to the groupings of key informants that had emerged from the research steps covered thus far. It had emerged from the household questionnaire that all households had access to water and energy services, and very few supplement this from natural resources, thus the local government cluster of interviews to gain a deeper understanding of the water and energy service delivery context.

Similarly, it emerged from the household questionnaire that many households' livelihoods were linked to the fisheries sector, a significant number were employed in the retail sector and all households relied on retail as the primary source of food. The three clusters of interviews were therefore local government, the fisheries, and retail sectors. I used the interview guide as a loose structure to ensure that I covered the key topics I had identified, however I did not always complete all questions due to time constraints (interviews were scheduled for one hour), and the emergence of information that I wished to explore further with the respondent.

Table 6: Key informant interview guidelines for the different groups of actors.

Local government	• Service delivery o Your role and responsibility with regards to water and or electricity service delivery in Noordhoek? o Your perception of service delivery in Noordhoek? o Cost recovery – Is water and or electricity service delivery affordable and sustainable to the Municipality? ▪ Payment for municipal services amongst Noordhoek residents o What is the municipal tariff structure for water and electricity? o What assistance do indigent households in Noordhoek receive from the municipality? o Are there incentives for consumers to use less water and electricity? ▪ If so, how does this affect municipal income stream?
	• WEF nexus o Who are the large consumers of water and electricity in Velddrif? o Do you have security of water supply, e.g. did the drought negatively impact your ability to supply water? o Does load shedding impact your ability to supply water?
	• Livelihood opportunities o Which sectors provide the most employment opportunities for people in Noordhoek? o Who are the large employers or employment sectors? o Does load shedding or drought impact employment in Noordhoek/ Velddrif? o How many people does the municipality employ in Velddrif?
Fisheries	• Livelihood opportunities o How many people do you employ? o Where do you draw your primary workforce from? o What is the nature of this employment (permanent / seasonal)?

	○ Does drought or load shedding affect employment figures?
	• WEF Nexus ○ You are a large water user and as such built a desalination plant in the drought, can you tell me more about this? ○ You are also a large electricity consumer, did the desalination plant affect your electricity consumption? ○ Are you doing anything to reduce your electricity consumption? ○ Why is fish processing so water and electricity intensive? ○ Will rising costs associated with water and electricity affect the sustainability of this plant?
	• Service delivery ○ Are the municipal water and electricity tariffs affordable? ○ Are the municipal water and electricity services reliable?
Retail	• Livelihood Opportunities ○ How many people do you employ? ○ What is the nature of this employment? ○ Does drought or load shedding affect employment figures?
	• WEF nexus ○ Where does your food come from? Any local? ○ Why large electricity usage? ○ Does load shedding impact your business? ○ Do you use a lot of water?
	• Service Delivery ○ Are the municipal water and electricity tariffs affordable? ○ Are the municipal water and electricity services reliable?

Representing step five in the research process depicted in Figure 21, I conducted two of the interviews as part of site visits to the physical water and electricity infrastructure in the town. These were also attended by the CRAs as part of the overarching project commitment to WEF capacity building amongst local unemployed youth.

As outlined in section 2.4.4.1 and illustrated in Figure 9, availability speaks to the biophysical and infrastructural availability of WEF resources. I have described water availability and the related supply system, from the national to the Noordhoek household level, in sections 2.5.1 and 3.2.4.1 respectively. Using this information as a basis from which to observe the Velddrif water supply system, I was guided on a site visit around Velddrif by interviewee BM01, who is responsible for the water and waste-water systems of the town. We started at a household in Noordhoek, looking at the household water meter, and worked outwards in spatial scale until we were at the main supply reservoir for the town.

I was guided on a site visit of the Velddrif electrical supply system by interviewee BM02, an official responsible for electricity infrastructure in Velddrif, and also a resident of Noordhoek. I drew on the descriptions of the national and local energy supply systems in sections 2.5.2 and 3.2.4.2 respectively, as background information which informed my questions. We started at the point where BRM receives Velddrif's bulk electricity supply from ESKOM and worked inwards in terms of scale until we reached the household scale. As illustrated in Figure 19 under section 3.2.4.2, a pipe carrying electrical conduiting runs from ESKOM's substation on the opposite bank, under the main road bridge over the Berg River to Velddrif's main substation. Here the power is stepped down and distributed via the municipal electricity distribution system through a system of transformers and switchboxes which we visited. Interviewee BM02 told me that the fish factory is the single largest consumer of electricity in Velddrif, and showed me the factory's bulk supply meter.

There are two electrical supply lines in Noordhoek, one comes from the Jameson sub-station which also feeds the fish factory and the other comes off the line that supplies the town of Dwarskerbos to the north of Velddrif. Interviewee BM02 explained that this gives Noordhoek additional security of supply. The substations, switchboxes and transformers we visited all appeared to be well-maintained and secured.

These two unstructured interviews were guided by questions related to the availability of water and electricity to households in Noordhoek, as well as the nexus of these systems at the municipal scale. Figures 26 and 27 below depict the CRAs being shown elements of the municipal water and electricity service delivery infrastructure.

Figure 26: Site visit with CRAs and municipal representative exploring Noordhoek's electricity system (Source: Author's own)

Figure 27: Site visit with CRAs and municipal representative exploring Noordhoek's water system. (Source: Author's own)

3.4.3.3. Analysis

I transcribed the interviews and manually coded them deductively into preconceived themes aligning with the interview guideline (Braun, 2006; Saldana, 2021). This was followed by an inductive approach of adding themes that emerged from the interviews beyond the scope of the interview guideline (Saldana, 2021). This thematic coding resulted in numerous themes that were pared down through combination and collapsing some of the codes into overarching themes responding to the key elements in the research objectives. These were then used as lines of evidence in supporting key narratives emerging from the research.

3.5. Limitations and Assumptions

The primary data collection tool, namely the household questionnaire, was designed to suit the case studies across all the overarching project sites. Inputs into the household questionnaire were invited by project partners who pointed out questions or phrasing they considered inappropriate with regards to local sensitivities. As a result, some lines of questioning or phrasing were removed or adapted. As cultural sensitivities varied across the catchments, this resulted in some questions being removed that may have been acceptable in one catchment, but not in another. As a result, some of the lines of questioning were limited, such as questions around affordability and household food security.

Although the use of local youth as research assistants eased access to many households in terms of introductions and trust, amongst other positive benefits, their involvement may also have had a limiting impact. It is possible that in the company of the local youth, respondents may have been reticent to reveal information they did not wish to be common knowledge in the community.

Despite efforts to make the complex subject matter covered in the questionnaire simple and accessible to the respondent cohort, this was not always successful, particularly in the case of translations. For example, respondents were asked what would help them to become more water secure in order to meet their household's needs. The same was asked for energy and food. Even though the concepts of the WEF nexus and resource security were covered in the introduction prior to questioning, this was a substantial body of information to relay in an introduction prior to an interview, and even more challenging for a respondent to grasp in an

initial sitting. As a result, few respondents answered that particular question, or if they did, they listed resource saving activities that they do or could do.

Finally, the overarching project incorporated an additional student exploring the drought and the WEF nexus in Noordhoek as a mini dissertation. As a result, most of the key informant interviews were conducted together, which limited the exploration of lines of questioning with the interviewees to those that intersected across both student topics. This was exacerbated by their approach of using structured interview questions, and mine of using semi-structured. As interviews were mostly one hour in duration, this limited the qualitative data collection component.

3.6. Ethical Considerations

Both the overarching research project and this case study received ethical clearance from the Faculty of Science Research Ethics Committee at the University of Cape Town. This was secured on the basis of the research proposals, questionnaire, and consent forms prior to the commencement of the research work. Every effort was taken throughout the study to treat all participants with care, sensitivity, and respect, and to ensure that they understood that they could choose not to participate, that their participation was voluntary, and that they could withdraw from the study at any stage if they no longer wished to participate. Prior to any interview or questionnaire being conducted, the purpose and nature of the study was explained to all participants, including that they would remain anonymous in the data analysis and written research outputs, and that anonymised selected quotes may be used from their inputs unless they specifically refused permission.

All participants signed a consent form indicating agreement to participate in the research, as well as indicating their agreement or not regarding being photographed, audio or video recorded, and the use of any such media in a properly anonymised form in websites or publications for the purposes of this research. Contact details of the researcher were also provided to ensure that any queries or additional information that may be required could be addressed with relative ease. All data and information obtained from participants during the study was treated with privacy and confidentiality and only accessed by the researcher and supervisor. This was done as part of the ethics clearance received for the research, code FSREC 90 – 2019.

Chapter 4 Results: Household WEF Status and Livelihood Options

4.1. Introduction

This is the first of two results chapters and as such presents the findings from the household questionnaire which focussed on establishing the household WEF status and livelihood sources and assets in line with objective one. Ninety-five households were sampled using the questionnaire, of which seventy were retained after data cleaning.

4.2. Household Livelihood Capitals

As outlined in section 2.4.2 and shown in Figure 8, household livelihood sources for meeting WEF basic needs have been assessed in terms of i) income / financial capital; ii) natural resource base / natural capital; and iii) social networks / social capital.

4.2.1. Human capital

The age range defined in this thesis as 'working age' includes the band from 18 to 65 years, which differs from the age band used nationally in statistics reporting of 15-64 years. This was due to the age bands applied in the overarching project, as shown in Table 7, which did not allow for the aggregation of age bands in line with national norms.

Table 7: Excerpt from the household questionnaire showing the age bands used in collecting household members' age.

Adults	61 & older	Youth	31-35	Children	10-12
	51-60		26-30		6-9
	41-50		19-25		2-5
	36-40		13-18		0-2

As shown in Table 8, the average household size is 3.7 members and the median is 4, with the largest household comprising 7 members. Most backyard dwellings had 1 or 2 household members, while the main dwellings were larger, primarily between 4 and 5 household members.

The data listed in Table 8 also reveals a relatively youthful demographic, with the 64% of household members falling into the 'working age' category of between the ages of 18 and 65 years (mean of 2.4 people / household). This left 28.7% falling into the 'under 18 years of age' cohort (mean of 1.1 people / household) and 7% in the 'over 65 years of age' (mean of 0.3 people / household). This results in a dependency ratio of 47.1.

Table 8: Characteristics of household occupants.

VARIABLE	RESULT
Mean number of household members. *Missing: 0; Valid: 70*	3.7
Mean number of household members of working age (between 18-65 years old). *Missing: 0; Valid: 70*	2.4
Percentage household members of working age. *Missing: 0; Valid: 70*	64
Mean number of household members under 18 years of age. *Missing: 0; Valid: 70*	1.1
Percentage household members under 18 years of age. *Missing: 0; Valid: 70*	28.7
Mean number of household members over 65 years. *Missing: 0; Valid: 70*	0.3
Percentage household members over 65 years of age. *Missing: 0; Valid: 70*	7

4.2.2. Natural capital

4.2.2.1. Water

As indicated in Table 9, none of the households sampled (0%) reported using local natural sources to meet their water needs, however in a later question, 5.8% reported that rainwater was the main source of water for their garden. From personal observations while conducting the research, some households did have rainwater tanks, but fewer than I expected given the aridity of the region. These were typically small, cheaper tanks, as opposed to the large green 'jo-jo' tanks common in South Africa.

Table 9: Results showing proportion of households drawing directly on natural capital to meet household water needs.

VARIABLE	CATEGORIES	RESULT
Percentage households using water from the natural resource water to meet some / all of their water needs *Missing: 0; Valid: 70*	Yes	0
Percentage households using rainwater as source of water for garden *Missing: 20[4]; Valid: 50*	Yes	5.8

4.2.2.2. Energy

When asked whether the households made use natural resources (wood, dung) to meet their energy needs, no respondents (0%) reported positively to this as shown in Table 10. However, when asked about measures taken when unable to meet household energy needs, 15.7% reported using wood as an alternative or complementary source of energy, and 17.1% a mixture of wood and gas. This seeming contradiction suggests that the wood is most likely purchased and not foraged. Furthermore, no households (0%) reported using renewable energy sources.

Table 10: Results showing proportion of households drawing directly on natural capital to meet household energy needs.

VARIABLE	CATEGORIES	RESULT
Percentage households using natural resources / environment to meet energy needs *Missing: 0; Valid: 70*	Yes	0
Percentage of other energy sources used in households *Missing: 0; Valid: 70*	Wood	15.7
	Wood & gas	17.1

[4] High number of missing values due to only those with a garden responded. This is not limited to a food garden, but included any garden.

Percentage households using any renewable energy sources *Missing: 0; Valid: 70*	Yes	0

4.2.2.3. Food

As indicated in Table 11, 2.9% of households sampled reported that they sometimes, and 1.4% reported that they frequently, forage for 'veldkos'[5] to supplement their household food needs. Similarly, 21.4% reported that they sometimes fish, and 2.9% that they frequently fish to supplement their household food needs. In addition, 12.9% of respondents reported that they grew food to supplement their household food needs. No households (0%) reported keeping livestock and / or poultry, as these are not allowed to be kept in residential Velddrif.

Table 11: Results showing proportion of households drawing directly on natural capital to meet household food needs.

VARIABLE	CATEGORIES	RESULT
Percentage households foraging 'veldkos' to supplement food needs *Missing: 0; Valid: 70*	Never	95.7
	Sometimes	2.9
	Frequently	1.4
Percentage households fishing to supplement household food needs *Missing: 0; Valid: 70*	Never	75.7
	Sometimes	21.4
	Frequently	2.9
Percentage households growing food to supplement household food needs *Missing: 0; Valid: 70*	Yes	12.9
Percentage households keeping livestock or poultry to supplement household food needs *Missing: 0; Valid: 70*	Yes	0

[5] Food gathered or harvested from the natural environment, i.e. not cultivated through agriculture

4.2.3. Financial capital

As shown in Table 12, the percentage of households with at least one member employed was 90%. The sectoral breakdown of this employment is as follows, indicating at least one member of the household employed in the sector: 40% of households in the fishing sector, followed by 17.1% in the construction sector, 14.3% in domestic work, 12.9% in the public sector, and 7.1% in retail.

There were zero households sampled that did not have at least some form of income. For 10% of the sample, this was only a social support grant. The grants included child support grants, unemployment grants, disability grants, and old age pensions. The percentage of households sampled with at least one member receiving a form of social support grant was 44.3%.

Table 12: Household income generation profile.

VARIABLE	CATEGORIES	RESULT
Percentage of households with at least one member employed *Missing: 0; Valid: 70*	Yes	90
Percentage households whose only income is a social support grant. *Missing: 0; Valid: 70*	Yes	10
Percentage of households with at least one member receiving some form of social support. *Missing: 0; Valid: 70*	Yes	44.3
Percentage households that did not have a source of income. *Missing: 0; Valid: 70*	Yes	0
Percentage of households with at least one member employment in the sector.	Fishing	40
	Construction	17.1

	Domestic Work	14.3
	Public Sector	12.9
	Retail	7.1
	Manufacture	5.7
	Agriculture	5.7
	Security	2.9
	Transport	2.9
Missing: 0; Valid: 70	Other	15.7

4.2.4. Physical capital

As outlined in section 3.4.2.1, the sampling for the household questionnaire was done according to sub-areas of Noordhoek. The 'residence time' data, as depicted in Figure 28, confirms the staged chronological development of these sub-areas from oldest to newest, i.e. from Oublok followed by Gauteng, then White City, then Crème City, then KwaMashu.

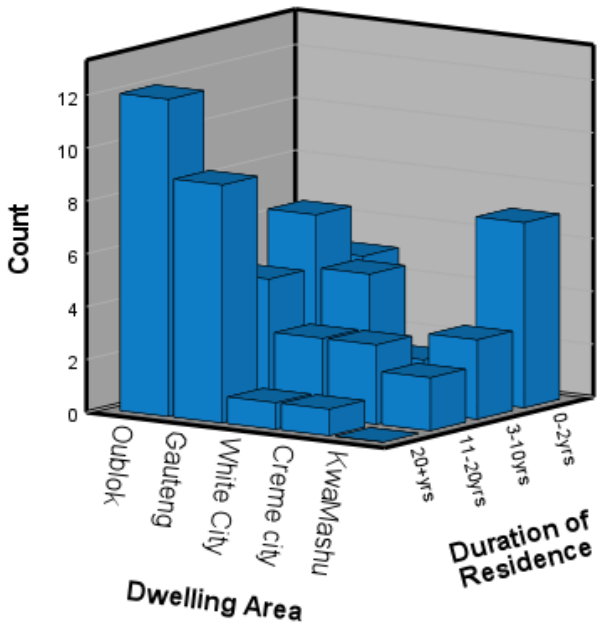


Figure 28: Chart showing the frequency of duration of residence per sub-area.

Results listed in Table 13 show that 67% of the homesteads sampled had a brick-and-mortar structure, whilst 21,4% were made of corrugated iron/zinc sheeting, the remaining 11,4% were made up of a mixture of building materials, including wood. In addition, 80% of the homesteads sampled were the main dwelling on the erf and 20% were what is referred to as 'back yard shacks', which are typically one-roomed informal homesteads constructed out of make-shift materials located in the yard of a 'main house' in South Africa. These backyard dwellings largely rely on the main house for services such as water and electricity, and either pay for these and / or rely on social capital (i.e. when family is concerned) (Turok & Borel-Saladin, 2016). Of the brick-and-mortar structures, 95.7% were the main dwelling on the erf, and of the zinc structures 66.7% were backyard structures and 33.3% were main dwellings, all of which were located in KwaMashu. The only informal dwellings in Noordhoek that I observed were backyard structures that residents built themselves (personal observation).

Table 13: Characteristics of homesteads sampled.

VARIABLE	CATEGORIES	RESULT
Percentage of households with different types of homestead structure *Missing: 0; Valid: 70*	Brick & Mortar	67.1
	Zinc	21.4
	Other	11.4
Percentage of households of homestead type *Missing: 0; Valid: 70*	Main Dwelling	80
	Backyard Dwelling	20
Percentage homestead type of the zinc dwellings *Missing: 0; Valid: 15*	Main Dwelling	33.3
	Backyard Dwelling	66.7

Results relating to household water and energy physical capital are reported under section 4.3.

