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IMPROVING THE CLIMATE CHANGE RESILIENCE OF INFORMAL SETTLEMENTS IN MOUNTAINOUS REGIONS OF AFRICA: COMPARATIVE CASE STUDIES OF QWAQWA IN SOUTH AFRICA AND KONSO IN ETHIOPIA

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DECLARATION

I, **Tamirat Wangore Melore**, declare that the thesis that I herewith submit for the doctoral degree Doctor of Philosophy at the University of the Free State is my independent work and that I have not previously submitted it for a qualification at another institution of higher education.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF EQUATIONS

LIST OF ACRONYMS AND ABBREVIATIONS

°C	Degrees Celsius
ACCCRN	Asian Cities Climate Change Resilience Network
ADPC	Asian Disaster Preparedness Centre
AIKS	African Indigenous Knowledge Systems
ARCISCW	Agricultural Research Council Institute for Soil Climate and Water
CAS	Complex Adaptive System
CCRC	Climate Change Resilience Capacity
CLFLCO	Chlorofluorocarbon
CO_2	Carbon Dioxide
CSA	Central Statistical Agency
DFID	Department for International Development
DRM	Disaster Risk Management
EEA	European Environment Agency
EIA	Environmental Impact Assessment
ENMSA	European Maritime Safety Agency
ETB	Ethiopian Birr
FDRE	Federal Democratic Republic of Ethiopia
FSIN	Food Security Information Network
GGHNP	Golden Gate Highlands National Park
GHG	Green House Gases
GIS	Geographic Information Systems
GVA	Gross Value Added
HAD	Housing Development Agency
HDI	Human Development Index
IDP	Integrated Development Plan
IFAD	International Fund for Agricultural Development
IFRCS	International Federation of Red Cross Society
IHS	Information Handling Services
IK	Indigenous Knowledge
IKS	Indigenous Knowledge System
IPCC	Intergovernmental Panel on Climate Change
M.a.s.l.	Metre above sea level
NASRS	National Academy of Science and the Royal Society
NGOs	Non-Governmental Organizations

NMIE	National Meteorology Institute of Ethiopia
OECD	Organisation for Economic Co-operation and Development
PCA	Principal Component Analysis
PCA	Principal Component Analysis
PSNP	Productive Safety Net Programme
RDP	Reconstruction and Development Programme
RSA	Republic of South Africa
SACN	South African Cities Network
SDF	Sustainable Development Framework
SNNPRS	Southern Nations Nationalities and People's Regional State
SPLUMA	Spatial Planning and Land Use Management Act
SPSS	Statistical Package for Social Sciences
SRA	Social Research Association
Stats SA	Statistics South Africa
TERI	The Energy and Resources Institute
UFS	University of the Free State
UN	United Nations
UNAIDS	United Nations Programme on AIDS
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programmes
UNECOSOC	United Nations Economic and Social Council
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UN-HABITAT	United Nations Human Settlements Programme
UNISDR	United Nations International Strategy for Disaster Reduction
UNU	United Nations University
UNU-EHS	United Nations University Institute for Environment and Human Security
UNWCED	United Nations World Commission on Environment and Development
USAID	United States Agency for International Development
WCRC	World Charter on the Right to the City

ABSTRACT

The aim of this study is to search for the strategies to improve climate change resilience of informal settlements in mountainous regions of Africa. The multidimensional and dynamic features of resilience require the use of a systems approach to research in the field. In line with this, informal settlements' resilience to climate change needs to be recognised as a phenomenon that is multidimensional and complex in its characteristics. Thus, the assessment emphasised analysing various social, economic, spatial and physical variables. Accordingly, the conceptual framework of this study was developed by adopting a systems approach to assess climate change resilience of informal settlements in mountainous regions of Africa. This approach encourages the use of integrated techniques in order to obtain a comprehensive insight into and to investigate the critical factors that determine vulnerability and resilience of informal settlements for climate change-induced risks.

Accordingly, the philosophical position of this study can be categorised as a pragmatic research paradigm. This research paradigm allows the use of mixed research methods. A complex and dynamic system can be understood better by identifying the characteristics of the whole system, such as its interconnectedness, processes and adaptation patterns over time by using a combination of qualitative and quantitative methods. Therefore, a mixed method of research was employed and the findings were confirmed by triangulation of both research methods. Furthermore, a comparative case study method was used, with the rationale of investigating in-depth information about contextual-vulnerability and assessing place-based resilience capacity. The assessment of resilience capacity of the case study areas was done by using a combination of two approaches, namely *"principles to build a resilient system"* and *"capitals for disaster resilience*". These approaches were customised to the context of the case study areas. The capitals existing in the study sites were assessed against those principles needed to build a resilient system.

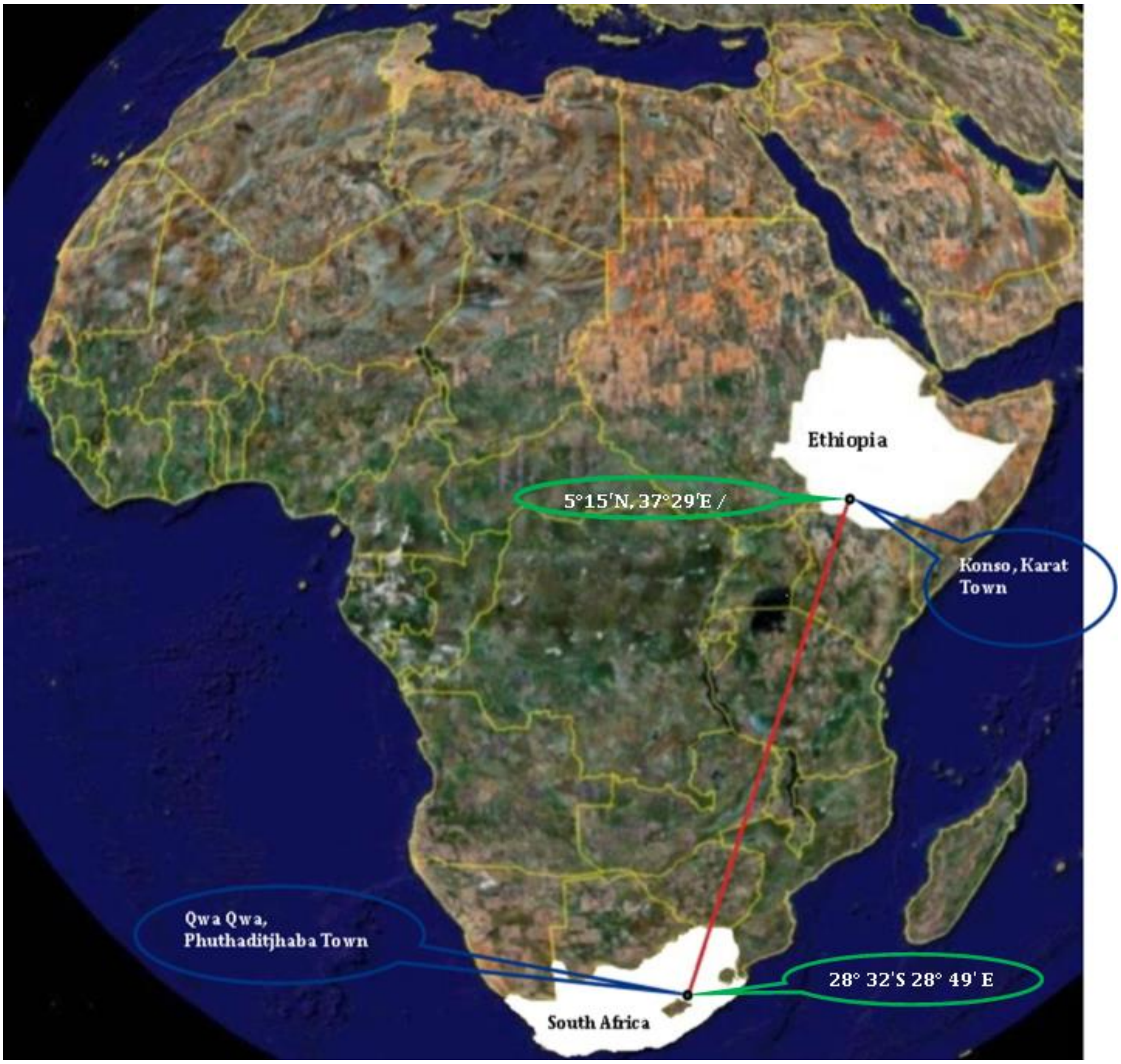
The case studies were conducted at the peripheries of Phuthaditjhaba in South Africa and Karat in Ethiopia. The cultural and natural landscapes of the surrounding areas of the two small towns were registered as world heritage sites by UNESCO. The influence of traditional leadership at the periphery of the two towns is high. The two small towns are both located in mountainous regions of Africa with an altitude exceeding 1 650 metres above sea level. These are the justifications to the selection of the two case study areas for the purpose of this research. To achieve the intended objectives of the study, a theoretical review has been conducted by considering different schools of thought about vulnerability and resilience assessment. The outcome revealed that there is no single universally applicable and accepted vulnerability and resilience assessment framework or model. This is mainly because of the complexity and conceptual pluralism of the concepts. Therefore, to minimise the drawbacks of using a single framework, it is recommended that the hybrid frameworks are used to generate comprehensive and reliable context-based outcome. In addition, flexibility in terms of devising fit-for-the-purpose frameworks is one of the fundamental considerations in theoretical and applied studies.

The findings in the case of Phuthaditjhaba indicated that the area is vulnerable to climate change threats such as shortage of water, flash flooding caused by heavy seasonal rainfall, extremely cold weather conditions during winter, and strong and damaging winds. This result in damage to houses in the informal settlements, soil erosion and rock falls from hillsides that damage the informal settlements situated at the bottom of the Drakensberg Mountains. In the case of Karat, the area is vulnerable to climate change shocks such as periodic droughts, rainfall variability and increasing temperature. This causes reduction of agricultural productivity and makes the local community susceptible to a shortage of water and food. In order to improve resilience, the local communities used to practise indigenous knowledge to build terracing and stonewalls to conserve water and soil, and they used to plant drought-resistant trees.

One outcome of this study revealed that the African indigenous knowledge system that encourages local solutions for local problems must be promoted for resilience planning. Building climate change-resilience capacity of informal settlements requires the successful application of indigenous knowledge and its integration with scientific knowledge. In line with this, the critical question is how to maximise the potential use of indigenous knowledge to cope with complex climate-change risks in informal settlements found in mountainous regions of Africa. Therefore, integration of the indigenous and scientific knowledge systems by considering the contexts of the application is one of the critical strategies to cope with climate change-induced risks. To realise this, the combination of both bottom-up and top-down planning approaches need to be practised and there must be local institutions that facilitate the ’hybridisation’ process. Finally, to improve climate change resilience of informal settlements in both case study areas, it is recommended that customised, hybridised and flexible climate change resilience planning needs to be promoted.

Key words: Climate Change Risks, Systems Approach, Vulnerability, Resilience, Informal Settlements, Hybridisation of Indigenous and Scientific Knowledge, Planning

FIGURE 1: LOCATION OF CASE STUDY AREAS IN THE AFRICAN CONTINENT



Source: Adopted from Google Earth (Retrieved on 11/13/2015).

Chapter 1
ORIENTATION TO THE STUDY

1.1 Introduction

The report of the Intergovernmental Panel on Climate Change [IPCC] (2007:3) revealed that the threats of climate change[1] have been clearly observed around the world. This is evidenced by the increasing concentration of greenhouse gases such as carbon dioxide, methane, chlorofluorocarbon and nitrous oxide in the atmosphere. This causes increasing temperatures and heatwaves, precipitation irregularities that lead to drought and flooding in different parts of the world and rising sea levels. However, the intensity of these risks differs from place to place and it is severe in poor countries. They are more vulnerable to these threats because of lower capacity to cope with them. In developing countries, the threats are aggravated by informal urbanisation, deforestation and poor solid waste management systems. Despite advocating the reduction of emissions of greenhouse gases to the atmosphere, recognising the facts and thinking about climate change resilience[2] should be a burning issue for all nations. These issues are complicated and interconnected between different sectors; hence, they require multi-sectoral solutions. The United Nations International Strategy for Disaster Reduction report [UNISDR] (2011:2) also indicates that informal settlements in developing countries in general, and Africa in particular, are characterised by poor infrastructure and service provision. This heightens the risks associated with climate change.

Nevertheless, climate change resilience of informal settlements has not received appropriate attention with the planning approaches previously focusing on formal systems. In the context of Africa, to achieve the sustainable development goals, there must be a paradigm shift in planning in terms of recognising the imperative of climate change resilience of informal settlements. Otherwise, only focusing on improvement of climate change resilience of formal settlements appears to be like trying to clap with only one hand, making it impossible to achieve the goals of sustainable development (Dodman, Soltesova, Satterthwaite and Tacoli, 2015:5). Therefore, this study focuses on the most ignored portions of informal settlements in terms of building climate change resilience.

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[1] ***Climate change*** *is a change in the pattern of weather, and related changes in oceans, land surfaces and ice sheets, occurring over time scales of decades or longer. It refers to any change in climate over time, weather due to natural variability or as a result of human activity (IPCC, 2007).*

[2] The term ***resilience*** *in this research refers to* ***climate change resilience*** *of a certain system. It does not stand for any other types of resilience.*

1.2 Background to the Study

Rapid informal urbanisation and population growth in Africa increased alarmingly in the last decades. The trend implies that the population will increase from 288 million in 2000 to 555 million in 2020 and it is expected to grow to 1.3 billion in 2050. This creates challenges for local governments to provide serviced land and infrastructure to accommodate the demand of the growing population. The degradation of the natural environment and low agricultural productivity because of climate change-induced risks push the inhabitants to leave their original location. Furthermore, the relative concentration of infrastructure, service facilities and employment opportunities attract the people from the rural areas. The paradox is that poverty is on the increase, while the people still migrate to both small and large towns in Africa (UN-Habitat, 2014:28). The poor migrating from the rural areas prefer to settle informally at the outskirts of these towns. In many cases, they settle in environmentally sensitive areas such as flood-prone areas, hillsides, riverbanks and other hazardous areas. For instance, near to discharges of toxic chemicals. This is a characteristic of informal settlements in developing countries, including Africa. The negative effects of climate change, coupled with chronic poverty in the towns of Africa, threaten the living conditions of poor people and increase the complexity of the challenges they face (Dodman, 2015:5).

As the IPCC report (2007:9) reveals, the degradation of natural resources and the overall ecosystem disorder are increasing. This is a signal for the potential of more climate change threats around the globe. The demand for non-renewable and renewable resources is rising at unprecedented rates. This is mainly because of uncontrolled informal urbanisation and population growth in the world, especially in developing countries. Corfee et al. (2011:169) indicate that unless the world changes the current trend of production, consumption and discharges of waste, the risk of climate change will be more severe, particularly in poor countries. According to the World Risk Report, South Africa and Ethiopia were categorised respectively as medium- and very high-level risks in terms of the vulnerability of their population to climate change-associated risks due to the combination of susceptibility, lack of coping capacities and lack of adaptive capacity (United Nations Universities, Institute for Environment and Human Security [UNU-IEHS], 2011:5).

Therefore, enhancing resilience capacity of climate change for vulnerable people who live in informal settlements is crucial to coping with these risks. People living on steep terrains and environmentally sensitive areas are more susceptible to flooding, landslides, mudslides and other hazards linked to climate change. High population density, the absence of adequate drainage systems, poor housing, the absence of adequate roads, poor liquid and solid waste disposal systems make inhabitants highly vulnerable to climate-change health risks. As indicated by Tyler and Moench (2012:311), the rising climate change-induced risks, coupled with proliferation in formalisation, will possibly increase the challenges to local governments as they attempt to respond to the vulnerabilities of the population, especially the poor. The dynamics of climate will continue over the next century, unless significant measures are taken to reduce greenhouse gas [GHG] emissions and improve climate change resilience in parallel.

Despite the existence of these challenges, planning for climate change resilience of informal settlements in the mountainous landscapes in Africa has not received the necessary attention by various projects undertaken in the towns. The poor populations have not often been considered as priorities in resilience planning and interventions. Thus, people who reside informally are excluded from the benefits of infrastructure, housing schemes and other development benefits found in the formal system. The study places special emphasis on people who settle informally in the mountainous landscapes at the periphery of small towns and their vulnerability to climate change-induced risks and how to improve climate change resilience in the mountainous topography of Africa.

1.3 Rationale of the Study

1.3.1 Problem Statement

As indicated by Sharma, Chettri and Oli (2010:909), mountains cover about 24% of the earth's land surface and are home to some 12% of the world's population. Mountains are an essential source of water, energy, minerals, forest and agricultural products, areas of recreation and other resources. They can be used as the storehouse of biological diversity; it is home to endangered species and comprises integral sections of the global ecosystem. However, most mountainous regions, including those in Africa, face severe environmental degradation because of man-made interventions. Mountains are also unique places that can easily be affected by climate change impacts. Nogus-Bravo, Araújo, Errea and Martine (2007:420) confirm that the montane ecosystems are among the most fragile places in the world and directly affected by climate change-related risks and other human-induced changes.

The phenomenon of uncontrolled informal urbanisation causes proliferation of informal settlements in environmentally sensitive areas in developing countries, such as Africa. This exacerbates the negative effects of climate change on mountainous regions. Informal settlements in mountainous landscapes are highly susceptible to risks like landslides, flooding, soil erosion and other catastrophes associated with extreme weather conditions. Due to this, the vulnerability of human beings and physical structures for climate change-induced risk is high. Informal settlements in montane areas are commonly characterised by poor-quality housing, the absence of infrastructure networks and services, lack of public facilities, overcrowding, poor solid and liquid waste-disposal systems, and degradation of natural resources (Dodman et al., 2015:5). These situations exacerbate the possible damages caused by extreme weather conditions.

According to UN-Habitat (2014:28), more than 70% of the population are settled informally and in slum areas in Africa. The majority of the populations residing informally in the mountainous landscapes are poor. This indicates that a significant number of this population residing in these areas are very exposed to the risks linked to climate variability. The impact of climate change affects human beings, security of food and the status of health, access to infrastructure and services, housing and overall social, economic and ecological system (Heltberg, Siegel and Jorgensen, 2009:5). In general, the poor are more susceptible to the consequences of climate change threats; this is because of limited capacity in terms of assets and resources to cope with the adverse impacts (Mearns and Norton, 2010:6).

To conduct the study, two traditional small towns from Africa have been selected, one from Southern Africa and the other from Eastern Africa. Phuthaditjhaba is found in South Africa, and is situated at the latitude 28° 32' 00"S, longitude 28° 49' 00"E and altitude of 1 646 m.a.s.l. On the other hand, Karat is found in Konso in Ethiopia and is located at the latitude of 5°15′N, longitude 37°29′E and an elevation of 1 650 m.a.s.l. Informal settlements at the periphery of Phuthaditjhaba and Karat are also exposed to climate change-associated risks. In the case of informal settlements at the periphery of Phuthaditjhaba, the following problems are also encountered: a shortage of water, landslides, extremely cold weather conditions during winter, damaging winds, heavy rainfalls and flash flooding that cause damage to below-standard houses (Maluti-a-Phofung Local Municipality, 2013:26). The risks observed in the case of informal settlements at the periphery of Karat are a high frequency of drought, shortage of water, irregular distribution of annual rainfall, increasing temperatures, low productivity of agricultural land, shortage of food, and malaria and the prevalence of other tropical diseases (Tadesse, 2010:17).

The UN-HABITAT (2013:20) report shows that

> *the existence of these serious climate change-induced risks in informal settlements in mountainous regions, the experience of the past planning approach was not in favour of improving resilience capacity of people residing informally in the mountainous areas. In contrast, the planning approach was focused on the demolition of below the standard housing and displacement of the poor section of the societies to other places. The previous planning approach exercised in favour of the formal system.*

However, without recognising and improving climate change resilience of informal settlements, it is impossible to achieve the goals of sustainable development by only focusing on the formal system. The characteristics of many small towns in Africa force planners to consider informal settlements in the process of climate change-resilience planning. Therefore, the vulnerability of the socio-economic and environmental conditions of informal settlers in the study areas necessitates a new way of resilience thinking to mitigate the risks proactively. Furthermore, the concept of indigenous knowledge and the role of traditional leadership have not been considered appropriately in the process of planning for improving climate change resilience of informal settlements. Rather, contemporary planning approaches place emphasis on advanced technological innovations. However, the existing reality in the context of African traditional small towns needs to consider the role of indigenous knowledge in the process of planning. Therefore, this study seeks feasible solutions in the context of informal settlements in traditional small towns in Africa through conducting case studies in the eastern and southern part of Africa.

1.3.2 Significance of the Study

The outcome of this research will enable policymakers to formulate an appropriate resilience-planning approach for improving the resilience of informal settlements in mountainous landscapes. As the report of IPCC (2007:9) reveals, the dangers interlinked with climate variability increase alarmingly from year to year, especially in environmentally sensitive areas. Therefore, to tackle these challenges thinking proactively about future risks is critical, especially in terms of saving lives as well as properties. This study specifically considers informal settlements in mountainous topographies and their susceptibility to climate change-induced risks, rather than most of the previous climate change-resilience studies that have focused on coastal areas. Based on this, searching for contextual resilience planning for informal settlements will enable decision-makers to coordinate various aspects such as spatial structure, socio-economic and financial capital, natural endowments, and intangible assets systematically. While understanding the overall variability in resilience, these capitals are deconstructed to their component parts to provide guidance to policy makers where intervention strategies should be focused in order to improve resilience capacity. Such evidence-based research has an opportunity to influence public policy and planning interventions focused on climate change-risk resilience in the informal settlements.

Further, the outcome of this study will help those administrators of traditional small towns in Africa through proposing context-specific solutions. The study also enables planners to know the level of application of resilience theories and principles in the areas of informal settlements in mountainous topographies. Findings of this nature add value to contemporary planning practice. This also opens the way for formulating a realistic policy to promote climate change-resilience planning for informal settlements.

1.4 Objective of the Study

1.4.1 General Objective

The study is aimed to investigate the vulnerability of societies living informally to climate change- induced risks; to propose mechanisms to build climate change resilience in informal settlements in mountainous regions of Africa; and to suggest appropriate planning methods for environmentally sensitive topographies.

1.4.2 Specific Objectives

1. To analyse the vulnerability to climate change-induced risks of societies living informally in the mountainous landscapes.
2. To analyse determinant indicators or variables that influence the climate change-resilience capacity of informal settlements in mountainous topographies.
3. To examine the integration of indigenous and scientific knowledge systems in order to enhance climate change resilience of informal settlements in mountainous regions of Africa.
4. To propose appropriate planning approaches to promote climate change resilience of informal settlements in mountainous landscapes.

1.5 Research Questions

1. What are climate change-induced risks that adversely affect the livelihood of societies living informally in mountainous topographies?
2. What is the level of damage in the areas of informal settlements that is possibly caused by climate change-induced risks in mountainous landscapes?
3. What are the determinant variables that directly affect climate change-resilience capacity of informal settlements in the mountainous topography?
4. How integration of indigenous and scientific knowledge systems enhances climate change resilience of informal settlements in mountainous regions of Africa?
5. What planning approaches are more appropriate to improve climate change resilience of informal settlements in mountainous topographies?

1.6 Thematic Scope and Geographical Demarcation of the Study

The theme of this research focuses on how to promote climate change resilience of informal settlements in mountainous landscapes through integrated planning approaches. Assessing the vulnerability of the areas and designing strategies to identify determinant variables that directly influence climate change-resilience capacity of the study areas are also the focal points. This process considers the capacity of the specific location to resist, absorb risks and promptly restore its function within the domain of uncertainty and complexity. Therefore, the climate change-resilience capacity of the study areas was assessed and an appropriate planning approach was proposed.

The geographical demarcation of the case study areas was intentionally focused on those informal settlements found at the periphery of traditional small towns, specifically at the peripheries of Phuthaditjhaba and Karat. However, the formal town systems of the two case study areas are not considered as the focus of this study. Accordingly, the whole research work emphasises climate change resilience of informal settlements found at the peripheries of the two traditional small towns found in South Africa and Ethiopia.

1.7 Limitation of the Study

Though the intended objectives of the study were achieved, there were some limitations in the process of collecting data from the field. These are shortcomings related to accessing detailed and organised longitudinal and cross-sectional data about climate change risks, vulnerability and resilience capacity of informal settlements in order to undertake an in-depth analysis. Shortages of finance and distance barriers to capture the required data at the right time were the primary challenges faced during the research process. Nevertheless, to minimise the negative effects of these drawbacks on the research findings, the required data were captured from different official publications and the previous research works undertaken the case study areas. Further, by recognising these challenges in advance, during the pre-data collection period, tailor-made training was given to data collectors and translators and validation of data has been done carefully in every step of data collection. Next, crosschecking of collected data was done to increase validation and reliability of the outcome of the study.

1.8 Ethics Statement

When conducting research in an educational context, professional ethical practice is essential to the rights of individuals (Australian Council for International Development [ACFID], 2016:4). For the purpose of this study, the data were collected from primary and secondary sources by using mixed data-collection instruments. Accordingly, the following ethical values were considered in this research. The purpose of the research was explicitly explained and research processes were reported to the participants to ensure their informed consent to participate in the research process. Participants were informed that they might withdraw at any time during the research process without penalty. The researcher was sensitive to the principles of human rights and dignity, and the importance of protection of the participants from harm (Mouton, 2001:8). Therefore, special care was taken to protect the privacy of respondents in the pre-, mid- and post-data collection period. The aim was to increase the confidence of informants during the whole research processes.

This is confirmed by written ethical clearance from the University of the Free State Research Ethics Committee (see Appendix 10) and verbal permission from the participants of the research. Participants were informed that their participation was voluntary and that they had the right to participate to the extent they wished, without penalty or consequence. In order to maintain objectivity and integrity when carrying out research, the researcher attempted to adhere to high technical standards in undertaking the research. The participants were also informed that only the researcher would have access to the information. They would be protected and names would be removed or pseudonyms used, if necessary. When doing a cross-culture research, the researcher has be aware of the multitude of cultural factors that affect the researcher and the participants. The researcher needs time to establish familiarity with the new culture and learn some of the many factors needed to collect data successfully (Social Research Association [SRA], 2003:15). To adhere to these ethical and cultural considerations, a pilot test of questionnaires was conducted before data collection for the purpose of this study. Final feedback was given to the university through this written and verbal report. Furthermore, especial care was taken to keep the originality of the study by applying a context-specific methodology to analyse the data. Finally, scholars and authors who publish different books and contribute to the body of knowledge related to this study were acknowledged and cited appropriately in the reference list.

1.9 Structure of the Research Work

The study is organised in eleven successive chapters. Chapter 1 deals with the introductory section of the study. It explains the background and rationale of the study. It also discusses the problem statement, the objective of the study, research questions, significance of the study, scope and limitation of the study, and ethics statement. The theoretical frameworks are discussed in the next three consecutive chapters. Chapter 2 deal with impacts of climate change risks on informal settlements. Chapter 3 explains systems theory and its application to climate change-resilience building. Chapter 4 discusses the concepts of systems' vulnerability and resilience and their assessment frameworks. Chapter 5 explains how indigenous knowledge system can be used as an instrument to enhance climate change resilience of informal settlements as well as how it can be integrated with the scientific knowledge to maximise synergy in the process of building resilience.

Moving on from the theoretical to the empirical, Chapter 6 discusses the research methodology and design. Chapter 7 describes the profile of the study areas and empirical analysis of the impact of climate change in the study regions and how perspectives about informal settlements influence resilience building. Chapters 8 and 9 comprise analysis and discussions of the case of informal settlements around Phuthaditjhaba and Karat, respectively. Chapter 10 contains the comparison of the case studies and the summary of key findings. Finally, the conclusion, synthesis and recommendations are discussed in Chapter 11. Based on the arrangement of the research work, the next four successive chapters review the literature to establish the theoretical frameworks that were used as the foundation for this study and to identify the knowledge gaps that were not addressed by the previous methodologies.

Chapter 2
IMPACTS OF CLIMATE CHANGE RISKS ON INFORMAL SETTLEMENTS

2.1 Introduction

The purpose of this chapter is to discuss the impacts of climate change-induced risks of global, Africa and regional scales in general, and of informal settlements in particular, based on the current scientific evidences. In line with this, the indicators for climate changes, the past trends and the future projected climate changes are discussed comprehensively. Finally, the impacts of informal urbanisation and climate change in the context of Africa are considered.