4.2.5. Social capital

The only direct question included in the questionnaire that gave an indication of social capital related to what households did when they couldn't meet their household water needs, as this was posed in the form of giving two choices for response, namely "Ask neighbours for help" or "Other, specify". This framing therefore posed the question as a choice of whether households drew on social capital, in the form of asking a neighbour, and / or did something else. The results indicate that 32% of respondents ask their neighbours for help, 14.5% buy water, and 5.8% do both. Amongst the other measures taken were 'approaching the municipality for help', and 'doing nothing'.

A similar question was asked around what measures households took when they could meet their energy needs, however this was framed as an open question with no direct choices given to respondents. In this case, only 4.3% of respondents asked family or neighbours for help, most responded that they use alternative sources of energy to electricity, such as candles, oil lamps, torches, gas, etcetera.

4.3. Status of Household WEF Resources

As described in section 2.4 and illustrated in Figure 9, household WEF status refers to the availability, access, and affordability of WEF resources to the household. These results are reported according to the individual WEF resources, as that is how the questionnaire was structured. However, one open-ended overarching question was asked, namely what the biggest challenge was that is facing the household. The results indicate that the highest frequency of response (27.1%) was around electricity being too expensive. and/or the units of electricity received being too little[6]. The second most frequent response (25.7%) was around the high costs of water, the third was around maintenance needed on the dwelling structure (e.g. roof leaks), fourth was that they did not have any problems (12.9%), and the last two were that the school fees were too high (2.9%) and that they could not afford to buy sufficient food (1.4%).

[6] The perception of receiving too few units for the amount of money paid is tied to the practice of the municipality docking a proportion of the money paid for prepaid electricity to go towards repayment of outstanding water bills.

4.3.1. Water

According to the results documented in Table 14, all households sampled (100%) reported that their main source of water was via service delivery by the local municipality. This was broken down into 77.1% with taps available inside their houses, 18.6% with a tap outside their homestead in the yard, and 4.3% (all backyarders) with taps inside the main house. No households (0%) reported using a rainwater tank, a neighbour's or a public/communal tap, borehole water in or outside the yard, or a wellpoint as their main source of drinking water. Similarly, all (100%) households reported having a flush toilet, with 72.9% of households inside their dwelling, 20% had a flush toilet outside their dwelling, and 5.9% (all backyarders) reported a flush toilet inside the main house. No respondents (0%) reported using a communal toilet or any other type of toilet. Only three respondents answered the question about whether drought impacts their water quantity, and their response was positive, although they did not elaborate as the question was framed in a yes/no manner alongside questions around other environmental impacts on their water quantity. All households (n=68, 2 missing) reported using tap water for laundry, cleaning of the household and bathing.

Perceptions of this service delivery included 20.3% of respondents that found the municipal water service delivery unreliable; and 23.5% felt that poor service delivery impacted household water quantity and 31.9% water quality. Results from household perceptions of change in access to water as shown in Table 14 indicated that the majority of households (62.9%) felt that water access had remained the same.

In terms of water quality, 74.3% of households regarded their main source of water as safe to drink, leaving just over a quarter that did not feel that the water was safe to drink. This is further substantiated by the response to a question about households' perceptions of change in water quality during the time they had lived in Noordhoek, where 4.4% reported that it had improved; 54.4% reported that it had stayed the same, and 41.2% reporting that it had deteriorated. In response to a question on the impact on the household of recurring water quality problems in the area, 25.7% responded that it makes them sick. In mitigation of this, 26.1% respondents reported that they buy water, 24.6% said that they treat the water at home, and another 24.6% do a combination of both.

In terms of affordability of water, a relatively high percentage of households (80.6%) reported that they were always able to meet their household water needs. Of those that reported they could not, the frequencies reported as shown in Table 14 were all relatively close, with the 'hardly ever' being the smallest category at 29%, and 'sometimes' and 'regularly' both being 35.5%. Perceptions of change in affordability however show a convincing 65.7% of households indicating that affordability had declined. In other words, the cost of water had become more expensive in the time they had been staying in Noordhoek. This sentiment was further supported by 24% of respondents citing the cost of water as one of the biggest challenges facing the household.

Table 14: Descriptive statistics of variables related to household water status.

VARIABLE	CATEGORIES	RESULT
Municipal water service delivery *Missing: 1; Valid: 69*	Percentage households that receive water as a municipal service	100
	Percentage households that found the municipal water service delivery unreliable	20.3
Percentage main source of household drinking water *Missing: 0; Valid: 70*	Piped (tap) water in house	77.1
	Piped (tap) water in yard	18.6
	Piped (tap) water in main house (backyarder)	4.3
	Other[7]	0
Type of toilet facililty	Percentage flush toilet inside	72.9
	Percentage flush toilet outside dwelling	20
	Percentage flush toilet in main house (backyarder)	5.9

[7] Other options included: Rainwater tank in yard, neighbour's tap, public/communal tap, borehole water in yard, borehole water outside yard, wellpoint

Missing: 1; Valid: 69	Percentage other (incl. communal toilet)	0
Percentage households main source of water for garden (other than rainfall or borehole reported in Table 9) *Missing: 20; Valid: 50*	Tap water	48.6
	Grey water	17.1
Percentage households using tap water as their main source of water for the following activities: *Missing: 2; Valid: 68*	Bathing	100
	Cleaning house	100
	Laundry	100
Percentage households saying that poor service delivery impacted their household water quantity *Missing: 2; Valid: 68*	Yes	23.5
Percentage households saying that poor service delivery impacted their household water quality *Missing: 1; Valid: 69*	Yes	31.9
Percentage of households that regard the main source of household water as safe to drink *Missing: 0; Valid: 70*	Yes	74.3
	Do nothing	7.2

Action taken if main water source water quality is poor. Percentage of households that: *Missing: 1; Valid: 69*	Buy water	26.1
	Treat the water at home	24.6
	Buy water to drink and treat water at home	24.6
	Did not report a problem with water quality	17.4
Percentage of households' perception of change in water quality since being resident in the area[8] *Missing: 2; Valid: 68*	Improved	4.4
	Stayed the same	54.4
	Deteriorated	41.2
Percentage households' perception of change in access to water since being resident in the area *Missing: 0; Valid: 70*	Improved	7.1
	Stayed the same	62.9
	Declined	30
Percentage households' perception of change in affordability of water since being resident in the area *Missing: 0; Valid: 70*	Improved	7.1
	Stayed the same	27.1
	Declined	65.7
Percentage of households that were always able to meet their water demands *Missing: 3; Valid: 67*	Yes	80.6
	Regularly	35.5
	Sometimes	35.5

[8] Although respondents were asked how long they had been resident in the area, there was no correlation between length of residence and perception of change.

Percentage of households' frequency of not being able to meet household water demands *Missing: 3; Valid: 67*	Hardly ever	29

4.3.2. Energy

As shown in Table 15, all households sampled (100%) reported that they receive electricity as a municipal service, and 87% found the service reliable. In a related question, 20.6% of households reported that electricity provision was a recurring problem in their area, with the majority of these (71.4%) attributing this to unreliable service provision by the municipality, followed by 14.3% attributing it to the cost being too high.

The results show that no households (0%) reported using renewable energy (including solar water heaters) to meet their household energy needs, however as shown in Table 15, some households (71.4%) did use alternative energy sources such as gas (34.4%) and wood (15.7%) amongst others. With regards to respondents' perceptions of change in access to electricity over time as shown in Table 15, 50% reported that it had 'stayed the same'.

In terms of affordability, as indicated in Table 15, 78.6% of respondents reported that they were always able to meet household energy needs, and of those unable to meet their energy needs, 82% reported that this occurs regularly. Perceptions of change in affordability of electricity revealed that 68.8% of households felt that affordability had reduced, in other words, that electricity had become more expensive in the time they had been staying in Noordhoek.

Relating to affordability, but with a water linkage, a number of respondents complained about BRM's practice of taking a portion of their prepaid electricity payments to cover outstanding municipal debt (usually water), with the result that the purchaser will receive less electricity units than what they paid for, with the balance servicing their water debt. Illustrating this when asked about household energy challenges, respondent VN35 said that the municipality "… vat van die [elektrisiteit] units vir die water …" [… takes from the (electricity) units for the water …].

Table 15: Descriptive statistics of variables related to household energy status.

VARIABLE	CATEGORIES	RESULT
Municipal electricity service delivery	Percentage households that receive electricity as a municipal service *Missing: 0; Valid: 70*	100
	Percentage households that found the municipal electricity service delivery reliable *Missing: 1; Valid: 69*	87
Percentage of other energy sources used in households *Missing: 0; Valid: 70*	Gas	34.3
	Wood	15.7
	Wood and gas	17.1
	Paraffin	2.9
	Paraffin and gas	1.4
	None	28.6
Percentage households using any renewable energy sources *Missing: 0; Valid: 70*	Yes	0
Percentage households finding electricity service provision a recurring problem *Missing: 2; Valid: 68*	Yes	20.6
Percentage households' perception of the cause of problems with electricity service provision *Missing: 2; Valid: 68*	Unreliable service provision by the municipality	71.4
	Unreliable service provision by Eskom	7.1
	Cost of electricity provision is too high for our household	14.3
	Municipality unreliable and costs too high	7.1

Percentage households' perception of change in access to electricity since being resident in the area *Missing: 0; Valid: 70*	Improved	14.3
	Stayed the same	50
	Reduced	35.7
Percentage households always able to meet their energy demands *Missing: 0; Valid: 70*	Yes	78.6
Percentage households' frequency of not being able to meet household energy demands *Missing: 0; Valid: 70*	Regularly	18
	Sometimes	82
	Hardly ever	0
Percentage households' perception of change in affordability of electricity since being resident in the area *Missing: 0; Valid: 70*	Improved	5.7
	Stayed the same	25.7
	Reduced	68.8

4.3.3. Food

As shown in Table 16, most households source over 80% of food categories from supermarkets. There are only two categories that fall below this threshold, namely fruit and bread, which are alternatively sourced from corner or 'spaza'[9] shops, with a very small number of respondents getting fruit and vegetables from street vendors and local farmers. In addition, 12.9% of respondents indicated that they grow vegetables or fruit to help meet their household food needs, however, as the keeping of livestock and / or poultry are not allowed in residential Velddrif, no (0%) respondents keep these. As shown in Table 16, 21.4%

[9] 'Spaza' shops are informal shops selling basic household items, typically set up in someone's home as a means of supplementing their income.

of respondents sometimes fish, and 2.9% sometimes harvest wild fruit and vegetables, but none (0%) reported hunting to supplement household food stocks.

The highest modality (37.7%) in the respondents' estimated percentage of weekly income spent on food is in the category 25-50% of household income, followed by the 76-100% and 51-75% categories with 24.6% and 23.2% respectively. No respondents (0%) reported receiving food parcels. As shown in Table 16, most respondents (85.7%) perceived food to be becoming increasingly less affordable over time. Following a similar trend, 69.6% of respondents perceived a reduced diversity in their weekly shopping basket since being resident in the area.

Table 16: Descriptive statistics of variables related to household food status.

VARIABLE	CATEGORIES	RESULT
Percentage of household food per category purchased from supermarket *Missing: 0; Valid: 70*	Meat	95.7
	Grains	95.7
	Tins	95.7
	Dairy Products	90
	Vegetables	82.9
	Eggs	80
	Fruit	75.7
	Bread	47.1
Percentage households that grow vegetables/ fruit to help meet food needs. *Missing: 0; Valid: 70*	Yes	12.9
Percentage households that keep livestock / poultry to help meet food needs. *Missing: 0; Valid: 70*	Yes	0
Percentage frequency of fishing to supplement household food needs.	Regularly	2.9
	Sometimes	21.4

Missing: 0; Valid: 70	Never	75.7
Percentage frequency of harvesting wild fruits or vegetables to supplement household food needs. *Missing: 0; Valid: 70*	Regularly	1.4
	Sometimes	2.9
	Never	95.7
Percentage estimated household income spent on food. *Missing: 1; Valid: 69*	0-25%	14,3
	26-50%	37,1
	51-75%	22,9
	76-100%	24,3
Percentage households receiving food aid. *Missing: 0; Valid: 70*	Yes	0
Percentage households' perception of change in affordability of food since being resident in the area. *Missing: 0; Valid: 70*	Improved	4.3
	Stayed the same	10
	Less affordable	85.7
Percentage households' perception of change in diversity of household food basket since being resident in the area. *Missing: 1; Valid: 69*	Improved	10.1
	Stayed the same	20.3
	Less diverse	69.6

4.4. Discussion

Livelihoods are understood in this thesis (section 2.3.1) to be the means through which households meets their basic needs, and in particular to this research, how they meet their basic needs of water, energy, and food. As outlined in section 2.4.2, this thesis draws on the five capitals (or assets) of the SLA (DFID, 1999), and as depicted in Figure 8, seeks to understand the spread of dependence on these assets for household access to water, energy

and food. The results revealed a concentrated dependence on financial capital, and very little direct dependence on natural capital. Given the wealth of the natural capital the highly productive estuary and coastline offers (Anchor Environmental, 2008), the low reliance on natural capital, particularly in terms of fishing for household food provisioning, is surprising. Three quarters of households sampled (75.7%) reported that they never fish to supplement their household food needs, and only 3% reported that they regularly do. Of relevance here is the 2003 restriction on small-scale commercial fishing in the estuary introduced in section 3.2.5 in response to unsustainable gillnet fishing in the estuary. This highlights a trade-off between livelihoods and sustainable estuary fisheries management. Such trade-offs are well-captured in the ELS framework used by (Biggs et al., 2014) and presented under section 2.3.1, where the need to balance human demand and natural supply to attain sustainability between the sometimes competing interests of the WEF nexus and livelihoods is highlighted.

Furthermore, indicative of a shift away from direct reliance on the natural resource base for provision of food, to an indirect reliance on the natural resource base for provision of jobs is the high number of household members employed within the fisheries sector (over 1/3rd of those employed). Industrial-scale commercial fishing and fish processing is a prominent industry all along the coastline adjacent to the highly productive Benguela Current, from the west coast of South Africa to southern Angola. This will be explored further in results chapter 5. Overall, there was little direct reliance on natural capital to meet any of the households' WEF needs, bar some respondents (5.8%) having rainwater tanks primarily for watering the garden. The low number of visible and reported rainwater tanks was also surprising given the aridity of the region and the popularity of these tanks elsewhere South Africa. Similarly, no households reported using renewable energy sources to meet their household energy needs. This was supported by my personal observations in that I did not see any solar water heaters or photovoltaic cells in Noordhoek during my fieldwork visits. Given the abundance of sunny days in the west coast region, combined with very high increases in electricity prices in the past decade, the total or partial subsidisation of solar water heaters would go a long way to alleviate household energy costs. Results showed that households already substitute electricity for cheaper available forms of energy, such as gas for cooking (34.3% of households sampled).

The indirect reliance on natural capital for household WEF provisioning illustrated in these results is indicative of the rapid urbanisation associated with the Anthropocene. This finding is similar to that encountered by Huntington et al. (2021) whilst applying the WEF nexus at the local scale in rural Alaska, where they found that the high water-demand fish processing plants are more of "… an economic rather than nutritional mainstay for the community" (p.674). The industrialisation of food provision, and the resultant indirect linkage between households and the natural food resource base was also noted by Gragg et al. (2018) when applying the WEF nexus in the context of urbanised food systems.

Although the primary unit of analysis is the household, and the results are reported in line with this, livelihood data was collected on each member in the household in order to get an idea of the household's human capital. This provided an understanding of the composition of the households as well as their livelihood status. The results revealed a relatively youthful community with average sized households (3.7 people), which was in line with the 2019 national estimates for rural areas (3.7 people) (Statistics South Africa, 2019a). As Bergrivier Municipality is predominantly a rural area characterised by small towns, the alignment with rural area household size is expected.

Figure 29 shows that 64% of household members fall within the 'working age' category[10], which equates to a dependency ratio of 47.1. Although not directly comparable to the conventional measures of age dependency, it does provide an indication of the ratio of economically productive members of Noordhoek households to those dependent on them. This is lower than the national age dependency ratio in 2019, which was 53 (The World Bank, 2021).

[10] As mentioned in Section 4.2.1, the 'working age' range applied to this thesis is 18 to 65 years, which differs from the convention of 15 to 64 years.

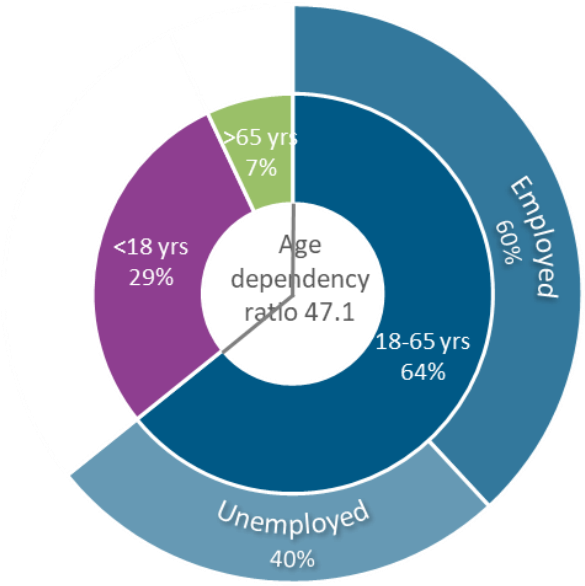


Figure 29: Household age dependency and employment status.

Figure 29 also shows the labour absorption rate of the 'working age' category, which again, due to differences in the age bands used, this measure cannot be directly compared to conventional figures, however it can provide a relative indication. The national average labour absorption rate of 42.2% for a similar period (Oct-Dec 2019) (Statistics South Africa, 2019b) is significantly lower than the 60% this research revealed. This human capital profile therefore points to an above national average capacity within households to provide financial capital through employment, which in turn accounts for the lower dependence on natural capital for water, food and energy.

Employment status of households, where at least one household member is employed is high (90%). For reference, the national percentage of households that reported salary income in the 2019 General Household Survey (Statistics South Africa), was 57.6%, and in the Western Cape was 68.4%. Although a slightly different measure, this does give an indication of this being anomalously high in the South African context, where unemployment figures are amongst the highest in the world (29.1%)(Statistics South Africa, 2019c). Similarly, the comparatively low level of households (10%) whose only income is derived from social support grants, is way below the national average of 52.9% and the Western Cape (45.4%)(Statistics South Africa, 2019a). The concentration of employment in the fisheries sector is expected, given the predominance of industrial-scale fisheries in the town.

In terms of physical capital, there was a high percentage of formal dwellings in Noordhoek, mostly brick and mortar (67.1%) with a some being a combination of brick and mortar and wood, and/ or zinc, whilst the informal structures were zinc or wood and zinc. Informal dwellings were mostly backyard structures, as I did not see any informal settlements in Velddrif during my fieldwork. Moreover, a s a resident of the city of Cape Town, where there are 254 (Cinnamon, 2023) recognised informal settlements, the absence of informal settlements struck me. Comparing Census 2011 data across the seven case study sites comprising the overarching project, informal housing in Noordhoek (6.7%) was higher than Pniel (0.8%) in the upper Berg catchment, Mpophomeni (0.4%) in the upper uMngeni, and Melani (0.7%) in the upper Keiskamma catchment. However, it was lower than Lanquedoc (12.5%) in the upper Berg catchment, Sobantu (9.8%) in the mid uMngeni catchment, and Hamburg (19,3%) at the estuary of the Keiskamma River. According to the 2020 General Household Survey (Africa, 2021), the national average number of people living in informal housing is 11,4%, which is higher than that for Noordhoek.

In addition, all the households sampled had access to piped water, flush toilets, and prepaid electricity supply either inside their homesteads or on their erf. This included the zinc homesteads in KwaMashu, which had one flush toilet per homestead, although these were located in a separate building in the yard. For context, a comparison of household access to drinking water across category B3 municipalities nationally revealed that 35.3% had access inside their households, while 38.3% had access in their yard (Statistics South Africa, 2017). The national figures for water access inside households was 44.4% and access inside their yards was 30% (Ibid.). The figures from the household survey for the same parameter revealed 77.1% with taps available inside their houses, 18.6% with a tap outside their homestead in the yard, and 4.3% (all backyarders) with taps inside the main house. These comparative figures show how anomalous the level of service delivery is for this type of settlement in South Africa.

All households sampled relied on service delivery by the local municipality as their primary source of water and energy, and almost completely on local supermarkets, or smaller vendors for food. As a result, there was a high reliance on financial capital to meet their household WEF needs, drawing on household human capital to secure this income.

It is encouraging that there were no households without some form of income, and a surprisingly low number of households (10%) that relied solely on social support grants as a form of income. This is in line with the 2019 statistics for the province which cite 10.4% of households with social support grants as their main source of income, but is way below the national mean of 20.4% (Statistics South Africa, 2019a). Although not always the primary source of income, social support grants played an important role in Noordhoek households, with 44,3% of all households sampled receiving at least one social support grant. In addition, households that could not meet their water and / or energy needs reported receiving assistance from the municipality in terms of being registered as indigent households in line with the provisions of the *Constitution* as described in sections 2.4.3 and 2.5. This was highlighted by respondent VN72, who stated in response to a question about the biggest challenge facing the household that it was "Kos wat duur is en die krag wat duur is. Alles is duur, maar alles is besorg." [Food that is expensive, and the electricity that is expensive. Everything is expensive, but everything is taken care of.] However, in contrast to the findings from some of the other sites in the overarching project, no households reported receiving food parcels.

Trade-offs across the WEF nexus that emerged through the household survey all occurred in response to decisions around affordability. For example, some households mentioned that they can live without electricity, but they cannot live without water, so they sometimes go without electricity if they run out of funds to purchase more units, but can't do that in terms of water. It emerged in comments related to affordability that electricity prepayments are linked to outstanding municipal water bills. For example, some respondents complained about the low number of units they received when buying electricity, and explained that the municipality "… vat van die units vir die water …" [… takes from the units for the water …] (respondent VN35), meaning that the municipality will allocate a portion of the payment towards the purchase of electricity units to an outstanding water bill, and then issue the balance in prepaid electricity units.

The reliability of the municipal water service was perceived positively as indicated by 79% of respondents reporting that they found it reliable. This reliability is illustrated by an example from one house sampled that had recently experienced flooding in the night from a burst pipe, and which they reported had been fixed by the municipality the following morning.

Some respondents also noted that they do not often get water cuts, and if they do, they are usually notified, as respondent VN86 said "… hulle sê as die water gaan af wees…" [… they [the municipality] say [tell us] if the water is going to be [switched] off…]. However, there was a common negative response to questions around water quality as indicated in the results.

As noted in section 3.2.2, the Western Cape Government's Municipal Economic Review and Outlook (MERO) (2020) reported that the agriculture, forestry and fisheries sector is the largest employment sector in the municipal area (50.6%). I disaggregated fisheries and agriculture sectoral data in the household questionnaire, and the results showed the significance of the fisheries sector (40%) in Noordhoek, as opposed to the agricultural sector (5.7%). The results also confirmed the reported dominance of low-skilled labour (57.5%) in the agriculture, forestry and fisheries sector (ibid.), as when asked for a job description or title, many of the respondents working in the fisheries sector used terms such as 'general worker', 'fish packer', or 'factory worker' indicating jobs that could be interpreted as low-skilled. Low-skilled or low entry level employment opportunities also dominated the results in the other significant employment sectors, such as construction (17.1%) and domestic work (14.3%). The retail sector accounted for 7.1% of employment opportunities, and all of these were either cashiers or packers.

As noted in section 3.2.5, the area is not ideal for fruit and vegetable growing due to the general aridity, poor soils and salty winds resulting from the proximity to the sea, however some households (12.9%) reported growing fruit and / or vegetables to help meet their food needs. I did note that households with food gardens tended to be in the older more established parts of the settlement. It should also be noted that this fieldwork was done in the first season post a significant drought, which may have had an impact on the number of people food gardening. An incentive for more households to install rainwater harvesting infrastructure would help alleviate pressure on the regional water resource in the face of future droughts. It would also reduce household water bills, thus freeing up income for other needs.

Chapter 5 Results: The Local Livelihoods and WEF Resource Context

5.1. Introduction

In response to objective two, this chapter presents the results from the key informant interviews (listed in Table 5) and site visits undertaken to gather data on the local context with regards to the WEF nexus and livelihood opportunities. These are explored in terms of the local WEF status, drawing on the framing used at the household scale, as well as the WEF nexus. The local livelihood opportunities are explored with reference to the results from chapter 4.

5.2. Local Context Relating to WEF Resources

Results from the household questionnaire revealed that all the participating households (100%) received municipal water and electricity services, and that these were their primary sources of household water and energy. Similarly, the questionnaire revealed a high reliance (≥80%) on supermarkets as households' primary source of most categories of food, besides bread and fruit. Using semi-structured interviews, site visits and personal observations, I set out to understand the local context surrounding this high level of service delivery and reliance on retail at the town and municipal scales, and how the WEF nexus plays out at this scale. Table 5 under section 3.4.3 lists the profile and codes of the interviewees.

5.2.1. Water

5.2.1.1. Water Availability - Infrastructure

As described in the methods section, I was guided on a site visit of the Velddrif water system by interviewee BM01. Drawing on personal observations and based on my experience of having explored urban water and waste-water systems, the Velddrif water infrastructure appeared to be in good working order and well maintained, with upgrades and maintenance taking place to both the water supply system and the waste-water system at the time of my visit. These did not appear to be compromising the delivery of these services to the residents of Noordhoek. Interviewee BM01 was highly knowledgeable, and the infrastructure appeared to be working well.

As the water supply system is powered by electricity, I enquired whether electricity load shedding or failure impacts water availability. Interviewee BM01 responded that they have backup diesel generators, which automatically switch on when there is a power failure, powering the pumps that pump water through the reticulation system. At the time (field work conducted in 2019), loadshedding was present, but not as frequent as it has subsequently become by the time of submitting.

5.2.1.2. Water Availability - Drought

As introduced in section 3.2.4.1, the area was subject to a significant drought during the period 2015-2018, which placed an enormous strain on biophysical water availability in the west coast region. An interview with the WCDM official responsible for bulk water provision in the area, interviewee WM01, confirmed the severity of the drought. When asked what their biggest challenge was in terms of water and Velddrif, they stated that "… drought was a massive challenge, Velddrif shares water with Cape Town – it's the same water source [Berg River]." They confirmed that Velddrif, which constitutes 5-6% of their overall supply, is one of 21 rural towns and seven irrigation schemes they supply. This was borne out by interviewee BM06, who stated that "[t]hey are all fighting for water from the same resource.", referring directly to the towns of Velddrif and Dwaskersbos, as well as the municipalities of Saldanha and Swartland, amongst others. Interviewee WM01 related how, in response to the deepening drought, they had to reduce the water allocation to all those they supplied, which resulted in increased water restrictions being imposed by BRM in Velddrif.

According to interviewees BM01 and BM03, one of the first measures BRM took in response to this reduced water allocation to Velddrif was to approach the industrial fish processing factory located in the town to request that they significantly reduce their water consumption. At the time the factory consumed between twenty-five and thirty thousand kilolitres of water per month, equating to around 35% of Velddrif's consumption, and 12.5% of total municipal consumption. As a result, the fish factory, which is owned by a large international company, installed desalination plants in their two fish processing plants in the west coast area, thus mitigating this loss of potable water supply.

Interviewee BM03 explained the situation as follows:

> "… we went to them and said 'listen you need to make a shift. You can't go on like this.' So, they did their seawater desalination, and they put eight, 100 000 litre tanks on both sites[11]. They use it for everything except the kitchen, the canning and where they need to have purified water. So, they have now dropped about 3 000 kilolitres a month."

Confirming the installation of the desalination plant, interviewee VE2, an employee of the company that owns the fish factory, said that:

> "… we had to go that route because of water scarcity and to make sure that we are still operational, because without water we cannot process. Water is vital in our processes. So, we had to invest in the desal plant in 2018."

Interviewee VE1, a management employee of the fish processing factory, provided further detail by explaining that when they are processing fresh pilchards, they use less fresh water as they use sea water to offload the fish, and only use fresh water for the cannery. However, they added that due to a decline in pilchard availability, the factory has been importing frozen pilchards, the thawing of which requires a lot more freshwater than when processing the fresh pilchards, expressing the difference by stating that: "… the fresh water used in the cannery is a lot of water, but when we do the thawing, its huge amounts." Interviewee VE1 explained that the company had sought to reduce this by installing a sea water filtration plant aimed at taking the impurities out of pumped sea water. This was not a desalination plant, so the water was still salty, but was of sufficient water quality to use in the thawing process which requires filling 24, 1.5m^3 tanks three time a day. However, due to high sodium levels in the resulting product, the use of filtered water in the thawing process has ceased, but the filtered water is still utilised where possible in the plant to reduce freshwater usage. They explained that as the factory is producing food, it requires very sterile conditions and thus requires potable water for cleaning. They noted that the desalination plant, more than the filtration plant, introduced significant additional energy costs to the company highlighting trade-offs associated with the WEF nexus. This foregrounds not only the WEF nexus in the interlinkages between water and energy in the production of food, but illustrates the

[11] The company has two large fish processing factories in the area, one at Velddrif and the other at nearby St Helena Bay.

amplified water and energy consumption patterns associated with industrial-scale food production.

As noted by interviewee VE3, the Velddrif Chamber of Business also discussed installing a desalination plant in Velddrif, but decided against it due to the high cost involved in building it. They noted that this cost would have to be recovered from the consumers, and that BRM was not in favour of passing this cost on to the consumers. Such an increase would have a significant impact on Noordhoek households, many of whom are already struggling to keep up with their municipal accounts. Relaying how everyone "… pulled together to make a plan …" in response to the drought, interviewee BM06 cited an example of a number of households in the upmarket residential marina of Port Owen (in Velddrif) installed small household-scale desalination plants. They also relayed how a private company set up a small desalination plant on the opposite bank of the river to the town, where the salt works were situated. Drawing from the estuary, they produced small tanks of fresh water for construction companies and the like, while using the brine as an input to the salt works.

Unfortunately, not all businesses had the means to be able to adapt, as interviewee BM06 pointed out, that:

> "… the smaller shops, the ones that sell water, like the Oasis [water vendor] type shops, they couldn't continue with their work any more. And some small businesses like car wash, hair dressers, the water intensive businesses, they had quite a struggle …"

This illustrates a connection beween affordability and availability, in that the larger companies had the means to find alternative supplies, and or scale back, whereas the smaller companies could not afford such measures. This foregrounds an issue of equity.

Although the fish factory's desalination plant resulted in a significant reduction in Velddrif's water demand, this was not enough given the severity of the drought. BRM therefore also introduced water restrictions, which at the height of the drought reached the level of limiting residents of Velddrif to 50 kl of water per person per day. In addition, BRM engaged with residents and businesses about the need to save water, as confirmed by interviewee VE3 who said that:

> "[t]he municipality went to a lot of effort to let people know of the drought and the water restrictions. They had an awareness campaign."

Interviewee BM06 expanded on this, reporting that the BRM strategy was:

> "… just to get the residents to save water, so we didn't do anything bigger than speak to people and awareness campaigns. I think its probably the difference between us and the City of Cape Town, (…) is that we spoke to everybody and we advertised and we put out pamphlets, etcetera, but we didn't really use punitive measures, we rather encouraged people to work together, so I think that has worked."

The effectiveness was believable given my personal observations when conducting the household questionnaire directly after the drought had broken. Residents of Noordhoek appeared to have a high degree of awareness of the need to save water as evidenced by some showing or telling me about the measures they had put in place, commonly associated with the use of grey water on gardens, but also included other measures and innovations. These observations resonated with what interviewee BM06 said, that:

> "The residents worked together extremely well, and most people tried their utmost to do everything that was suggested and more. And it is strange how people find ways to get things done with nothing, and everybody has new ideas, and these got shared. So we actually did very well."

It was not just the residents who were doing what they could to save water, BRM took some pragmatic measures to reduce water consumption, as explained by interviewee BM01, and verified by interviewee BM06 who stated that the municipality had:

> "… appointed extra plumbers to go into the areas where people can't actually afford, and they actually visited some of the houses with the large water bills to have a look at where the problem lies, because usually it was a leakage somewhere. So, if it was a leakage, they would quickly fix that. We thought that would be more cost effective than – well you can't get the water back, so if it has run it is gone, so we had to stop it and whatever it was costing was worth it. It was great because we actually helped a lot of people. I think it was possible to help a lot of people who had high accounts anyway because they could not afford to fix the leak."

When asked whether the drought had impacted employment in Velddrif, interviewee BM06 replied that "[i]t was close, if it was longer and people couldn't sustain their companies financially, then it would prbably have been a problem, but I think everybody tried their utmost to keep everybody working."

5.2.1.3. Water access and affordability

Referring to results from the household survey (4.3.1) in which respondents complained about the municipality's practice of deducting a portion of the funds from their prepaid electricity payments to recoup outstanding municipal water debt, I questioned interviewee BM01 when being shown a household water meter. They explained that as water services are billed post-use through residents' monthly municipal rates accounts, arrears are recouped by the municipality in this way. In other words, the household will receive fewer electricity units than they paid for, as part of the funds are directed toward servicing their outstanding municipal account. According to interviewee BM03, this measure is effective as there are not many households that have large outstanding water bills, adding that in this manner, "… arrears are not allowed to get out of hand." Measures such as this contribute towards the financial viability of the municipality, allowing them to continue to deliver services. However, this must be seen in light of other results from the household survey presented in section 4.3.1, whereby a quarter of the respondents cited the cost of water as one of the biggest challenges facing the household.

In compliance with the Municipal Systems Act (Republic of South Africa, 2000), local municipalities classify households that fall below a monthly income threshold as 'indigent' and thus entitled to a measure of free basic services as stated in sections 2.5.1 and 2.5.2. Exploring this threshold with interviewee BM03, they explained that BRM has defined the income threshold required to qualify as indigent as falling below two state old age pensions plus 40%. Posing feedback to them that I had received while doing the household survey, namely that the municipality helps people who are indigent, they responded that BRM:

> "… subsidise their [indigent households] refuse in full, we subsidise their sewage in full, we subsidise the water basic in full, and the first six kilolitres of water. So that's why you got out of your research the feedback that we do try and look after the indigent, and try and reduce the impact of the [municipal] account. We even, this year, we give a 60% rates rebate on our pensioners that only has one property. We

did 50% in the past, but we implemented a new evaluation last year and then we increased that to 60% - because you are busy taxing people out of their homes where they are living. So, we do look after our indigent, we do look after our elderly, and unfortunately the rest have to pay."

5.2.2. Energy

5.2.2.1. Energy availability - infrastructure

As mentioned under the methods section, I was guided on a site visit of the Velddrif electricity supply system by interviewee BM02. In response to a question about the reliability of supply from Eskom, they responded that beside loadshedding, they do not have a problem with supply from Eskom. With regards to electricity supply to Noordhoek, they explained that there are two different electricity supply lines feeding Noordhoek, so if there is a problem on one, they can switch to the other, giving Noordhoek additional security of supply. In response to me asking whether they would agree with the finding that 87% of household respondants reported BRM electricial service delivery to be reliable, they responded affirmatively, claiming a rapid response time to any reported faults. The substations, switchboxes and transformers we visited all appeared to be well-maintained and secured.

In terms of the high state of service delivery and well-maintained and functional state of the municipal infrastructure, interviewee BM03 stated that: "I think BRM went a long way in trying to help or to better our services that we do deliver. We have spent a lot of money on infrastructure - we are still busy."

In response to a question on the large electricity consumers in Velddrif, interviewee BM02 responded that the single largest consumer is the fish factory, and showed me the large bulk electricity supply meter that supplies the factory. In support of this statement, interviewee BM03 informed me that the fish factory consumes about 40% of the electricity supply to the town. They also pointed out there are two mussel processing factories in Velddrif that consume quite a lot of water and electricity for their size. They added that the mariculture takes place in St Helena Bay, but the produce is processed and packaged in Velddrif. These examples indicate the high energy and water consumption required for industrial-scale seafood production.

Similarly, the cold chain required to ensure food safety and longevity on the shelves in food retail outlets also has a high energy demand. For example, in response to a question on the consumption of water and electricity by the retail sector, interviewee BM03 stated that they consume "… a lot of electricity, but not so much water."