2.2 Definitions and Concepts

The Intergovernmental Panel on Climate Change [IPCC] (2014a:1) defines climate change as a change in the condition of the climate that can be distinguished statistical techniques, as well as by the irregularities of its feature, which continues for a prolonged period, usually decades or more. The change can be initiated by natural or anthropogenic driving forces, such as variation in the solar cycles, and volcanoes increasing the concentration of greenhouse gases in the atmosphere because of discharges from the industries. Similarly, the Framework Convention on Climate Change [UNFCCC], in its Article 1, defines the climate change as a change of climate characterised by anthropogenic effects that increase the concentration greenhouse gases in the atmosphere and the natural climate variability detected over decades (United Nations Framework Convention on Climate Change [UNFCC], 2007:1). From both these definitions, it is possible to recognise the driving forces or causes for climate change are both human–induced and natural.

IPCC (2014b:5) also describes the term risk as the potential adverse effect because of vulnerability and exposure of a system for possible incidences of hazards. The United Nations Development Programme [UNDP] (2004:4) describes climate-associated risk as the effect of physical exposure of the systems and their limited capacity to cope with hazards. Therefore, the intensity of risk can be determined by probability of occurrence of climate change hazard and the vulnerability of the system for these hazards. Accordingly, these definitions can be considered as operational definitions for the purpose of this study. The following section discusses indicators of climate change risks at a global scale.

2.3 Indicators of Climate Change Risks

The United Nations Framework Convention on Climate Change [UNFCCC] (2007:8) indicates that rising fossil fuel burning and land use changes emit the greenhouse gases into the atmosphere. The concentration of greenhouse gases, such as carbon dioxide, methane, chlorofluorocarbon and nitrogen dioxide has increased at an alarming in the atmosphere since the industrial revolution. The greenhouse gas effect increases the amount of heat in the atmosphere and causes global warming. According to IPCC (2013:6), the National Academy of Science and the Royal Society [NASRS] (2014:3), the amount of earth's surface and air temperatures increases because of anthropogenic emissions of the greenhouse gases. Warming of the atmospheric system is unequivocal. The amount of carbon dioxide in the atmosphere rose from 278 parts per million that are a pre-industrial estimation to 379 parts per million in 2005, and the average global temperature rose by 0.74 °C. This is the biggest and quickest warming pattern ever observed.

As indicated by IPCC (2014b:14), NASRS (2014:3) and UNFCCC (2007:8), the consequences of climate change affect the human being as well as the ecosystem adversely. As per the World Bank (2008:34) report, the level of risk is directly linked with the degree of increase in the global average temperature. Thus, an increase of the global average temperature by 1 °C may cause serious damage on the environment and could cost all nations greater than $68 trillion per year. Though the effect of climate change differs in spatial and time scales, some of the regions are already experiencing hot, dry and wet weather conditions. This is mainly because of the adverse effect of the greenhouse gases in the atmospheric system. Consequently, the IPCC cautions that if global society keeps on emitting greenhouse gases at the current rate, the average global temperature could increase up to 4.8 °C by 2100 (IPCC, 2014b:14). As indicated by the UNISDR (2011:2), this will proceed unless all countries change their systems that produce, consume and waste both man-made and natural resources.

In addition, uncontrolled urbanisation has changed the world from 10% urban in 1990 to more than 50% urban in only two decades (United Nations Department of Economic and Social Affairs, [UNDESA], 2010:10). Although urban areas (with over 50 000 inhabitants) share less than 3% of the land surface, they are accountable for more than 71% of global energy-related carbon emissions (International Panel on Climate Change, [IPCC], 2014c:1). In line with this, the way how the most vulnerable groups can adapt to climate change impacts, and what the most feasible strategies are to help them, are still basic enquiries requiring urgent reactions. Because of this, scientists propose that, to protect the safety the planet securely, the rise in temperature should be limited to no more than 2 °C (World Bank, 2008:36). The following section discusses the analyses of global, continental and regional scale climate variability and changes based on the scientific evidence.

2.4 Analysis of Climate Variability and Change

2.4.1 Trends and Projections of Global Climate Change

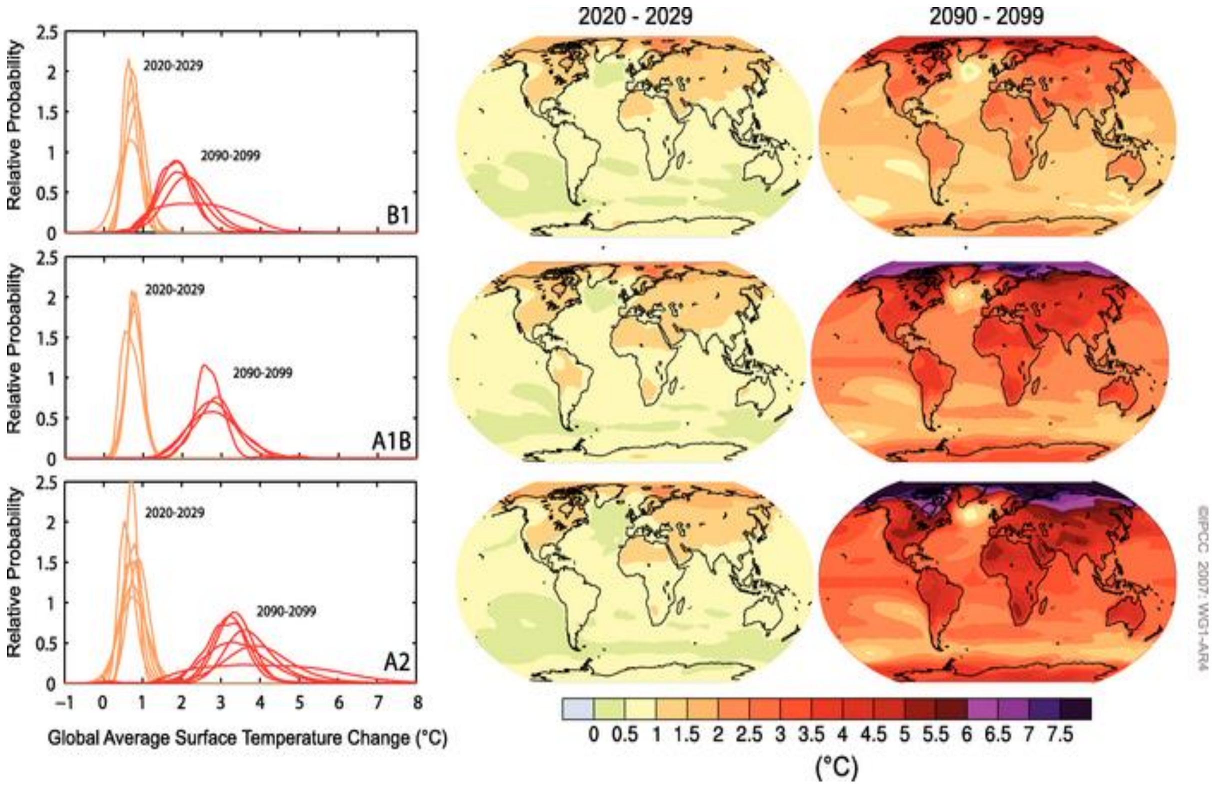
2.4.1.1 Trends of Global Climate Change

In the past 60 years, the atmospheric emission has accelerated because of carbon-reliant production system and the fast economic growth without conservation of the natural environment. Thus, current global average temperature increases by 0.8 ºC, while a rise of 2 ºC may be recognised as tolerable to some extent. However, a rise of 4 ºC is considered as very dangerous for the fate of the planet because of anthropogenic effects and loss of control. At current patterns, the world will pass the 2 ºC emission limit around 2025. In this way, the window of chance for meeting the Copenhagen agreement is as of now closing (IPCC, 2014b:8).

Although global warming is just part of a broader domain of environmental degradation, it can be recognised as a substantial indicator (UNFCCC, 2007:8). This shows unequivocally that current global development practices are in a general sense unsustainable at a planetary scale. Humankind cannot survive climate change without solving the fundamental causes of natural environmental depletions, which are necessary to current development paths. Continuing with the past production system will create significant environmental catastrophe for the world in general and Africa, in particular as atmospheres turn out to be increasingly threatening, and ecosystems become noticeably damaged (UNISDR, 2011:2).

2.4.1.2 Projections of Global Climate Change

The IPCC (2007:8) report gives definite projections for the 21st century and these demonstrate that a global temperature change will proceed and accelerate. The best-case scenario projection indicates that the earth surface could be hot by 3 °C by 2100. Regardless of the possibility that nations diminish their greenhouse gas emissions, the earth will keep on warming. There is currently higher confidence in the projected global warming and regional scale changes in wind pressure and precipitation. Continued greenhouse gas discharges at or above current rates would bring on additional warming and stimulate many changes in the global climate system during the 21st century that would be higher than that has seen during the 20th century (National Academy of Science and the Royal Society [NASRS], 2014:3).

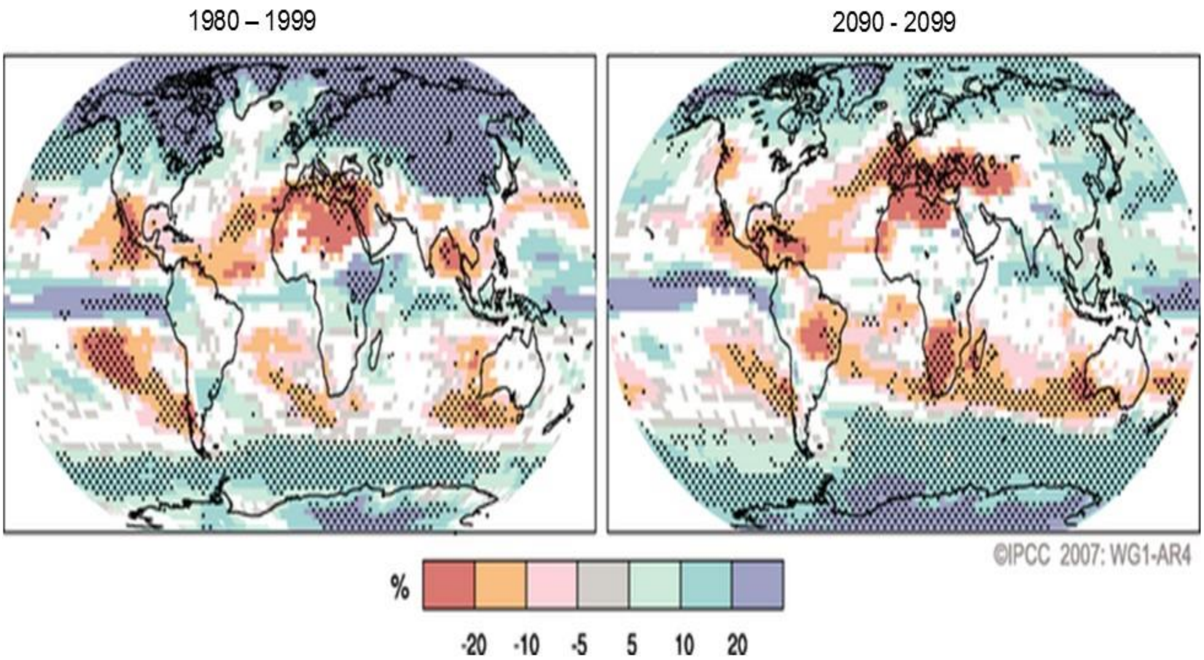


Source: (IPCC, 2007:8)

FIGURE 2: Projection of Global Surface Temperatures

Figure 2 indicates the projected surface temperature changes for the early and late 21st century with compared to the period 1980–1999. The middle and right pictures demonstrate the Global Circulation Model multi-model average projections for the low carbon-emission scenario at the top, moderate at the middle and high carbon-emission scenario demonstrated at the bottom. Scenarios averaged over the decades 2020–2029 are indicated at the centre and 2090–2099 indicated at the right. The left side graph demonstrates the possible uncertainties as for the relative worldwide average warming. Projections for 2100 range from a 1.8 °C to 4 °C rise in global average temperatures (UNFCCC, 2007:8). The present rate of greenhouse gas concentration is possibly to raise the average temperatures to 0.2 °C every decade, reaching the limit of 2 °C above pre-industrial levels by 2050. The heat waves and irregular precipitation patterns will continue (UNISDR, 2011:2).

The higher frequency of tropical cyclones, coupled with continuous rises of tropical ocean surface temperatures will be the possible observable phenomenon. The rise in the intensity of storms in some regions since 1970 is much higher than simulated by the models for that period (IPCC, 2007:33). The amount of precipitation will increase in high altitudes, while reductions of about 20% will be observed in most subtropical areas in 2100. Figure 3 shows the relative changes in precipitation in percent for the period 2090–2099, compared to 1980-1999. This pattern of climate change will create new challenges for the human and overall ecosystem.



Source: (IPCC, 2007:14)

FIGURE 3: PROJECTED PATTERNS OF GLOBAL PRECIPITATION

2.4.2 Trends and Projections of Africa Climate Change

2.4.2.1 Trends of Africa Climate Change

The Fifth Assessment Report IPCC (2014b:52) also presents strong evidence that warming over land across Africa has increased over the last 50–00 years. Surface temperatures have already increased by 0.5–2 °C over the past hundred years. The observed precipitation pattern indicates where data are available, a decrease in annual rainfall over the past century in parts of the western and eastern Sahel region in northern Africa and increases over parts of eastern and southern Africa. Data from 1950 onwards indicate that the magnitude and frequency of some extreme weather events in Africa have been changed (Niang et al., 2014:133). As showed in Boko et al. (2007:433), the livelihoods and food security of individuals in Africa have been influenced by climate change. Researchers have detected changes in Africa's climate during the previous century, with records demonstrating rising heat over Africa's land surface. Climate change is now adversely affecting Africa. It is affecting the land surface, marine-based biophysical systems, and a considerable portion of poor people living in environmentally sensitive areas (Christensen et al., 2007:108).

2.4.2.2 Projections of Africa Climate Change

Throughout this century, temperatures in the African landmass will probably rise more rapidly than in other land zones, especially in more dry areas. Under a high carbon-dioxide emissions scenario, average temperatures will rise more than 2 °C – the maximum limit set in the current global agreement – over a large portion of the mainland by the middle of the 21st century (IPCC, 2014b:52; Niang et al., 2014:134). Average temperatures will have risen over 4 °C all over the sub-regions by the late 21st century. Changes in average temperature are anticipated to be more prominent over northern and southern Africa and generally lower in central Africa. Under a low carbon-dioxide emissions scenario, the average temperature will increase all over Africa, but it will be below 2 °C by the late 21st century (IPCC, 2014b:52).

Models propose a possible rise in precipitation distribution in eastern Africa, with diminishing in northern and southeastern Africa. With more than one-fourth of the people living within 100 kilometres of the coast and most urban areas established there, the vulnerability to marine-initiated calamity from tsunamis and tempest surges will rise. The net impact will be to intensify social and economic vulnerabilities, undermining individuals' capacities to adapt to life in a more threatening climate (Boko et al., 2007:433)

Projections for precipitation are less sure than projections for temperature. Most regions of the African landmass do not indicate changes in annual average precipitation under low carbon-dioxide discharges scenario. Notwithstanding, projections do demonstrate a reasonable decline in annual average precipitation over regions of southern Africa, starting in the mid-21st century, and will rise considerably by the late 21st century, under a high carbon-dioxide emissions scenario. Conversely, rises in annual average precipitation are anticipated over territories of central and eastern Africa, starting in the mid-21st century, for a similar high carbon-dioxide discharges scenario (IPCC, 2014b:52). As climate change impacts more dramatic, their impact on a variety of climate extremes in Africa, including overwhelming precipitation, hot temperature and droughts, will turn out to be progressively critical (Christensen et al., 2007:108). In Africa, climate change will exacerbate the shortage of water and decline in Agricultural production, especially in semi-arid regions. Therefore, Africa’s climate will be changed and the frequency and intensity of extreme weather phenomena will increase, resulting in high risks (Few et al., 2004:45, Christensen et al., 2007:108; Nicholls, 2004:69; McMichael et al., 2004:1543).

2.4.3 Trends and Projections of Eastern Africa Climate Change

2.4.3.1 Trends of Eastern Africa Climate Change

As showed in the Climate and Development Knowledge Network [CDKN] (2012:online), the central and southern parts of eastern Africa have encountered a critical rise in temperature since the mid-beginning of the 1980s. The average temperatures have also increased in many parts of eastern Africa in the most recent 50 years. Nations neighbouring the western Indian Ocean experienced hotter temperatures and more incessant heat waves in the years 1961 to 2008. There is confirmation that temperature changes have contributed to the prevalence of malaria in Eastern Africa. The precipitation distribution in eastern Africa is extremely fluctuating in time and space (Daron, 2014a:9). Many changes in the biophysical environment as well as the impact of the El Niño Southern Oscillation influence precipitation in this region. Models propose that increasing warming of the Indian Ocean might be the reason for less precipitation over eastern Africa amongst March and May-June in the most recent 30 years. Summer storm precipitation declined in the Horn of Africa in the last 60 years (Schreck and Semazzi, 2004:681).

Precipitation distribution and patterns in the course of recent years are less clear than temperature, and there are substantial differences in the geographical and seasonal distribution across this region. Overall, there is weak evidence or low certainty regarding the patterns of extreme temperature, precipitation and drought in East Africa (Daron, 2014b:5). Nevertheless, dry seasons and storms have been more common in eastern Africa in the last 30–60 years. Progressive warming of the Indian Ocean has caused more successive East African spring and summer droughts in the last 30 years. It is uncertain whether these progressions are because of anthropogenic impacts or to natural climatic variation. Extreme precipitation changes over Eastern Africa, for example, drought and considerable precipitation have been experienced over the last 30-60 years (IPCC, 2014b:49).

2.4.3.2 Projection of Eastern Africa Climate Change

The projections of temperature change indicate significant rises over the eastern Africa. The highest rise in temperature is projected for central and northern areas. Projected rises in average annual temperatures run from no change to 4 °C by 2050; however, model projections are liable to significant uncertainties. Comparatively, rises of temperatures are more probable under a higher greenhouse- gas emission scenario (Daron, 2014b:5). Projections for medium- to high-emanations scenario demonstrate that ranges of the maximum and minimum temperatures over central East Africa will rise and that there will be hotter days contrasted with the relative to the mid and late of this century. Climate projection models demonstrate hot days in each of the four seasons over Ethiopia, which may cause heat waves that occur more often (Setegn et al., 2011:04511).

According to Setegn et al. (2011:04511), despite the decreasing precipitation pattern observed, the global projections suggest that during the late 21st century, in contrast to the past patterns, the climate in eastern Africa will more significant wet seasons and fewer droughts in October-December and March-May. In addition, Regional models suggest that most parts of Uganda, Kenya and South Sudan will be drier in August and September during the late 21st century. Projections show shorter spring precipitation in the 2050s for Ethiopia, Somalia, Tanzania and southern Kenya, and longer summer precipitation in southern Kenya and Tanzania.

Daron (2014b:5) also indicates that the projections of precipitation change both potential rises and declines. Therefore, the projections of precipitation by using different models vary significantly. There is a tendency of more wet days over the region from October to March, however, there is a lack of confirmation to supplement explanations proposing the possible shift to drier or wetter conditions in most areas. The impacts of climate change on water resources are uncertain, but increasing evaporation because of rising temperature may cause shortage and extra challenges for already vulnerable sectors including agricultural production system. Consequently, the availability of water is fundamentally determined by changes to its consumption and land-use system.

2.4.4 Trends and Projections of Southern Africa Climate Change

2.4.4.1 Trends of Southern Africa Climate Change

As indicated by IPCC (2014b:16), southern Africa's warming will probably surpass the worldwide mean land-surface temperature rise in all scenarios. This could bring about a conceivable rise of up to 6 °C before the end of the century, while provincial precipitation is relied upon to diminish in general. This may result in expanded dry seasons, flooding, more wind tempests, hot spells and rapidly spreading fires in some parts of the region.

Since the mid-20th century, the larger part of southern Africa has encountered an increase in annual average, maximum and minimum temperatures. The most observable warming has been experienced in the last two decades. The minimum temperatures have risen more quickly relative to most extreme temperatures over inland southern Africa. The western parts of southern Africa, from Namibia to Angola and the Congo, had less late summer rainfalls in the second half of the 20th century. Additionally, Botswana, Zimbabwe and western South Africa have had a diminishing pattern in precipitation (Daron, 2014b:11). The distribution of seasonal precipitation and incidence of drought have changed. Heat waves were related to an absence of precipitation amid El Niño occasions experienced in the southern Africa region in the last decades (IPCC, 2014b:16).

2.4.4.2 Projections of Southern Africa Climate Change

Warming in southern Africa in all seasons will exceed average global warming. Towards the end of the 21st century, projections for high carbon-dioxide emissions scenarios show a temperature increase of 3.4–4.2 °C, far exceeding increases in temperature from natural climatic variability. Projections indicate there will be a rapid warming in semi-arid southwestern parts of southern Africa, northwestern South Africa, Botswana and Namibia (Mois and Hudson, 2008:113; IPCC, 2014b:113).

Over southern Africa, global model projections show drying in the southwest, extending northeast from the Namibia and Botswana deserts. During the southern summer months, global models project dry conditions in the southwest, while regional models project wetter conditions in the southeast of South Africa and the Drakensberg Mountains (Hewiston and Crane, 2006:1315). As in the *Fourth Assessment Report of IPCC*, projections indicate that there will be drier winters over a large part of southern Africa by the end of this century (Daron, 2014b:12).

According to Hewiston and Crane (2006:1325), projections indicate that during the 21st century and beyond, the risk of severe droughts in southwestern regions will be high and there will be an increase in the area affected by drought. There is considerable uncertainty concerning projected changes in occurrence of tropical cyclones originating in the southwestern Indian Ocean. These cyclones led to intense flooding in the 20^{th} century. More parts of southern Africa have observed increases in extreme rainfall than decreases, although trends vary over this area. The projections indicate that both extremely low rainfall and extremely high rainfall in southeastern regions may become more common in the future, although there is a lack of agreement for the region as a whole (IPCC, 2014b:17).

2.5 'Informalisation' and Climate Change Impacts in Africa

The characteristics of urbanisation and climate change impacts in Africa include increasing population, intense resource uses and the proliferation of informal settlements, many in environmentally sensitive areas. The poor and marginalised people face more severe consequences when compared to other sections of society, because they have insufficient resources and capacities to cope with and recover from disasters (Wisner, Blaikie and Cannon, 2004:1). Accordingly, this condition will exacerbate the complexity of the challenges to deal with it. The combination of demographic pressures, rapid urbanisation, environmental and climate change now appear to reinforce a host of negative urban externalities. At the same time, the prevailing development concepts applied to Africa's rapidly expanding urban areas seem incapable of attaining the post-independence visions of human development and prosperity for all (UN-Habitat, 2014:34). There will also be a high possibility of loss of lives, livelihoods, assets and infrastructure. These challenges are commonly beyond the capability of local municipalities. Many scholars have been agreed that informal settlements contribute to most of the housing in many towns of Africa. Informal settlements, typically characterised by substandard services, poor-quality housing and inhabitants with a low income. The areas are regularly observed as risky because it is related to poverty, environmental sensitivity, irregularity in settlements, social exclusion. As per UN-Habitat (2008:15), throughout the following four decades, urban communities in developing nations will retain 95% of the world's urban population increase. However, in the developing countries including Africa, the urbanisation can be characterised as 'informalisation'.

Different causes underlie the formation of informal settlements in Africa. These include the failure of land and housing market to address the capacity of poor people, failure of state policy, competition for resources by speculators, colonial or apartheid history, poverty, poor governance and corruption, which are among the causes of the proliferation of informality in Africa. There is also a paradox in the situation of how to manage informal settlements in developing countries and in Africa as well. There are contradictory ideas regarding how to manage the informality[3] from the point of view of informal rights and the perspective of planning experts who are concerned about the esthetical value of urban centres (Huchzermeyer, 2011:17). After independence, many African urban centres characterised by various crises such as the proliferation of informal housing and urban poverty (UN-Habitat, 2014:16). A vast number of people are forced to live in sub-standard housing conditions in different parts of urban regions, including peripheral areas.

Environmental degradation, loss of rural incomes and strict building codes lead the incoming populations to the only available land, to the risk-prone urban fringes (UN-Habitat 2008:9). Among the determining factors for the crises be setting sub-Saharan African countries during the1980s and 1990s are economic recessions, high levels of unemployment, lack of serviced land and infrastructure, uncontrolled population growth, degradation of natural resources and poor governance. Rural and urban areas have always been closely connected but, in recent decades, new relationships have emerged. The boundaries between rural and urban areas are now less defined than previously and new types of land use and economic activity are

[3] See Chapter 7: section 7.4 for a detail discussion about 'how perspectives matter managing informal settlements?'

appearing. These changes are important for understanding the impacts of climate change, vulnerabilities and opportunities for adaptation (Stren and Halfani, 2010:473).

Informal settlements have existed in most developing countries for more than half a century. Despite this fact, few countries have tried to kerb their formation. Formalisation and improvement of these settlements are often complex, and costlier than predicted. Unstable political leadership at national and local level makes the situation worse. Yet, people residing informally in urban centres create and design their own life-sustaining mechanisms. Due to this reality on the ground, building climate change resilience of informal settlements was not get appropriate attention by politicians, planners and other stakeholders. Previously, demolition or total clearance of informal settlements was considered the best option and has been practised in many African urban centres. However, the paradox is that this measure could not stop the proliferation of informality and kerb these crises. Thus, it is essential to recognise people's own way to solve the problems they face. Still, one of the challenging questions is how to link informal settlements with the formal urban system smoothly. This concept is now receiving recognition by international donor agencies and development partners (UN-Habitat, 2014:28).

As Huchzermeyer (2011:16) indicates, we need to emphasise the positive aspects of informal settlements, such as social capital and indigenous knowledge of society, the potential of solving the problem by using local resources, creativity to provide small-scale goods and services for the formal system and a reduction of social crises that may possibly happen if the people lose the space to live. However, this does not mean there is no negative externality on the formal urban system. The existing facts have forced us to focus on those positive aspects and improve people's living standards through upgrading, rehabilitation, regularisation, provision of services and infrastructures without adversely affecting the existing nature of settlements. From the above explanation, it is possible to consider the urban informality as a part of the overall urban system and the improvement of the resilience of urban centres is a critical issue that requires special attention. In other words, recognition of the positive aspects and resilience attributes of informal settlements as a functional section of the whole system rather than excluding them from the formal system. In this perspective, the notion of climate change resilience in association with informal settlements is challenging, but it is still possible to come with an innovative solution. Creating job and livelihood opportunities, providing serviced land and affordable housing, aligning these settlements with the formally built environment, building settlement patterns that can resist, absorb and easily recover from natural disasters and other weather extremes, are the critical factors that need to be dealt with.

The impact of climate change adversely affects all nations; however, it is more severe in developing nations. The assessment undertaken by World Bank (2010:9) demonstrates that around

75–80% of the cost of disasters incurred because of climate change. Even 2 °C warming above pre-industrial temperatures, the world is going to experience perpetual decreases in GDP of 4–5% in the case of Africa. Most developing nations need adequate money and specialised abilities to oversee expanding climate change risks. Dependency on climate-sensitive natural resources for income and wellbeing sustenance exacerbates the cost of coping with climate change risks. Most of the population in tropical and subtropical areas are already affected by climate change risk. Physical exposure of the population coupled with weak institutional and economic capacity magnify the danger caused by these risks (Christoplos et al., 2001:4; UNDP 2006:online).

Consequently, as suggested by the IPCC (2014b:18) report, the African society must get ready for inescapable changes in the climate in the next decades, even though they are part of international agreements to combat the effect of greenhouse gas emissions. In Africa, climate change will aggravate the shortage of water and the incidence of drought and flooding (World Bank, 2010:5). The magnitude and recurrence of future climate risk mainly determine the level of commitment to worldwide mitigation measures. For this reason, the IPCC focuses on the importance of combining adaptation and mitigation measures into long-term development planning (IPCC, 2014b:19). On top of this, climate change resilience is more essential in the context of Africa because the continent is a less contributor to the emission of greenhouse gases. Therefore, Africa should invest in programmes to promote climate change resilience and proactively prepare to cope with already predicted climate change threats. This may be costly; however, it will not be greater than the cost possibly incurred by post-disaster conditions (World Bank, 2013:10).

The United Nations (UN, 2016:online) also indicate that *Sustainable Cities and Communities* is one of the sustainable development goals set by the informal settlement upgrading and climate change resilience is part and parcel of this goal. This goal could be achieved when the required motivation to achieve resilience of social, ecological and economic systems has been created. As described by (United Nations World Commission on Environment and Development [UNWCED], 1987:online), sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their needs. In this case, the goal of sustainable development can be achieved when the current generation uses resources efficiently and effectively. However, globally challenges associated with climate change increase in the last decades (IPCC, 2007:9). Therefore, building coping mechanisms with these challenges is the central idea of building climate change resilience.