When asked about the municipality's own consumption, they responded that the "… biggest cost on our budget is personnel and our bulk electricity purchases, which together form about 80-85% of our total budget." They added that that the biggest contributers to this consumption was the water and waste-water systems, as well as the large municipal offices in Piketberg. However, they clarified that in terms of comparison to other bulk users, this constituted only 8% of the total municipal supply (not including the areas that ESKOM supply directly).

In a subsequent interview with the management of the fish factory, interviewee VE01 was asked what their main concerns were in terms of energy security, they replied that:

> "Eskom is a huge concern to everybody. We are reliant on Eskom, so whatever Eskom cannot provide it is going to have a huge impact on us. Such a big impact that the company has now decided to invest big millions on both our plants for standby generators. That is a project that will happen in the new financial year - so both plants will be getting a substantial generator to be able to keep the plant running."

The company, having already invested in securing their water supply, is now preparing to invest in securing their energy supply.

5.2.2.2. Energy access and affordability

Results regarding household energy access and affordability were presented in chapter 4, however the site visit with interviewee BM02 shed light on some of the access and affordability issues. They informed me that households registered as indigent had a 20 ampere (A) restriction on their supply, as opposed to the convention of 60A. The 20A tariff is lower than the 60A, thus more affordable for the indigent, however they told me that households cannot run much on 20A, for example one can't run the stove while boiling the kettle, or have the stove and the fridge on at the same time, as the meter will trip.

The issue of illegal connections was confirmed by interviewee BM06 who in response to a question on the biggest challenges facing the municipality regarding the WEF nexus responded that:

> "I think at the municipal level, our biggest problem becomes affordability. People cannot afford to use it any more, and they need it, because you need it for life, so they start stealing, … I don't want to call it theft because it is more like survival. … For both water and electricity, most of our material losses are due to theft. Sorry to say. It is very sad."

I did not observe any illegal electricity connections when conducting the household survey, and when I asked BM02 about this, they responded that people "…fiddle with the meter…" in order to get free electricity.

Energy affordability is not just a concern to households, but to local businesses as well, especially those that are large electricity consumers. This was confirmed by interviewee VE3, the manager of one of the big retail stores in Velddrif, who when asked what their biggest energy challenge was, responded that:

> "In terms of energy, affordability is a big thing – it is the second highest input cost to our operation. With availability we have experienced significant losses during load shedding as our generator broke down. The store is currently being upgraded and we are installing energy efficient equipment to assist with saving on the cost of electricity."

As mentioned in section 5.2.2.1, the fish factory are planning on installing diesel generators in order to maintain supply to essential components of their operations during loadshedding. However, interviewee VE02 mentioned concerns about the associated impact the rising price of diesel would have on their operational costs, as well as the impact on their carbon footprint in light of carbon taxes. They mentioned should loadshedding increase, they would not be able to afford a large enough generator to power the plant, and would then explore solar energy, however stated that this was still too expensive at this stage.

5.2.3. Food

5.2.3.1. Food availability

Although Velddrif is renowned as a 'fishing town', the household survey revealed that very few residents in Noordhoek still fish as a means of household food provision or as artisanal / small-scale fishers. However, my observations indicated that the fishing industry still plays a prominent role in the town as evidenced by the highly visual physical presence of the fish factory dominating the harbour (refer Figure 15 in section 3.2.1) and abutting the residential area as shown in Figure 30; the scenes of fishing trawlers docked in the Berg River estuary as you cross the main road bridge into the town; a tourist attraction called 'Bokkom Laan' where one can buy local artisanal dried fish known as 'bokkoms'; the presence of other smaller fish packaging outlets adjacent to the harbour; the presence of a Department of Fisheries, Forestry and *the* Environment (DFFE) compliance office at the harbour; the unmistakeable odour associated with fishmeal production permeating the air of Velddrif; as well as two smaller, mussel processing and packaging plants, which are still highly visible due to their size. The town is therefore undeniably still a fishing town, but this is largely centred around industrial-scale fishing and fish processing, and therefore fish as natural capital, is not directly exploited by Noordhoek residents as a food source, but rather as a source of financial capital, through employment opportunities.

Figure 30: A fish factory in Velddrif letting off steam, taken from an adjacent residential area. (Source: Author's own)

As reported under chapter 4, supermarkets form the backbone of food availability to household in Noordhoek. Interviewee VE3 from the retail sector stated that although the drought disrupted the supply of some of the produce to their stores (i.e. availability), it was typically on discrete occasions and short-lived. They were of the opinion that this did not have a significant impact on the food status of households in Noordhoek.

5.2.3.2. Food access and affordability

The emergence of industrial-scale fisheries as one of the mainstays of Velddrif's economy, and the seeming absence of Noordhoek residents' direct reliance on fish (natural capital) as a food source raises the question of why this is the case. I gained insight from attending a meeting of the Berg Estuary Advisory Forum (BEAF), where members informed me that only recreational fishing is allowed on the estuary and fishers need a permit for this activity. No net fishing is allowed on the estuary following the closure of net fishing by the Department of Environmental Affairs and Tourism in 2003 (James, 2011). Access to fish (natural capital) as a direct source of food is therefore restricted, as one would need a boat, and the fuel to power it, to go to sea to fish. The need for fuel and other physical capital such as fishing vessels,

introduces the element of affordability, i.e. it requires financial capital to procure physical capital in order to access the natural capital. As relayed to me by one householder surveyed (VN28), direct access to fish is further compounded by the permits required by small-scale fishers, who need to register as a member of a local fishing co-operative to get a permit. Not all small-scale fishers who apply for status as a member of the co-op are granted this, which was the case with this fisher, who explained that he could not prove that he was a small-scale fisher, so was excluded. Thus, fishing for household consumption is constrained by both the challenges posed by the permitting system and the environmental protection of the natural resource base.

A finding that surfaced when exploring whether the lack of access to water due to the drought, affected the availability of food in the retail sector, was that the lack of access to electricity through loadshedding had more of an impact on Noordhoek household's access to food. Interviewee VE02 explained that they cannot open the store when there is no electricity, and they lose turnover as a result. They also reported that a lot more of their perishables spoil due to loadshedding. It is arguable that such losses in profit will ultimately be passed onto the consumer, in this case Noordhoek households, in the form of higher food prices.

As stated under section 5.2.2.1, the retail sector are large electricity consumers, consuming on average "… about 150 to 200 000 units of electricity [per month]." according to interviewee BM03.

The centrality of food to the WEF nexus and livelihoods interface have surfaced in this chapter and will be explored in more depth in the following chapter.

5.2.4. Loss of municipal income

Local municipalities are reliant on the sale of water and electricity as one of their main sources of income. Confirming this, interviewee BM03 stated that along with property rates, this constitutes about 30% of their income. The remaining 70% is comprised of income received for the indigent through the equitable share (as covered in section 2.4.3), and other conditional grants such as the Extended Public Works Programme (EPWP) and Community Development Workers (CDWs). They expanded on this by adding that with the conditional grants, "… you have to incur the expense to get the income."

A reduction in water consumption due to the drought therefore resulted in a loss of income for BRM. As stated by interviewee BM03, "[w]e've lost 40% of our water income in the last two years …" adding that their consumption went from about 250 000 kilolitres a month down to a low of 100 000 kilolitres a month, but "… is picking up now - we are running at about 140 000 [kilolitres], but we will never get back to even 200 000 [kilolitres]."

In addition to the loss of municipal income due to reduced water consumption, they were also seeing a reduction in electricity consumption. When asked if BRM had seen an increase in electricity consumption due to all the desalination plants being installed[12], interviewee BM06 responded:

> "No, not really. Because we had a decrease in electricity use because of the water not needing to be pumped and all of that, and our [water supply] plant in Piketberg not working at full capacity. So actualy we had a little bit of a decrease in electricity usage."

Asked whether that meant that the water-related costs to the municipality were reduced, they replied affirmatively, but added that the sales had also decreased.

Adding detail to this, interviewee BM03 explained that in the previous year[13] their income from water sales had reduced from R28 to about R22 million, and the electricity had reduced by 10%, "…because there's a direct correlation between the two." They concluded by saying that in the current year[14] it looks like

> "… we are going to just break even, or maybe have a few R100 000 income (. …) So, unfortunately there are some things that happen outside our scope, that we have no control over, but at the end of the day it has a huge impact on our budget."

On electricity sales they added that another part of the reduction in electricity sales was due to loadshedding, stating that "ESKOM is making it very difficult for us (. …) people start buying generators and banks of batteries, it's forcing people off the grid …".

[12] It was reported by BM06 that many residents in Port Owen had installed home-scale desalination plants.
[13] The year previous to the interview taking place, i.e. 2018/19 financial year. The drought broke in winter of 2019.
[14] The 2019/20 financial year.

Furthermore, they reported that the large increases in electricity tariffs imposed by Eskom and managed by the National Energy Regulator or South Africa (NERSA) also had an impact on their income, which they explained as follows:

> "… what happens ESKOM goes to NERSA and say, 'I want a 15% tariff increase' and NERSA determine if they can get the 15%, then if they get the 15% increase, NERSA will then come to us and say 'you are only allowed to do a 12% increase'. So, although our costs went up by 15%, we can only cover 12% with our income (. …) And we still have to maintain [the infrastructure], we still have to do everything. So, the buffer that you have is busy being eroded, and you get to a point where your income and expenditure on electricity is basically the same. Or your electricity expenditure is going to be more than your income."

BRM interviewee BM03 concluded by saying that: "I think in future if you don't get to a point where you can increase your water and electricity sales again, you are going to have problems."

Another key observation from the site visits, was the apparent functional, well-maintained and neat state of Velddrif's water and energy infrastructure. Along with knowledgeable, accessible, and responsive municipal officials, the state of the infrastructure gave the impression of a local municipality that is committed to good service delivery and takes pride in their work. The site visits confirmed my initial impressions from walking around Noordhoek whilst conducting the household survey, as well as the results of the survey itself where respondents reported a relatively high degree of reliability regarding the delivery of water and energy services.

5.3. Local Livelihood Opportunities

This section reports on livelihood opportunities within the town of Velddrif and its surrounds which are available to Noordhoek residents. Results showed that the livelihood strategies related to WEF resources of Noordhoek residents are highly dependent on financial capital, despite living on a highly productive estuary and coastline with high levels of natural capital in terms of fish. Given the heavy reliance on financial capital for household WEF security, I explored the livelihood context of Velddrif in terms of understanding the availability and security of employment options.

5.3.1. The fisheries sector

Results from the household questionnaire indicated that the sector showing the highest prevalence of employment was the fishing sector (40% of households), which is not surprising given the historical significance of fishing in Velddrif.

In order to gain a deeper contextual understanding, I visited the South African Fisheries Museum located in Velddrif, adjacent to the harbour at the mouth of the Berg River. This visit provided me with a deeper understanding of the significance of the fisheries sector in the area, and the cultural heritage and identity associated with it. I also learnt about the significant infrastructure investment accompanying this heritage, such as the breakwater built at the mouth of the river to secure a permanently open river mouth of necessary depth for uninterrupted boat entry, and permanent jetties for the fishing trawlers adjacent to a large-scale fish processing factory as depicted in Figure 15 in section 3.2.1.

The day I visited the fishing museum and the harbour, I observed a group of women manually fixing large purse seine fishing nets as depicted in Figure 31. On speaking to the women, they informed me that this is ad hoc work that they do when there is demand and that they get paid daily. Some lived in Noordhoek, some in Laaiplek and one from St Helena Bay. They informed me that there were not many small-scale fishers in Velddrif, and that most of the fishers now worked on the commercial trawlers associated with industrial-scale fishing. This was borne out by the household survey which recorded one small-scale fisher amongst 70 respondents.

Figure 31: Women manually fixing fishing nets on an open field with the chimneys of the fish processing factory visible in the background. (Source: Author's own)

In an interview with the management of the fish processing factory (interviewees VE1 and VE2), I sought clarity on the status of many respondents to the household questionnaire, namely that they were employed permanently, but seasonally. They explained that they employ roughly 800 people permanently, 600 of whom are guaranteed an 18-hour work week during the season and the remaining 200 are guaranteed a 40-hour working week during the season, thus the 'seasonal-permanent' classification. In other words, once a person is employed under this arrangement, they have permanent employment, which is temporarily halted annually for the 'out-of-season' period, and then resumes once the season opens again. Workers are not paid during this out of season period, but those that qualify for the threshold can register with BRM as indigent during this period. Interviewee BM03 confirmed this by explaining that the fish processing factory informs BRM when the season starts and ends and provides a list of the seasonal workers involved, so that BRM can accept their applications for indigent status for that period. The 18-hour a week, in season guarantee is an agreement made with the union governing the industry, namely the Food and Allied Workers Union (FAWU), which came about with the new ownership of the factory and the subsequent investment in the thawing capacity in 2016. Interviewee VE01 relayed how previous to this arrangement, there were no guaranteed weekly hours, and workers were tied into the processing of fresh fish only, so the employment was less secure.

They went on to explain that there are two main products from the fish processing factory, firstly there is fishmeal made from anchovies, and secondly there is the cannery which produces canned pilchards[15]. The fishmeal side provides the 40-hour week arrangement to the smaller group of employees and the cannery guarantees the 18-hour week for a larger group of employees.

When I asked if the determination of 'the season' is linked to the issuing of fishing permits, interviewee VE01 replied that it used to be, as the permits used to last from January to August/September, but that these typically now last from January to December, so they do not influence the timing of the season anymore. They explained that the pilchards get caught roughly at the beginning of the year in February, March, and April, and that the main anchovy season comes after that in May, June, and July, and then pilchards get caught again towards

[15] Pilchards is the name given to larger, older sardines.

the end of the year in October and November. However, that there has been a major decline in the availability of pilchard, resulting in very small quota allocations being issued. In response to this resource insecurity, as well as a change in ownership of the fish factory in 2015 (Oceana Group, 2015), the company invested in thawing capacity which allows them to import frozen pilchards mainly from Mauritania and Morocco, and thaw them for canning. The thawing operation is limited to the number of thawing vats currently installed, thus the cannery functioning purely on frozen imports only runs four days a week. However, it can operate around the clock, seven days a week, if fresh fish are landed, providing an opportunity for the cannery employees to increase their income beyond the guaranteed 18-hour week. The intensity associated with the landing of fresh catch is illustrated in this quote form interviewee VE01:

> "… if our vessels should catch fresh pilchards, that's a totally different ballgame. Then the cannery runs full one hundred percent capacity, and we work 24/7. If the vessel is here, it gets offloaded - Saturday, Sunday - we'll process. Then everybody works at the same time in two shifts – a day shift and a night shift."

In response to further questions about how the season is determined, interviewee VE01 informed me that:

> "… we will decide on when we will start up in the beginning of the year, which is normally the middle of January. … and at some stage towards the end of the year, October or November or whatever, if there is no fresh fish to be caught, and at some stage the frozens will stop, then we will say it is the end of the season, and they go on holiday. … We have to do off season maintenance. We have boilers, so we have to stop for at least six weeks to do all the boiler maintenance and plant maintenance."

Although this guaranteed 18-hour week 'permanent-seasonal' arrangement is much more secure than the pre-2016 period when the bulk of the workers would rely on fresh pilchard catches for work, it still includes an element of uncertainty regarding when the season will start and end. As a large proportion of the factory's workforce is drawn from Noordhoek, this seasonality of income must have a profound effect on the household WEF status.

Exploring the high level of water consumption at the fish factory surfaced an earlier adaptation to the reduced availability of fresh fish stocks. In response, the factory had

invested in an additional process that allowed them to use frozen imported fish stocks, and not have to rely solely on the highly variable locally-caught fresh fish. However, like the alternative water supply, this too came at a cost, introducing trade-offs across the WEF nexus. The thawing process required a significant increase in the factory's water and energy consumption. Thus when the drought occurred shortly after the introduction of the new thawing plant, the fish factory was highly vulnerable as a large water consumer. As a result they had to invest in another capital intensive adaptation, this time a desalination plant as already mentioned. Navigating changing circumstances in the availability of WEF resources have triggered trade-offs across the WEF nexus for the fish factory, however whilst navigating these, they have managed to secure jobs, the bulk of these filled by Noordhoek residents. Interviewee VE02 put this so well when asked about these trade-offs:

> "… yes, it is quite a tricky equilibrium that you have to maintain, because you need to look at the wellbeing of the company, and I think the company thus far has done tremendously well in a constrained environment not to lay off people. … So, I think in terms of being a responsible employer, we certainly understand the impact and the delicate balance that you have to strike in terms of natural resource to provide food security, but also job security. And in communities like this where we are the largest employer, it has quite a big impact because entire families could be working in the facility. So, you often find that the wife and the husband work in the same facility. So, if the company retrenched, it affects the immediate family, but also the extended family, and obviously the community because the businesses here would suffer because they wouldn't get the same level of grocery shopping, the municipal rates not being paid, and those kind of things, so the team has got quite a tough job in keeping that delicate balance."

5.3.2. Other employment sectors

The construction sector emerged from the household survey as the second largest employment sector amongst respondents (17.1% of households). Interviewee BM03 informed me that Velddrif used to have a much larger fishing industry, but that this had reduced due to a decline in the availability of fish, resulting in:

> "… a lot of unemployment - a big dive in the fish industry, so a lot of people went over to the building industry. So currently there's a lot of development, residential development, going on. So, there was a huge shift from local fishing to the building industry. But the factory then picked up again by importing fish for processing."

The upswing in employment opportunities in the local construction industry was corroborated by interviewee BM05 who stated that "…we are receiving lots of applications, residential applications, from people moving to Velddrif because of the IDZ[16] [Industrial Development Zone]". The IDZ was proclaimed around the Saldanha Bay port in 2013 with the aim of expanding the port's capacity to service the oil and gas, and marine repair clusters (Winde, 2012).

Domestic work had the third highest prevalence amongst the household respondents (14.3% of households), but no further information was gathered about this from the key informant interviews.

In response to the public sector emerging from the household survey results as the fourth highest employment sector (12.9% of households), interviewee BM03 informed me that municipality employs approximately 400 core permanent employees municipality-wide, and approximately another 200 to 300 contract employees, mostly employed conditional grant programmes such as EPWP and CDW, both mentioned in section 5.2.4.

Retail was the fifth highest employment sector amongst respondents (7.1% of households). From personal observations, the retail sector in Velddrif is dominated by large supermarket chains. These play an important role in household food status, as shown in the results in section 4.3.3, highlighting the central role they play in Noordhoek households' food sources. As noted in sections 5.2.2.1 and 5.2.3, they are also large electricity consumers.

Despite Noordhoek being situated in a largely rural municipality, only two respondents reported working in the agricultural sector.

[16] The Industrial Development Zone (IDZ) that is being developed around the nearby port of Saldanha, which involves a lot of construction, including upgrades to roads, new office and port facilities, amongst others.

5.4. Discussion

One of the most significant results gained from the key informant interviews, site visits and personal observations, was the centrality of the fishing industry to the intersection of the WEF nexus and livelihoods in Velddrif. As the results in Chapter 4 indicate, Noordhoek households rely predominantly on financial capital (income and social grants) to resource their WEF needs, and this chapter finds that the fish factory is the single largest employer in the town. The findings in Chapter 4 also indicated that amongst the households sampled, the primary sector of employment was the fisheries sector, thus corroborating the dominance of the fisheries sector in terms of local employment opportunities. However, not only is it a food producer that is the primary employer, thus being a key contributor to the means with which households secure their WEF resources, but the food producer in question is also the town's largest water and energy consumer by a significant margin. The results therefore show that the fish factory itself exhibits a nested WEF nexus-livelihood intersection.

Furthermore, the fish factory's heavy dependence on the natural resource base introduces a state of vulnerability to the sustainability of its business model, and by association, to the livelihoods of a large proportion of the town. This is evidenced both by the scarcity of fresh fish stocks, and scarcity of water during the drought, both of which were limiting factors to the viability of the business. In both cases the company was able to mitigate the risk by making large capital investments, made possible by it having a sufficiently sizeable balance sheet which enabled this response. A similar response to resource scarcity concerns is noted by Allouche et al. (2015), (Terrapon-Pfaff et al., 2018) and (Wiegleb & Bruns, 2018) in large-scaled WEF nexus applications which have been characterised by large capital investments in water, energy and food infrastructure. Moreover, the authors note the access to power and or money a capital-intensive response requires, a pattern seen amongst the larger companies and wealthier households of Velddrif investing in alternative sources of water supply in the face of the drought. An example of this is illustrated by the households in the upmarket residential area of Port Owen, some of whom installed household-scale desalination plants. This brings issues of equity to the fore as smaller businesses and low-income households did not have the means to invest in alternative sources.

Despite the fish factory's responses in both cases having secured the short- to medium-term survival of the enterprise, and thus secured employment, they did trigger trade-offs across the nexus. The shift to processing imported frozen fish resulted in a significant increase in water and energy consumption; and the introduction of a desalination plant in the face of the drought introduced increased electricity consumption. This reveals a strong intersection between livelihoods and the WEF nexus at this local scale and once again, as noted in Chapter 4, aligns with Biggs et al. (2015) who centred the need to balance the human demand associated with livelihood pressures with natural supply as the pivot point between the environmental nexus and sustainable livelihoods.

Biophysical water availability however is beyond the control of BRM, and has been seriously compromised by the recent drought. This created a knock-on effect in terms of water availability, with the WCDM restricting water allocation to BRM, and BRM restricting water allocation to Velddrif. One of the first things BRM did in order to accommodate this reduced allocation, was to approach their largest bulk water consumer which accounted for 35% of the town's overall consumption, namely the fish factory. The fish factory responded by installing a desalination plant, which produced water at a higher cost than the fresh water they were purchasing from the municipality. It also increased their electricity consumption, which was surprisingly not recorded by the municipality, but was spoken about by the fish factory. This may be explained by a potential slowing down of production in order to try and stabilise input costs in the face of the large financial layout the desalination plant required. What is also worth noting in this example is that the reduced biophysical availability of one of the WEF resources was passed on from the primary supplier in this case, WCDM, to the local municipality, and onto its customers. As the WEF resources are so strongly interlinked with livelihoods in this case, this would have had a significant impact on livelihoods had the fish factory not had the capacity to adapt to this shortage. The fish factory was therefore able to buffer the need for a negative livelihood trade-off across the water-energy-food-livelihood nexus.

For context it is important to note that the BRM falls into municipal category B3, defined by the Municipal Infrastructure Investment Framework (MIIF) as "… local municipalities with small towns, with relatively small populations and significant proportions of urban population but with no large town at its core." (Statistics South Africa, 2017, p. 2). As municipalities

generate income from property rates and service delivery charges, the smaller the population, the smaller their income. This is further compounded by the levels of poverty in a municipal area, which will also affect the level of municipal income. Municipal income is therefore key to service delivery, and vice versa, as a lack of service delivery will not generate municipal income, resulting in a downward spiral of service delivery backlogs and limited financial resources to address this.

In order to provide and maintain the high level of service delivery witnessed during this research, the municipality needs to maintain financial viability. In light of the drought, and to some extent electricity loadshedding, the municipality has experienced a loss of income associated with reduced water and electricity sales. This poses a challenge to the sustainability and standard of service delivery, thus also posing a challenge to the WEF status of Noordhoek households, who, as shown in Chapter 4, are completely reliant on municipal services for their water and electricity needs.

Another nexus point surfaced in this chapter is that of BRM's own electricity consumption, which although small in comparison to other bulk consumers in the town, is largely used on running the water and waste-water systems, highlighting the water-energy-livelihood nexus.

In addition, although BRM presents as a significant employer, a lot of the employment opportunities are annual contracts associated with public sector run job creation programmes such as EPWP, which typically consist of the 'working for' programmes. This does not provide long-term job security for Noordhoek residents employed in these programmes, as employment typically only lasts one year, and remuneration is very low.

A further key finding that has emerged from this chapter is the adaptive capacity of many of the actors in response to constraints on WEF availability. These included the fish factory which invested in thawing capacity to ensure their continued viability as a business in the face of dwindling or relocated fish stocks. It also installed a desalination plant in the drought and are preparing to install diesel generators in the face of loadshedding. All of these measures secure the employment of many Noordhoek residents. Another is the example of the municipality fixing significant household water leaks in order to save water, as this made more financial sense than running out of water altogether. BRM also protected the residents from large utility service cost increases, such as turning down the Chamber of Business's proposal

to build a costly desalination plant for the town, and not implementing a punitive water tariff structure like the City of Cape Town did during the drought. Further examples include of upmarket households installing household water desalination plants, and using grey water for their gardens. The following quote from interviewee BM06 in response to a question on lessons learnt as a municipality regarding the drought illustrates the point well:

> "People are more resilient than you think. I think that is the biggest lesson that I learnt. I was surprised by how dilligently the community worked together for this whole thing, and people were actually very positive, with all the help that they gave us and gave the municipality. They all had plans, we were inundated by people with ideas and how to do things and how to do things better, so I think that was the biggest thing."

Although these are all examples of a pro-active approach exhibiting adaptive capacity, the bottom line remains that reduced consumption threatens the financial viability of the municipality, which places the continued provision of basic services at risk. This in turn threatens the WEF security of Noordhoek households who have a high reliance on the municipality for basic services. It also brings issues of equity to the fore, as many of the alternative measures are not available to everyone, but only to those who can afford them. This is supported by my observation of few rainwater tanks amongst Noordhoek households, and no solar water heaters or solar electricity generation reported in the household survey.

The Velddrif food outlet landscape is dominated by large supermarket retail chains, which provide many job opportunities to residents of Noordhoek. However, they are also large electricity consumers largely due to cold chain requirements. Once again this illustrates the linkages across the WEF nexus and livelihoods.

Chapter 6 Integrating Livelihoods and the WEF Nexus

In answering to objective three, this chapter presents a final integration of the findings from objective one and two, exploring interlinkages within and between the household WEF status and livelihood options, and the local livelihood and WEF resource contexts. Figure 32 provides an illustrative synthesis of these complex interlinkages and will be used as the primary reference point for this chapter. As many of these interlinkages have already surfaced in the results reported in chapter five, this chapter largely serves as a synthesis and conclusion of the thesis.

6.1. Water-Energy-Food-Livelihood Nexus in Velddrif

The exploration into how Noordhoek households utilise their assets to meet their basic WEF needs revealed a complex web of interlinkages across the WEF nexus, between the WEF nexus and livelihoods, and across nested spatial and governance scales, even extending into the global economy. The primary interconnections involve Noordhoek households, Bergrivier Municipality, the fish factory and to a lesser degree the local food retail outlets.

One of the notable features Figure 32 highlights is the pivotal role the local municipality plays in sustaining the WEF-Livelihood nexus in the area. Not only does it maintain a high degree of service delivery as discussed in section 4.4 where comparative figures for the national context show how anomalous it is, particularly for a small rural municipality, but it also prioritises support for the indigent, as illustrated in section 5.2.1 and 2. However, in order to remain the anchor of service delivery it is, the BRM needs to maintain financial viability, as discussed in section 5.2.4. The research surfaced some of the challenges faced by the BRM in its efforts to balance the availability and affordability of water-energy resources to Noordhoek households, in the context of decreasing availability and affordability on a national scale. An example of this was the impact the drought had on the biophysical availability of water, which BRM had to navigate whilst attempting to retain employment at their largest water consumer, namely the fish processing factory. In other words, BRM knew that a substantive reduction in the fish factory's access to water, could result in job losses at the factory, their single largest employer. As the household survey revealed, many Noordhoek households are reliant on the fish factory for income. BRM were therefore

reluctant to impose water restrictions on the factory, until it became clear that they had no other choice, but to make that trade-off between jobs and water. Once BRM had imposed the restrictions, the trade-off decision was passed on to the company owning the fish factory, Fortunately, they are an international company with a healthy enough balance sheet to enable them to absorb the loss and instal a desalination plant to continue to run the factory without reducing jobs. This did however increase their energy consumption, illustrating another trade-off across the WEF-Livelihood nexus. Ironically the same company had a few years previously invested heavily in the factory when faced with a similar dilemma, this time the reduced local availability of another natural resource, namely fresh fish, a key food source. The trade-off was similar, where the company faced closing the factory resulting in huge job and profit losses, or investing in another source of fish, which they did. The investment included retrofitting the factory to process imported frozen fish, sourced globally, which resulted in a significant increase in water and energy consumption in the factory, but retained and even improved job security. This example highlights a complex set of interlinkages and trade-offs across the WEF-Livelihoods nexus playing out at this local level. It also confirms the applicability of the availability, access and affordability framing adopted in this research as presented in section 2.4.4 and illustrated in Figure 9. Framing the availability of WEF resources as not only external to the household, but also divided into biophysical, infrastructural and service delivery/food supply chains, enabled an understanding of the biophysical scarcity of both fish and water in this case study as potentially having a devastating effect on Noordhoek households' ability to generate financial capital, their key household asset in terms of servicing their WEF needs, revealing a cascading series of nested WEF-Livelihood nexus's.

The paragraph above discussed the implications of the drought on the local SES, with a particular reference to trade-offs related to jobs. However, gauging from the number of income streams relating to service delivery the local municipality has, as depicted in Figure 32, the financial viability of the municipality is heavily reliant on these sales as a source of income. Reduced consumption of water and electricity therefore reduces their income base, threatening their financial viability, as discussed in section 5.2.4. As indicated in the paragraph above, reduced consumption of water was largely due to the reduced biophysical availability of water. A similar pattern emerged around electricity consumption, where

reduced availability due to loadshedding, has resulted in reduced consumption. In addition, the national electricity tariff has been increasing exponentially, introducing the need for the municipality to increase their electricity tariffs. In the context of many Noordhoek households reporting an inability to afford a full month's worth of electricity, this introduced further challenges to the municipality's pro-poor policies. The reduced availability of both water and electricity are beyond the control of the municipality, yet their financial viability, and the WEF-livelihood security of Noordhoek households relies on the availability and affordability of both. The local municipality therefore plays a pivotal role in managing and trying to mitigate trade-offs and increase synergies across the WEF-livelihood nexus that impact Noordhoek households. As clearly illustrated in Figure 32, many of the factors determining WEF resource availability and affordability to these households are beyond BRM's control, extending into other governance and sectoral scales. An example of governance scale includes the governance of the bulk water supply, which initially resides at a national level in terms of determining the allowable draw form the natural resource, then to the district municipal level which acts as the water service provider, providing potable water to the local municipality. These scalar issues around governance resonates with one of the key challenges noted by a number of authors (Bizikova et al., 2013; Liu et al., 2017; Mabhaudhi et al., 2019; Mohtar et al., 2020; Naidoo et al., 2021; Pahl-Wostl, 2019b; Simpson & Jewitt, 2019) around operationalising the nexus, namely the issue of cross-sectoral and cross-scalar governance.

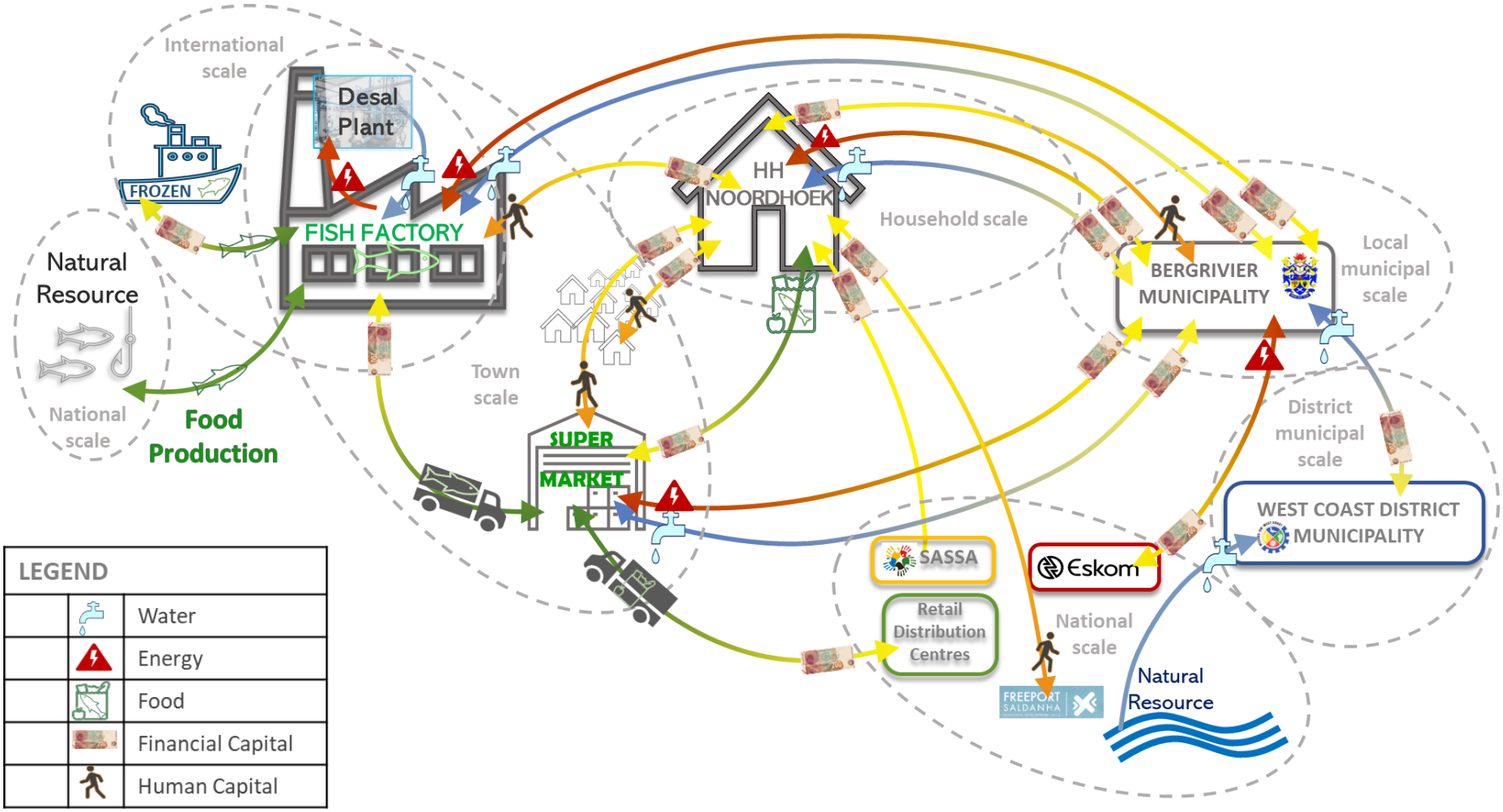


Figure 32: Illustrated synthesis of the water-energy-food-livelihood nexus pertaining to households in Noordhoek, Velddrif. (Source: Author's own)

6.2. Reflection on the Application of the WEF-Livelihoods Nexus at the Local Scale

As argued by Hoff (2011), presented in chapter 2, the WEF nexus is a useful framing for understanding complex social-ecological interactions in these systems. This was illustrated by the surfacing of a complex web of interconnections across the water, energy, and food systems relied upon by Noordhoek households. Applying it to the household scale through the household WEF status framing presented in section 2.4, revealed useful information about WEF resource sources. Drawing on Biggs et al., Spiegelberg (2017), and Wolde (2020), and applying the nexus in combination with the livelihood component, through the use of the SLA five capitals, enabled an enquiry into household members' livelihood activities. Like Spiegelberg et al. (2017) and Wolde et al. (2020), I used a household questionnaire to gather detailed household level data on WEF sources, uses, and perceptions, as well as livelihood activities. This provided a rich empirical basis to the research, based on the lived experience of the household members. As argued by Albrecht, et al. (2018), Mguni et al. (2020), and Stringer et al. (2018), I found the application of mixed methods extremely useful as it allowed me to address the physical and social aspects of the WEF nexus, as illustrated by the research design presented in Figure 21. It was also particularly suited to the spatially nested design of my research, allowing the more quantitative empirical base of the household survey to be deepened by the qualitative methods seeking to answer questions related to the context within which the household was located. This resonates with Dalla Fontana et al (2021) who describe the value of social approaches in answering the 'who, how and why' questions. As mentioned in section 3.1, the framing developed for this thesis differed slightly from the other three case studies in the overarching project. The case study in the Keiskamma River catchment, which was conducted through an agricultural economics lens, relied solely on the household questionnaire as an empirical tool to explore the WEF status at household level. The data collected was used to determine a water poverty index, multidimensional energy poverty index and household food insecurity access score. Although this quantitative approach allowed for a definitive comparison across other studies applying the same indices, it did not explore the explore the contextual SES of which the household is a part. The study in the Umngeni River catchment on the other hand did not use the household questionnaire at all, but rather followed a qualitative approach using guided conversations, focus groups,

and photovoice methods. These methods were selected due to the prevalence of a culture of non-payment for services in the communities selected. The methods therefore allowed for a less inquisitorial approach associated with direct questions, and thus allowed the researcher to gain insights into the highly sensitive issues of poverty, food insecurities, and motives for illegal connections. This resulted in a highly contextual and nuanced understanding of the WEF nexus within communities with a non-payment culture, and scaling of resource provisioning through a hydrological lens. The other site in the Berg River catchment also used the household survey as the primary empirical instrument and included focus groups as a complimentary method. That research aimed to establish whether the degree of social cohesion between households had an influence over their household WEF status.