Accordingly, it is possible to say that climate resilient systems open the way, or can serve as a roadmap towards achieving sustainable development goals.

Therefore, focusing on the neglected part of the urban system, informal settlements and particularly improving their climate change resilience, is one of the vital policy and planning interventions that should be applied in urban centres in developing countries. Otherwise, it is almost impossible to think of achieving sustainable development goals in urban centres in developing countries as well as in Africa. On top of this, the multi-dimensional nature of sustainable development requires the understanding of the complex interaction among social, ecological and economic sectors. Integration among the major variables that significantly affect – positively or negatively – the development prospects of communities need to be identified from each sector in specific contexts. Because of limitations of resources, any policy or planning practice could not propose solutions by dealing with all variables in all sectors. Here the very critical point is systematically identifying the most significant variables that affect the development situation. Furthermore, the cause and effect relationship among the variables should be critically analysed. This guide to solving one big problem may enable the planners to solve minor problems with the same energy or resource (World Bank, 2013:10). Therefore, this can save energy and other resources for the purpose of further development projects.

2.6 Conclusion

The effect of climate change has been witnessed all over the world. Global warming is caused by an increase in the concentration of greenhouse gases in the atmosphere. Industrial discharges from different parts of the world are the major source of these greenhouse gases accumulations. Due to this, the global environment is facing unprecedented heatwaves, which have become a threat to the survival of organic life. The unwise resource production, consumption and discharging practices by all humankind create unfavourable living conditions. The negative impact of climate change will proceed unless the discharges of greenhouse gases are minimised. The paradox is that industrialised countries are the major contributors to emissions of greenhouse gases, whereas the adverse impacts of climate change highly affect developing countries, especially poor and marginalised communities living in the areas of informal settlements.

Chapter 3 THEORY OF SYSTEMS

3.1 Introduction

This chapter discusses the theory of systems, the ontological and epistemic perspectives of the systems, reductionist versus systems approach to problem-solving, complexity, interconnections and dynamics in the systems, the renaissance and application of the systems approach, systems approach to solve the problems, customising systems approach for climate change resilience planning, and limitations of the systems approach to problem-solving.

3.2 Theory of Systems

3.2.1 Concepts and Definitions

According to Jenins (in Beishon and Peters 1985:3), the concept of "system" derived from the Greek word "systema" that means "together". A system is a design or scheme based on the elements that are connected to a whole. A system as a set of interconnected entities that create combined functional whole, its properties could not be predicted based on the understanding of separate elements (Dale et al., 2004:119; Anderson et al., 1999:4; Jordan, 1998:47). Thus, each system has a unit of wholeness with separate property or structural threshold that delineates one system form another. Von Bertalanffy termed this threshold as a system's boundary that makes any system unique and determines it definition (Macy, 1991:72). Bertalanffy's conceptualisation of a system is grounded on holistic properties and behaviour of the system in order to understand the root cause of the problems and to solve them (Connors, 2007:1).

In addition, Innes and Booher (2010:3) and Meadows (2008:1) indicate that the systems theory is grounded on the assumption that the whole is not a collection of sub-components; rather, it is an organised, distinct phenomenon with its own unique characteristics, qualities and behaviour that are different from the properties of its component parts. In other words, emerging properties of the whole is different from those of the properties of individual elements in the system. This critical point differentiates the system approach from the reductionist approach to analyse problems. The complex interactions among the sub-parts and their organised functions create unique behaviour of the whole system. Thus, changes in one part of the system may cause changes in other parts of the system. It is through these relationships that a system is greater than the sum of the individual parts.

Although the emergence of the basic notion of systems theory can be traced back to Aristotle, Descartes and Galileo, its contemporary incorporation into general systems theory is generally credited to Von Bertalanffy (Brenda, et al, 2010:41). The general systems theory provides a way to increase integration among scientific disciplines through the concept of the system. Von Bertalanffy applied the general systems theory to biological organisms such as the human body but in the 1970s, it was adopted by the emerging science of ecology. Von Bertalanffy defines the system as a configuration of parts connected and joined together by a web of elements in standing relationship. As Richardson (2005b:104), Beinhocker (2006:14), Meadows (2008:7) indicate, the system approach to problem-solving advocates a holistic understanding of complex interactions of components in a given system, contrary to the reductionist approach that promotes isolated analysis of individual elements of the system to deal with the problems.

3.2.2 Ontological Perspectives of Systems

According to Gerring (2007:98) and Ormerod (2006:905), the ontological perspective of systems is concerned with nature, structures, properties, events, processes and relationships of objects or phenomena in a reality. Systems ontology conceptualises the systems with the functional, structural and behavioural connections of its components and the circumstances it exists. The way how a system designed is the central concern of the systems ontology. It also emphasises the interconnections of the system with its components and the external environment that the system itself exists.

Accordingly, the systems approach to problem solving recognises the world in terms of integrated systems. It focuses on the characteristics of the whole system rather than the individual parts. The complex interactions among its constituent parts determine the overall behaviour of the system. However, the emerging behaviour of the whole system varies from the properties of the individual elements within the system. Therefore, it is difficult or impossible to predict the behaviour of the whole system based on the characteristics of individual components in the given system (Cornell and Jude, 2015:1; Jordan, 1998:11).

3.2.3 Epistemic Perspectives of Systems

Systems epistemology concerned with the process of by which the knowledge of ‘system’ is established. It addresses the question: How we do know what we know? What are the basic assumptions and principles that influence the perception? (Gerring, 2007:98; Ormerod, 2006:905). Accordingly, the notion of systems theory originated with Von Bertalanffy, because he was not satisfied with the justification that the growth and changes in living organisms can be determined by linear-cause and effect relationships among the components. Based on this, Von Bertalanffy (1968:12) demonstrates that the growth and changes into the biological organism should be considered from the point of view of the external and internal circumstances or the whole system that the organism is surviving. This perception strengthens the idea of Aristotle, “the whole is more than the sum of its parts”. This is contrary to the reductionist approach that promotes the notion of understanding the characteristics of whole the system by analysing its individual elements (Du Plessis, 2009:13; Heylighen, 2006:10).

The notion of the mechanistic worldview of the system first originated with Isaac Newton. This nation highly influences the developments in sciences, education, economy, industries and the overall socio-ecological system. The mechanistic worldview of system assumes that overall material and living systems are governed by universal laws (Du Plessis, 2009:13). Consequently, this perspective of system considers the idea of reductionism and determinism as a better way to understand the system’s behaviour and to solve the problem. Reductionism assumes the complexity of certain system only understood by analysing the components of the system (Heylighen, 2006:10). In addition, the idea of determinism assumes that the behaviour of the whole system can be predictable by observing the characteristics components of the system. This is possible because of the existence of universal law governs the whole system (Gleick, 1998:1). This worldview of the system was practised as the dominant method of problem solving for long periods. However, the increase of the complexity of the problems associated with technological advancement requires the new approach of problem solving. Therefore, the systems approach to problem solving is considered as an alternative method and has been practised in many fields, including urban planning. Table 3.1 compares the reductionist and systems approaches to problem solving.

TABLE 3.1 REDUCTIONIST APPROACH VERSUS SYSTEMS APPROACH TO PROBLEM-SOLVING

No.	Reductionist Approach	Systems Approach
1	Focuses on parts	Focuses on wholes
2	Linear causality A causes B	Circular causality A causes B Causes C causes A
3	Observer status-objective	Observer status-subjective
4	Context not very relevant	Context highly relevant
5	One 'truth' or best answer	Multiple truths and answers
6	Externalities not important	Externalities important
7	Problems solved	Problems dissolved

Source: Leonard and Beer (1994:1)

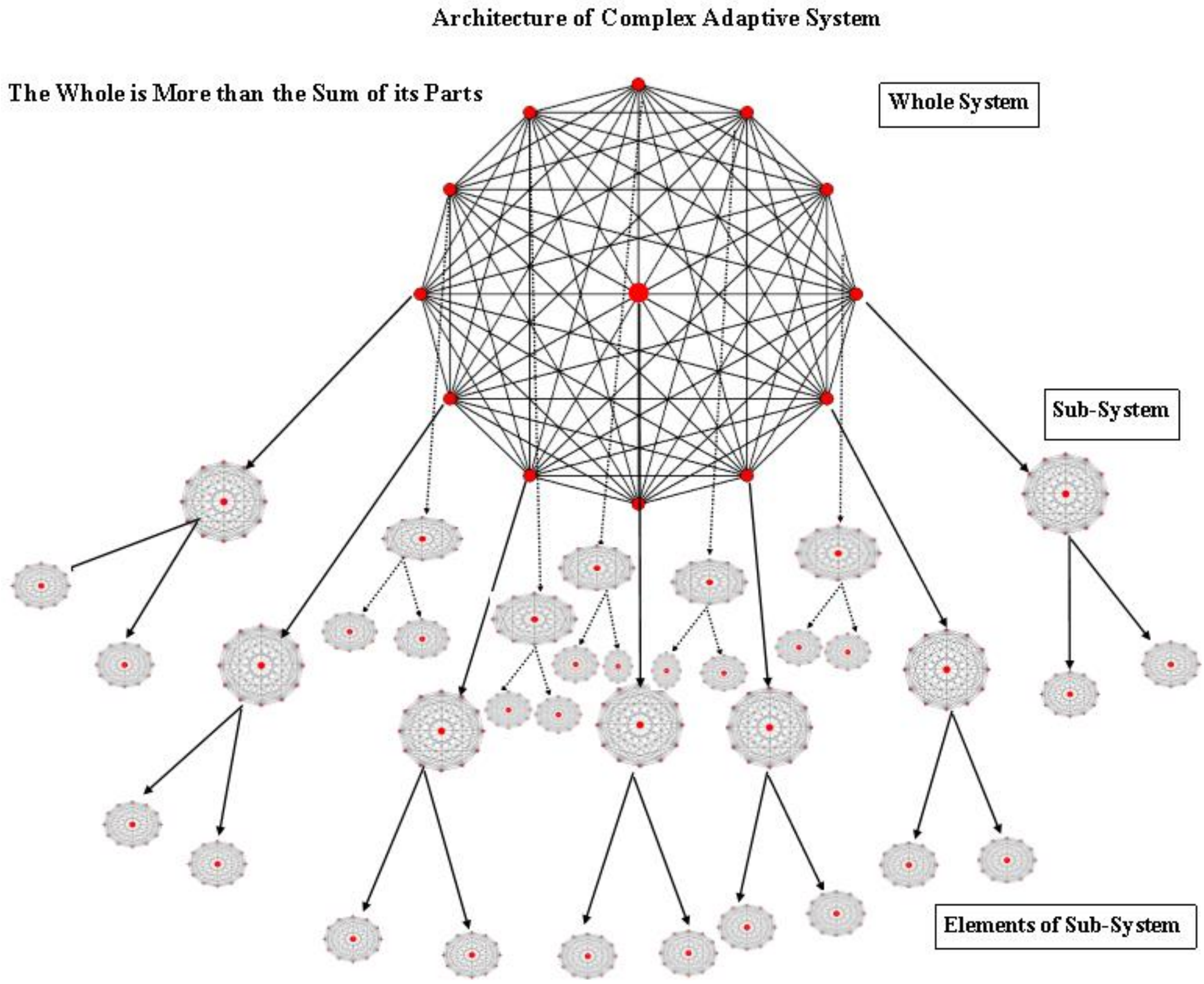
Meadows (2008:8) and Skyttner (2005:498) describe that the existence of open and closed systems and their characteristics can be determined by the ability to allow inward and outward exchange of energy and materials. The closed systems do not exchange the energy and materials with the external environment or another system because they have impermeable boundaries. Contrary to this, open systems allow the exchange of energy and materials with the external environment and another system in the given circumstances. This results in progressive changes of properties of the given system. For instance, the culture of the certain society can be considered as an open system, because it allows the exchange of energy and materials. Continuous interaction with the human being and their environment can also be considered as an open system. Due to this, the characteristics of the open system are dynamic because of the progressive transformation caused by internal and external driving forces.

3.3 Complexity, Interconnections and Dynamics in Systems

A system encompasses an interconnected, complex and functionally related components. There is the web-like network of interconnection among the components. Due to this characteristic of the system, a change in one part of the system may affect the whole system negatively or positively Therefore, a small change in one subcomponent can have significant consequences for the system as a whole (Folke et al., 2010:21; Phelan, 2001:132; Cornell and Jude, 2015:5). As indicated in Bodenschatz (2009:2), complexity in a system can be described by synergistic interactions of the sub-components that result in emergent functional characteristics of the system that may not be observed at each component level. Therefore, complexity often related to certain kinds of system features. A system can be considered as complex, if it demonstrates the characteristics, such as the emergence of the new behaviour, nonlinearity or disproportionality of cause and effect relationships among the components and availability of multiple stable identities of the components. In addition, there is functional redundancy among the components of the system and their interactions (Dixona et al., 2013:342; Rosser, 2011:13). A complex system may have many components that collaborate to create a functioning whole. Thereby the function creates itself by the dynamic interaction of the components without an intervening regulatory body (Bodenschatz, 2009:1).

As indicated in Norberg and Cumming, (2008:2), complex systems are systems that can produce unexpected dynamic results because of nonlinear interactions among components. Nonlinear dynamics mean that these systems have the possibility of self-reinforcing or self-moderating processes. This transfers a change in the proportional contribution of different processes to the structure of the entire system. Dynamics in the system can be described by transformation of the behaviour of the system because of the change of emergent properties of the individual components. Therefore, dynamics in each component may affect the whole function of the system (Innes and Booher, 2010:3).

According to (Jordan, 1998:10), structurally, a system is a divisible whole, but functionally it is an indivisible unity with emergent properties. An emergent property is described by the presence of original features demonstrated on the level of the whole system, but not by the components in isolation. Two important characteristics of growing properties can be observed during the analysis of the system. The possibly of loss of emergent features when the system breaks down to its components, and the loss of the emergent behaviour of the whole system because of the dynamics of each component.



Source: Author's own, 2016

FIGURE 4: CONCEPTUAL DESIGN OF COMPLEX, INTERCONNECTED AND DYNAMIC SYSTEM

3.4 Renaissance and Application of Systems Approach

The systems approach is a method used to solve problems through holistic and integrative consideration of the social, economic and environmental situations (Landsberg et al., 2005:17). Systems approach to solving the problem has a potential to provide a trans-disciplinary framework for a simultaneously critical and normative exploration of the cause-effect relationship among the components under study (Richardson, 2004a:76). The systems approach allows using knowledge, methods, ideas and procedures from the academic, scientific and practitioners to bear on problems faced by political, business and industrial decision-makers and in planning and programming contexts (Abraham, 2011:383). It provides alternative decision-making ways or scenarios to investigate how best to aid decision or policy-maker faced with complex problems to choice under uncertainty. In addition, it is a practical philosophy for carrying out decision-oriented multidisciplinary approach, and a perspective on the proper use of the available tools to solve the problems (Richardson, 2007:163; Miser and Quade, 1985:30). In addition, the systems approach regards everything as ultimately connected to everything else. Nevertheless, boundaries of concern are possible to establish and to designate for the most relevant relationships. One of the most helpful insights provided by the systems approach is an appreciation of the differences introduced by a change of scale in time or space. Sometimes small or incremental changes may be indistinguishable from chance variations until they are seen from a broader perspective or across a threshold (Leonard and Beer, 1994:6).

Accordingly, the systems approach to problem solving has been practised in many disciplines. For instance, this technique has been used to address uncertainty and complexity in mathematics; to describe the survival, adaptation and growth processes in biology; to understand how the brain function to process perceptions in neurophysiology; to comprehend relativity, complementarity and uncertainty in physics; to identify communication media and transfer of information; and to assess the behaviour of people in psychology (Ahn et al., 2006:209; Leonard and Bee, 1994:3). In addition, a systems approach has been practised in the military context, in the industrial production processes, business administration, management tasks and transportation system. During the second half of the 1960s, urban and regional planners in Britain, whose interests influenced by political, technical and managerial understandings, practised systems approach as an integral parts of the spatial and transport planning methodology. This notion became a central theoretical assumption for urban, spatial and transport planning processes (Sandmeier, 2011:9).

Furthermore, a systems approach has been used in application to organisational communication. Organisations are systems that have many different members and relationships within those members. When an organisational system is functioning properly, synergy can be created. Systems approach allows this synergy to be generated because of the communication channels that are open in a properly functioning system (Seary et al., 2008:182). The systems approach to deal with problems encourages the use of models that are well understood and may be generalised and practised at various circumstances as long as the common dynamics of the disciplines have been distinguished and proven. In the field of computer science, computational capability reaches to the level that cannot be performed manually and makes the extensive use of quantifiable models. In general, the systems approach has been applied in various areas. It is gaining prominence because of high interconnections among the global society because of the advancement of information and communication technologies (Leonard and Beer, 1994:3). The advantage of using a systems approach is that it helps to give some structure to complex and ill-defined policy fields. Furthermore, the field of systems approach provides useful guidelines, tools and techniques that allow developing comprehensive models for decision-making. Even if the systems approach cannot provide complete and detailed prescriptions, it can minimise the risks (Miser and Quade, 1985:4; Seary et al., 2008:182).

Overall, a systems approach has been applied with varying success to a wide spectrum of problems, both in type and area. For instance, in the field of education the application ranges from efforts to increase the more efficient use of space by using computer programmes in classrooms to analyse of the basic objectives of education. In the field of environmental protection it is applied designing a wildlife impact reporting and selecting alternative methods of controlling pollution. Conceptually, a systems approach can be applied in any situation where decisions have to be made (Abraham, 2011:384; Sandmeier, 2011:13; Seary et al., 2008:184; Miser and Quade, 1985:23).

3.5 The Systems Approach as a Method to Solve Problems

The methodology of the systems approach to solving a problem involves an intuitive element in applying systems concepts (Jordan, 1998:12). The systems approach to solve the problem enables a decision maker to compare the alternative solutions to problems. Practically, a systems approach can be regarded as a systematic way of helping a decision-maker to choose a course of action by investigating the problem, searching out objectives and alternatives, and comparing them in the light of their consequences by using an appropriate framework (Saravanan 2008:203). A systems approach to problem solving is a multidisciplinary problem-solving method that has evolved to deal with the complex problems that arise in different circumstances. Since the systems approach deals with diverse problems and different contexts, it assumes many forms adapted to the problems, the systems and their contexts. To utilise its potential benefits, it must be contextualised and fit into the social process of problem-solving (Jansen, 2009:172).

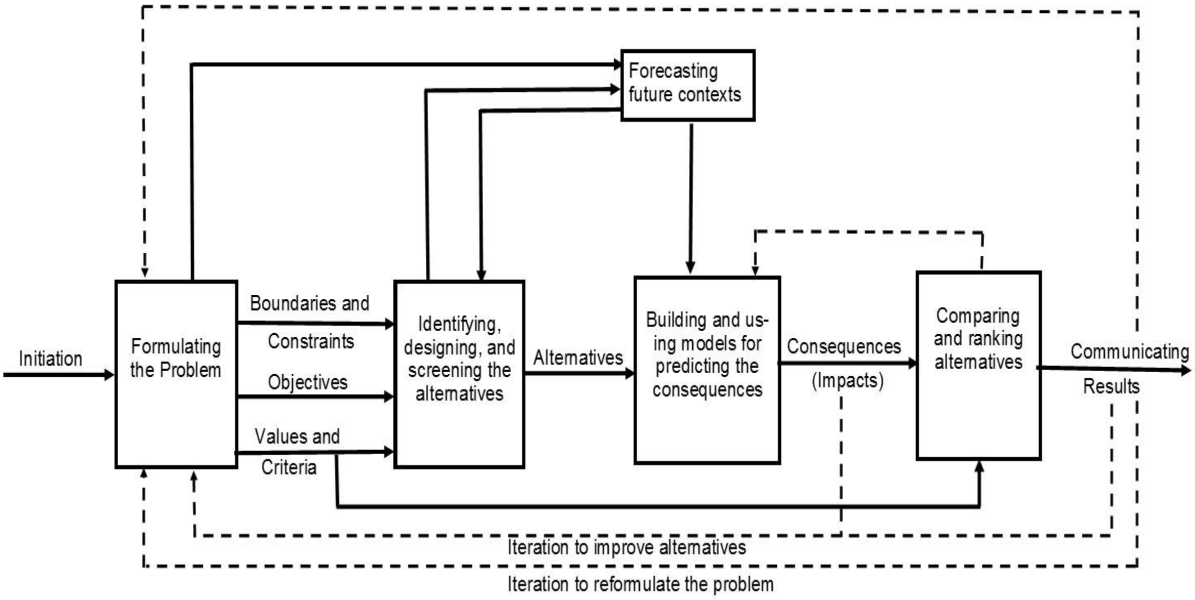
As indicated in Miser and Quade (1985:18), a systems approach to problem solving may encompass the following major activities. These activities may not be sequential and in some instances may occur in parallel. They are: arranging the evidence and scientific knowledge having bearing on it, examining the purposes relating to the problem and helping persons and institutions to reconsider these purposes; exploring alternative ways of solving the problems that commonly encompass formulating new solutions; reconsidering the problem and its possible reformulation in the light of the knowledge accumulating during the analysis; assessing the impact of alternative actions by considering the uncertain future; selecting the most feasible alternative to using different criteria to their outcomes; describing the outcome of the assessment in a framework appropriate for selection; and evaluating the impact of implementing alternative measures.

A systems approach can be used to demarcate system boundaries and to separate symptoms from problems. An essential output of a systems approach to problem solving is a holistic understanding of the root cause of the problem and its appropriate solution. The systems approach to problem solving can stimulate holistic thinking and provide a common ground for people participating in the analysis (Jansen, 2009:172; Rotmans and Loorbach, 2009:184). In particular, the systems approach provides a big picture of the system and comprehensive characteristics of the system. The attributes of the elements of the system as well as the connections among them have to be distinguished (Saravanan 2008:214). The properties of the system can be used to provide a view of its historical development and elaborate historical path of interconnectedness (Rotmans and Loorbach, 2009:185).

The systems approach to problem-solving applies a scientific method to map and analyse the system, whereby this scientific method is characterised as a structured way of working that is open and explicit, empirically based, aligned with an existing body of knowledge, and the outcomes can be tested and are replicable (Walker, 2000:12). In addition, it seeks to develop and test ‘theories’: causal assumptions of how the world works. Despite this emphasis on the scientific method, another key feature of the systems approach to problem-solving is the recognition of the complexity of the systems and dynamics of the properties of the components, as well as that the systems approach is essentially an art and a craft, based on tacit and informal methods, rather than formal and explicit (Miser and Quade, 1985:19).

3.6 Customising the Systems Approach for Climate Change Resilience Planning

The systems approach to solving problems is concerned with formulating the problem, defining the goals and objectives, identifying constraints, projecting the future contexts of the system and its circumstances, developing models for predicting the outcomes and assessing alternatives to support the decision-making process (Findeisen and Quade, 1985:117). The system approach to solving a problem comprises certain major steps that allow an understanding of the real problem and come up with the best alternative solution to the given problem. This can be realised by determining the boundaries and constraints, identifying the objectives, and by determining the decision-maker's values and criteria. Figure 5 indicates a schematic representation of systems approach to problem solving.



Source: Adopted from Findeisen and Quade, (1985:117)

FIGURE 5: THE SYSTEMS APPROACH TO CLIMATE CHANGE RESILIENCE PLANNING

The methodological framework of a systems approach to problem solving provides planners with a crucial means to understand the relationship between humankind and ecology, and a potentially powerful means for its control and guidance (Sandmeier, 2011:9).

3.7 Limitations and Drawbacks of the Systems Approach to Problem-Solving

Although the systems approach to problem solving has been practised in a multitude of disciplines, it has its own limitations and drawbacks in terms resource requirement. Not all aspects of causes of the problems might be addressed in reality (Miser and Quade, 1985:21). Consequently, uncertainties remain about some the parts systems that are not considered in the study. In addition, the systems approach to problem solving requires huge data from all sectors and sophisticated models to forecast the future and to produce alternative solutions. This necessitates assigning a large amount of money and skilled personnel. Otherwise, it may not be feasible when serious shortages of resources (skilled manpower and finance) are faced. However, if the required resources are available, the systems approach to problem solving is preferable to a reductionist approach. This approach enables planners to realise informed decision-making and solve problems in a sustainable manner (Schedegger, 1992:213)

3.8 Conclusion

The systems approach advocates using holistic or integrated techniques to assess changes in a particular area. By using a single or unimodal approach, it is difficult or impossible to comprehend the changes and provide a solution to existing challenges of climate change risks in the areas of formal and informal town establishments. Thus, a sustainable solution could not be devised by using unimodal approach to analyse climate change impacts in the given area. This is mainly because certain interventions to provide a solution based on the analysis outcome of a single approach may create another problem in other parts of the town. Therefore, to cope with the threats of climate change impacts in the areas of informal establishments, a systemic view of the issue is essential in order to suggest a sustainable solution. The systems approach dealing with impacts of change helps planners to consider the broader social, economic and environmental functions in order to propose appropriate interventions. In addition, it enables them to understand complex interactions among the formal and informal establishments in the town. For instance, the impact of climate change-induced risks in areas of informal settlements may have a direct adverse effect on the formal system because of these complex interrelations. Overall, to come up with an innovative and sustainable solution for climate change-associated risks, a systems approach is an essential method that should be practised by planners or any other decision makers.

Chapter 4
INFORMAL SETTLEMENTS' VULNERABILITY AND RESILIENCE TO CLIMATE CHANGE RISKS

"A problem clearly stated is a problem half-solved" Dorothea, B. (1893-1948)

4.1 Introduction

This chapter discusses the propensity of informal settlements to exposure, sensitivity, as well as their adaptive capacity to climate change-induced risks and their resilience capacity. In line with this, the techniques to examine and measure the level risks and their coping capacity are discussed, based on different perspectives suggested by scholars. The interfaces of vulnerability, resilience and sustainability concepts are discussed and customised within the context of this study. In addition, the potential level of application of the theory of resilience in the contexts of informal settlements is examined. Finally, climate change-resilience measurement instruments that facilitate informal settlement resilience planning are discussed.

4.2 Definitions and Concepts of Vulnerability

In the context of climate change, the concept of vulnerability has gained increasing popularity in climate change studies (Canon, 2000:1; Wisner et al., 2004:7). Vulnerability is applied as a key concept in assessing who will experience the greatest impact of climate change. Even though there are multitudes of definitions across various disciplines, only those definitions of vulnerability associated with climate change are discussed in this section. The United Nations International Strategy for Disaster Reduction [UNISDR] (2004:14) defines vulnerability as the propensity of exposed components, such as human beings, their livelihoods and assets to suffer negative effects of hazard. Vulnerability is commonly assessed in terms of *exposure;* that is, the intensity with which a system is exposed to a hazard; *sensitivity* is the nature and intensity with which a system is influenced by a hazard; and *adaptive capacity* is the ability of a system to adjust and moderate possible potential damages and cope with consequences.

According to the International Panel on Climate Change [IPCC] (2014b:127), vulnerability is the propensity to be affected harmfully. It is a measure of exposure, sensitivity and adaptive capacity to hazards. This explanation of vulnerability associates the sensitivity and exposure components with economic and geographic features and the coping capacity with a community's capacity to create resiliency. Therefore, it indicates how a system or asset is susceptible to a hazard caused by climate change (Levina and Tirpak 2006:16; AECOM et al., 2011:1).

The adaptive capacity influences a system's vulnerability by kerbing both exposure and sensitivity to a hazard. Thus, the higher the adaptive capacity of a system, the lower the influence of the exposure and sensitivity of the components is (Engle 2011:648).

The concept of vulnerability is critical for understanding climate change in the context of social and environmental conditions. Its vulnerability is an outcome of various historical, social, economic, political, cultural, institutional, natural resource and environmental conditions. Therefore, in order to understand understanding the vulnerability to climate change one needs to understand multi-scale and interdisciplinary issues (Adger, 2006:268). As confirmed by different scientific models' projections, the climate change will continue and increase human vulnerability because of both short-term extreme events and long-term environmental degradation.

To provide a comprehensive insight into the notion of vulnerability, some of the definitions used in natural-hazards risk assessment and global environmental change are presented in Appendix 7. The following sections also discuss the school of thought that influences the definitions and the frameworks assessing vulnerability to climate change risks.

4.3 School of Thoughts about System's Vulnerability

As indicated in Birkmann (2006:55), there are multitudes of definitions, conceptual pluralism and methodological variations in measuring vulnerability to climate change-induced risks. Birkmann noted that there is a paradox in terms of measuring systems' vulnerability to hazards and conceptual vagueness of the term vulnerability. Nonetheless, broadly speaking, there are two fundamental perspectives in which vulnerability can be assessed and that are closely linked with the evolution of the concept (Brooks, 2003:1). These are engineering and social school of thoughts about system's vulnerability.

4.3.1 Engineering School of Thought about a System's Vulnerability

This technical or engineering sciences-oriented perspective dominated the disaster-risk perception in the 1970s, emphasising the amount of damage caused to a system by a particular hazard (Roxana et al., 2013:6). The Engineering School of Thought also focuses on assessments of hazards and their impacts, in which the role of human systems in mediating the outcomes of hazard events is downplayed or neglected (Blaikie, 1994:5). This technical-sciences perspective of vulnerability focuses primarily on physical aspects such as critical infrastructure, housing and landscape, and other physical environmental characteristics (UNDRO, 1979:online). As indicated by Blaikie et al. (1994:9) and Cannon (1994:22), the most visible area of vulnerability is physical or material poverty. Poor people suffer more often from crises than people who are richer, because they have less income and production options and limited resources. This category relates to buildings, agriculture, land, climate, environment, people's health, skills, infrastructure, food, housing, capital and physical technologies.

4.3.2 The Social School of Thought about a System's Vulnerability

This is a social-science oriented perspective emphasise at a state that exists within a system before it encounters a hazard. It is an alternative paradigm, which considers vulnerability as a starting point for risk reduction, developed since the 1980s (Roxana et al., 2013:6). The social school of thought puts the human system at the centre of the stage and focuses on the coping capacity of the society to hazards (Blaikie, (1994:5). As UNISDR (2004:online) indicates, the social-sciences perspective takes into account different factors that influence vulnerability, such as physical, economic, social, environmental and institutional. The different definitions of vulnerability can also be viewed from a functional and subject- or object-oriented perspective and the vulnerable entity, for example, critical infrastructure, elderly population, communication networks, mountain ecosystems (Roxana et al., 2013:6). There, perspectives matter to operationalise the definition of vulnerability.

For the purpose of this study both the engineering and social schools of thought were combined and operationalised. This is mainly because the assessment of the vulnerability of informal settlements to climate change risks necessitates considering all the socio-ecological aspects; physical as well as social dimensions of vulnerability.

4.4 Dimensions, Scales and Dynamics of Vulnerability

4.4.1 Dimensions of Vulnerability

Vulnerability is multi-dimensional concept that needs to be assessed from different aspects. It varies from individual elements to a combination of elements that form the whole system and vary in different physical and socio-economic contexts. Broadly speaking, five aspects need to be considered in the process of vulnerability evaluation. The first is the physical or functional aspect. This is related to the exposure of the structure to a certain hazard. The second is the economic aspect related to the economic condition of a region endangered by a hazard. The third social aspect includes individuals, households or communities and their capacity to cope with the adverse impacts of hazards. Fourthly, the environmental aspect can be described by to the interrelation between different ecosystems and their ability to cope with impacts of hazards over different time and space scales. The fifth is the institutional aspect, which refers to an institutional capacity to cope with hazards (O'Brien et al., 2004:303).

4.4.2 Scales of Vulnerability

Vulnerability can vary in terms of scale, types, intensity, duration and hazards, as well as the type of elements at risk. Consequently, the methods used for the evaluation of earthquake vulnerability are not directly transferable to droughts, for example. The vulnerability of exposed objects or systems may vary also for similar processes (Glade, 2003:121; Cutter, 1996:529). The elements at risk can be described as the either people, materials, activities and processes that may be affected differently by hazards in a given area, directly or indirectly (Hufschmidt, 2005: 375).

4.4.3 Dynamics of Vulnerability

Vulnerability must be considered as a dynamic process, and not static. Assessment should integrate changes and developments that alter the probability of loss and damage of all the exposed elements. The dynamics of vulnerability can be also expressed by continuously changing systems characteristics in time and space. Lewis (1999:14) also indicates that the measure of vulnerability should not be regarded as static; rather, vulnerability expresses changing social, ecological and economic conditions in relation to the nature of the hazard and is part of a dynamic and evolutionary process. As a result, it can be argued that vulnerability is embedded in complex social, ecological and economic relationships and processes (Thomalla et al., 2006:39).

4.5 Frameworks to Analyse Vulnerability to Climate Change Risks

As stated in De Satge et al. (2002:267), the purpose of vulnerability analysis is highlighted as a means to provide a basis for the government at macro level, local authorities and communities to define strategies and to draw up feasible, prioritised, cost-effective plans of action to reduce risk and vulnerability, as well as to enhance preparedness towards effective disaster risk reduction. Therefore, this analysis must identify the risks and vulnerabilities affecting different areas and populations and how risks and vulnerabilities might change; determine which risk and vulnerabilities are the most important and reducible; estimate the likely effectiveness and costs of various feasible reduction measures; and identify early warning indicators relevant and feasible in the local situation (Turner et al., 2003:8074).

Some of the conceptual approaches to analysing vulnerability are discussed in the following successive sections. As mentioned above, different schools of thought suggest their own conceptual approaches with the purpose of assessing vulnerability. Consequently, the discussion encompasses the vulnerability viewed from a double structure; within the context of hazard and risk; in the context of global environmental change community; the Pressure and Release

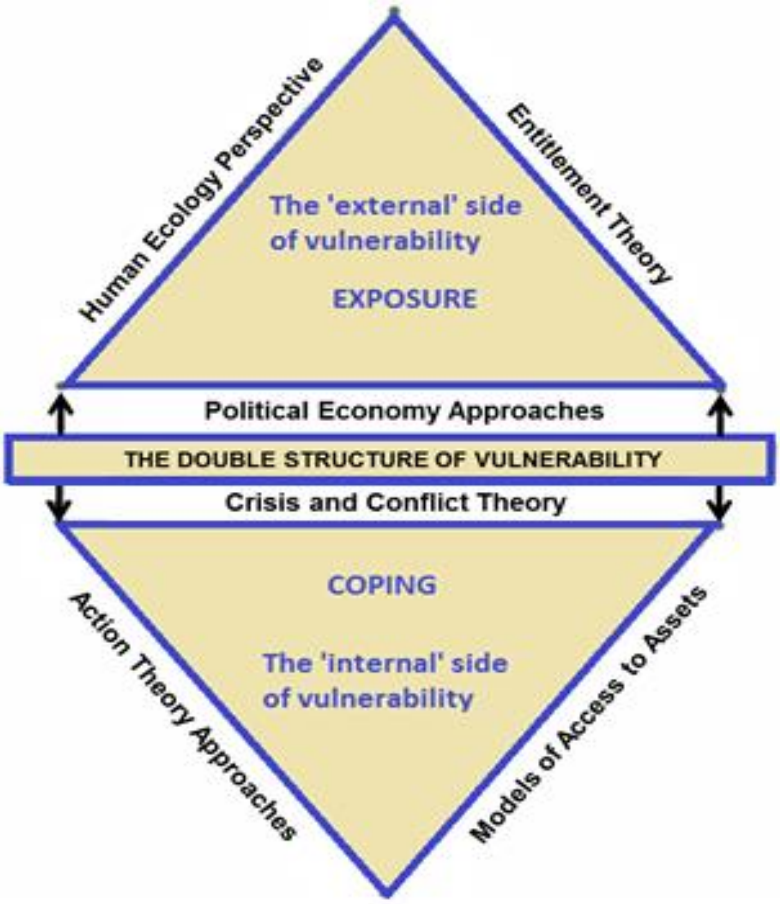
Model (PRM); a holistic approach to risk and vulnerability assessment; the Sustainable Livelihood Framework [SLF]; and two different conceptual frameworks of vulnerability developed by United Nations University Institute for Environment and Human Security [UNU-EHS], such as the ‘‘Onion Framework’’ and the ‘‘BBC conceptual framework’’.

4.5.1 The Double Structure of Vulnerability

According to Van Dillen (2004:23), this framework views vulnerability from two dimensions having external and internal factors. The external factors contributing to the vulnerability of a system are associated with the political economy approaches, human ecology perspectives and entitlement theory. The political economy approaches are linked with social inequities, a disproportionate division of assets. The human ecology perspectives are associated with population dynamics and environmental management capacities. The entitlement theory links vulnerability with the inability of the community to access or administer assets through legal means. These factors include access to land, education, natural resources, healthcare, food and freedom of speech.

The internal factors are associated with the capacity to anticipate, cope with, resist and recover from the adverse impact of a hazard. The internal dimension of vulnerability directly influenced by the crises and conflict possibly occurs in the process of controlling resources. In this case, the capacities to manage crises and resolve the conflicts determine the level of vulnerability to hazards. It furthermore includes people’s capacity to react to hazards that are related to social, economic or institutional capacity and access to assets. This includes cumulative effects of factors that determine the degree to which community’s living condition is put at risk. While the internal coping capacity is declining, it will be unprotected and the tendency for risk will be high. Consequently, some section of the society is more susceptible than others because of variations in this internal capacity, even facing similar hazards (Blaikie et al., 1994:9).

Thus the framework clearly identifies vulnerability as a potentially detrimental social response to external events and changes such as environmental change. Interestingly, Bohle’s conceptual framework describes exposure to hazards and shocks as a key component of vulnerability itself. Within the debate of social vulnerability, the term *exposure* also deals with social and institutional features, meaning processes that increase defencelessness and lead to greater danger, such as exclusion from social networks. These alter the exposure of a person or a household to risk (Cannon et al., 2003:6). Therefore, as the conceptual framework of the double structure indicates, vulnerability cannot be considered adequately without taking into account coping[4] and response capacity[5] (see Figure 6).



Source: Adopted from (Bohle, (2001:1)

FIGURE 6: BOHLE'S CONCEPTUAL FRAMEWORK FOR VULNERABILITY ANALYSIS

4.5.2 Vulnerability within the Framework of Hazard and Risk

This approach usually considers vulnerability, exposure and coping capacity as distinct components. The risk-hazard conceptual framework is useful for assessing the vulnerability of a particular asset that comes from their exposure to certain extreme events in a particular pace. As a result, the individual's vulnerability has often been considered simply as exposure to hazards (Hewitt, 1997:27) or being in the wrong place at the wrong time (Liverman, 1990:27).

[4] ***Coping capacity*** is the ability of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters [UNISDR., 2004:online)

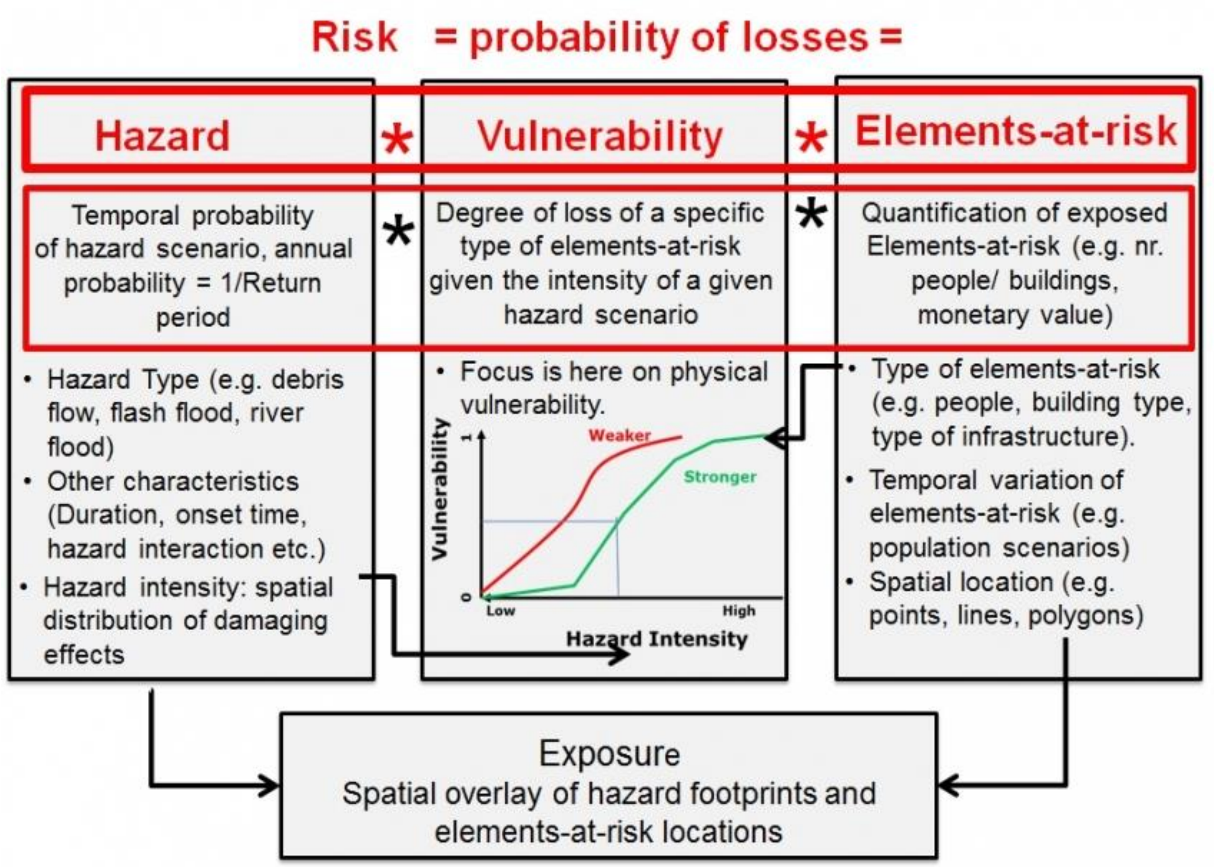
[5] ***Response capacity*** is the combination of all the strengths attributes and resources available within a community, society or organization that can be used to achieve agreed goals (UNISDR, 2004:online)

The risk-hazard framework hypothesises that hazard events are static, rarely occur and are well-recognised (Downing et al., 2001:13).

According to this framework, communities perceive vulnerability as a factor within the context of hazard and risk. This perception usually recognises vulnerability, coping capacity and exposure as independent components. Therefore, this framework considers risk as the sum of hazard,[6] exposure,[7] vulnerability and capacity measures. Hazard is described by the probability of the risk, whereas vulnerability is viewed as physical, social, economic and environmental factors exposed to these risks. Capacity and measures are linked to the availability of the physical planning and management, as well as social and economic capacity (Bollin, 2003:8).

As indicated in IFRCS (2000:6), there is a dynamic relationship between the concepts of hazard, risk and vulnerability. Chen et al. (2003:546) justify this dynamic relationship as, if there is a greater tendency of a hazard occurrence, there will be more vulnerable people, and the higher the intensity of risk. Therefore, it is possible to consider vulnerability as a lack of capacity to cope with disaster. When the community lacks appropriate prevention and mitigation strategies, high risk will occur. Contrary to the double structure of the vulnerability assessment framework, this hazard and risk framework explains vulnerability as one component of disaster risk and differentiates between exposure, vulnerability and coping capacity (Van Westen, 2016:2; Bollin et al., 2003:67). The United Nations Office for Disaster Risk Reduction [UNISDR] evaluate a vulnerability in terms of the context of sustainable development (UNISDR, 2009:online). Accordingly, vulnerability analysis focuses on the existence of early warning systems, preparedness, and response and recovery capacity in a particular area. It explains the potential for damage to the elements at risk induced by the hazard, and it depends on multiple factors related to physical, social, economic and environmental conditions that are interrelated in space and time scales. This can be elaborated more by a lack of the protection of assets, shortage of information and awareness, poor design and building constructions, limited preparedness and unwise environmental management. In addition, coordinated measures to cope with climate change risks are directly associated with addressing all three aspects of the risk, such as hazard, vulnerability and exposure.

[6] ***Hazard*** is "a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage"(UNISDR, 2009:online).



Source: Van Westen (2016:2)

FIGURE 7: CONCEPTUAL FRAMEWORK FOR RISK IDENTIFICATION

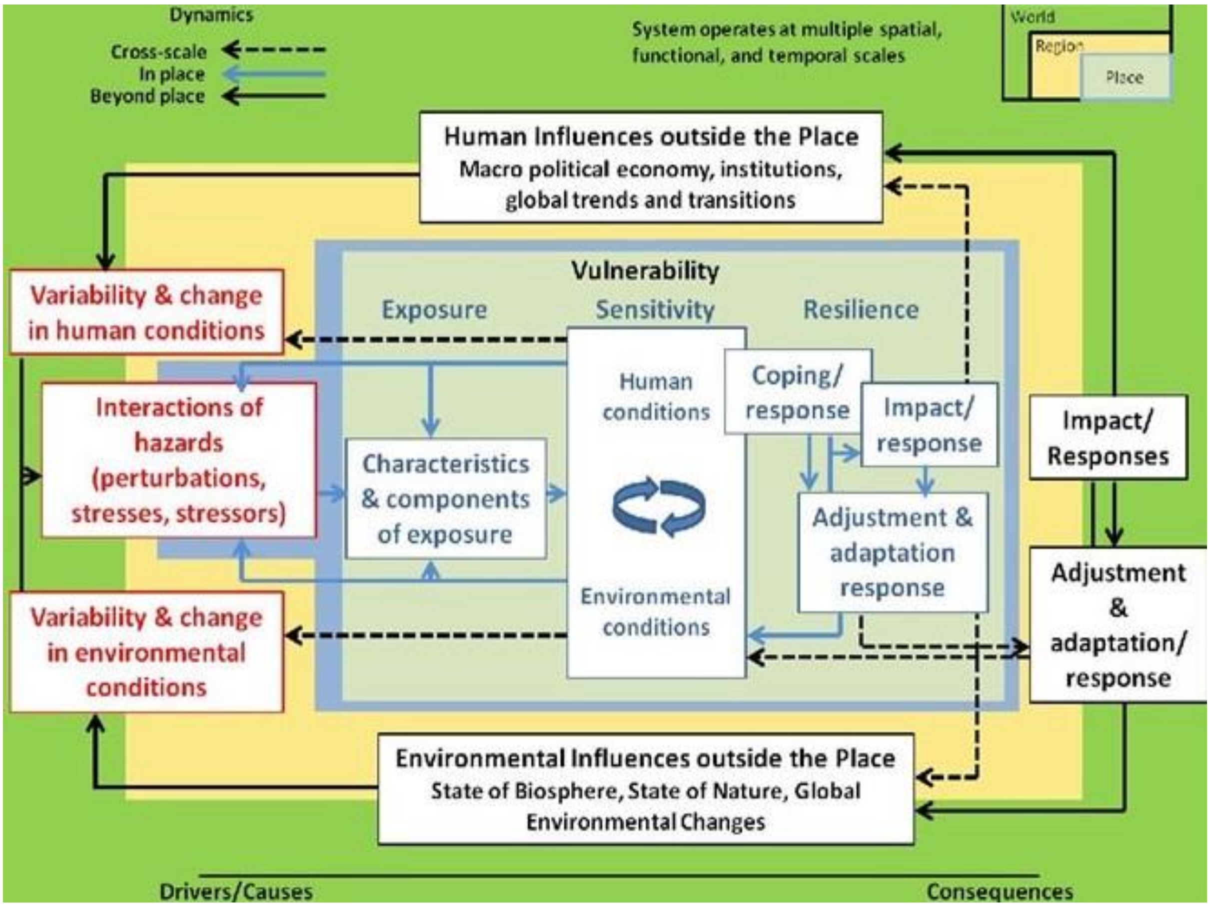
4.5.3 Vulnerability in the Global Environmental Change Community

This conceptual framework describes exposure, coping, impact and adaptation responses explicitly as components of vulnerability. The framework was formulated with the purpose of dealing with the impacts of global environmental change and to evaluate the interaction of human and natural environment. Contrary to the disaster-risk community framework, this approach of vulnerability involves exposure,[8] sensitivity and resilience.[9] Exposure refers to a set of elements subjected to possible risk in a particular area. The scale of influence or exposure varies from individual level, to states, as well as the overall ecosystem. The sensitivity is characterised by the human and environmental situations. The human condition indicates the available social capital and natural endowments. The environmental situations describe the existing natural capital or biophysical endowments, which are easily affected by climate change risks. The resilience component refers to the ability of the system to resist, adapt and transform

[8] ***Exposure*** is defined as the totality of people, property, systems or other elements present in hazard zones that are thereby subject to potential losses (UNISDR, 2004:online).

[9] **Resilience:** The theory of resilience and interfaces of resilience and vulnerability are discussed in section 4.7 and 4.7.1 respectively.

in the face of climate change risks (Turner et al., 2003:8075). (See Section 4.7 for detail explanation of the concept of resilience.)



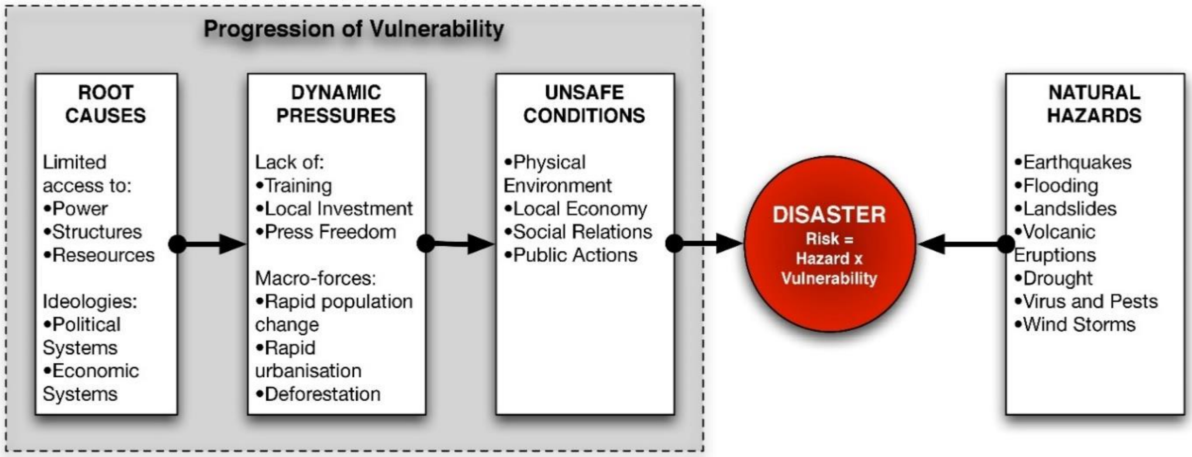
Source: Adopted from Turner et al. (2003:8074)

FIGURE 8: CONCEPTUAL FRAMEWORK FOR VULNERABILITY TO GLOBAL ENVIRONMENTAL CHANGE

Consequently, a system's vulnerability to hazards is determined by the interaction of broader human and biophysical environmental situations and the operating process coupled in the system. In addition, it includes the possible disturbance and stress that emanate from this process. Overall, the combined human and environmental system exposure to risks and the response capacity determine the level of vulnerability of the system (Turner et al., 2003:8076; Kasperson, 2005:9). (See **FIGURE 8**.)

4.5.4 The Pressure and Release Model (PAR Model)

The disaster pressure-and-release (PAR) model first start by considering the risk-hazard framework, introducing risk because of vulnerability and hazard (Wisner et al., 2004:6). Then it describes vulnerability by identifying the root causes and driving forces. This model is designed to function at different spatial and temporal scales and considers the interrelations of the multiple disturbances and stresses.[10]



Source: Wisner et al., (2004:5)

FIGURE 9: THE PRESSURE AND RELEASE MODEL (PRM) TO ANALYSE VULNERABILITY

Hazards are described as being affected from inside and outside the given system; nevertheless, because of their character, the possible hazards are commonly site-specific. Therefore, considering the complex nature of hazards, they may be within or outside the domain of the analysis. Accordingly, the Pressure and Release model are based on the equation, which defines risk as a function of the hazard and vulnerability (Turner et al., 2003:807). The model focuses on the fundamental driving forces that contribute to vulnerability and the system's propensity to disaster when a hazard occurs. Thus, vulnerability is linked to three conditions, such as identifying the root causes associated with limited access to power, structures or resources; the dynamic pressure represented by demographic or social changes in time and space scale; and unsecured condition induced by the physical environment linked with unprotected properties, high slopes or socio-economic context, such as lack of local institutions and prevalence of endemic diseases. As indicated in Birkmann (2006:55), this conceptual framework is an essential tool that assesses vulnerability beyond the identification of the root causes and driving forces behind the human-environmental system. Generally, the Pressure and Release model (PAR model) model is important in the process of addressing the release phase and the root causes that contribute to disaster situations.

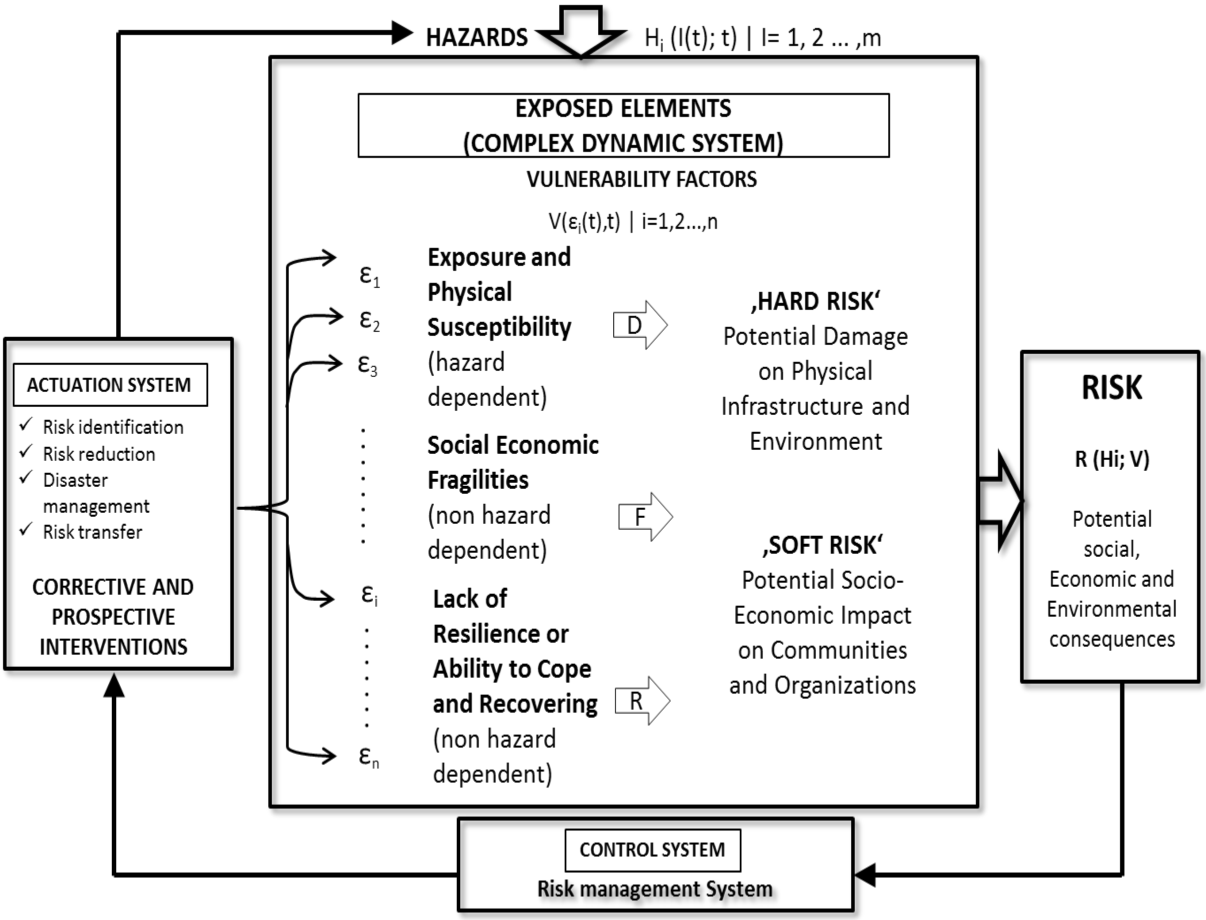
[10] Stress is a continuous or slowly increasing pressure, commonly within the range of normal variability. Stress often originates and stressors (the sources of stress) often reside within the system (Turner et al., 2003:8075)

4.5.5 The Holistic Approach to Risk and Vulnerability

This is a framework to analyse risk and vulnerability by using a holistic approach and categorising vulnerability into three components. Physical exposure and susceptibility comprise the first category and is dependent on the hazard. The fragility of the socio-economic system is considered as the second category and it is dependent on non-hazard conditions. Finally, lack of resilience capacity to cope with and recover from climate change risks is categorised as the third component, which is also non-hazard dependent (Carreño et al., 2007:137). Carreño et al. focus on the necessity of measuring vulnerability from a multidisciplinary and comprehensive view. This framework considers the outcome of directly observable physical impacts that are related to exposure and susceptibility, and the indirect outcomes that are associated with the socio-economic fragility and weakness in the resilience capacity.