Comparatively, the aim of this study was not agricultural economics requiring a strong quantitative empirical base as evidence by the Keiskamma catchment research; nor did it require the sensitivity the qualitative approach fostered in the Umngeni catchment; nor the use of focus groups that the enquiry into social cohesion required. Instead, this case study aimed to understand the status of household WEF resources and explore the role local livelihood opportunities play in this. This required the quantitative determination of the household WEF status, and which livelihood capitals the households drew on to meet their WEF needs, as well as contextual understanding of the livelihood opportunities available to these households and the broader WEF resource context. The framing therefore developed for this study, as presented in Figures 8 and 9, has worked well in terms of making visible the livelihood options and strategies adopted by households, their WEF status, the local livelihood opportunities and WEF context, and the intersection between all of these layers.

6.3. Conclusion

The research revealed that even though this case study is located in a rural setting and is renowned as a fishing village, there is little direct connection between the natural resource base and the household WEF status. Instead, what emerged was that households depend entirely on trading their human capital for financial capital through employment, which they then use to provision their household with WEF resources.

In addition, employment opportunities within the town are dominated by the food sector, in the form of the industrial fish processing sector and the retail sector. These sectors, particularly the fish processing sector, also have complex WEF-employment interlinkages.

Another key finding is that the local municipality in this case plays a proactive and often pivotal role in mitigating trade-offs across the WEF-employment nexus that would ultimately negatively impact Noordhoek households. This demands that the municipality walk a fine line between remaining financially viable and actively pursuing pro-poor policies within an increasingly resource constrained environment – particularly when it comes to water and electricity.

6.4. Recommendations

This case study has highlighted significant interdependencies between the WEF nexus and livelihoods at the local scale. Many of these are highly co-dependent, with a failure in one having significant implications for others. For example, most households in Noordhoek are almost exclusively dependent on financial capital to secure basic household WEF needs. In order to sustain this, it is imperative that existing job and economic opportunities are retained and that new opportunities are created, particularly given the high need for job creation in South Africa. However, as there is high dependence on industrial fishing for job opportunities, and the sector is reliant on dwindling fish stocks, as well as requiring large volumes of water and electricity to process the fish, there is a high degree of vulnerability to sustained economic activity within this sector. It is therefore recommended that this local nexus, and associated trade-offs and opportunities, between industrial fish processing, water, energy, and jobs is articulated within economic development planning, water resource planning, and energy planning. Economic development pathways for the region should take these interdependencies into account and explore trade-offs with relevant stakeholders, including people employed in this sector. There is a big push to increase aquaculture in the broader west coast region, and this recommendation applies to these initiatives as well, as they too require high volumes of water and electricity to run aquaculture facilities and processing plants.

Furthermore, the low incidence of rainwater tanks amongst Noordhoek households and the complete absence of any solar water heaters further underlines the high dependence

amongst Noordhoek households on the municipal service provision. It is therefore recommended that a programme including government-subsidised or incentivised rainwater tanks and solar water heaters be adopted in the area. This will reduce Noordhoek households' water and energy costs and could be applied nationally.

Another high level of interdependence which introduces vulnerability to sustained and or improved household WEF security, is the generation of municipal income from water and energy service provision. The local municipality does an excellent job in sustaining water and electricity service delivery to households in Noordhoek, while doing its best to buffer ratepayers, particularly the poor, from increased tariffs and availability constraints imposed at the national level. However, as municipal income margins shrink, due to reduced consumption of water because of the drought, and reduced consumption of electricity because of loadshedding, as well as ratepayers switching to alternative supply sources, their ability to sustain the level of service provision while keeping rates as low as possible is being compromised. It is therefore highly recommended that alternatives to the current model of municipal income generation, that are not premised on the sale of basic services, be explored. Alternatives should address the tightly coupled need for ratepayers to consume municipal services, and pay increasingly high costs for these, to generate municipal income. The municipality is thus incentivised to encourage consumption of resources that are in short supply. In the context of non-payment for basic services, as witnessed in the Umngeni Catchment case study conducted under the overarching project, the current municipal income generating model leads to bankrupt municipalities and an ultimate failure of service delivery.

References

Africa, S. S. (2021). *General Household Survey: Selected development indicators 2020*. Pretoria: Statistics South Africa

Afshar, A., Soleimanian, E., Akbari Variani, H., Vahabzadeh, M., & Molajou, A. (2021). The conceptual framework to determine interrelations and interactions for holistic Water, Energy, and Food Nexus. *Environment, Development and Sustainability*. https://doi.org/10.1007/s10668-021-01858-3

Albrecht, T. R., Crootof, A., & Scott, C. A. (2018). The Water-Energy-Food Nexus: A systematic review of methods for nexus assessment. *Environmental Research Letters*, *13*(4). https://doi.org/10.1088/1748-9326/aaa9c6

Allan, T., Keulertz, M., & Woertz, E. (2015). The water–food–energy nexus: an introduction to nexus concepts and some conceptual and operational problems. *International Journal of Water Resources Development*, *31*(3), 301-311. https://doi.org/10.1080/07900627.2015.1029118

Allouche, J., Middleton, C., & Gyawali, D. (2015). Technical Veil, Hidden Politics: Interrogating the Power Linkages behind the Nexus. *Water Alternatives*.

Anchor Environmental. (2008). *Berg Estuary Situation Assessment*.

Ashley, C. a., & Carney, D. (1999). *Sustainable Livelihoods: Lessons from early experience*.

Ateba, B. B., Prinsloo, J. J., & Gawlik, R. (2019). The significance of electricity supply sustainability to industrial growth in South Africa. *Energy Reports*, *5*, 1324-1338. https://doi.org/10.1016/j.egyr.2019.09.041

Bazilian, M., Rogner, H., Howells, M., Hermann, S., Arent, D., Gielen, D., Steduto, P., Mueller, A., Komor, P., Tol, R. S. J., & Yumkella, K. K. (2011). Considering the energy, water and food nexus: Towards an integrated modelling approach. *Energy Policy*, *39*(12), 7896-7906. https://doi.org/10.1016/j.enpol.2011.09.039

Benson, D., Gain, A. K., & Rouillard, J. J. (2015). Water governance in a comparative perspective: From IWRM to a 'nexus' approach? *Water Alternatives*, *8*(1), 756-773.

Bergrivier Municipality. (2017). *Bergrivier Municipality: Fourth Generation Integrated Development Plan 2017 - 2022*.

Bergrivier Municipality. (2019). *Bergrivier Municipality Spatial Development Framework: 2019 - 2024*.

Bergrivier Municipality. (2020a). *Annual Report Final Draft: 2019/20*. http://www.bergmun.org.za/resource-category/annual-reports

Bergrivier Municipality. (2020b, 30 September 2020). *Bergrivier Municipality website: News* http://www.bergmun.org.za/water-restrictions-lifted

Biggs, E. M., Boruff, B., Bruce, E., Duncan, J. M. A., Haworth, B. J., Duce, S., Horsley, J., Curnow, J., Neef, A., McNeill, K., Pauli, N., Van Ogtrop, F., & Imanari, Y. (2014). *Environmental livelihood security in Southeast Asia and Oceania: a water-energy-food-livelihoods nexus approach for spatially assessing change. White paper.*

Biggs, E. M., Bruce, E., Boruff, B., Duncan, J. M. A., Horsley, J., Pauli, N., McNeill, K., Neef, A., Van Ogtrop, F., Curnow, J., Haworth, B., Duce, S., & Imanari, Y. (2015). Sustainable development and the water–energy–food nexus: A perspective on livelihoods. *Environmental Science & Policy*, *54*, 389-397. https://doi.org/10.1016/j.envsci.2015.08.002

Bizikova, L., Roy, D., Swanson, D., Venema, H. D., & McCandless, M. (2013). *The Water–Energy–Food Security Nexus: Towards a practical planning and decision-support framework for landscape investment and risk management*. I. I. f. S. Development.

Bowman, A. (2020). Parastatals and economic transformation in South Africa: The political economy of the Eskom crisis. *African Affairs*, *119*(476), 395-431. https://doi.org/10.1093/afraf/adaa013

Brandt, P., Ernst, A., Gralla, F., Luederitz, C., Lang, D. J., Newig, J., Reinert, F., Abson, D. J., & Von Wehrden, H. (2013). A review of transdisciplinary research in sustainability science. *Ecological Economics*, *92*, 1-15. https://doi.org/10.1016/j.ecolecon.2013.04.008

Braun, V., and Clarke, Victoria. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*, 77-101.

Caiado Couto, L., Campos, L. C., Da Fonseca-Zang, W., Zang, J., & Bleischwitz, R. (2021). Water, waste, energy and food nexus in Brazil: Identifying a resource interlinkage research agenda through a systematic review. *Renewable and Sustainable Energy Reviews*, *138*, 110554. https://doi.org/10.1016/j.rser.2020.110554

Cairns, R., & Krzywoszynska, A. (2016). Anatomy of a buzzword: The emergence of 'the water-energy-food nexus' in UK natural resource debates. *Environmental Science & Policy*, *64*, 164-170. https://doi.org/10.1016/j.envsci.2016.07.007

Chambers, R., and , & Conway, G. (1992). *Sustainable rural livelihoods: practical concepts for the 21st century.* Institute of Development Studies.

Chirisa, I., & Bandauko, E. (2015). African Cities and the Water-Food-Climate-Energy Nexus: an Agenda for Sustainability and Resilience at a Local Level. *Urban Forum*, *26*(4), 391-404. https://doi.org/10.1007/s12132-015-9256-6

Cinnamon, J., and Noth, Tanner. (2023). Spatiotemporal development of informal settlements in Cape Town, 2000 to 2020: An open data approach. *Habitat International*, *133*.

Clark, B. M., Hutchings, K., & Lamberth, S. J. (2009). Long-term variations in composition and abundance of fish in the Berg Estuary, South Africa. *Transactions of the Royal Society of South Africa*, *64*(2), 238-258. https://doi.org/10.1080/00359190909519255

Clark, V. L. P., and, & Ivankova, N. V. (2016). *Mixed Methods Research: A Guide to the Field*. https://doi.org/10.4135/9781483398341

Cole, M. J., Bailey, R. M., Cullis, J. D. S., & New, M. G. (2018). Spatial inequality in water access and water use in South Africa. *Water Policy*, *20*(1), 37-52. https://doi.org/10.2166/wp.2017.111

Collins, K., M.T. (2010). Advanced Sampling Designs in Mixed Research:

Current Practices and Emerging Trends in the Social and Behavioral Sciences. In A. Tashakkori & C. Teddlie (Eds.), *SAGE Handbook of Mixed Methods in Social & Behavioral Research* (pp. 353-378). Sage. https://doi.org/10.4135/9781506335193

Comins, L. (2021, 5 September 2021). Eskom's double-digit tariff request unaffordable for struggling consumers. *Mail & Guardian*. https://mg.co.za/business/2021-09-05-eskoms-double-digit-tariff-request-unaffordable-for-struggling-consumers/

Creswell, J., & Plano Clark, V. (2007). *Designing and Conducting Mixed Methods Research*. Sage.

Creswell, J. W., & Creswell, J. D. (2018). *Research Design : Qualitative, Quantitative, and Mixed Methods Approaches* (Fifth ed.). Sage Publications.

Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A., & Sheikh, A. (2011). The case study approach. *BMC Medical Research Methodology*, *11*(1), 100. https://doi.org/10.1186/1471-2288-11-100

Daher, B. T., & Mohtar, R. H. (2015). Water–energy–food (WEF) Nexus Tool 2.0: guiding integrative resource planning and decision-making. *Water International*, *40*(5-6), 748-771. https://doi.org/10.1080/02508060.2015.1074148

Dalla Fontana, M., Wahl, D., Moreira, F. d. A., Offermans, A., Ness, B., Malheiros, T. F., & Di Giulio, G. M. (2021). The Five Ws of the Water-Energy-Food Nexus: A Reflexive Approach to Enable the Production of Actionable Knowledge. *Frontiers in Water*, *3*. https://doi.org/10.3389/frwa.2021.729722

Dargin, J., Daher, B., & Mohtar, R. H. (2019). Complexity versus simplicity in water energy food nexus (WEF) assessment tools. *Sci Total Environ*, *650*(Pt 1), 1566-1575. https://doi.org/10.1016/j.scitotenv.2018.09.080

Department of Agriculture Forestry and Fisheries. (2015). *Proclaimed Fishing Harbours*.

Department of Energy. (2019). *South African Energy Sector Report*. Pretoria: Department of Energy

Department of Environmental Affairs. (2018). *South Africa's Third National Communication under the United Nationas Framework Convention on Climate Change*. Pretoria, South Africa,: Department of Environmental Affairs,

Department of Social Development, D. o. A. F. a. F. (2014). *The National Policy on Food and Nutrition Security for the Republic of South Africa*.

Department of Water Affairs. (2013). *National Water Resource Strategy*. Pretoria: Department of Water Affairs

DFID. (1999). SUSTAINABLE LIVELIHOODS GUIDANCE SHEETS. In D. f. I. Development (Ed.): DFID.

Ellinger, A. D., & McWhorter, R. (2016). Qualitative Case Study Research as Empirical Inquiry. *International Journal of Adult Vocational Education and Technology*, *7*(3), 1-13. https://doi.org/10.4018/ijavet.2016070101

Endo, A., Tsurita, I., Burnett, K., & Orencio, P. M. (2017). A review of the current state of research on the water, energy, and food nexus. *Journal of Hydrology: Regional Studies*, *11*, 20-30. https://doi.org/10.1016/j.ejrh.2015.11.010

Fader, M., Cranmer, C., Lawford, R., & Engel-Cox, J. (2018). Toward an Understanding of Synergies and Trade-Offs Between Water, Energy, and Food SDG Targets. *Frontiers in Environmental Science*, *6*. https://doi.org/10.3389/fenvs.2018.00112

FAO, I. a. W. (2013). *The State of Food Insecurity in the World 2013. The multiple dimensions of food security.*

Fernandes Torres, C. J., Peixoto de Lima, C. H., Suzart de Almeida Goodwin, B., Rebello de Aguiar Junior, T., Sousa Fontes, A., Veras Ribeiro, D., Saldanha Xavier da Silva, R., & Dantas Pinto Medeiros, Y. (2019). A Literature Review to Propose a Systematic Procedure to Develop “Nexus Thinking” Considering the Water–Energy–Food Nexus. *Sustainability*, *11*(24). https://doi.org/10.3390/su11247205

Foden, M., Browne, A. L., Evans, D. M., Sharp, L., & Watson, M. (2019). The water–energy–food nexus at home: New opportunities for policy interventions in household sustainability. *The Geographical Journal*, *185*(4), 406-418. https://doi.org/10.1111/geoj.12257

Foran, T. (2014). Node and regime: Interdisciplinary analysis of water-energy-food nexus in the Mekong region. *Water Alternatives*, *8(1)*, 655-674.

Future Earth. (2018). *Research and Engagement Plan for the Water-Energy-Food Knowledge-Action Network* (Report of the Development Team, Issue. F. Earth.

Givens, J. E., Padowski, J., Guzman, C. D., Malek, K., Witinok-Huber, R., Cosens, B., Briscoe, M., Boll, J., & Adam, J. (2018). Incorporating Social System Dynamics in the Columbia River Basin: Food-Energy-Water Resilience and Sustainability Modeling in the Yakima River Basin. *Frontiers in Environmental Science*, *6*. https://doi.org/10.3389/fenvs.2018.00104

Gragg, R. S., Anandhi, A., Jiru, M., & Usher, K. M. (2018). A Conceptualization of the Urban Food-Energy-Water Nexus Sustainability Paradigm: Modeling From Theory to Practice. *Frontiers in Environmental Science*, *6*. https://doi.org/10.3389/fenvs.2018.00133

Halbe, J., Pahl-Wostl, C., A. Lange, M., & Velonis, C. (2015). Governance of transitions towards sustainable development – the water–energy–food nexus in Cyprus. *Water International*, *40*(5-6), 877-894. https://doi.org/10.1080/02508060.2015.1070328

Harwood, S. A. (2018). In search of a (WEF) nexus approach. *Environmental Science & Policy*, *83*, 79-85. https://doi.org/10.1016/j.envsci.2018.01.020

Hoff, H. (2011). Understanding the Nexus. Bonn 2011 Conference: The Water, Energy and Food Security Nexus., Bonn.

Howells, M., Hermann, S., Welsch, M., Bazilian, M., Segerström, R., Alfstad, T., Gielen, D., Rogner, H., Fischer, G., van Velthuizen, H., Wiberg, D., Young, C., Roehrl, R. A., Mueller, A., Steduto, P., & Ramma, I. (2013). Integrated analysis of climate change, land-use, energy and water strategies. *Nature Climate Change*, *3*(7), 621-626. https://doi.org/10.1038/nclimate1789

Hulley, S. (2015). *The food-energy-water-land-biodiversity (FEWLB) nexus through the lens of the local level: An agricultural case study* Univeristy of Cape Town]. Cape Town.