Accordingly, each category of vulnerability is described with the combination of indicators. The framework encompasses a control system that indirectly changes the intensity of risk by adjusting measures. These measures can be described as risk identification and reduction, and disaster minimisation. The framework associates the vulnerability situations with not only with the exposure and sensitivity of physical drivers in vulnerable areas, but also with the socio-economic susceptibility The holistic model considers vulnerability as an interaction of the possible physical loss and the impact driver that are linked to economic and social susceptibilities and unavailability of resilience (see **Error! Reference source not found.**).

The holistic model of disaster risk views risk as a function of the potential physical damage and the impact factor (social and economic fragilities and lack of resilience). While the potential ‘‘physical damage’’ is determined by the susceptibility of the exposed elements (e.g. a house) to a hazard and its potential intensity and occurrence, the ‘‘impact factors’’ depend on the socio-economic context – particularly social fragilities and lack of resilience. Based on the theory of control and complex system dynamics, Carreño et al. (2007:137:8) also introduce a feedback loop encompassing corrective and prospective interventions to underline the need to reduce both the vulnerabilities and the hazards. Thus, risk management requires a system of control (institutional structure) and an actuation system (public policies and actions) to implement the changes needed.



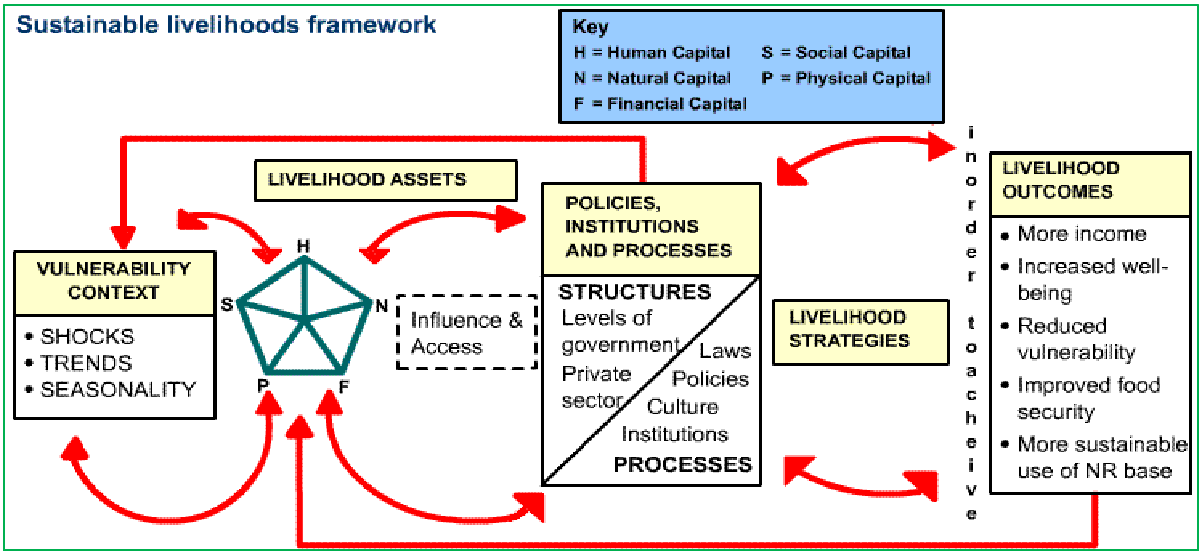
Source: Carreño et al., (2007:137)

FIGURE 10: HOLISTIC APPROACH TO DISASTER RISK ASSESSMENT AND MANAGEMENT

4.5.6 Sustainable Livelihood Framework (SLF)

Sustainable Livelihood Framework acknowledges that politico-economic, historic and social factors make certain individuals, populations or segments of the population more vulnerable to hazard events; these people then disproportionally suffer the consequences of the disaster. Blaikie at et al. (1994:9) state that the essence of vulnerability assessment is to investigate the role of social, economic and political relations in the creation of hazardous situations in a specific place. It also explains the social distribution of risk in that place that is associated with the identification of which social groups are more or less at risk. Some groups are more prone than others are to damage, loss and suffering in the context of different hazards. The fundamental components of this framework are the five livelihood capitals, namely the human, natural, financial, social and physical capitals. Thus, vulnerability is observed as shocks, trends and seasonality, as well as the effect of changing structures on coping strategies and outcomes (DIFID, 1999:online). This framework recognises sustainability as often related to the capacity to respond and recover from the stress and shocks to maintain the natural capital.

The framework focuses on the changing institutions and policies in the public as well as the private sector that affect the vulnerability and regulate access to livelihood assets. Further, the framework emphasises the necessity of the empowerment of marginalised sections of society to reduce vulnerability to hazards (Schmidt, 2005:45). The main imperative for this framework is to devise a technique that considers the community based on their daily necessity rather than operationalising uniform general intervention without recognising different potential capabilities the poor people may provide (De Haan and Zoomers, 2005:33).



Source: DFID (1999:online)

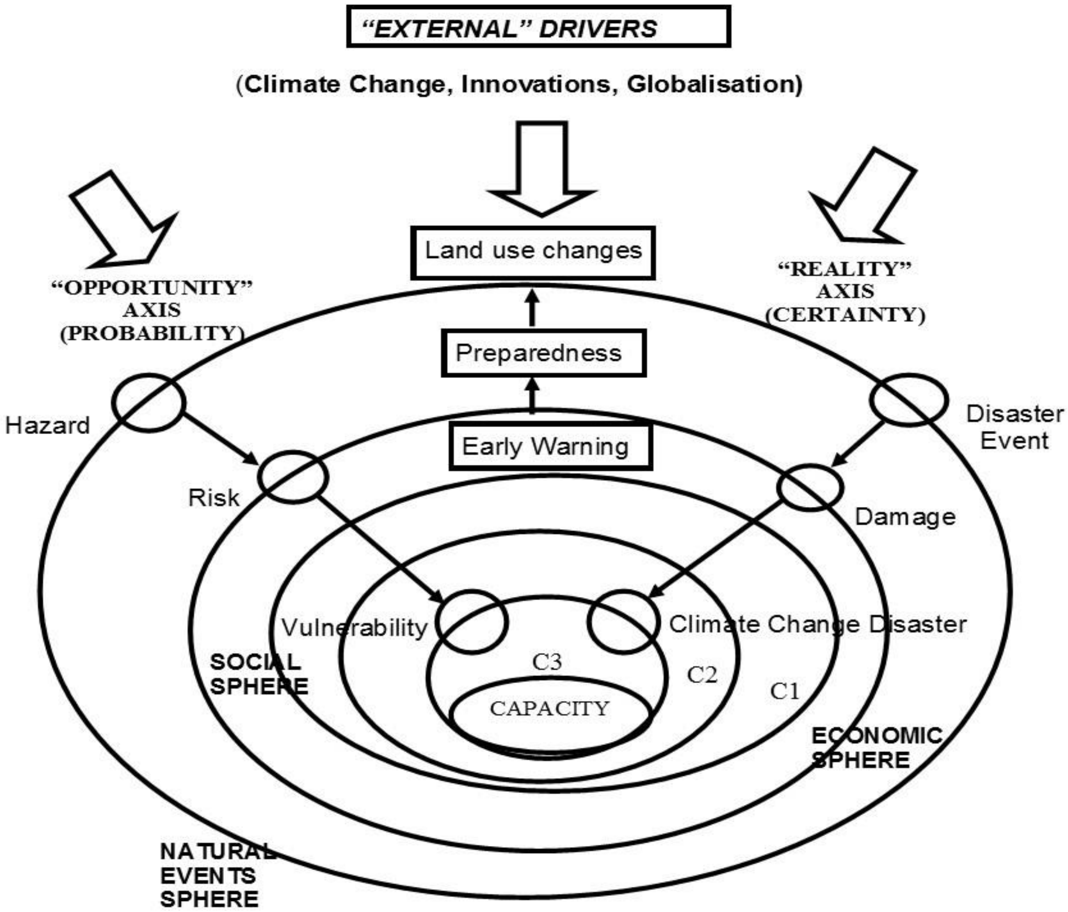
FIGURE 11: The Sustainable Livelihood Framework (SLF)

The sustainable livelihood framework emphasises the multiple connections that determine the ability of a person, household or society to cope with and recover from shocks. In this context, De Haan and Zoomers (2005:33) emphasise that access and the role of transforming structures are key issues that have not been sufficiently examined so far. In particular, the flexibility of the interchanges of different capitals and assets (human capital, financial capital, social capital) have to be considered more closely, which means that the configuration of power around these assets should be explored. De Haan and Zoomers propose that the concept has the tendency to focus on relatively static capitals and activities within different livelihoods and livelihood strategies (De Haan and Zoomers, 2005:34).

Furthermore, Allenby and Fink (2005:1034) indicate that it is important to recognise that the notion of livelihood contributes only to positive outcomes. In some instances, the feedback processes undermine the importance of livelihood outcomes regarding the natural environment conservation. For instance, the sustainable use of natural resources can be considered as an essential instrument to minimise the intensity and frequency of hazards such as flooding, drought or landslides. This interconnection between the human and natural environment may contribute to building resilience in the given area. However, this framework can also be used as an essential source for other frameworks designed for identifying susceptibility and resilience capacity for manmade as well as natural hazards. The framework categorises the disaster-risk components such as hazard, exposed and susceptible components, the driving forces and the outcomes. Therefore, the livelihood strategies and outcomes can be considered a combination of different interventions and responses to possible risks. Consequently, the concept of vulnerability in the sustainable livelihood framework is broad and involves the hazard domains. Considering these factors is essential in the process of disaster risk reduction. Failure to consider all these factors at grassroots level, especially in the process of resilience planning processes, may cause potential losses during the natural and climate change hazards. Additionally, there may be opportunities to reduce vulnerability and enhance resilience at macro- and micro-level if attention is paid to the possibility in the planning process (Adger et al., 2005:1036).

4.5.7 The Onion Framework to Assess Vulnerability

The onion framework describes susceptibility to hazard with regard to different hazard impacts related to the economic sphere and the social sphere. The impact of a disaster is revealed on the framework. Analytically, the framework distinguishes a reality axis and an opportunity axis. For instance, the flood affects the economic condition and may cause damage (see Figure 12). Economic assets can be replaced, but the disruption of the inner social sphere of a society would cause long-term injuries and losses, which in this model are primarily associated with the term vulnerability. Different capacities exist within the centre of the social sphere (C1–C3), which means that a disaster is determined by the capacity of the community. While C1 shows the fact that although the social sphere is affected, adequate coping capacities still exist, an impact of the flood event on the inner circle of the social sphere C3; however, would imply that social capacities are entirely insufficient to deal with the flood event, thus precipitating the occurrence of a disaster (Bogardi and Birkmann, 2004:75).



Source: Bogardi/Birkmann, 2004:75

FIGURE 12: The Onion Framework to Assess Vulnerability

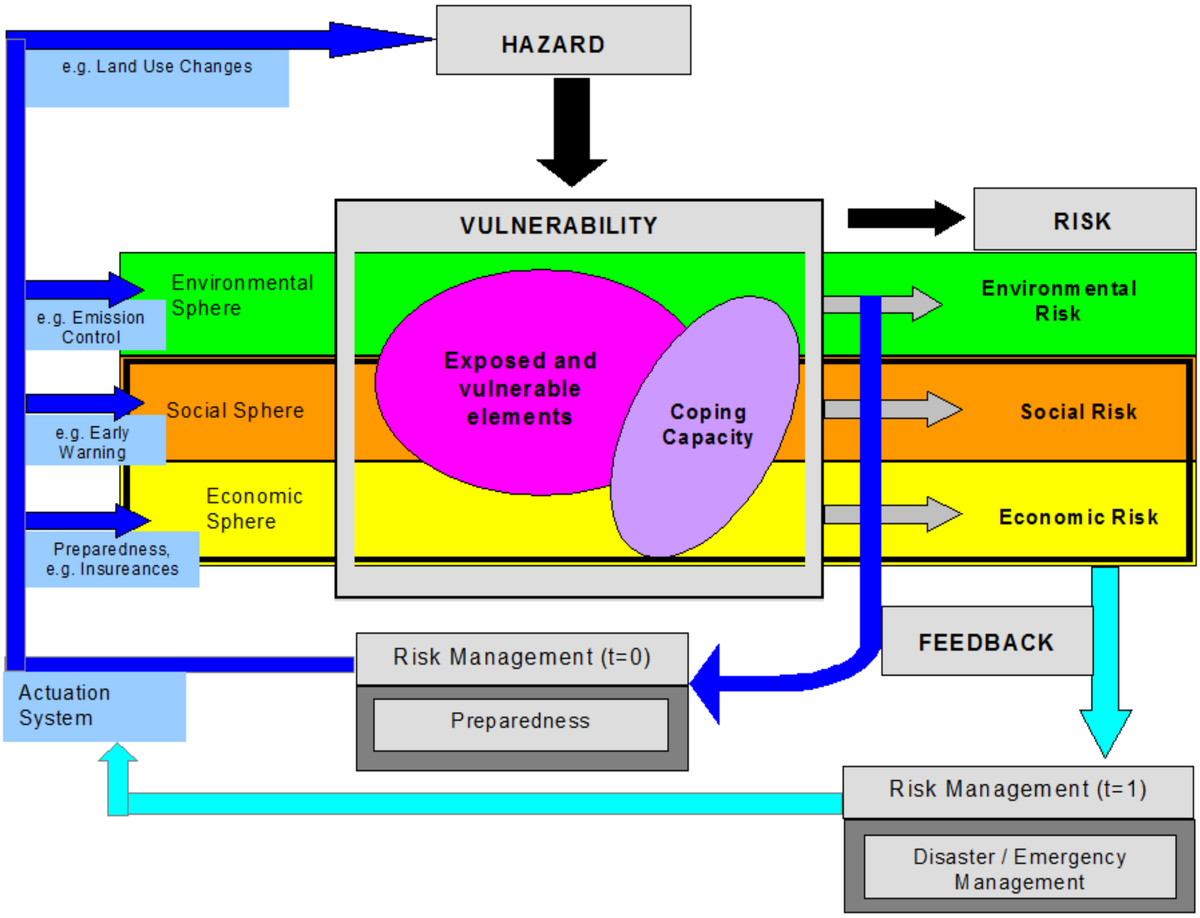
The ''onion framework'' associates the risk, vulnerability and damages caused in the three different dimensions. The framework emphasises that vulnerability deals with different ''loss categories'', such as economic and social losses. This means it stresses the fact that if a community or a person's losses go beyond economic losses, for example, extending to loss of confidence and trust, the flood event has reached the ''intangible'' assets. This implies a serious disruption of the functioning of the society, to the point that vulnerability becomes evident. According to this framework, the more comprehensive concept of social vulnerability should incorporate the monetary dimension (likelihood of economic harm) as well as ''intangibles'' like confidence, trust and fear as potential consequences of the flood.

4.5.8 BBC Conceptual Framework

This conceptual framework was developed by Bogardi and Birkmann (2004:76) and Cardona (2001:12). It came from three emphasises on how to connect human security to sustainable development and vulnerability (Bogardi and Birkmann, 2004:76) and a wider argument on developing different approaches to measuring environmental impacts in the context of sustainable development. This means that the BBC framework highlights the importance of considering social, environmental and economic spheres of vulnerability by integrating and linking sustainability to the vulnerability framework. The BBC conceptual framework combines different elements of the frameworks discussed earlier. Therefore, presentation of this framework will also reflect on the frameworks analysed before and will stress some key aspects, which are still controversial.

The BBC framework stresses the fact that vulnerability analysis goes beyond the estimation of deficiencies and assessment of disaster impacts in the past. It underlines the need to view vulnerability within a dynamic process, which means focusing simultaneously on vulnerabilities, coping capacities and potential intervention tools to reduce vulnerabilities by using a feedback-loop system. Furthermore, as shown in the BBC conceptual framework (see Figure 13), vulnerability should not be viewed as an isolated feature. Rather, vulnerability assessment also has to take into account the specific hazard type and potential event that the vulnerable society, its economy and environment are exposed to, and the interactions of both that lead to risk. This means the BBC framework underlines the necessity to focus on social, environmental and economic dimensions of vulnerability, clearly linking and integrating the concept of sustainable development into the vulnerability framework. Within the three sustainability dimensions (social, economic and environmental sphere), additional frameworks can be integrated, for example, the sustainable livelihood framework within the social sphere.

In contrast to a hazard and risk-analysis framework, the BBC conceptual framework emphasises the different exposed elements, the coping capacity and the potential intervention tools to reduce vulnerability. In contrast to the model of holistic approach to estimate vulnerability and risk (Cardona and Hurtado, 2000a:17), the BBC conceptual framework does not account for hard and soft risk; rather, the three main thematic spheres of sustainable development define the inner thematic composition in which vulnerability should be measured: the economic, the social and the environmental dimensions. In this context, the environmental dimension is not represented within the framework of the holistic approach to estimate vulnerability and risk developed by Cardona and Hurtado (2000a:17), but rather encompasses vulnerability regarding ‘‘exposure and physical susceptibility’’, ‘‘social and economic fragilities’’ and ‘‘lack of resilience or ability to cope and recovering’’. Another difference between the two frameworks refers to the response chains. The BBC framework distinguishes between the response before risk and disasters are manifested and the response needed when risk and disasters occur. While during the disaster, emergency management and disaster response units play a crucial role, vulnerability reduction should give particular emphasis to responses, thus focusing on preparedness rather than on disaster response and emergency management.



Source: Bogardi and Birkmann (2004:75)

FIGURE 13: The BBC Conceptual Framework to Assess Vulnerability

The framework emphasises the interconnection between sustainable development and vulnerability reduction by recognising also the environmental dimension on which the human being depends (Turner et al., 2003:8075). Further, it advocates a proactive method of coping with the possible climate change risks. This approach also accommodates those capitals found in the Sustainable Livelihood Framework (SLF) and encompasses appropriate planning measures to be taken in order to facilitate access to those livelihood assets. Besides the examination of the vulnerable elements within the society, the economy and the environment, the BBC conceptual framework shows the importance of reducing risk by reducing vulnerability and mitigating hazard, even before any risk can manifest itself. Vulnerability assessment should therefore also encompass the identification and analysis of potential intervention tools to reduce the various vulnerabilities and to increase the coping capacities of a society or system at risk. (See Figure 13.) Finally, the framework also stresses that the changes of vulnerability from one thematic dimension to another should be taken into account and viewed as a problem, since these shifts do not imply real vulnerability reduction.

4.6 Indicators of Vulnerability to Climate Change Risks

4.6.1 Criteria to Develop Vulnerability Indicators

As indicated by UNDP (2012:online) to understand of the intensity of informal settlements' vulnerability to climate change risks, it is crucial to identify context-based indicators. Accordingly, this section discusses the guiding principles and criteria to select vulnerability indicators under any circumstances. Systems' vulnerability to climate change risks can be analysed based on various indicators that determine the level of susceptibility, coping and resilience capacity of a certain system. The structure and identification of indicators for systems' vulnerability to climate change is complex. However, generally, there are nine interrelated phases in the process of vulnerability indicators development (Maclaren, 1996:184). The first step starts with by setting the goal or the purpose of identification of vulnerability indicators. Secondly, the scope of vulnerability to be assessed is identified. The third phase focuses on developing a fit-for-purpose conceptual framework that enables the involvement of those potential vulnerability indicators. The fourth phase is explaining the selection criteria. The fifth phase sets possible alternative vulnerability indicators. The sixth phase focuses on examining and selecting the most appropriate vulnerability indicators from the previous checklist. The seventh phase focuses on the analysis and validation of the indicators by using empirical data. This phase is the most important part in relation to identifying quantifiable and non-quantifiable, intangible components of vulnerability. The eighth phase is the preparation of the report regarding the indicators developed. Finally, the ninth phase focuses on evaluation and feedback processes to identify quality indicators for the next development.

Consortium MOVE (2010:1) further proposes essential criteria to develop vulnerability measurement indicators. These are the sensitivity of the indicators to describe the required phenomenon, relevance to the purpose, measurability of the indicators, analytical and statistical significance, validity in terms of outcome, reproducibility of the indicators and effectiveness in terms of cost. However, this criterion works for all measurable or quantifiable variables. In the context of vulnerability to climate change risks, various qualitative indicators are not easily measurable, but significantly indicate vulnerability in the given condition. Due to the multi-dimensionality of the concept of vulnerability, identifying the key indicators is a critical step in the process of vulnerability assessment. These indicators can be used as an input for composite indices that are easily used by decision makers and planners (Consortium MOVE, 2010:1).

4.6.2 Informal Settlements Vulnerability to Climate Change Risks

In terms of vulnerability to climate change risks, the IPCC (2001:6) report confirms that developing countries, especially poor countries, have limited capacity to cope with this challenge. The climate change results in rising magnitude and frequency of disasters in the areas of informal settlements located in environmentally sensitive areas. As discussed above, the key parameters of vulnerability are exposure to hazards, sensitivity and adaptive capacity (IPCC, 2014:117). Accordingly, the vulnerability of informal settlements to climate change risks is discussed based on these parameters in the following section.

4.6.2.1 Exposure of Informal Settlements to Climate Change Risks

According to Gasper (2010:23), exposure of informal settlements to climate change refers proximity of the inhabitants, infrastructure, assets and environmental resources to hazard-prone areas. Thus, exposure can be described as the intensity to which a system practises natural or anthropogenic climate change risks. The attributes of these risks can be determined by the extent, the level of incidence and the period which the adverse impact affects the system. The exposure can be explained by long-run dynamics in the climate or short-run climate variability (O'Brien et al., 2004:303). In addition, people living in environmentally sensitive areas are frequently exposed to natural and climate change risks (Preston and Stafford, 2009:4). The higher exposure of informal settlements to climate change can be associated with the geographical location, weak infrastructure and housing, and overall governance system. The level of vulnerability is increased by the broader uncertainty of the risk that is exacerbated by the lack of access to the resources and decision-making power (Pasteur 2011:9).

As the UN Habitat (2003: 69) report indicates, informal settlements are physically vulnerable to climate change risks because of their location and poor housing quality. They are often situated in areas to prone to hazards and not favourable for habitation. Generally, climate change risks are distributed irregularly and more severely in marginalised communities.

4.6.2.2 Sensitivity of Informal Settlements to Climate Change Risks

In the context of informal settlements, sensitivity to climate change risks refers the intensity that the inhabitants affected adversely. Thus, the sensitivity of informal settlements is influenced by both the effects of natural and social factors. Deressa, Hassan and Ringler (2008:248) indicate that people who experience the effects of natural hazards will relatively be more sensitive to climate change risks. In addition, when the livelihood system of the community is highly dependent on natural resources, this community is relatively more sensitive to climate change risks (Marshall et al., 2007:359). For instance, the communities that are dependent on forest resources for fuelwood; they will be affected more if the resource depreciates because of climate change. As Gbetibouo and Ringler (2009:5) describe, sensitivity to climate change risk can be also determined by social and demographic factors, such as population density, migration and population growth. The more densely populated, the higher propensity to be exposed to climate change risks and the higher the need for support.

The unplanned, chaotic and disorderly nature of informal settlements significantly contributes to the increase of vulnerability and the adverse impact of climate change risks in the areas (Roy, 2010:87). The urban expansion in most developing countries is characterised by informal settlements that are vulnerable to climate-change risks because of poverty, lack of infrastructure and service facilities (UNHABITAT, 2008:7). Thus, any planning interventions to reduce the vulnerability of the community should involve the poor and people living in environmentally sensitive areas.

4.6.2.3 Adaptive Capacity of Informal Settlements to Climate Change Risks

The system's ability to adjust and modify its attributes to cope with climate change risks and changes in the institutional and policy arrangements can be considered as adaptive capacity. This enables the system to function within a range of challenging circumstances. This capacity is determined by various components, such as social, physical, economic and environmental conditions, as well as access to information. A community that has access to information in relation to climate change will have a better adaptive capacity than others are, because they have more opportunities to respond proactively. A certain section of society is more susceptible to climate change risks than the others are. This is mainly because of the lack of those livelihood capitals and adaptive capacity. The more the community have those livelihood capitals, the higher adaptive capacity they have and the less vulnerable it is to climate change risks (Marshall et al., 2010:15).

Accordingly, many direct and proxy variables affect the capacity to adapt climate change risks, for example, the income level, educational status, gender, age, physical and mental status, access to resources, decision-making power and others (Cutter et al., 2003:242). This implies that when a certain community has weak socio-economic capitals they will be subjected to the negative impacts of climate change (Ojerio et al., 2011:28). Most of the informal settlements are vulnerable to natural and climate change risks because of their physical exposure, social fragility and weak adaptive capacity. Lack of infrastructure and public services and weak institutional capacity contribute to the severity of the risks. Problems associated with land tenure also limit disaster recovery measures of the settlers because they cannot get local government support, nor credit facilities without legal titles. The social segregation, ethnic conflict, low educational level, and high unemployment rate of settlers may increase the vulnerability of informal settlements (UN Habitat 2003: 69). Therefore, adaptation strategies are one of the most critical measures in the process of minimising the level of vulnerability to climate change-induced risks of informal settlements.

4.7 Theory of Resilience

4.7.1 Definitions and Concepts

As Folke, Carpenter, Walker, Scheffer, Capin and Rockström (2010:20) indicate, the concept of resilience commenced in the 1970s in the discipline of ecology. However, the use of this concept dramatically increased in different fields of studies, such as psychology, engineering, sociology, economics and others. Accordingly, scholars such as Folke et al. (2010: online), Holling (1973:1) and Walker and Salt (2006:45) have tried to define the concept of resilience. However, due to the multidisciplinary and abstract nature of resilience and the epistemic variation of the scholars, there is no universally agreed single definition. However, past experience has indicated that there are significant advances towards a comprehensive definition. The IPCC (2014b:127) report demonstrates resilience as the ability of social, economic and environmental systems to deal with a probable incidences risk, reacting or readjusting in a manner that keep their normal or original function, identity and structure, while also acquiring the ability to resist the disaster, transition or learning, and transformation[11] to the new normal. Therefore, the three critical elements under this definition are the capacity to resist, learn and transform.

Accordingly, Meerow et al. (2016:45) characterise urban resilience as the capacity of the urban system as well as its integral socio-ecological and technical subcomponents to function normally in the face of hazards through maintaining adaptive and transformative capacity across the spatial and temporal scales. From this definition, it is possible to recognise urban resilience as a dynamic and multidimensional process. The ability to persistence, transition, and transformation are the major characteristics of resilience. Therefore, this definition is considered as the operational definition for the purpose of this study.

[11] ***Transformation***: A change in the fundamental attributes of natural and human systems. Within this summary, transformation could reflect strengthened, altered, or aligned paradigms, goals, or values towards promoting adaptation for sustainable development, including poverty reduction (IPCC, 2014).

To give more insight into the definitions of resilience from multidisciplinary perspectives, detailed explanations are indicated in Appendix 8.

4.7.2 Epistemic Perspectives of Resilience

The epistemological origin of the term resilience comes from the Latin word *resilio*, meaning "to bounce back" (Klein, Nicholls and Thomalla, 2003:35). As an academic concept, its meaning is ambiguous and subjected to conceptual plurality (Adger, 2000:347; Friend and Moench, 2013:98; Lhomme, Serre, Diab and Laganier, 2013:109; Pendall, Foster and Cowell, 2010:71). The meaning of resilience is flexible, allowing stakeholders to decide on a common terminology without necessarily requiring of them to agree on an exact definition (Brand and Jax, 2007:1). Nevertheless, this vagueness can make resilience difficult to operationalise, or to develop generalisable indicators or metrics for this (Gunderson, 2000:425). According to Davoudi et al. (2012:299), Folke (2006:253) and Wang and Yamashita (2015:2), there are three main types of resilience, namely engineering resilience, ecological resilience and evolutionary or socio-ecological resilience. To get a better insight, three of the major theoretical backgrounds of resilience are outlined in the subsequent sections.