Huntington, H. P., Schmidt, J. I., Loring, P. A., Whitney, E., Aggarwal, S., Byrd, A. G., Dev, S., Dotson, A. D., Huang, D., Johnson, B., Karenzi, J., Penn, H. J. F., Salmon, A., Sambor, D. J., Schnabel, W. E., Wies, R. W., & Wilber, M. (2021). Applying the food–energy–water nexus concept at the local scale. *Nature Sustainability*, *4*(8), 672-679. https://doi.org/10.1038/s41893-021-00719-1

Hussien, W. E. A., Memon, F. A., & Savic, D. A. (2017). An integrated model to evaluate water-energy-food nexus at a household scale. *Environmental Modelling & Software*, *93*, 366-380. https://doi.org/10.1016/j.envsoft.2017.03.034

Hutchings, K., Clark, B., Atkinson, L., and Attwood, C. . (2008). Evidence of recovery of the line fishery in the Berg River estuary, Western Cape, South Africa, subsequent to closure of commercial gillnetting. *African Journal of Marine Science*, *30*(3), 10.

Independent Electoral Commission. (2022). *Election Types*. Independent Electoral Commission. Retrieved 12 January 2022 from https://www.elections.org.za/content/Elections/Election-types/

IPBES. (2018). *THE IPBES REGIONAL ASSESSMENT REPORT ON BIODIVERSITY AND ECOSYSTEM SERVICES FOR AFRICA*. S. o. t. I. S.-P. P. o. B. a. E. Services.

IPCC. (2021). Summary for Policymakers. In V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, & B. Zhou (Eds.), *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Jaka, H. (2019). *An exploration of WEF-nexus coping strategies of rural women in Masvingo Province, Zimbabwe and Limpopo Province, South Africa* [Doctorate, North-West University]. https://repository.nwu.ac.za/bitstream/handle/10394/33088/Jaka_H.pdf?sequence=1

James, A. (2011). *The impacts of the gillnet fishery closure on small-scale fishers at the Berg Estuary* University of Cape Town]. Cape Town.

Jamshed, S. (2014). Qualitative research method-interviewing and observation. *J Basic Clin Pharm*, *5*(4), 87-88. https://doi.org/10.4103/0976-0105.141942

Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2007). Toward a Definition of Mixed Methods Research. *Journal of Mixed Methods Research*, *1*(2), 112-133. https://doi.org/10.1177/1558689806298224

Keskinen, M., Guillaume, J., Kattelus, M., Porkka, M., Räsänen, T., & Varis, O. (2016). The Water-Energy-Food Nexus and the Transboundary Context: Insights from Large Asian Rivers. *Water*, *8*(5), 193. https://doi.org/10.3390/w8050193

Kurian, M., Scott, C., Reddy, V. R., Alabaster, G., Nardocci, A., Portney, K., Boer, R., & Hannibal, B. (2019). One Swallow Does Not Make a Summer: Siloes, Trade-Offs and Synergies in the Water-Energy-Food Nexus. *Frontiers in Environmental Science*, *7*. https://doi.org/10.3389/fenvs.2019.00032

Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M., & Thomas, C. J. (2012). Transdisciplinary research in sustainability science: practice, principles, and challenges. *Sustainability Science*, *7*(S1), 25-43. https://doi.org/10.1007/s11625-011-0149-x

Leck, H., Conway, D., Bradshaw, M., & Rees, J. (2015). Tracing the Water–Energy–Food Nexus: Description, Theory and Practice. *Geography Compass*, *9*(8), 445-460. https://doi.org/10.1111/gec3.12222

Leese, M., & Meisch, S. (2015). Securitising Sustainability? Questioning the 'Water, Energy and FoodSecurity Nexus. *Water Alternatives*, *8*, 695-709.

Liu, J., Yang, H., Cudennec, C., Gain, A. K., Hoff, H., Lawford, R., Qi, J., Strasser, L. d., Yillia, P. T., & Zheng, C. (2017). Challenges in operationalizing the water–energy–food nexus. *Hydrological Sciences Journal*, *62*(11), 1714-1720. https://doi.org/10.1080/02626667.2017.1353695

Mabhaudhi, T., Nhamo, L., Mpandeli, S., Nhemachena, C., Senzanje, A., Sobratee, N., Chivenge, P. P., Slotow, R., Naidoo, D., Liphadzi, S., & Modi, A. T. (2019). The Water–Energy–Food Nexus as a Tool to Transform Rural Livelihoods and Well-Being in Southern Africa. *International Journal of Environmental Research and Public Health*, *16*(16), 2970. https://doi.org/10.3390/ijerph16162970

Mabhaudhi, T., Simpson, G., Badenhorst, J., Senzanje, A., Jewitt, G. P. W., Chimonyo, V. G. P., Mpandeli, S., & Nhamo, L. (2021). Developing a Framework for the Water-Energy-Food Nexus in South Africa. In *Climate Change and Water Resources in Africa* (pp. 407-431). Springer International Publishing. https://doi.org/10.1007/978-3-030-61225-2_18

Mcgrane, S. J., Acuto, M., Artioli, F., Chen, P. Y., Comber, R., Cottee, J., Farr-Wharton, G., Green, N., Helfgott, A., Larcom, S., Mccann, J. A., O'Reilly, P., Salmoral, G., Scott, M., Todman, L. C., Gevelt, T., & Yan, X. (2019). Scaling the nexus: Towards integrated frameworks for analysing water, energy and food. *The Geographical Journal*, *185*(4), 419-431. https://doi.org/10.1111/geoj.12256

Mdee, A. (2017). Disaggregating orders of water scarcity The politics of nexus in the Wami-Ruvu River Basin, Tanzania. *Water Alternatives*, *10*(1), 100-115.

Melo, F. P. L., Parry, L., Brancalion, P. H. S., Pinto, S. R. R., Freitas, J., Manhães, A. P., Meli, P., Ganade, G., & Chazdon, R. L. (2020). Adding forests to the water–energy–food nexus. *Nature Sustainability*, *4*(2), 85-92. https://doi.org/10.1038/s41893-020-00608-z

Merriam, S. B. (1998). Case Studies as Qualitative Research. In *Qualitative research and case study application in education* (2nd ed., pp. 26-43). Jossey-Bass.

Methner, N., Midgley, S. J. E., Price, P., Ningi, T., Nxumalo, N. P., Rebelo, A. J., Stuart-Hill, S. I., Zhou, L., Mjanyelwa, V., & Taruvinga, A. (2021). *EXPLORING THE EVIDENCE OF WATER-ENERGY-FOOD NEXUS LINKAGES TO SUSTAINABLE LOCAL LIVELIHOODS AND WELLBEING IN SOUTH AFRICA* (WRC Report No 2718/1/21).

Mguni, P., Van Vliet, B., Spaargaren, G., Nakirya, D., Osuret, J., Isunju, J. B., Ssekamatte, T., & Mugambe, R. (2020). What could go wrong with cooking? Exploring vulnerability at the water, energy and food Nexus in Kampala through a social practices lens. *Global Environmental Change*, *63*, 102086. https://doi.org/10.1016/j.gloenvcha.2020.102086

Mguni, P., & Van Vliet, B. J. M. (2020). Rethinking the urban Nexus - Resilience and vulnerability at the urban Nexus of Water, Energy and Food (WEF). An introduction to the special issue. *Journal of Integrative Environmental Sciences*, *17*(2), i-v. https://doi.org/10.1080/1943815x.2020.1866617

Middleton, e. a. (2015). The Rise and Implications of the Water-Energy-Food Nexus in Southeast Asia through an Environmental Justice Lens. *Water Alternatives*.

Midgley, S., New, M., Spelman, S., & Parker, K. (2014). *The Food-Energy-Water-Land-Biodiversity (FEWLB) Nexus and Local Economic Development in the Berg River Catchment: Framework and Description*.

Miller-Robbie, L., Ramaswami, A., & Amerasinghe, P. (2017). Wastewater treatment and reuse in urban agriculture: exploring the food, energy, water, and health nexus in Hyderabad, India. *Environmental Research Letters*, *12*. https://doi.org/10.1088/1748-9326/aa6

Mohtar, R., Lawford, R. G., & Engel-Cox, J. A. (2020). Editorial: Achieving Water-Energy-Food Nexus Sustainability: A Science and Data Need or a Need for Integrated Public Policy? *Frontiers in Environmental Science*, *8*. https://doi.org/10.3389/fenvs.2020.00132

Moyo, B. (2019, 5 March 2019). The right to food in South Africa: We need a manifesto for food justice. *Daily Maverick*. https://www.dailymaverick.co.za/article/2019-03-05-the-right-to-food-in-south-africa-we-need-a-manifesto-for-food-justice/

Muller, M. (2015). The 'Nexus' As a Step Back towards a More Coherent Water Resource Management Paradigm. *Water Alternatives*, *8*, 675-694.

Naidoo, D., Nhamo, L., Mpandeli, S., Sobratee, N., Senzanje, A., Liphadzi, S., Slotow, R., Jacobson, M., Modi, A. T., & Mabhaudhi, T. (2021). Operationalising the water-energy-food nexus through the theory of change. *Renewable and Sustainable Energy Reviews*, *149*, 111416. https://doi.org/10.1016/j.rser.2021.111416

National Planning Commission. (2018). *NPC Economy Series: Energy*. Pretoria

Nepfumbada, M. (2020). *National Water Security Framework for South Africa.* Pretoria: National plannign Commission

Nhamo, L., Mabhaudhi, T., Mpandeli, S., Dickens, C., Nhemachena, C., Senzanje, A., Naidoo, D., Liphadzi, S., & Modi, A. T. (2020). An integrative analytical model for the water-

energy-food nexus: South Africa case study. *Environmental Science & Policy*, *109*, 15-24. https://doi.org/10.1016/j.envsci.2020.04.010

Nhamo, L., Ndlela, B., Mpandeli, S., & Mabhaudhi, T. (2020). The Water-Energy-Food Nexus as an Adaptation Strategy for Achieving Sustainable Livelihoods at a Local Level. *Sustainability*, *12*(20), 8582. https://doi.org/10.3390/su12208582

Oceana Group. (2015, 11/02/2015). *OCEANA GROUP ACQUIRES FOODCORP* https://oceana.co.za/oceana-group-acquires-foodcorp/

Olawuyi, D. (2020). Sustainable development and the water-energy-food nexus: Legal challenges and emerging solutions. *Environmental Science & Policy*, *103*, 1-9. https://doi.org/10.1016/j.envsci.2019.10.009

Pahl-Wostl, C. (2019b). Governance of the water-energy-food security nexus: A multi-level coordination challenge. *Environmental Science & Policy*, *92*, 356-367. https://doi.org/10.1016/j.envsci.2017.07.017

Ponelis, S. R. (2015). Using interpretive qualitative case studies for exploratory research in doctoral studies: A case of Information Systems research in small and medium enterprises. *International Journal of Doctoral Studies*, *10*, 535-550.

Ramos, E. P., et al (2021). The climate, land, energy, and water systems (CLEWs) framework: a retrospective of activities and advances to 2019. *Environmental Research Letters*, *16*(033003).

Rasul, G. (2014). Food, water, and energy security in South Asia: A nexus perspective from the Hindu Kush Himalayan region☆. *Environmental Science & Policy*, *39*, 35-48. https://doi.org/10.1016/j.envsci.2014.01.010

Republic of South Africa. (1996). *Constitution of the Republic of South Africa, Act No. 108 of 1996*. Cape Town: Government Gazette

Republic of South Africa. (1998). *National Water Act, No. 36 of 1998*. Cape Town: Government Gazette

Republic of South Africa. (2000). *Municipal Systems Act, No. 32 of 2000*. Cape Town: Government Gazette,

Republic of South Africa. (2004). *National Energy Regulator Act, No. 40 of 2004*. Cape Town: Government Gazette

Republic of South Africa. (2006). *Electricity Regulation Act, No. 4 of 2006*. Cape Town: Government Gazette

Republic of South Africa. (2019). *Division of Revenue Act, No.16 of 2019*. G. Gazette.

Ringler, C., Bhaduri, A., & Lawford, R. (2013). The nexus across water, energy, land and food (WELF): potential for improved resource use efficiency? *Current Opinion in Environmental Sustainability*, *5*(6), 617-624. https://doi.org/10.1016/j.cosust.2013.11.002

Rode & Associates CC, A. P. L., Anneke de Kock Environmental Consultants, Prof Wolfgang Thomas. (2008). *Bergrivier Municipality Spatial Development Framework*.

Saldana, J. (2021). *The coding manual for qualitative researchers* (J. Seaman, Ed.). SAGE Publications Ltd.

Saunders, M., Lewis, P., & Thornhill, A. (2019). Understanding research philosophy and approaches to theory development. In *Research Methods for Business Students* (8th ed., pp. 128-170). Pearson.

Scoones, I. (1998). *SUSTAINABLE RURAL LIVELIHOODS A FRAMEWORK FOR ANALYSIS*.

Seeliger, L., de Clercq, W. P., Hoffman, W., Cullis, J. D. S., Horn, A. M., & de Witt, M. (2018). Applying the water-energy-food nexus to farm profitability in the Middle Breede

Catchment, South Africa. *South African Journal of Science*, *114*(11/12). https://doi.org/10.17159/sajs.2018/5062

Shackleton, S., Bezara, J. C., Cockburn, J., Reed, M., & Abu, R. (2021). Interviews and Surveys. In R. Biggs, A. De Vos, R. Preiser, H. Clements, K. Maciejewski, & M. Schluter (Eds.), *The Routledge handbook of research methods for social-ecological systems* (pp. 107-118). Routledge.

Sihlobo, W. (2021, 14 July 2021). South African riots and food security: why there's an urgent need to restore stability. *The Conversation*. https://theconversation.com/south-african-riots-and-food-security-why-theres-an-urgent-need-to-restore-stability-164493

Simpson, G. B., Badenhorst, J., Jewitt, G. P. W., Berchner, M., & Davies, E. (2019). Competition for Land: The Water-Energy-Food Nexus and Coal Mining in Mpumalanga Province, South Africa. *Frontiers in Environmental Science*, *7*. https://doi.org/10.3389/fenvs.2019.00086

Simpson, G. B., & Jewitt, G. P. W. (2019). The water-energy-food nexus in the anthropocene: moving from 'nexus thinking' to 'nexus action'. *Current Opinion in Environmental Sustainability*, *40*, 117-123. https://doi.org/10.1016/j.cosust.2019.10.007

Slorach, P. C., Jeswani, H. K., Cuéllar-Franca, R., & Azapagic, A. (2020). Environmental sustainability in the food-energy-water-health nexus: A new methodology and an application to food waste in a circular economy. *Waste Management*, *113*, 359-368. https://doi.org/10.1016/j.wasman.2020.06.012

Smajgl, A., Ward, J., & Pluschke, L. (2016). The water–food–energy Nexus – Realising a new paradigm. *Journal of Hydrology*, *533*, 533-540. https://doi.org/10.1016/j.jhydrol.2015.12.033

South African Government. (2022). *Home » FAQs » Government Services*. Government of South Africa. Retrieved 07 January 2022 from https://www.gov.za/faq/government-services/how-do-i-access-free-basic-municipal-services

Spiegelberg, M., Baltazar, D. E., Sarigumba, M. P. E., Orencio, P. M., Hoshino, S., Hashimoto, S., Taniguchi, M., & Endo, A. (2017). Unfolding livelihood aspects of the Water–Energy–Food Nexus in the Dampalit Watershed, Philippines. *Journal of Hydrology: Regional Studies*, *11*, 53-68. https://doi.org/10.1016/j.ejrh.2015.10.009

Srivastava, S., & Mehta, L. (2014). *Nexus and Security Not Another Nexus? Critical Thinking on the New Security Convergence in Energy, Food, Climate and Water* (STEPS Working Paper, Issue. S. Centre.

Stake, R. E. (1995). *The art of case study research*. Sage Publications Ltd.

Statistics South Africa. (2012). *Census 2011: Statistical release*.

Statistics South Africa. (2017). *The state of basic service delivery in South Africa: In-depth analysis of the Community Survey 2016 data*. (03-01-22 2016). Pretoria: Statistics South Africa

Statistics South Africa. (2019a). *General Household Survey 2019*. Pretoria: Statistics South Africa

Statistics South Africa. (2019b). *Quarterly Labour Force Survery: Quarter 4 2019*. Pretoria: Statistics South Africa

Statistics South Africa. (2019c). *Quarterly Labour Force Survey: Quarter 3 2019*. Pretoria: Statistics South Africa

Statistics South Africa. (2019d). *Towards measuring the extent of food security in South Africa: An examination of hunger and food adequacy*. (03-00-14). Pretoria: Statistics South Africa

Stein, c., Barron, J., & Moss, T. (2014). *Governance of the nexus: from buzz words to a strategic action perspective* (Nexus Network Think Piece Series,, Issue.

Stevens, L., & Gallagher, M. (2015). The Energy–Water–Food Nexus at Decentralized Scales: synergies, trade-offs, and how to manage them. In. Practical Action Publishing,.

Stringer, L. C., Quinn, C. H., Le, H. T. V., Msuya, F., Pezzuti, J., Dallimer, M., Afionis, S., Berman, R., Orchard, S. E., & Rijal, M. L. (2018). A New Framework to Enable Equitable Outcomes: Resilience and Nexus Approaches Combined. *Earth's Future*, *6*(6), 902-918. https://doi.org/10.1029/2017ef000694

Sušnik, J., Chew, C., Domingo, X., Mereu, S., Trabucco, A., Evans, B., Vamvakeridou-Lyroudia, L., Savić, D., Laspidou, C., & Brouwer, F. (2018). Multi-Stakeholder Development of a Serious Game to Explore the Water-Energy-Food-Land-Climate Nexus: The SIM4NEXUS Approach. *Water*, *10*(2), 139. https://doi.org/10.3390/w10020139

Tawodzera, G. (2016). *Local food geographies: The nature and extent of food insecurity in South Africa*. U. a. C. o. E. o. F. S. PLAAS.