4.7.2.1 Engineering School of Thought about Resilience

Davoudi et al. (2012:300), Folke (2006:253) and Seeliger and Turok (2013:2108; 2014:184) indicate Engineering Resilience as the system's ability to absorb and 'bounce back' after a shock such as a natural catastrophe, like flooding, landslides or social crises and return to equilibrium while still maintaining the same functional and structural identity. The higher the resilience, the faster the system will return to equilibrium. Single-state equilibrium is also prevalent in the fields of disaster management, psychology and economics (Pendall et al., 2010:71). Based on this, the capacity to withstand shocks and the prompt manner in which the system bounces back to its normal structure could be considered as a measure of resilience. The faster the system turns back, the more resilient it is. The focus is on the time required to return to its stable condition. This theory also assumes that predictability of the future, emphasis on the efficiency of resources utilisation, and regularity of the circumstances of the system exist (Gunderson et al., 2002:531).

Engineering resilience is criticised because it assumes the existence of a single stable condition that a system functions "normally". This way of the conceptualisation of resilience ignores the nature of certain systems to adapt and formulate a new identity to function in new circumstances. It only concerns resisting external disturbances, but does not consider when the external energy that possibly created the shock exceeds the resistance capacity of the system (Folke et al., 2010: online).

4.7.2.2 Ecological School of Thought about Resilience

The concept of resilience originated from ecological science and was used by Holling (1973) in a book, *Resilience and stability in ecological systems*. He describes the concept of resilience as the capacity of a certain system to persist within a stable condition, irrespective of the dynamics of the circumstances. In addition, resilience is one of the fundamental factors to maintain the structure and function of the system (Gunderson, 2000:425). This definition of resilience acknowledges that a system may have several stable states or attractors to which it could move. Here the emphasis is on the system's ability to maintain its functions and processes while undergoing internal or external stress and/or pressure by either resisting, adapting or reorganising itself in order to build its adaptive capacity (Davoudi et al., 2012:299; Folke, 2006:253). Multiple-state equilibrium resilience promotes the idea that systems have different stable states and may be transformed from one stable domain to another (Holling, 1996:7).

The school of ecological resilience focuses on the capacity to learn and persist in the face of change. Accordingly, the concept of resilience is defined, not only based on the time required for the system to return to its original state, but also on the degree of shocks that can be accommodated to maintain the original structure and function of the system. The fundamental difference between the engineering and ecological schools of thought is that the latter does not require the existence of a single stable equilibrium, but recognises the availability of multiple equilibria that enable the system to function normally and maintain its identity (Gunderson et al., 2002:530). However, the two schools of thought consider the existence of equilibriums that can be reached through bounce-back or bounce-forward changes.

4.7.2.3 Evolutionary School of Thought about Resilience

The term *socio-ecological resilience* is interchangeably used as *evolutionary resilience* in different literature (Simmie and Martin, 2010:27). It is the ability to adapt or transform in the face of dynamic and unexpected change observed in the socio-ecological systems, in a manner that functions to sustain the human wellbeing (Chapin et al., 2010:241, Biggs et al., 2015:4). The evolutionary school of thinking challenges the existence of equilibriums in the system and stable states, because the characteristics of a system may be altered over time due to external and internal changes. This development has moved theory away from the idea of resilience as "bouncing back"; the engineering school of thought (Matyas and Pelling, 2014:6). Evolutionary resilience challenges the existence of equilibrium in complex systems and promotes the dynamics of systems, with or without an external disturbance. The focus is on the fact that a system may not go back to a previous stable state, but will rather evolve or adapt in reaction to stress and transform the new stable state (Davoudi et al., 2012:299; Folke, 2006:253; Wang and Yamashita (2015:2).

Furthermore, this argument indicates that resilience is not recognised as a measure of ability to bounce back to the original state or function; rather, it is the capacity of complex socio-ecological systems to change, adapt and transform in order to cope with stress. Thus, evolutionary resilience can be illustrated based on the essential attributes. As Carpenter (2005:941) explains, it is the ability of a system to control and persist within its functional state; the capability of a system to self-organise whenever it faces internal or external change; and the capacity for learning and adaptation to cope with uncertainties and radical changes.

This epistemic perspective of resilience indicates that there is a paradigm shift in how people think about complex, uncertain and unpredictable phenomena. The notion of evolutionary resilience appreciates that the existing state of stability could change radically and the previous system may lose its original identity. Such change of the state of a system may not only be the result of external shocks, but it also may be caused by internal dynamics of subcomponents of the system. As indicated by Duit, Galaz, Eckerberg and Ebbesson (2010:367), past trends can no longer be used as the predictor of future circumstances. Extrapolation of data that indicate past trends for the purpose of forecasting future conditions may lead to misguided decisions arising from the existence of high uncertainty, which requires new and flexible models that consider possible variations due to uncontrolled forces (Barata and Erkip, 2014:107; Klein et al., 2003:35). Climate change and urbanisation will likely exacerbate the already unstable nature of urban areas. Thus, resilience is posited as a normative vision or agenda urban areas should strive for (Weichselgartner and Kelman, 2014:2).

4.7.3 Concepts in Socio-Ecological Resilience Theory

Berkes (2007:4) also describes the socio-ecological system as the integration of the social and the ecological systems at different scales. It emphasises the social and ecological systems that are linked and the delineation between the two is artificial. Such integrated systems of humans and nature are sustained together if there is a stewardship between the ecosystem and the institution designed to manage it. Continuing with this perspective (Shackeroff, 2008:90) individual people, social networks and institutions continually affect and are affected by ecological systems across local, regional and global scales. Understanding the complexity of socio-ecological systems requires the incorporation of multiple knowledge systems. Berkes and Turner (2006:479) explain that, particularly in social systems, it is difficult or impossible to understand a complex socio-ecological system without considering its history as well as its social and political contexts. Accordingly, the socio-ecological theory has the following integral concepts: thresholds, adaptive cycles and panarchy (Holling and Gunderson, 2002:25).

4.7.3.1 Thresholds

As Pisano (2012:13) indicates, the concept of thresholds can be customised to an urban system by recognising the limit of function in a stable condition within the dynamics of the social, ecological and economic circumstances. In other words, it is an abstract functional boundary or limit of capacity of an urban system. As Walker and Meyers (2004:3) also indicate, a threshold is the boundary among different system states. Therefore, a threshold reflects the capacity of the system to manage progressively changing variables through feedback loops that cause the system to reorganise (Walker and Salt 2006:63). The system can be influenced by various internal and external variables. The overall features of the system may be altered when the external driving forces exceeds the system's capacity to withstand. However, the level of influence may vary, depending on the capacity of the system to withstand changes. Therefore, the resilience capacity of the system can be measured by the range of functional boundaries. The existence of complex and interconnected sub-components of the system may enable the system to function in more than one stable identity (Pisano, 2012:13).

4.7.3.2 The Adaptive Cycle

The second essential concept within the resilience approach is adaptation. Adaptation is the capacity of a system to adjust, learn and function adequately, regardless of the existence of external disturbances and internal process changes. It is a process rather than a one-time action and it has different phases. The evolutionary nature of socio-ecological systems means that there is always dynamism of exogenous and endogenous variables that urge the system to manifest change in the state of function. The overall process of adaptation has four stages, namely rapid growth (r-phase); conservation (K-phase); release (omega-phase); and reorganisation (alpha-phase) (Holling and Gunderson, 2002:25; Walker and Salt, 2006:38; Christopherson et al., 2010:3; Hassink, 2010:45; Burkhard, 2011:2878). However, these sequences can be varied in different situations. The system can function in various ways; this is determined by the intensity of dynamism of a system's internal interactions, its elasticity and its resilience capacity. This is called the adaptive cycle. These different phases work at different spatial and time scales. The interactions among the subcomponents at different scales determine the overall functioning of the system (Holling and Gunderson, 2002:25). Comprehending the importance of a system's internal linkages, its ability to absorb shocks and how these attributes vary from one stage to another, enable planners to analyse the resilience capacity of a system. This is crucial for contextually appropriate resilience planning and policy formulation in order to protect the socio-ecological system and to make appropriate interventions.

4.7.3.2.1 The stage of rapid growth [r-phase]

This is one of the four phases of the adaptation cycle where the socio-ecological system possibly characterises itself at the early stage. For instance, when we consider a certain new business at its early stage, it possibly grows in an accelerated manner until it reaches maturity level. This is mostly because of resource exploitation and the use of innovative ideas not shared with rivals. During this phase, the system's elements are loosely interlinked and its internal condition is weakly controlled (Walker and Salt, 2006:40). When we relate this rapid growth stage of the adaptation cycle with the attributes of the urban system, it can be associated with the early stage of establishment of an urban area. Obviously, during the early stages of establishment of urban areas, there is a high rate of population growth and resource utilisation. This is because people compete for limited resources and the completion will continue until the existing resources are fully exploited.

4.7.3.2.2 The stage of conservation [K-phase]

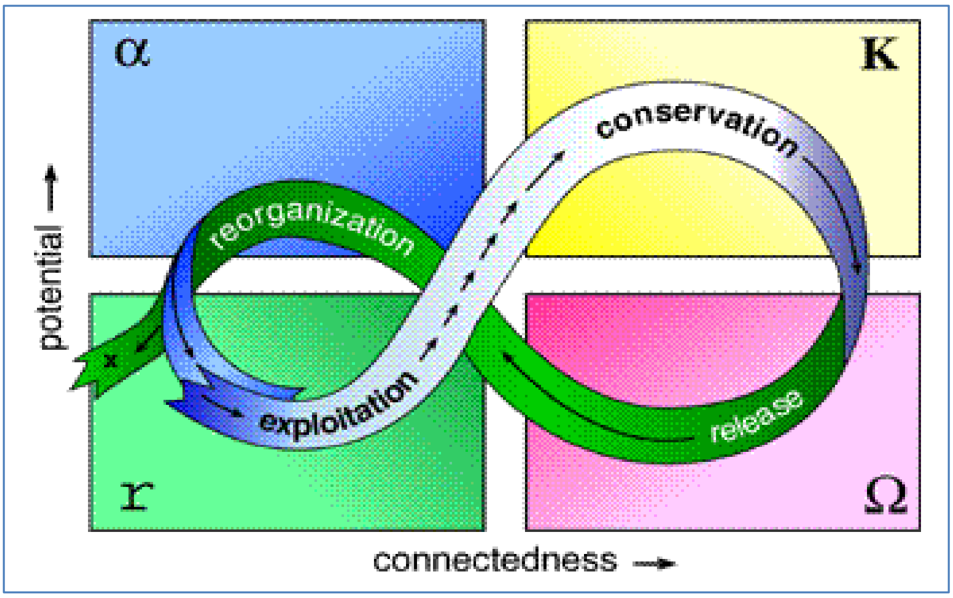
This is the next stage of the adaptation cycle that is characterised by the accumulation of energy and materials. At this stage, the connections among the components of the system increase, while the pace of change decreases because of the rigidity of the subsystems. The competition among different actors is reduced and they tend to focus on mutually benefiting one another. The rigidity of components caused by high interconnectedness to one another makes the system less resilient to disturbances. This is because of the high dependency of the system on existing rigid structures and processes (Holling and Gunderson, 2002:30). When we relate the attributes of this phase with the urban system, it characterises the stable but less resilient urban system for exogenous and endogenous forces that will make changes. This is because there is no flexibility to deal with uncertainties that may be caused by different factors.

4.7.3.2.3 The stage of release or creative destruction (omega [Ω]-phase)

After the conservation phase, a system might be forced to change and shift to another stage because of internal and external factors. Resources that were highly controlled at the conservation stage start to lose control. The overall structure of the system may change because the interconnection among the natural, social and economic capital becomes weak. However, this may present opportunities for creativity and innovation that could lead to reorganisation of the system with a different identity (Walker and Salt, 2006:42). For instance, the cause of a socio-economic crisis such as crime may lead people to think differently and devise technologically advanced security that makes the system more efficient.

4.7.3.2.4 The stage of re-organization (alpha [α]-phase)

The innovation made possible in the creative destruction phase may enable the system to renew or reorganise. The system acquires new identities that have a new structure and components. This enforces the idea of multiple equilibriums promoted by evolutionary resilience. It ensures that there are multiple ways of doing things to achieve the desired results. This process may lead the system to function differently, while resilience can be positive or negative, as shown in Figure 14 (Walker and Salt, 2006:45).



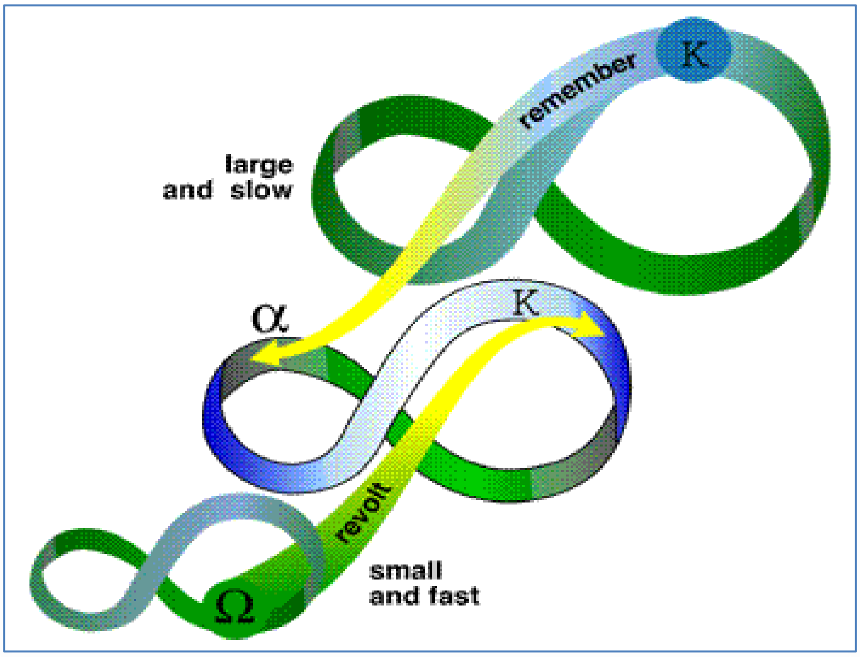
Source: Walker and Salt (2006:38)

FIGURE 14: Diagrammatical Expression of the Adaptive Cycle

4.7.3.3 Panarchy

As Holling and Gunderson (2002:25) indicate, the term *panarchy* was devised to explain evolving hierarchical systems with many interconnected components. Systems are interconnected through progressive adaptation cycles of growth, accumulation, restructuring and renewal in the structure. Therefore, panarchy is a key aspect of complex adaptive systems. Understanding complexity and interconnectedness of socio-ecological systems is very important for planning to improve resilience. Planning is about being ready for creative management of the system in the face of uncertainty. According to Gunderson (2000:425), there are many contradictory ideas within adaptive cycles, such as persistence against change, flexibility against efficiency, resilience against transformation and connected against adaptability. The following panarchy model depicts the complexity and interlinks of the four stages of adaptive cycles (See Figure 15).

As a possible solution, Holling and Gunderson (2002:26) suggest that the stages in adaptable cycles are not necessarily sequential or rigid; there is no single cycle for a systems function; rather, multiple adaptive cycles interact with each other and operate together. This kind of characterisation of interactions among the variables allows the system to be efficient and innovative. Therefore, the concept of panarchy supports the evolutionary explanation of resilience.



Source: Holling and Gunderson (2002:34)

FIGURE 15: The Panarchy Model of Adaptive Cycle

In the context of urban socio-ecological systems, identifying the complex relationships of different factors or variables that influence adaptive capacity can provide an opportunity to address uncertainty through planning. However, clear identification of the status or the stage of the adaptive cycle is very challenging in practice. This is mainly because the interconnectedness of those variables may not be regular in a different time and space. The critical point that can be adopted from the theory of panarchy is that urban centres are complex adaptive systems. Therefore, any planning intervention should consider the holistic and interlinked relation of the subcomponents within a system (Holling and Gunderson, 2002:34).

4.7.4 Application of the Theory of Resilience

As indicated by Meerow et al. (2016:38), strengthening resilience in the face of environmental and socio-economic uncertainty is quite challenging. Accordingly, it attracts academicians and practitioners across different disciplines and scales. Conceptually, disaster resilience has been used in various ways such as a combination of networked capacities, as suggested by

Norris et al. (2008:127) and place-based models of resilience (Cutter et al., 2008:598; Zhou, et al, 2010:21; Frazier et al., 2013:95). In addition the concept of resilience used as the attributes of a particular system such as infrastructure (Flynn 2007:1; Biggs et al., 2015:6), and to various research titles such as climate change (O'Brien, et al., 2009:online), sustainability science (Turner, 2010:570) and governance (Tierney, 2012:341).

The application of the theory of resilience has been observed in diverse fields and it is mainstreamed in different policy goals, including urban planning systems (Coaffee, 2009:114). Though the concept is criticised because of epistemological variations among scholars, every discipline at least agrees on the existence of risks and uncertainties that cannot be managed by only past experiences (Wisner and Pelling, 2009:23). Also, this concept is commonly recognised as the capacity to accommodate, absorb, bounce back, bounce forward and adapt to changes (Hamin and Guran, 2009:239; World Bank, 2008:32). Resilience theory provides insights into complex socio-ecological systems and their sustainable management (Pickett et al., 2013:16), especially with respect to climate change (Leichenko, 2011:164). As socio-ecological resilience theory understands systems as a dynamic, it is appropriate for dealing with future climate challenges (Rodin, 2014:8; Tyler and Moench, 2012:311).

This notion was later considered as an essential instrument to build or strengthen capacities in organisations, local communities and different systems to accommodate unprecedented changes. Initially, the concept was used to indicate the capacity of an ecosystem to resist disturbance; currently, the concept is applied in many disciplines and contexts, including urban, peri-urban and rural systems (Kuhlicke, 2013:67). Resilience thinking within urban planning should consider the critical components relating to uncertainties in the future, and the urban system should be planned and managed in a manner that accommodates unforeseen changes. However, such an approach to planning requires the projection of possible future changes with more reliable instruments along with multiple and flexible planning scenarios (Bristow, 2010:153).

Among the new approaches, the notion of urban resilience and resilient planning have gained increasing attention and interest over many years in the field of environmental management and urban planning. The study of resilience in relation to planning started in the late 1990s in response to environmental threats of adjusting social and institutional frameworks (Mileti, 1999:6). The focus was on physical and infrastructure improvements to prevent disturbances. Over recent years, the challenges of climate change have become more noticeable. Due to this, the problem could not be addressed completely by using a mitigation approach only; rather, devising resilience strategy in parallel is crucial. In planning practice, however, the use of the term *resilience* is often limited in scope and often considered as synonymous to adaptation. Planning practice for resilience is often embedded in and mixed with other approaches. The literature on resilience planning has indicated considerable progress from focusing only on preparation and mitigation actions, especially at the local scale to adaptation with the realisation of that mitigation is not sufficient to prevent disturbances from occurring (Godschalk, 2003:136).

According to Jabareen (2013:220), studies of urban resilience often overlook the multidisciplinary and complex nature of the notion of resilience and /or use the term with limited understanding. This presents difficulties in applying resilience as a new paradigm to planning practice. Nevertheless, the concept of resilience is becoming increasingly important in facing climate uncertainty and its environmental impacts.

Therefore, the practical application of the resilience approach necessitates selecting and working on the most feasible scenario for a place (Bristow, 2010:153). Scenario planning does not entail directly considering the outcome of forecasting. It does not necessarily require one to define the future trajectory of a certain place, but rather considers the likelihood of different futures. Preparation for unforeseen situations may enable planners to reverse the negative outcomes of any kind of shock. Though the concept has been the theme of research in many disciplines and attracts the attention of different development agents, there is no universally agreed definition. This directly affects the application and measurement of resilience in a certain area.

The following questions posted by Davoudi et al. (2012:299) need to be answered clearly to comprehend and apply this theory:

> *The resilience of what, to what and for whom? Who is benefiting from mobilising and imposing a biased understanding of resilience and to what end? Whose interests are best promoted and accommodated by a post-disaster 'dynamic transformation'? Who decide about the type of interventions for post-disaster rehabilitation, which socio-spatial-unit focus is chosen, whose knowledge and whose recovery is prioritised?*

Therefore, the concept of resilience can be used in any tangible and intangible phenomenon, such as environmental, social, economic and institutional contexts, and within different philosophical disciplines. Due to the multifaceted and versatile nature of the concept of resilience, it is difficult to determine a universally agreed single definition (See Appendix 8). Nonetheless, in contemporary urban planning, we can adopt the perspective of evolutionary resilience. This approach places special emphasis on the uncertainty of the future, transformability and adaptability of a system (Bristow, 2010:165). In other words, contemporary planning practice should encourage flexibility in decision-making rather than depend on only rigid technocratic planning practices. In addition, the current climate change risks forced planners to devise new ways of thinking and proactive measures. Two important facets of the process of mainstreaming resilience in the planning practice are identifying indicators and formulating measurement units to assess the resilience capacity of specific locations. To realise this, area-specific and appropriate identification of indicators of resilience from different sectors are critical. Therefore, formulating a contextualised resilience index is essential in the practice of planning to deal with climate change risks. In addition, as indicated by Davoudi and Strange (2009:37), there are some similarities between evolutionary resilience and interpretive planning perspectives, because the two approaches both focus on flexibility, multiplicity and complexity. Evolutionary resilience endorses the spatial context, not as units of analysis, but as complex and interlinked socio-spatial systems with unforeseen response processes that work at the variety of space and time scales. Both approaches consider the existence of novelty and innovation in the face of complexity and uncertainty.

4.7.5 Principles to Build Resilient System

Building a resilient urban system has to focus on the potential of reducing the vulnerability of the socio-ecological system to climate change. Furthermore, it should focus on improving the capacity of the urban system to withstand extremes of climate incidents and disturbances. It has to emphasise enhancing the institutional capability of the urban system to build a resilient system. Therefore, regarding an urban system, resilience has to be recognised from social, economic, physical, human, natural and institutional perspectives. Generally, there are principles or attributes of a resilient system. The application of these principles in the process of building a resilient system requires identification of the purpose of the resilience to build, such as “resilience of what, to what and for whom?”, for instance floods, drought, food security and informal settlements (Davoudi et al., 2012:299). In other words, the operationalisation of these principles also needs appropriate contextualisation and assuring technical, legal, social, economic and political feasibility. As indicated by Biggs, Schlüter and Schoon (2015:4-18), the principles to build a resilient system are: 1) maintain diversity and functional redundancy; 2) manage connectivity and independence of system components; 3) manage variables and feedbacks; 4) foster complex adaptive systems thinking; and 5) promote participation and polycentric governance systems.

4.7.5.1 Diversity and Functional Redundancy

As demonstrated by Ahern (2011:1-10), resilient systems are flexible and major operational units are diversified in a manner that they can respond effectively during disasters and should not collapse in the event of a disaster. These systems concern physical infrastructure and social, economic and ecological features within, or surrounding the urban area, while working to provide essential services like food production, flood control or runoff management. The urban system can be considered as a complex socio-ecological system. The combination of the subsystems or elements such as infrastructure, landscapes, housing, and sources of energy, cultural setups, governance institutions and business entities creates the entire urban system. The existence of various alternatives to provide services for the urban population can create an opportunity to respond to the unprecedented changes and surprises. The systems with various elements or subsystems are practically more resilient than those of few alternative elements are. The availability of various elements that can provide similar services enables the system to function without interruption. The existence of multiple components (redundancy) should not be considered as the inefficiency of resource allocation; rather, it should be considered as a strategy for sustaining the normal functioning of the system (Sturle, 2014:3).

The principle of redundancy can be explained as “don’t put all your eggs in one basket”. Redundancy is more valuable if the elements respond in various ways to changes and surprises. Variations in the size and scale of elements provide certain services to have various strengths, but may sometimes also lead to weaknesses. Therefore, certain shocks are unlikely to interrupt all the elements all at once. For instance, the governance system encompasses different organisational setups such as government institutions, community networks and non-governmental organisations, and private sectors can provide similar functions, but react differently to address certain changes. Diversified networks of actors, with different roles in the process of building the resilience of the urban system are important. The principle of diversity incorporates three interconnected dimensions such as a variety of different elements, the balance of each component and disparity among the elements (Biggs et al., 2015:4)

The existence of multiple systems in the urban area is critical in terms of improving the capability to succeed, endure and return or bounce forward, when internal and external disruptions happen. The availability of multiple options to deal with the prevailing risk may minimise the negative effects that will possibly happen on the overall system. This promotes the efficiency of the system to deal with severe destruction. The availability of many actors with varying roles to solve the same problem is very important in the process of building socio-ecological resilience (Kerner and Thomas, 2014:686). Every component has its own strength to respond to the risks. For example, promoting functional redundancy of infrastructure such as electric power, gas supply, liquid waste management, food and water supply systems may minimise the disturbance by providing sufficient time to replace the damaged section of the system.

4.7.5.2 Manage Connectivity and Independence of System Components

Strong connectivity among the subsystems enables the system to recover from internal and external shocks caused by different forces. Connectivity in every system refers to the characteristics and strength of the linkages among the components. From the perspective of social capital, individual actors are part of the overall social system set in a network of connections. These strong linkages can protect the ecosystem services against disturbances through collective actions. In relation to landscape connectivity, it enhances conservation of the natural environment by creating favourable conditions for the survival of different species. The reduction of connectivity caused by man-made or anthropogenic actions, such as the construction of roads, may have an adverse impact on the living system. However, sometimes highly interlinked system components may also spread hazards more rapidly (Biggs et al., 2015:6)

From the perspective of infrastructure development, the independence of the subsystems has a positive impact on improving the resilience of the system. In this case, it is better to differentiate the lifelines (for instance, water, electricity, telecom and road systems) structurally. When components of a system are independent in terms of supplying services, the probability of failure in service provision becomes lower and this promotes resilience of the system. For instance, if the water supply is dependent on more than one source of electricity, the possibility of disconnection of water due to natural or manmade damages will be reduced. The more the independent these system components become, the more resilient the system is. Therefore, during designing of certain infrastructure and services considering the independence of system components is crucial to enhance resilience (ibid).

4.7.5.3 Manage Variables and Feedbacks

The urban system has interconnected social and ecosystem components that affect one another. Feedback channels transmit signals or information through the back and forward feedback communication loops that are found in a system. It is the capacity of the system to detect and react to variations in its sub-elements. The more promptly a system can notice and react to changes all over the system, the more resilient it will be. Thus the more efficient and effective the feedback channels of the socio-ecological, economic and technical system the stronger the resilience. Feedback channels have two-way communications between variables that enforce positive or negative change. Appropriately designed feedback channels are critical to deal with risks that might possibly occur. The existence of various feedback loops to dampen the level of disturbances may to create a stable system. The availability of laws, values and customs that promote conservation of the ecosystem variables can contribute to system resilience (Walker and Salt, 2006:8). For instance, forest conservation law, water and land policy have a direct impact on the ecosystem of a forest. The critical point is the existence of feedback channels and governance structures that transmit the required information at the right time.

4.7.5.4 Foster Complex Adaptive Systems Thinking

The identification of complex and network connections among social, economic and environmental variables in the urban system is a point of departure to manage and enhance resilience capacity in a certain area. Complex adaptive system [CAS] thinking promotes consideration of unprecedented changes that affect the system and flexibility in managing the impacts. The process of adaptation enables the system to learn the new circumstances in order to provide normal functioning (Godfrey, 2010:221). Urban infrastructure systems that are designed to adapt promptly to a changing situation will enhance resilience. Resilience focuses on adaptation and transformation of the system in the face of changing circumstances. Socio-ecological systems are always in a continuous change. Therefore, readiness for a creative resilient system for this dynamic condition is important. In order to improve the resilience capacity of the system, scenario planning can be considered as a preferable instrument, because it gives room for assessing different development alternatives. To strengthen the resilient system, encouraging CAS thinking and employing different systemic and participatory approaches are crucial. Furthermore, re-engineering the institutional structures and responsibilities to shift from the traditional resource administration system to a more integrated management approach is important (Kerner and Thomas, 2014:686).

The uncertainty of the future and complexity of the system encourage learning from the circumstances. The central idea of resilience deals with unprecedented changes and adapting and transforming to manage the changes in a flexible manner. Since the urban system continuously faces changes, there must be a regular revision of available knowledge in order to promote adaptation and an appropriate management style. In this case, learning is a major part of decision-making and devising strategies associated with building a resilient system. Knowledge sharing among the society and governance institutions also strengthens the process of building a resilient system. Learning by knowledge sharing may link different actors and motivate them towards achieving the common goals. The learning process pursued among different communities and institutions helps to create cooperation and strengthens social capital (Pahl 2009:354). Managing or recording the changes in key urban system components facilitates knowledge sharing among all actors. In addition, allocating resources to enhance sharing of the practical knowledge in society enhances the creation of a strong network and resilience capacity (Anderies et al., 2013:8).