Terrapon-Pfaff, J., Ortiz, W., Dienst, C., & Gröne, M.-C. (2018). Energising the WEF nexus to enhance sustainable development at local level. *Journal of Environmental Management*, *223*, 409-416. https://doi.org/10.1016/j.jenvman.2018.06.037

Theron, S. N., Archer, E., Midgley, S. J. E., & Walker, S. (2021). Agricultural perspectives on the 2015-2018 Western Cape drought, South Africa: Characteristics and spatial variability in the core wheat growing regions. *Agricultural and Forest Meteorology*, *304-305*. https://doi.org/10.1016/j.agrformet.2021.108405

Ting, M. B., and, & Byrne, R. (2020). Eskom and the rise of renewables: Regime-resistance, crisis and the strategy of incumbency in South Africa's electricity system. *Energy Research & Social Science*, *60*. https://doi.org/10.1016/j.erss.2019.101333

Treasury, N. (2011). *2011 Local Government Budgets and Expenditure Review*. Pretoria: National Treasury

Turok, I., & Borel-Saladin, J. (2016). Backyard shacks, informality and the urban housing crisis in South Africa: stopgap or prototype solution? *Housing Studies*, *31*(4), 384-409. https://doi.org/10.1080/02673037.2015.1091921

UNDESA. (2019). *World Population Prospects 2019: Ten Key Findings*. U. Nations.

UNGA. (2015). *Transforming Our World: The 2030 Agenda for Sustainable Development*. UN General Assembly. https://sdgs.un.org/sites/default/files/publications/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

Van Wynsberghe, R., and , & Kahn, S. (2007). Redefining Case Study. *International Journal of Qualitative Methodology*, *6*(2), 80-94.

Vermeulen, H. (2020). *A balanced food basket approach to monitor food affordability in South Africa* University of Pretoria Pretoria]. Pretoria.

Villamor, G. B., Guta, D. D., Djanibekov, U., & Mirzabaev, A. (2018). Gender Specific Perspectives Among Smallholder Farm Households on Water-Energy-Food Security Nexus Issues in Ethiopia. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3180530

Weitz, N., HuberLee, A., Nilsson, M., Davis, M., & Hoff, H. (2014). *Cross-sectoral integration in the Sustainable Development Goals: a nexus approach*.

Welsch, M., Hermann, S., Howells, M., Rogner, H. H., Young, C., Ramma, I., Bazilian, M., Fischer, G., Alfstad, T., Gielen, D., Le Blanc, D., Röhrl, A., Steduto, P., & Müller, A. (2014). Adding value with CLEWS – Modelling the energy system and its interdependencies for Mauritius. *Applied Energy*, *113*, 1434-1445. https://doi.org/10.1016/j.apenergy.2013.08.083

West Coast District Municipality. (2020). *West Coast District IDP Amended-IDP-2020-21-V4-1*.

Western Cape Government. (2020). *Municipal Economic Review and Outlook*.

Western Cape Government. (2021). *Draft Berg River Estuarine Management Plan*.

Wichelns, D. (2017). The water-energy-food nexus: Is the increasing attention warranted, from either a research or policy perspective? *Environmental Science & Policy*, *69*, 113-123. https://doi.org/10.1016/j.envsci.2016.12.018

Wiegleb, V., & Bruns, A. (2018). What Is Driving the Water-Energy-Food Nexus? Discourses, Knowledge, and Politics of an Emerging Resource Governance Concept. *Frontiers in Environmental Science*, *6*. https://doi.org/10.3389/fenvs.2018.00128

Winde, A. (2012, 19 November 2012). *The Saldanha Bay Industrial Development Zone (IDZ) would create up to 25 000 jobs* https://www.gov.za/saldanha-bay-industrial-development-zone-idz-would-create-25-000-jobs

Wolde, Z., Wei, W., Kunpeng, W., & Ketema, H. (2020). Local community perceptions toward livelihood and water–energy–food nexus: A perspective on food security. *Food and Energy Security*, *9*(3). https://doi.org/10.1002/fes3.207

World Bank Group. (2021, 2021). *Climate Change Knowledge Portal*. World Bank Group. Retrieved 07/01/2022 from https://climateknowledgeportal.worldbank.org/country/south-africa/climate-data-historical

World Economic Forum. (2011a). *Global Risks 2011, Sixth Edition. An initiative of the Risk Response Network*. W. E. Forum.

World Economic Forum. (2011b). *Water Security: The Water–Food–Energy– Climate Nexus*. I. Press.

World Wildlife Fund and SAB Miller. (2014). *The Water-Food-Energy Nexus: Insights Into Resilient Development*. http://assets.wwf.org.uk/downloads/sab03_01_sab_wwf_project_nexus_final.pdf

Yin, R. K. (2002). *Case Study Research, Design and Methods, 3rd ed.* (S. Publications, Ed.).

Yin, R. K. (2009). *Case study research: design and methods* (Vol. 5). Sage.

Yuan, M.-H., Chiueh, P.-T., & Lo, S.-L. (2021). Measuring urban food-energy-water nexus sustainability: Finding solutions for cities. *Science of The Total Environment*, *752*, 141954. https://doi.org/10.1016/j.scitotenv.2020.141954

Appendices

Appendix A: Household Questionnaire

C:\Users\USER\Dropbox\FEW Nexus\WRC WEF Nexus Household Scale\Masters\Pen's thesis\Submission\WEF Household Questionnaire Velddrif.docx

Water Energy Food Nexus Questionnaire

We, the University of Cape Town are carrying out a questionnaire which forms part of a larger research project that examines the interplay between the life-sustaining resources of water, energy and food (WEF Nexus) at a household level. The aim of the project is to establish how this nexus impacts on livelihoods and wellbeing at both a household and community level. This project is working in three catchments across the country, the Berg River catchment being one of these. In the Berg catchment, the project is working in two sites, namely in the Velddrif area, as well as in the Pniel area. The other two catchments involved in the study are the Keiskamma catchment in the uMngeni and the Eastern Cape in KwaZulu-Natal. The project is funded by the national Water Research Commission.

The aim of this questionnaire is to improve our understanding of household energy, water and/or food insecurities and their impacts on the household (primary focus on access to these resources).

Before completing the questionnaire, we would like you to read and sign the **Informed Voluntary Consent to Participate in Research Study.** Please note that your participation in this study is completely voluntary. You can decline to participate, and you can withdraw at any time.

If you have any questions about this questionnaire, please contact Penny Price, who is the researcher in the Velddrif area on xxx xxx xxxx.

Thank you for taking the time to complete in this questionnaire jointly with me. It should only take an hour of your time.

Section A: General Information

Interviewer Details

Questionnaire No. _____

Student Name Penny Price

Interviewer Name _____

Location Details

Site Velddrif

District West Coast

Municipality Bergrivier

Suburb/Ward/Village _____

Street address _____

GPS code from Smart Phone _____

Type of Building Structure *(Mark both building structure and type of dwelling)*

Brick and mortar □ Main house □

Wood □ Backyard dwelling □

Zinc □ Other □ Specify: _____

Person Interviewed Details

Name _____

Contact Number: _____

A1. How many years have you been living here? *(Mark relevant box with a x)*

0 - 2 years □ 11 - 20 years □

3 - 10 years □ 20+ years □

A2 How many people live in this house?

Household Members	Gender	Age	Head of Household	Main Source of Income	Other Income
Person 1					

Person 2					
Person 4					
Person 5					
Person 6					
Person 7					
Person 8					
Person 9					
Total in Household					

Age Categories:

Adults	61 & older	Youth	31-35	Children	10-12
	51-60		26-30		6-9
	41-50		19-25		2-5
	36-40		13-18		0-2

A5. What is the nature of employment of the members of the household that are employed? *(Mark relevant boxes)*

Household Members	**Full Time** (*40 to 45 hours a week)*	**Part Time** (*less than 40 hours a week)*	**Permanent**	**Contract**	**Seasonal** (*having employment for a seasonal period, e.g. in autumn for harvest.)*	**Casual** (*having employment on an ad hoc basis, nothing regular or planned, but as the employer sees the need on a day to day basis.)*
Person 1						
Person 2						
Person 3						
Person 4						
Person 5						
Person 6						
Person 7						
Person 8						
Person 9						

A5.1 What sectors do the household members work in? *(Fill in details for roles and sectors)*

Household Members	**Sector** (e.g. building, retail, engineering, municipality, agriculture, fishing, etc)	**Role** (e.g. labourer, driver, cleaner, manager, own business, etc)	**Duration** (how long)	**Were they employed before this?** If yes, give details.
Person 1				
Person 2				
Person 3				
Person 4				
Person 5				
Person 6				
Person 7				
Person 8				
Person 9				

A6. Does your household receive any of the following municipal services? *(Mark relevant answers with a x)*

Electricity	□	Refuse removal	□
Water	□	Sewerage	□

A6.1. If yes, how would you rate the reliability of the municipal services in terms of water and electricity supply in your neighbourhood? *(Mark relevant answers with a x)*

	Water	**Electricity**	**Refuse Removal**	**Sewerage**
Reliable *(always available except for maintenance or rare accident)*				
Unreliable *(lack of supply which leads to significant disruption of household activities)*				

A7. Does your household use local natural resources/environment *(e.g. river, estuary, beach)* for meeting the household water energy and food needs? *(Write down detail of resource use)*

	Food *(e.g. fishing)*	Energy *(e.g. collecting wood)*	Water *(e.g. washing clothes)*
River			
Estuary			
Beach			
Ocean			
Other			

A8. What are the biggest challenges that your household is facing at the moment? (*List all that applies)*

Section B. Water

W1. Are you always able to meet your water demands?

Yes □ No □

W1.1 If no, is it:

Regularly □ Sometimes □ Hardly ever □

W2. What is your household's main source of drinking water? *(Mark relevant answers with x)*

Piped (tap) water in house	□	Borehole water in yard	□
Piped (tap) water in yard	□	Borehole outside yard	□
Rain-water tank in yard	□	Public/communal tap	□
Neighbour's tap	□	Well point	□
Inside main house (if backyarder)	□		

Other, specify _____

W2.1 How far is the water source indicated above from the house / dwelling? *(Mark relevant answers with x)*

Inside the house	□	Less than 200 metres	□
Inside the yard/plot	□	Do not know	□

W2.2 What is the quality of your main source of drinking water (before you have treated it)? *(Mark relevant answers with a x)*

	Yes	**No**
Safe to drink?	□	□
Looks bad (colour)	□	□
Taste bad	□	□
Smells bad	□	□

W2.3 If your main source of drinking water looks, tastes or smells bad, what do you do? *(Mark relevant answers with x)*

Nothing □

Use an alternative source (e.g. buy water) □

Treat the water at home (e.g. boiling or filtering) □

Other, specify _____

W3. Please list the main water source for all other household uses in the table below:

Activities	Sources
Washing clothes	
Bathing/ washing	
Cleaning the house	
Home business use	
Watering the garden	
Watering livestock *(e.g. chickens)*	

W4. What type of toilet facility does this household have? *(Mark relevant answers with a x)*

Flush toilet inside □ Communal flush toilet □

Flush toilet outside □ Other, within house premises □

W5. When you can't meet your water needs what measures do you take? *(Mark relevant answers with a x)*

Ask neighbours for help □

Other, specify _____

W6. Do local environmental issues (such as groundwater depletion, water pollution, drought, flooding) impact the availability and quality of water in your household? *(Mark relevant answers with a x)*

Yes □ No □

W6.1 If yes please specify:

	Water Quality	Water Quantity
Water Pollution		
Drought		
Flooding		
Ground Water Depletion		
Other, Specify		

W7. Is the availability and quality of water in your household negatively impacted by poor government service delivery? *(If yes, mark relevant answers with a x)*

Water Quality: Yes □ No □

Water Quantity: Yes □ No □

W8. If water quality is a recurring problem in your area, please specify the impacts this has on the following:

Area	Specify Impact
Your household *(e.g. drinking water)*	
Your home-based business *(e.g. catering)*	
Your workplace outside the home	

W9. If water shortage is a recurring problem in your area, please specify the impact this has on the following:

Area	Specify Impact
Your household *(e.g. drinking water)*	
Your home-based business *(e.g. catering)*	
Your workplace outside the home	

W10. In the x years you have been living in this community has your household access to water:

Improved ☐

Stayed the same ☐

Declined ☐

W11. In the x years you have been living in this community has your household affordability of water:

Improved ☐

Stayed the same ☐

Declined ☐

W12. In the x years you have been living in this community has your household water quality:

Improved ☐

Stayed the same ☐

Declined ☐

W13. Do you take any measures to save water?

Yes ☐ No ☐

W13.1 If yes, can you list them?

W14. What would help you in terms of water security?

Section C. Energy

E1. What types of energy sources do you currently use and approximately how much does each cost per week? *(You can give answer in monthly terms if the respondent prefers)*

	Use	**Estimated cost/week Winter**	**Estimated cost/week Summer**
Electricity	Yes □ No □		
Gas	Yes □ No □		
Paraffin	Yes □ No □		
Fuelwood	Yes □ No □		
Petrol/diesel for generator	Yes □ No □		
Other, specify			

E1.1 Please specify the sources for each household energy use activities:

Household Energy Use Activities	**Sources of Energy**
Cooking	
Lights	
Appliances *(TV, kettle, microwave, fridge, etc)*	
Water heating for bathing	
Water heating for washing dishes	
Laundry *(washing clothes)*	
Household heating	
Home-based business activities	
Others	

E2. Are you always able to meet your energy demands?

Yes □ No □

E2.1 If no, is it:

Regularly □ Sometimes □ Hardly ever □

E3. What measures do you take when you can't meet your energy needs?

_____

_____

_____

_____

_____

_____

E4. Do you use renewable energy sources *(e.g. solar energy, wind power, biogas)* for your household? *(Mark relevant answers with x)*

Yes □ No □

If yes, for what purpose? *(list purpose for each identified renewable energy source)*

Renewable Energy Sources	Purpose

E5. Is electricity service provision a recurring problem in your area? *(Mark relevant answers with x)*

Yes □ No □

E5.1. If yes, please specify the reasons. *(Mark relevant answers with a x)*

Unreliable service provision by the municipality □

Unreliable service provision by Eskom □

Cost of electricity provision is too high for our household □

Other, specify

_____

E5.2 If yes, please specify how / if it impacts you in the following areas:

Area	Specify Impact
Your household *(e.g. lighting or cooking)*	
Your home-based business *(e.g. catering)*	
Your workplace outside the home *(i.e. at work)*	

E6. In the x years you have been living in this community has the access to household electricity:

Improved □ Stayed the same □ Declined □

E7. In the x years you have been living in this community has the affordability of household electricity:

Improved □ Stayed the same □ Declined □

E8. Do you take any measures to save electricity?

Yes □ No □

E8.1 If yes, can you list them?

E9. What would help you in terms of energy security? *(i.e. consistently meeting your energy needs to an affordable price)*

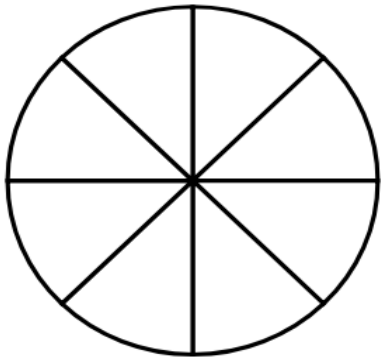
Section D. Food

F1. What regular food items are included in your weekly household 'food basket'?

(Food basket is the food that is typically in your house for a week, can be bought, grown, caught, bartered, etc.)

Food Category	**Balanced Food Basket** *(for low income consumers)*	**Additional Items**
Starch-rich staple foods	Maize meal, brown bread, white bread, rice, potatoes and wheat flour;	
Animal protein foods	Beef mince, chicken pieces, canned pilchards, eggs, polony and beef sausage;	
Vegetables	Tomatoes, onions, carrots, cabbage and pumpkin;	
Fruit	Apples, bananas and oranges;	
Dairy	Full cream milk, sour milk / maas and cheddar cheese;	
Fats & oils	Sunflower oil, margarine and peanut butter;	
Sugary foods	White sugar	
Legumes	Dried beans and baked beans in tomato sauce	

F2. If you think of your weekly household income as a pie, how much of the pie gets used up on food expenses? Indicate what category the remainder is spent on *(i.e. electricity, transport, school, debt, education, rent, clothes, etc.)*



F3. Do you grow your own vegetables/ fruit to help to meet the food needs of the household?

Yes □ No □

F3.1 If yes, what are the sources of water used?

_____

_____

F3.2 If no, please specify the reasons with an x:

No access to land	□	No money to buy seeds/ plants	□
No access to water	□	No interest	□
Poor soil quality	□	No time	□
Security issues	□		

Other, specify _____

F4. Do you keep any animals to help meet the food needs of your household *(e.g. chickens)*

Yes □ No □

F4.1 If yes, please specify what animals

_____

_____

F5. Do you fish to supplement your weekly household food needs?

Regularly □ Sometimes □ Never □

F6. Do you harvest any wild fruit or vegetables to supplement your weekly food needs of the household *(e.g. veldkos)*?

Regularly □ Sometimes □ Never □

F7. Do you hunt to supplement your weekly household food needs?

Regularly □ Sometimes □ Never □

F8. Please indicate where the food items that you buy/ purchase each week come from:

	Bread	Meat	Milk/ diary	Cereal	Canned food	Eggs	Vegetables	Fruit
Supermarket								
Corner shop /spaza shop								
Street trader								
Local farmer/ neighbour								
Other, specify								

F9. Does the household receive food aid *(food parcels)*?

Yes □ No □

F9.1 If yes, from where?

_____

_____

_____

F9.2 If yes, when did the household last received food aid?

Within the last month □ Within the last 6 months □

Within the last 3 months □ Within the last 12 months □

F10. Reflecting on the past x years would you say the affordability of food has:

Improved □ Stayed the same □ Declined □

F11. Reflecting on the past x years the diversity of your weekly household food basket (includes bread, milk, fruit, vegetables, meat, etc) has:

Improved □ Stayed the same □ Declined □

F12. Do you take measures to provide your household with nutritious food at an affordable price?

Yes □ No □

F12.1 If yes, would you please list them?

F13 What would help you in terms of food security?

Glossary

FOOD SECURITY "is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO 2002, p. 49).

Dimensions of food security:

- food availability
- access
- stability of supply
- utilization

ENERGY SECURITY is defined by the International Energy Agency (IEA) as "the uninterrupted availability of energy to an affordable price".

Dimensions of energy security as defined by Sovacool and Brown (2010):

- availability
- affordability
- efficiency
- environmental stewardship

WATER SECURITY "refers to the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies". (Grey and Sadoff, 2007: 545)

The **WATER ENERGY FOOD NEXUS:** describes the interrelationships, synergies and trade-offs between water, energy and food demands and between the natural resources that support these sectors.