4.7.5.5 Promoting Participation and Polycentric Governance System

Active involvement of all key stakeholders is vital in the process of building urban resilience, especially within the context of limited resources to deal with challenges related to unforeseen changes. It creates trust among the stakeholders and facilitates the way for informed and balanced decision-making in relation to resource utilisation. It accommodates diversified interests of the stakeholders and helps to enhance resilience through encouraging successful implementation of resilience planning (Andersson and Ostrom, 2008:71). The level of participation varies from just informing the stakeholders to empowering them to participate in the decision-making process (Fung, 2006:66). There are a variety of benefits of broadening the active participation of key stakeholders. It helps to create room for informed decision-making, incorporates the interest of societies with different cultural backgrounds, promotes a common understanding of the challenges and the way forward to deal with them, and encourages collaborative actions towards strengthening resilience. Building an effective participation process requires consideration of the context of the specific area and identification of the relevant approaches to involve stakeholders, setting goals and expectations of the participation, building the capacity of the people involved, discussing the power relations and conflict resolution strategy, and assigning the required resources to enhance participation. Through this kind of carefully designed participation process, it is possible to create synergy and to build the required resilience capacity (Kerner and Thomas, 2014:679).

The governance system that promotes decentralisation of the decision-making power may facilitate the favourable environment to cope with local challenges by using local resources. Understanding the context of existing challenges is part of the solution. A vertical and horizontal polycentric governance system can be recognised as one of the best ways to make inclusive decision-making. Governance of the urban system needs integration of different institutions to work on the process of building resilience. The collaboration of these institutions encourages social involvement and contextualised action that best fit to deal with the existing challenges. To strengthen the governance system, tailor-made and continuous capacity-building programmes are essential to empower the people at grassroots level. Polycentric governance creates opportunities for learning, broadens participation, strengthens connectivity, enhances modularity of system components, diversifies response for similar problems, and promotes functional redundancy to achieve the objectives of efficiency and effectiveness in the process of building resilience (Andersson and Ostrom, 2008:82). In addition, this kind of governance provides an opportunity to practise local knowledge that is built by local society and used to solve the challenges by employing local resources appropriately. It also provides an opportunity to integrate traditional and scientific knowledge to solve local problems. This is an important system of governance, particularly in the context of small urban centres in Africa that are surrounded by traditional societies.

4.7.6 Capacities to Build Climate Change Resilience

Assessing socio-ecological resilience is a complex process because of the dynamic interactions of people, community, societies and the environment. There must be frameworks that enable one to analyse capitals or factors that contribute to promoting socio-ecological resilience (Cutter et al., 2014:65). Socio-ecological systems are intricately linked living and non-living systems. As indicated by Anderies et al. (2004:8), a system consists of interconnected components that operate in harmony. Thus, any possible change in one subcomponent may affect the whole system. Similarly, any human activities have direct or indirect influences on the ecological system because both are interdependent on each other (Chapin et al., 2009:3). Therefore, improvement resilience capacity of a certain area can be directly proportional to the potential of such capitals in a particular area. It requires identification of critical and crosscutting variables found within these capitals. The six capitals suggested by Cutter et al. (2014:65) are explained below.

4.7.6.1 Social Capital

The Department for International Development [DFID] (1999:online) also defines social capital as the value created for certain organisations, cities or neighbourhoods by societal interaction and synergy. It encompasses different formal and informal organisational arrangements people use to work towards shared visions (Parkin, 2005:58). Social capital thus comprises social networks, communication channels, relatives, community-based voluntary organisations, schools and trade unions, as well as cultural and social norms. The trust and synergy within the society create an opportunity to reduce the cost required to produce certain goods and services. They may also be informal safety nets for the poorer section of society.

Green and Haines (2002:8) indicate that there are different ways of characterising social capital, but there is a common understanding in terms of considering the social structure, trust, norms, and social networks that facilitate synergetic actions. Regarding the community resilience, social capital demonstrates the strength of social networks to cope with disasters. The concept of social capital is important, because it allows the community to resolve collective problems. As described by Davidson (2006:10), the most resilient communities are those that work together towards a common goal in terms of disaster reduction. Community involvement, cooperation, and networks and solidarity amongst community members facilitate collective action to generate greater resilience (Green and Haines, 2002). This increases the likelihood of the community to draw on social resources and address common concerns. Therefore, the higher the strength of social networks or bonds available in a given area, the lower the vulnerability of the society to disaster risks (Davidson, 2006:13)

4.7.6.2 Human Capital

Human capital relates to people and their ability to do some productive work and the quality of the labour force available in the specific location. This varies in terms of skills acquired, leadership capacity, health and educational status. The skills, knowledge, ability and health of the labour force enable people to improve their livelihood and resilience capacity DFID, (1999:online). When the educational status of individuals increases, their capacity to generate income also increases. This empowers them to solve the problems they will face, including possible future climate change risks. Smith et al. (2001:32) relate the human capital with the inherent or derived capacity accumulated through time that allows involvement in productive work.

Mayunga (2007:7) also indicates human capital as the ability of the workforce of a community for overall growth and development. Having an adequate, skilled and trained workforce is a prerequisite for economic development and capacity building. It can be obtained with experience, education or training. This encompasses components required for people to be involved in productive work and generation of wealth, thereby forming strategies for improved standard of livelihood. It also includes people's value systems and their relationships. This capital can be considered as intangible capital, but it is essential to improve livelihood as well as resilience capacity.

Human capital is probably one of the most important determinants of resilience among other forms of capital. Having an adequate, skilled and trained workforce is a prerequisite for economic development and capacity building. This means that the more human capital available in the community, the more the capacity for building resilience. Human capital can thus be measured through education attainment (e.g. years of schooling), health, population density, population growth, demographic characteristics (e.g., racial and ethnicity), access to transportation services, household characteristics, housing quality and dependence ratio (Smith et al., 2001:32).

4.7.6.3 Economic Capital

Economic capital refers to the existence of goods and services that generate a stable income and employment opportunities for the people. It also depicts financial capacity that can be described by profit, sales, shares and cash that is possibly generated in the process of the transaction. It includes those assets that are available in the form of currency owned by someone, such as bonds and banknotes and access to credit. The diversity of income sources and level of income of the people are some of the major determining variables that should be considered in the process of assessing resilience capacity of a certain location. Stable income sources create an opportunity for households to respond to disasters and improve their resilience capacity by enabling alternative living styles (Stokols et al., 2013:7).

The contribution of economic capital to building community resilience and reducing vulnerability is high. Economic capital is an important determinant of community resilience. For example, the capability of a household to gain access to credit is associated with the level of household preparedness and ability to take protective measures against threats. A stable and growing economy will generally enhance resilience, while an unhealthy or declining economy is an indicator of increasing vulnerability (Buckle et al., 2001:online). Among other factors, economic capital can thus be measured through household income, property value, employment and investments. Important indicators for economic capital would be employment opportunities and income. The number of people engaged in the formal and informal sector, the number of men and women and their wages, and the dependent population of a community do make a substantial contribution to determining the resilience of that community.

4.7.6.4 Physical Capital

Physical capital refers to the infrastructure developed to support the living conditions of the people and to promote their productivity. It comprises of residential housing, public buildings, business/industry, dams and levees, and shelters. It also includes electricity, water, telephone, roads, hospitals, schools and others. Physical capital is one of the most important resources in building the capacity of the community to cope with disasters. Critical facilities are important to ensure that people have resources and support arrangement during emergencies. In general, the lack of physical infrastructure or critical facilities may have a direct negative impact on the community's capacity to cope with disasters. Physical capital can thus be measured by the number, quality and location of housing units, business/industry, shelters, lifelines and critical infrastructures (Parkin, 2005:58). Thus, a shortage of this capital in the given area will make the community vulnerable to climate change risks and they become less resilient.

4.7.6.5 Natural Capital

Natural capital denotes natural resources and ecosystem services to sustain life and production of other outputs. It includes biological and ecological resources such as forests and vegetation, grasslands, minerals, spring water, soil and other natural gifts. This capital can be categorised as resources, living systems and ecosystem services. Ecosystem services encompass sinks that absorb, neutralise or recycle wastes and mechanisms that play a part in regulating the climate. Areas with a better accumulation of natural resources are more resilient to climate change-associated hazards than those with limited accumulation are. The existence of accumulated natural resources in a certain area provides an opportunity to build more reliable climate change-resilience capacity (Guerry et al., 2015:7349).

Smith et al. (2001:33) indicate that natural capital is essential in sustaining all forms of life, including human life. However, human activities are often responsible for the depletion of the stock and quality of natural capital. The quality of water and land may be degraded through the disposal of wastes and consumption by households. Therefore, recycling of non-renewable resources such as steel and plastics, and renewing resources such as forests and fish stocks are essential for future production and hence community resilience. In the context of disaster resilience, natural resources such as wetlands and vegetation cover play an important role in protecting certain areas from weather-related hazards such as floods. This capital can be measured through water quality, air quality, soil quality, wetland, forests, and national and local parks.

4.7.6.6 Institutional Capital

Institutional capital indicates that the existence of rules, regulations, programmes, policies and governance structures enable and support resilience capacity in the area. This can be determined by the availability of strong coordination among the government, private sector and civil society to enhance disaster resilience capacity in a certain area (Nel, 2009:25). As indicated in Innes and Booher (2010:3), the availability of proactive disaster mitigation strategies, insurances, coordination among different stakeholders, and climate education programmes can be considered as institutional capital. In respect of informal settlements, their capacity for climate change resilience is determined not only by the physical condition of the settlements and characteristics of society, but also by the existence of flexible institutional governance systems that have strong coordination with local and external actors.

Furthermore, an important dimension for achieving high resilience for a community is capacity building, access to services and political freedom. Often when individuals or the community itself faces shortage of infrastructure and services, a well-organised institution may facilitate relief and response. In a democracy, the role of political representatives and institutions of local governance becomes important. Many community-based organisations and women's involvement through self-help groups in a community signify a systematised involvement of community members. In addition, non-governmental organisations, voluntary associations or religious organisations not only provide vital support during crisis situations, but also give voice to the voiceless. They facilitate collectivisation and provide a sustained platform for delivery of a host of services. Therefore, the existence institutions become crucial in determining the resilience of a community. The collaboration of internal as well as external institutions can maximise the impact of resilience improvement interventions (Andersson and Ostrom, 2008:71).

4.7.7 Interfaces of Vulnerability, Resilience and Sustainability

There is a vast array of literature available on defining resilience and the relationship of resilience to other commonly used and often misunderstood terms such as vulnerability and sustainability. Different scholars suggest that the relationship remains contested, and choosing a certain understanding will affect the kind of decision-making and interventions (Manyena 2006:436).

4.7.7.1 Vulnerability and Resilience: Considered as Opposite Concepts

According to Manyena (2006:436) and Wilson (2012:1218), resilience and vulnerability are opposite ends of a sustainable development spectrum, while resilience is a positive direction towards sustainable development. Vulnerability is then perceived as an exposure to a hazard; the possibility for loss or conditions pushes the people towards disaster risk. Resilience is the response to those disaster risks.

They justify this conceptual perspective with a definition of vulnerability that focuses on the lack of capacity to cope with disasters, whereas resilience is the existence of capabilities to deal with disasters. They are "two sides of the same equation on a continuum" (Wilson, 2012:1218). Folke et al. (2002:437) also consider vulnerability as the 'flip-side' of resilience. Each is an indicator of the status of the other, which can lead to a circular justification. The two concepts are inversely proportional and the status of both concepts depends on the availability or lack of capitals, such as social, economic, human, physical, natural and institutional capital. The stronger the capitals in a given area, the more the community will be become resilient, whereas the fewer capitals, the more vulnerable to climate change and other risks. The alternative approach may be to view resilience and vulnerability as distinct concepts that are both associated with disasters, but function separately. Consequently, the vulnerability cannot be included into resilience or vice versa (Manyena 2006:436).

4.7.7.2 Vulnerability and Resilience: Considered as overlapping concepts

Cutter et al. (2014:73-74) describe resilience and vulnerability as separate concepts with some undetermined level of overlap. They arrived at these findings after conducting a quantitative analysis of resilience capacity in a specific geographical area. They justify this finding by explaining the two concepts. The higher the social vulnerability to disasters, the lesser the resilience capacity in a given area. The indicators for social vulnerability and climate change resilience are not inversely proportional to one another; rather, there is overlap between the two concepts. Climate change resilience is a broader and separate notion relative to social vulnerability. Thus, they conclude that the indicators demonstrate the existence of some level of overlap between the two concepts, though one is broader than the other.

Gallopín (2006:293) also explains that a resilient system is less vulnerable than a non-resilient system, but the relation does not necessarily imply symmetry. He also points out that, depending on definitions used, there is considerable overlap in the concepts of resilience, vulnerability and adaptive capacity. The notion of resilience is a counterpart to the concept of vulnerability, not only as a means of coping with external changes or shocks but also of responding actively and positively to risks. These responses can differ across space and time according to the environmental, social and economic context. He concludes that vulnerability, resilience and adaptive capacity are related in non-trivial ways.

According to Ibarrarán et al. (2008:4), resilience includes components of sensitivity and coping/ adaptive capacity, which are components of vulnerability, and adaptation, which is not a component of vulnerability. Resilience does not include exposure, the third component of vulnerability. Therefore, they suggest that resilience is not simply the inverse of vulnerability. Similarly, McAslan (2011:5) proposes that the two concepts are not necessarily inversely proportional. The vulnerability of a community depends on the connection of the natural, built and socio-economic environment. This is why some communities are at greater risk than the others and being exposed to hazards. When a community is well-organised, with social and institutional capitals, they will be less vulnerable to disasters. The higher vulnerability does not necessarily indicate low resilience (McAslan, 2011:5; Ibarrarán et al., 2008:4).

4.7.7.3 Vulnerability and Resilience: Considered as one is the component of another

Turner (2010:570), also considers resilience as a component of vulnerability. This means resilience is a subset of the vulnerability concept. In this case, social vulnerability is a broader concept than disaster risk resilience. On the other hand, vulnerability can be viewed as a component of resilience (Maguire and Cartwright 2008:5), or indeed, as suggested by Brabhaharan (2006:5), resilience is a function of vulnerability and the rate of recovery. Therefore, infrastructure can be assessed as vulnerable, but still have a level of resilience due to other influencing organisational, financial and social dimensions. When vulnerability is defined, with few affinities to resilience, the concepts may not be related at all.

4.7.7.4 Resilience and Sustainability

According to Grubinger (2012:online), the notions of sustainability and resilience overlap over a temporal scale, as resilience can be achieved in the short term through adaptation, leading into sustainability over the medium term through mitigation, and eventually sustainability will be achieved through transformation. Therefore, resilience is a positive contributor to sustainability. This can be explained by using the rise of sea levels due to climate change as an example. Resilience to sea level, rise-related hazards could be achieved, in theory, through a variety of structural, planning and response activities, such as relocation of houses and building of defences. Mitigation could be achieved by lowering carbon-dioxide emissions by reducing and substituting fossil fuel use. Accordingly, sustainability could be the result of a long-term transformation to a low or zero-carbon society.

Zolli (2012:online) argues that sustainability aims to ensure balance in terms of resource utilisation, while resilience looks towards to managing imbalanced resources. Hence, resilience is recognised as a more practical and inclusive response to climate change risks. Thus, a system's sustainability is an indicator for its lifespan. On the other hand, resilience is one indicator of a system's sustainability. Since resilience is subcomponent of sustainability, they can be both realised through simultaneous interventions (McRoberts 2010:online). Grubinger (2012:online) also explains the relationship between resilience and sustainability in terms of short, medium and long-term timescales. Over the short term, a system can adapt disaster risks; in the medium term, disaster risks could be mitigated; in the long term, transformation of the system to the new state. These are the characteristics of a resilient system that enable to achieve the goal of sustainable development.

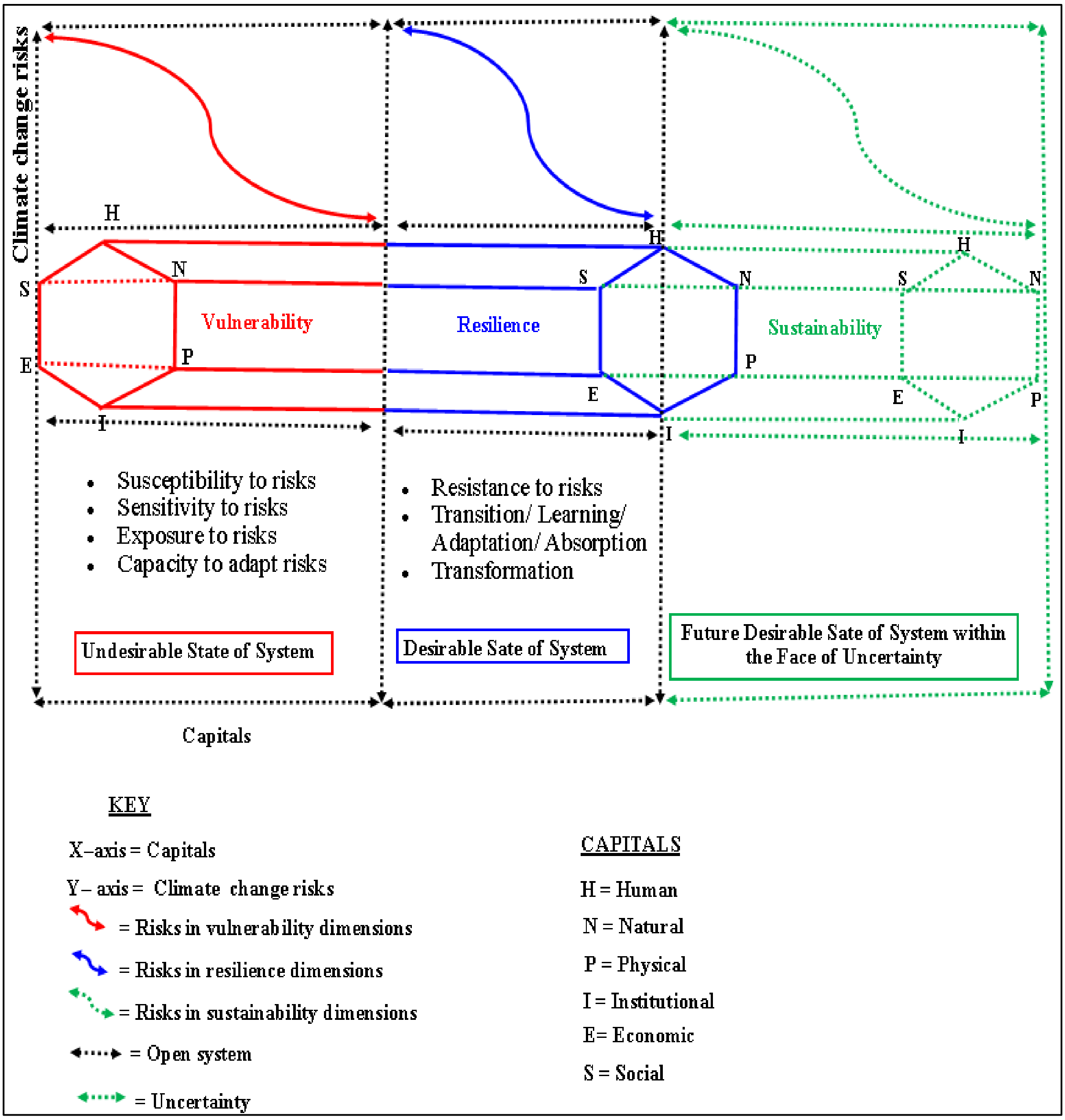
4.7.8 Customisation of the Concepts of Vulnerability, Resilience and Sustainability

Sustainable development and vulnerability reduction do not have particular ends; rather, they are processes over time that enhance resiliency and reduce vulnerability (UNISDR, 2004:128). Environmental degradation can significantly influence disaster vulnerability because a degraded environment is much more susceptible to disaster. The short-term "on-way" use of natural resources characteristic of much market-oriented development frequently exacerbates risk and heightens vulnerabilities. A central tenet of sustainable development holds that development initiatives must operate within environmental limits. This ensures that resources are not used beyond their capacity to regenerate, thus providing longer-term economic benefits and maintaining hazard protections and buffering capacities that come from an intact natural environment. Sustainable use of natural resources will increase the resilience of communities to disasters by reversing current trends of environment degradation

UNISDR (2004:128) recognises inappropriate, inadequate, or misguided development activities often create vulnerability to disasters; thus, much can be gained by incorporating risk and disaster considerations into comprehensive planning. Consideration of the relationships between development and hazards can help identify possible interactions among development plans and existing risks and vulnerabilities. As opposed to traditional development, the more holistic framework of sustainable development considers the relationships between environmental, economic and social issues. By understanding these relationships, and by identifying the best use of available connections, sustainability can contribute to the reduction of disaster vulnerability (UNISDR, 2004:128). In this section, resilience and vulnerability are considered as opposite poles of the spectrum with an inverse relationship (Foke et al., 2002:437). Sustainable development acts as the motive force that moves a community from a more vulnerable to a more resilient state. The following diagram reveals interfaces of vulnerability, resilience and sustainability.

Figure 16 indicates the capital-based framework of the dimensions of a system's vulnerability, resilience and sustainability within the face of climate change-related risks and uncertain future (Cutter et al, (2014:65). From this framework, it is possible to customise the concepts of vulnerability and resilience, as they are opposites or, *'two sides of the same equation on a continuum',* as indicated by Wilson (2012:1218). The more capitals the system has, the more resilient the system will be to climate change risks. On the other hand, the vulnerability of the system to climate change is directly proportional to lack, or absence of these six capitals. In addition, a resilient system for climate change risks paves the way for sustainable future. As Leichenko (2011:166) writes, the idea that resilience is a positive trait that contributes to sustainability is widely accepted. Therefore, it is possible to assess system's vulnerability, resilience and sustainability with this comprehensive capital-based approach.

Some of the literature indicates that vulnerability and resilience are overlapping concepts (Cutter et al., 2014:73; Gallopín, (006:3). This argument indicates that some vulnerable systems can be resilient at the same time. Malone (2009:1) observes that climate change research initially focused on vulnerability and is now shifting towards a more resilience-based approach, because "resilience is a positive concept that can be more integrated with general development goals". If resilience is considered the inverse of vulnerability, then it follows that focusing on resilience means focusing on vulnerability, and that emphasising the positive (i.e. resilience) may be of value. On the other hand, it is possible that emphasising vulnerability will spur more policy action on the part of decision-makers.



Source: Author, 2016, Capitals are adapted from DFID (1999:online)

FIGURE 16: Dimensions of System's Vulnerability, Resilience and Sustainability

Carpenter et al. (2001:765) note that resilience is not always positive; systems that decrease social welfare, such as polluted water supplies and dictatorships can be highly resilient. Therefore, vulnerability and resilience capacity are relative and specific to particular circumstances. In other words, it depends on the existence or absence of those six capitals in the given area and the type and intensity of the external threat, in this case, climate change risks. Increasing community resilience is directly linked to addressing the factors that underlie their vulnerability. Building community resilience requires an understanding of challenges and stresses to a community's overall health, income, environment and physical security, as well as its coping mechanisms that enable people to address these issues through a 'bottom-up' process of adaptation and change. The level of vulnerability is greatly influenced by a system's capacity to deal with threats (Christmann et al., 2012:259). Therefore, this study operationalises observing vulnerability of the informal settlements to climate change risks by using the lenses of resilience assessment frameworks. This is preferred with the aim of dealing with challenges in systematic and holistic manner.

4.7.9 Measuring Climate Change Resilience of Informal Settlements

> *Measurement is the first step that leads to plan and eventually to improvement. If you can't measure something, you can't understand it. If you can't understand it, you can't plan about it. If you can't plan about it, you can't improve it.*
>
> *H. James Harrington*

The concept of resilience has become popular and attracted the attention of researchers, policy-makers and different development agents to improve livelihood, disaster risk management and climate change resilience, particularly focusing on the poor section of societies vulnerable to risk (Winderl, 2014:3; Siegel, 2010:1). A growing number of institutions and scholars have developed and highlighted resilience indicators as a key component of measuring programme success. Building resilience and reducing vulnerability to climate change disasters have been specified as critical targets in the Post-2015 Development Goals (UN, 2013:1).

The Hyogo Framework for Action emphasises building the resilience of nations and communities to disaster 2005-2015 and encourages the integration of disaster risk reduction and resilience to climate change into the sustainable development programmes. (United Nations Office for Disaster Risk Reduction [UNDSIR], 2015:28). The latest IPCC working group II (2014b:27) report stresses the need for metrics to assess resilience, vulnerability and risk. However, it states that this is a challenging task and that we are still far from adopting common standards, paradigms or analytical languages (IPCC, 2014b:888). An increasing body of literature has been produced to build metrics for the key determinants of climate change risk, design index assessing the climate change impacts, vulnerability and risks, to develop support tools for planning for resilience and evaluating climate change resilience. Nevertheless, no commonly agreed measurement system is yet available for evaluating climate change resilience. This is due to the conceptual and methodological plurality of resilience (Levine, 2014:3). Theoretically, it is challenging to quantify something unless it is known precisely what it is that must be measured, yet meanings of resilience do not encourage this (Klein et al., 2003:42).

It is also difficult to relate resilience to thresholds, despite the fact that assessing the stages of resilience could be meaningful. Hypothetical or theoretical resilience frameworks are frequently not connected to endeavours to quantify resilience. It is difficult to quantify adaptive capacity, which is the capacity to cope with dynamic change, as it has psychological, social, technical, budgetary, cultural and political components. The accompanying inquiries should be considered. Are there least preconditions for building resilience? What should be said about the future? Things that have added to resilience in the past may not do as such in future, in the light of the fact that resilience is dynamic (Levine, 2014:25). In addition, the multi-scale, dynamic and multi-dimensional nature of resilience implies that numerous standard survey frameworks are ill suited to measuring resilience comprehensively (Béné et al., 2015:12).

The methodological challenges to measure resilience are associated with obtaining reliable and meaning full data to measure resilience. It is easier to measure formal dimensions of life than informal dimensions, but formal dimensions might offer less meaningful insights into resilience (Levine, 2014:26). The conceptual differences in the practice of defining the resilience cause differences in using framework to measure practically (Cutter, Burton and Emrich, 2010:6; Orencio and Fujii, 2013:62). As Klein et al. (2003:42) rather pessimistically argue, the problem with resilience is the multitude of different definitions and operational tools, and the vagueness of the concept itself.

Further, selecting the best-fit analytical framework to assess resilience and the scale of resilience to be studied, such as individuals, households, community, infrastructure, or overall system, requires an appropriate response. As the literature reveals, different methodologies or frameworks are practised to measure climate-change resilience (Constas et al., 2014:1; Brooks et al., 2014a:15; Béné et al., 2012:21; Cutter, Ash and Emirch, 2014:65; Maxwell et al., 2015:1). Frankenberger and Nelson (2013:1) echo the existence of a variety of techniques, including statistical and multivariate techniques, the use of composite indicators and impact evaluations, in order to measure contextual resilience capacity. A range of these resilience-measurement techniques uses a variety of methods. Due to this, there are significant differences in the methodologies, frameworks and measurement systems. Thus, the outcome of different studies may not be consistent because of the materialisation of different approaches (Levine, 2014:25).

Nevertheless, there are some common grounds in the process of the operationalisation of resilience in all disciplines dealing with hazards or risks. The central idea is how to build resilience capacities (Food Security Information Network (FSIN), 2016:40). This conception may open the way to assess the internal capacities to withstand, absorb and restore from shocks and stresses. Resilience is the key predictor of how vulnerable an individual, community, region or country is to future climate change-related risks. It therefore provides information about where problems may arise in advance of a disaster event or stress, and helps us prioritise where future investment in resilience improvement-related projects should be realised. Therefore, identifying and measuring the indicators of climate change resilience are critical steps to enhance resilience capacity in the given area (Brooks et al., 2014a:12). Climate-change resilience capacity can be measured in different phases of the development process. Therefore, it is advisable to undertake measurement of resilience capacity in all phases of the development processes (Brooks et al., 2014a:13).

4.7.9.1 Analytical Framework to Measure Climate Change Resilience

The reasons, assumptions and underlying decision-making processes behind all methodological choices should be made clear. Developers of climate resilience indices should strive to articulate coherent and compelling theoretical and conceptual frameworks and to select the most appropriate and credible indicators to represent key aspects of interconnected physical, social, demographic, economic, political, institutional, environmental, ecological and resource systems (OECD, 2008:15; USAID, 2014:1). Index developers should explicitly identify and communicate overarching values and principles, underlying assumptions and theories, frameworks of analysis, intended goals and audiences, available data sources and data limitations. They must also make methodological choices about how to organise, standardise, weigh and aggregate the selected indicators to build index components (sub-indices) and to arrive at the final index results. Uncertainty analysis and sensitivity analysis, essential to index development and indicator selection, are used to assess and compare the robustness of alternative index designs and rankings (USAID, 2014:2).

Most of the methodological problems are due to the presence of a plurality of frameworks, possible interpretations and the selection of indicators. A clear definition of intended objectives would reduce the vagueness of definitions. This could be a first step to building an index fit-for-purpose method (Hinkel, 2011:198). The analysis of measuring and comparison of resilience capacity by using composite indices indicates that the focus should on contextual indicators of resilience (Apollonia et al., 2015:3).

4.7.9.2 Campsite Indices as an Analytical Tool

A composite index combines multiple individual indicators to give a new measure or a cumulative statistic of a complex, multidimensional and significant outcome. Composite index techniques have developed to meet an extensive variety of purposes and to advise specific choices or decision-making. Examples incorporate appraisals of human development, prosperity, standards of life, sustainability, administration quality, sexual orientation imbalance, destitution, multiple deprivations, security of food, security of energy, resilience capacity and disaster risk management (Balica, 2012b:963; Ravallion, 2012:3). Sets of indicators for resilience can be chosen, orchestrated and joined to deliver sub-indices representing the principal components or measurements of the system under assessment. For example, an education sub-index might include indicators such as rate of literacy, enrolment and educational accomplishment. An arrangement of sub-indices can then be further combined into a last composite index.

Vulnerability and resilience indices can help societies to identify priorities, establish and refine standards, develop policy guidelines and allocate resources for interventions. To meet these goals, composite indices should be developed through participatory processes that encourage input and feedback from experts and/or that incorporate public opinion (Balica, 2012b:963; Ravallion, 2012:6). Index-based analyses and comparisons of climate change vulnerability and resilience can be more challenging when local geographic, ecological and socioeconomic contexts vary widely within a given area of interest. For example, it may be more challenging to analyse countries possessing both coastal and inland districts than landlocked countries at subnational levels if the same set of indicators is not appropriate for different ecological zones within a country (Zhou and Ang, 2009:83). The power of the composite index approach is in its ability to portray the results of an integrated analytical framework. While individual indicators can be informative, a well-designed and rigorously implemented composite index has the potential to capture "the bigger picture", i.e. the multidimensionality of complex systems, and to provide summary statistics that communicate system status and trends to a variety of relevant audiences (Booysen, 2002:115). Therefore, a potential advantage of designing a composite index to analyse multidimensional complex systems is its understandability when results are presented as scores or rankings that key stakeholders, decision makers and the public can easily comprehend (Kenney et al., 2012:4).

When baseline conditions are established, an indicator of resilience or a composite index can be assessed at regular intervals over time to interims to screen changes in system status or to track performances in a system (Organisation for Economic Cooperation and Development [OECD], 2008:16; Balica, 2012b:964). As indicated by Kenney et al. (2012:5), a cumulative index value for climate change vulnerability and resilience capacity indicator may serve a variety of decision-making processes and inform the type of intervention in given area. Composite indices aim to capture complex quantities and multidimensional features that cannot be appropriately addressed by a single indicator. Ideally, the process of designing and implementing a composite index is reflexive and serves to raise awareness, promote debate and dialogue, and improve understanding and communication of the complex, multidimensional issue. Process-oriented composite indexing should help build consensus among stakeholders and support decision-making (Booysen, 2002:115).

Given these multiple purposes and functions, composite index approaches may be well-suited to help assess and track vulnerability and resilience to climate variability and change, at national and subnational scales; analyse and compare units of analysis in particular geographic areas or socio-economic sectors; estimate expected or possible future climate vulnerability and resilience for comparison with assessments of past and current conditions by adjusting input values according to future climate and socioeconomic scenarios and projections; and help guide policy decisions, set priorities, target resources, and manage progress toward climate change resilience (Balica, 2012b:964; Ravallion, 2012:3). An index or composite indicator[12] intends to provide an overall assessment of changes of the subject in focus, such as economic, environmental or other social conditions, which can be interpreted easily and communicated well to the intended target audience. It is useful in indicating progress on the underlying goals or for benchmarking or policy-making purposes (Organisation for Economic Cooperation and Development (OECD), 2008:16).

4.7.9.2.1 Techniques to Develop Composite Indices

According to the OECD (2008:18), there are ten main issues should be addressed to build an index or a composite indicator. ***First, the theoretical framework***: this constitutes the basis for the selection and combination of indicators under a fitness-for-purpose principle. Ideally, the composite indicator, as well as the choice of indicators fully reflects the aims behind it. The theoretical framework should encompass key elements, such as the definition of the concept, the subgroups related to multi-dimensional concepts and identification of selection criteria.

Second, variables selection: When starting with a large number of candidate indicators, it is desirable to reduce the pool by identifying the most significant indicators, removing indicators of low relevance, and minimising the redundancy of highly correlated variables. A variety of statistical techniques and stakeholder engagement processes is available to carry out the indicator reduction process, such as exploratory factor analysis, principal component analysis, derivative method, correlation method, expert survey and stakeholder discussion (Adger and Vincent,

[12] ***An indicator*** is a direct measure, an indirect measure (proxy indicator), or a calculation used to represent an attribute of a system of interest (e.g. a population, geographic region, socioeconomic sector, or coupled human-environment system). Indicator values are derived from processed data. An indicator can be a quantitative or a qualitative measure (USAID, 2014:1).

2005:399; Balica and Wright, 2009:2983; Balica, 2012b:965; Babcicky, 2013:133). A simple correlation table can help to identify which indicators are highly correlated with one another to the degree that one might safely be removed. Principal component analysis used to reduce the number of indicators to manageable level and enable to identify major indicators of resilience. However, data are not always available or of high quality, so it must be accepted that at times, 'second-best' or 'proxy' indicators have to be used as component indicators (Balica and Wright, 2009:2983). This ought to be done on the premise of significance, analytical soundness, measurability, scope and basic connections. However, in the absence of the quantitative data, subjective decision can be used as an alternative to identify resilience indicators (Zhou and Ang, 2009:84).

Third, imputation of missing data: consideration should be given to different approaches for imputing missing values using statistical and technical knowledge on environmental themes to be combined. Extreme values should be examined, as they can become unintended benchmarks. ***Fourth, multivariate analysis***: this will explain the methodological choices and provide insights into the structure of the indicators and the stability of the data set. An exploratory analysis should investigate the overall structure of the indicators, assess the suitability of the data set and explain the methodological choices, for example; weighting, aggregation. ***Fifth, normalization***: this is done to facilitate comparison by using the indicators. Consideration should be paid to extreme values as they may affect successive steps in the process of developing a composite indicator. Likewise, skewed data ought to be distinguished and represented. Once one or more indicator sets are selected, integration of the selected indicators into sub-indices and a final composite index may require data transformation by means of data normalization or data standardization techniques; that is, data sets measured using different scales or measurement units can be made comparable by transforming them into a common scale or measurement unit and/or by adjusting the directionality of the values by performing inverse adjustment (Abson et al., 2012:6; Kenney et al., 2012:8; Tate, 2013:526).

Sixth, weighting and aggregation: this is done in line with the theoretical framework. Correlation and compensability issues among indicators need to be considered and either corrected for, or treated as features of the phenomenon that need to remain in the analysis. There are multiple approaches for weighting and aggregating components in the process of constructing a multidimensional composite index. *Differential weighting*, also referred to as unequal weighting, can be applied when there are sufficient knowledge and understanding of the relative importance of index components or of the trade-offs between index dimensions (Tate, 2013:527), whereas equal weighting is typically applied when the differences in component significance or the trade-offs between dimensions are poorly understood and therefore assignment of differential weights cannot be reliably justified (Nguefack et al., 2011:183; Tate, 2013: 530; Decancq and Lugo, 2013:7; Tofallis, 2013:1325).

When an index value is a result of multiple variables or factors that have different significance in terms of indicating resilience capacity, the assignment of equal weights to individual indicators may generate wrong index value. In this case, modifying weights of the individual indicators is necessary (Decancq and Lugo, 2013:8). Furthermore, as Tate (2013: 531) explains, the existence of high correlations between indicators might introduce an implicit weighting into an equal weighting scheme, as the associated dimensions could effectively be double counted. When the decision is made to experiment with and set unequal weights to index components, these weights can be assigned by means of normative, data-driven, or hybrid approaches (Decancq and Lugo, 2013:8). Normative approaches include use of participatory methods, such as expert consultation, stakeholder discussion and public opinion surveys to inform weighting schemes on the basis of the expertise, experience, local knowledge, perceptions, value judgments, preferences and insights of particularly relevant individuals and groups (Cherchye et al., 2007:111; Barnett et al., 2008:102).

Data-driven methodologies might be preferred when there is a considerable difference among the participants or selection of the participants is subjected to bias. Data-driven differential weighting strategies apply statistical techniques to produce indicator weights. As Blancas et al. (2013:683) state, the use of statistical techniques to set weights may help to balance the impact of subjective choices made at different phases of the index design process. Statistical methods, for example, Principal Component Analysis (PCA) and Factor Analysis (FA), might be connected to test indicators for correlation, in this way permitting analysts to modify the weighting by decreasing the weights of correlated indicators, and limit the number of indicators for analysis.

Principal Component Analysis and Factor Analysis enable analysts to generate weighting schemes that account for as much of the variation in the data as possible, with the smallest possible number of indicators (Deressa et al., 2008:8; Nguefack et al., 2011:184; Tofallis, 2013:1326). The results of a correlation-based PCA may provide justification for equal weightings. A number of studies have used regression coefficients in linear regression or the inverse of the coefficient of variation to arrive at statistical weights (Tate, 2013:526). Well-established, data-driven approaches to statistical weighting and aggregation in composite index construction also include data envelopment analysis. Data envelopment analysis is a flexible weighting method that eliminates the need for data normalisation prior to weight setting; this may be seen as an important advantage in situations where normalisation procedures are found to have an undesirable impact on index rankings (Cherchye et al., 2007:117). One of data envelopment analysis's main conceptual starting points is that some information on the appropriate weighting scheme for performance benchmarking, in fact, can be retrieved from the data themselves (Nguefack et al., 2011:184).

Seventh, Robustness and Sensitivity: by means of these tests it can be decided to exclude certain indicators or use another technique for completing the data sets. The analysis should be undertaken to assess the robustness of the composite indicator in terms of the mechanism for including or excluding component indicators, the normalization scheme, the imputation of missing data, the choice of weights and the aggregation method (OECD, 2008:17). ***Eighth, links to other variables*****:** find out about linkages to other composite or aggregate indicators. Attempts should be made to correlate the composite indicator with other published indicators, as well as to identify linkages through regressions (Abson et al., 2012:5). ***Ninth, back to the real data***: to improve transparency it should be possible to decompose the indicator into underlying values. ***Tenth, presentation and visualisation***: composite indicators can be visualised or presented in a number of different ways, which can influence their interpretation and understanding (Kenney et al., 2012:8). Although the composite index is a powerful tool to make a comparison of complex issues across local, regional and countries scales, the operationalisation of composite indices has its own merits and limitations (USAID, 2014:4).

4.7.9.2.2 Merits of Composite Indices

Composite indices using multivariate procedures have been used as an effective instrument to break down data represented in terms of numerous factors. Multivariate methods of analysis are largely practical and realistic; they have the capacity to examine complex data (Balica, 2012b:963; Ravallion, 2012:3). The fundamental goal underlying composite indices is to present a collection of complex data in a simplified way in order to facilitate informed decisions. Thus, the main contribution of these methods is in arranging many complex data captured into a simplified outcome (Kenney et al., 2012:9). Furthermore, composite indices permit meaningful comparison of changes observed among different geographical areas, contrary to univariate analysis (Malone, 2009:8).

4.7.9.2.3 Limitation of Composite Indices

Composite induces provide the simplest and most transparent measure of climate change resilience. They are, however, not immune to criticisms, especially on the selection of indicators in terms of what constitutes resilience, comprehensiveness-comprehensibility trade-off; weighting decisions that are arbitrary or data-driven; setting the thresholds in order to identify who is resilient, namely at what level do we say that a household or community is resilient; and focus on aggregation techniques across indicators and across dimensions. McGillivray and Noorbaksh

(2004:2) criticise composite indices in the context of human development poverty and measurement. Their critique is pertinent to resilience measurement, using composite indices as well. This includes the following: indicator selection is by and large ad hoc; universalism or the assumption of uniform needs and contexts; combining measures of means (e.g. income, assets) and measures of outcomes (well-being, health, psychosocial measures); equivalence scales cannot assume that transformations over time are comparable; correlation between indicators is not immune to double counting; weighting if correlation is high, then there is no point weighting.

In general, indicators and dimensions used in measuring resilience capacity need to describe the priorities and contexts of different spatial and time scales. Furthermore, they should reflect the levels of well-being needed to be achieved as well as cultural values. However, some scholars argue that the selection of indicators needs to be supported by subjective criteria. A contextualised measure is always better than an entirely data-driven exercise, because data-driven indicators only may not reflect the reality on the ground (Cherchye et al., 2007:117; OECD, 2008:23; USAID, 2014:2).

4.7.9.3 Criteria for Selecting Fit-For-Purpose Climate Change Resilience Indicators

The selection of indicators depends heavily on assumptions about what is measured. Consequently, how resilience is defined matters (Hinkel, 2011:198). Although there is some agreement on which indicators should be included in an index for climate-resilient development, there is no single approach to develop index. Any index should address a specific policy request with a clear objective. This is a first step to building a fit-for-purpose indicator (Apollonia et al., 2015:3). Three approaches can be followed for the development of indicators, namely the deductive, inductive and normative or expert judgement approaches (Hinkel, 2011:199). Deduction uses available scientific knowledge in the form of frameworks, theories or models about the resilient system. These give an indication of variables that potentially determine resilience, but cannot be used for aggregation, as they do not explain the links between resilience and its determinants. The only deductive argument that can be used for aggregation purposes is expert judgement (IPCC, 2014:888; European Environment Agency [EEA], 2008:8). Induction uses data for building statistical models that explain observed capacities through some indicating variables. The main limitation of this approach is that it works with few variables and insufficient data; therefore, they are applicable to local analyses only. By showing statistical relationships, it does not explain the links between the real determinant variables and resilience capacity. Finally, normative arguments use value judgement for selecting and aggregating variables. For climate risk-assessment purposes, the normative approach is used to select exposure variables and to aggregate variables with equal weights. This approach is used by, for example, the Human Development Index [HDI] (Brooks et al., 2005:152)

IPCC (2014:885) set the following criteria in order to select climate change-resilience indicators. To identify criteria for indicators selection, first present general criteria, which are valid for all indicators, and then those pertinent mainly to resilience indicators? These general criteria are valid for any assessment study, and are useful for checking whether the screened indicators are robust. However, to ensure consistency and theoretical robustness, it needs to consider the purposes and aim of the study. Secondly, the specific criteria relevant to selected indicators for climate change resilience need to be developed. As indicated in Jennifer (2014:62), there is a wide range of potential criteria for selecting indicators that fall into three major categories, such as, data criteria, usefulness criteria, understandability and acceptance criteria. The data criteria recognise data availability, reliability, cost and spatial representation. The usefulness criteria consider the degree to which the indicator is relevant and sensitive to climate change and provides useful information. The understandability and acceptance criteria measure the transparency, understandability and public acceptance of an indicator. There is also a possibility of using the combination of relevance, data quality, sensitivity to climate and understandability in selecting indicators related to climate change.

Once potential indicators have been selected using consistent criteria they can be classified into types based on whether appropriate data and modelling techniques are available immediately, expected in the medium term or not available at all. Indicators for which no data or modelling techniques are available may still be kept on the list if they are particularly relevant. Once indicators are selected, approaches to interpreting indicators should be considered (Jennifer, 2014:62).

TABLE 4. 1: General Criteria for Selection of Climate Change Resilience Indicators

	Criteria	Explanation
Validity	Not ambiguous	Agreement on the direction of influences between the indicator and what is sought to be measured(target measure)
	Well founded	Based on a tested theoretical framework
	Well defined	So that unwitting errors are minimised (e.g. measuring a family or household)
	Purpose is known	This helps fix problems in data collection; misunderstanding between different collecting agencies
	Accurate	Measuring what is should, and responds quickly
	Precise	Statistical variations between measurement is low
	Quality checked	Ideally subject to independent checking; is there across checking mechanisms?
	Transparent	Information source and control of information flow is known
	Honest	There should be no rationale or opportunity for individuals to manipu-late or distort the data (e.g. manipulating rain-gauges used for weather index insurance)
Value	Comprehensible	Relatively easy for user to understand
	Relevant	Applicable to a wide range of circumstances (geographic, social, eco-nomic)
	Responsive	Can measure usefully small changes in the target measure
	Actionable	The quality or quantity of what is being measures can be affected by human appropriate actions
	High information content	Usually quantitative is more useful than qualitative, than binary data; and real measurement more useful than modelled estimates or expert judgment
	Disaggregatable	Can the indicator be collected for specific groups (e.g. children, wom-en and men)
	Participatory	can local people be involved in the data collecting; does the data help inform and possibly empower them
Data	Available	Data is publicly and easily available; affordable
	Homogenous	Data collection is consistent across location and time
	Periodic	Data is collected at a frequency that is suitable for tracking changes
	Long time-course	Data has been consistently collected for some years
	Spatial coverage	Spatial coverage must be sufficient to provide a fair representation of the measure (e.g. Density of rain gauges)

Source: (IPCC, 2014:885)

4.7.9.4 Techniques to Select Principal Indicators for Climate Change Resilience

Principal variables are variables that have significant influence over the whole system and any changes in this type of variable affect many other minor variables (Tofallis, 2013:1326; Nguefack et al., 2011:183). Principal variables influence the behaviour of the whole system. Accordingly, policy or planning intervention to enhance systems resilience should focus on identification of these variables. This increases feasibility of any development intervention in the process of strengthening the practice of climate change resilience. The selection of indi-cators or variables for climate change resilience is direly related with the type of framework decided to measure resilience capacity in the given area (OECD, 2008:15, USAID, 2014:4).

Accordingly, there are different statistical techniques and qualitative approaches used to identify these principal indicators (Constas et al., 2014:24; Frankenberger and Nelson, 2013:9). The type of techniques or approaches to identify resilience indicators depends on the characteristics of indicators, such as easily identifiable and quantifiable, and difficulty in measuring resilience because of its abstract nature. To get valid and reliable results using the combination of statistical techniques and normative approaches is essential (Constas et al., 2014:25). As indicated in the resilience theory discussion section, because of the multidimensional nature of resilience, all indicators may not be measurable. To fill this gap, qualitative narration about the features of indicators is equally important. The identification of the principal indicators is necessary to minimise the number of data and the amount of cost required to calculate climate change-resilience index (Balica and Wright, 2010:321)

4.7.9.4.1 Statistical Method to Select Principal Indicator

One of the statistical techniques to identify the indicators for climate change resilience is the Principal Component Analysis [PCA] method. This technique uses correlation analysis to identify the strength of relationship among the variables determines resilience capacity. Principal Component Analysis is useful when one wants to condense and simplify the multivariate data (Sasan et al., 2013:173). This method can also uncover the underlying factors that could not be directly observed and identify connections among many variables regarding the study. The principal component analysis may show some noticeable features of indicators through statistical techniques. These may be used in the context of empirically clustering indicators to facilitate a classification of variables when data scored on various rating scales have to be grouped together (Cutter, Ash and Emirch, 2014:65).

This technique of indicator identification has its own limitations (Sasan et al., 2013:173). The Principal Component Analysis method also has its own limitations in terms of identifying the real variable(s) that determine(s) resilience capacity in the given area. Indicators identified through this method may not truly represent the qualities that researchers want to measure, variables may overlap with one another, and gaps may be observed because of lack of data. Moreover, they may focus policy attention on fixing the indicator, rather than the conditions represented by the indicator (Malone, 2009). Further, Principal Component Analysis requires complex computational skills and data that may be costly. Principal components are blurred averages that may not indicate the real characteristics of resilience capacity in the given sector (Sasan et al., 2013:174). However, when it functions well, Principal Component Analysis helps the researcher to understand substantial collections of interlinked data. (Kothari, 2004:330).

4.7.9.4.2 Normative Method to Identify Principal Indicators

This is a qualitative approach to select principal indicator(s) can be used when there is difficulty in accessing quantifiable variables (Frankenberger and Nelson, 2013:9). According to Barnes et al. (2007:10), the identification of the principal indicator, through a qualitative approach, should recognise the following combinations of criteria that can be determined by the context of the application: the theoretical and conceptual relevance of the indicators; relevance to policy of the given region or country; common understanding among the stakeholders and experts about the indicators; consider cultural values of the local community; social capital; intra- and inter-sectoral influence or relationship; critical for persistence of livelihood; strategic or long-term influence over the system; unique to specific location; impact over a wide spatial area; and renewability or reversibility in terms of resource utilisation, etc.

Similarly, the Asian Disaster Preparedness Centre [ADPC] (2006:14) has developed the following list of qualitative indicators for a community resilience, such as the existence of a community organisation to deal with disaster risk; availability of strategies and plan to disaster risk reduction; the existence of emergency facilities; infrastructure connectivity and housing quality; and awareness about possible risks. However, quantification or identifying specific targets for these qualitative indicators is challenging. In such kinds of circumstances, a combination of statistical techniques and qualitative approach of the decision-makers can be used (Frankenberger and Nelson, 2013:14).

To support the process of identification of major variables or factors, there must be a broad-based participatory approach that involves all stakeholders (USAID, 2014:3). The principal indicators or variables can be found in all sectors, such as economic, social, demographic, political, environmental and physical aspects of urban-rural sectors and informal settlements at the periphery. Successful identification of these principal variables from all sectors provides a systemic view to deal with climate change resilience. Therefore, the policy and planning interventions should focus on those variables or factors that have a significant effect on the overall system's behaviour in terms of climate change-resilience building (Levine, 2014:25).

4.7.9.5 Empirical Frameworks to Measure Climate Change Resilience

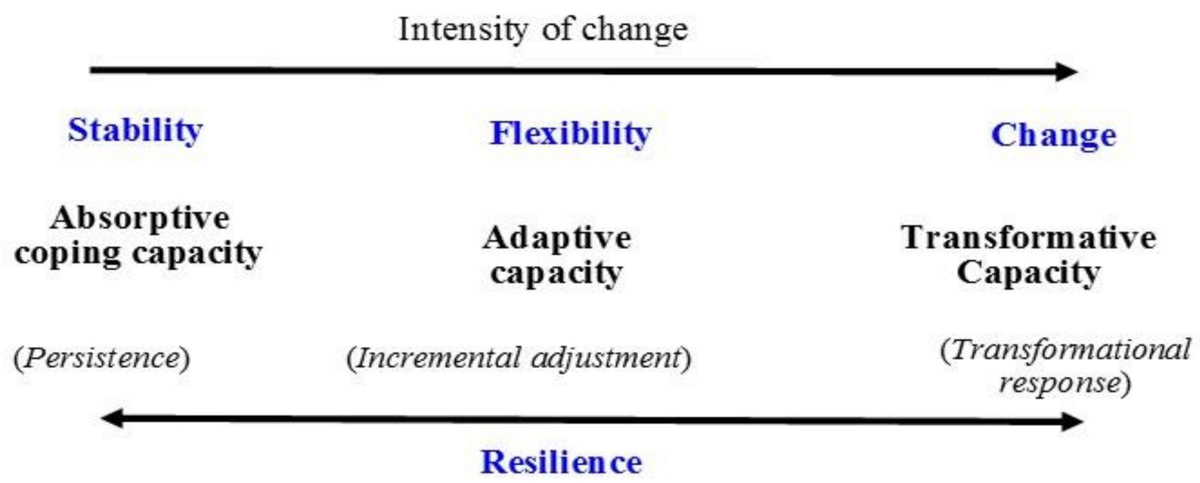
Notwithstanding the theoretical and methodological difficulties to assess resilience, there has been an advance in framing general standards to support endeavours to measure resilience and in building pertinent indicators to evaluate the development performance. Constas et al. (2014:2) suggest ten general standards of measuring resilience. These can be summarised as follows:

- Observing resilience from the point of absorptive, adaptive and transformative capacity with a minimum threshold that allows communities to function in the face of disasters.
- Include subjective assessments and qualitative data as well as quantitative data.
- Recognise that systems are complex and non-linear.
- Be specific about types of shocks or stressors that threaten a development outcome.
- Include indicators that help to identify if a return to a previous state is desirable or not.
- Recognise inherent systemic volatility.
- Consider multiple scales and interactions at multiple levels.
- Design timing of measurements to account for rates of change and dynamic factors.
- Build on studies of vulnerability.
- Design measures that account for heterogeneous responses to shocks.

Following this discussion on resilience measurements, some of the frameworks to measure resilience are discussed in this section. These include the 3-D Resilience Measurement Framework; Capital-Based Resilience Measurement Framework; 'Costs of Resilience' Measurement Framework; and Subjective Resilience Measurement Framework (See Appendix 9 for more empirical resilience measurement frameworks).

4.7.9.5.1 The 3-D Resilience Measurement Framework

In the 3-D Resilience Framework, Béné et al. (2012:21) propose that resilience emerges as the result of three capacities that are absorptive, adaptive and transformative capacities. Each capacity leads to a different outcome, such as persistence, incremental adjustment, or transformational responses. Figure 17 demonstrates that these different interventions or responses can be associated with different intensities of disasters. The lower the intensity of the initial shock, the more likely the system will be able to resist it effectively. As pointed out by Norris et al. (2008:132), the ideal outcome of a crisis is resistance, meaning that the resources have coped effectively with the risk and, accordingly, there is virtually no dysfunction, no matter how temporary. These authors point out that individuals or systems benefit from resistance strategies on a daily basis, referring to the human immune system as one of the most effective resistance strategies known to exist. Beyond our internal resistance, resistance strategies are also appropriate at a higher scale for dangers.



Source: Béné et al. (2012:21)

FIGURE 17: The 3-D Resilience Measurement Framework

4.7.9.5.2 'Capital-Based' Climate Change Resilience Measurement Framework

Constas et al. (2014:44) describe the paradigm of resilience measuring frameworks. It is moving away from characteristics-based approaches towards capacity-based approaches. The weakness of characteristic-based approaches is that they may lead to circular logic, whereby resilience is measured using the same characteristics that are considered the key elements of resilience. Also, they may not adequately consider shocks, or the relevance of the identified characteristics when shocks do occur. Likewise, resilience is not static, and its determinants are constantly changing. Malone (2009:6) indicates that the capital-based approach to resilience measure comes from the sustainable development research community. This approach considers vulnerability as a lack of capabilities or capitals. Resilience becomes the opposite of vulnerability and is thus defined as the possession of these capabilities or capitals. These capitals are defined as "livelihood capitals" and similar capitals are used or proposed in many studies measuring resilience (Elasha et al., 2005:12; Malone, 2009:6). Cutter, Burton and Emrich (2010:6) also use a capital-based approach to calculate disaster resilience index. The capital-based approach uses five major forms of capital, though related, each with its own contribution to the overall community disaster resilience. Each form of capital is, therefore, an independent domain that can be measured by a combination of different indicators.

The DFID Sustainable Livelihoods Framework [SLF] (1999:online) is regarded as comprehensive and dynamic in nature, as it encourages analysis that cuts across different sectors and tries to understand the complex interplay between different factors. The framework differentiates livelihood assets into five types of capitals; Human, Physical, Social, Financial and Natural. It gives importance to 'Institutions' in building the resilience of a community. Institutions must be considered a significant factor for a sustainable society. Capitals comprise several variables that are collectively important for a sustainable and resilient community. These kinds of capitals are directly associated with the existence of strong social, economic, physical, financial, natural and institutional capitals in a particular place. The framework focuses on factors that could reduce vulnerability and increase community resilience (Mayunga, 2007:5).

4.7.9.5.3 'Costs of Resilience' Measurement Framework

Béné (2013:1) sets forward the concept that '*costs of resilience'* that is, costs to cope with a shock, give independent measure resilience across all scales and dimensions. The costs possible includes financial, ecological, social, psychological and nutritional. Nevertheless, some the indicators are more easily measurable than others are. Therefore, the total resilience costs can be captured by combing the anticipation, impact and recovery costs. The anticipation costs refer to the ex-ante investments for disaster or shock preparedness. The impact costs indicate the costs of destruction following the impact of the shock. The recovery costs denote the post-recovery costs, including adaptation and aid. Thus, the resilience costs are equal to anticipation costs plus impact costs plus recovery costs. The lower the resilience costs, the more resilient a system is (Béné, 2013:2)

4.7.9.5.4 'Subjective Resilience' Measurement Framework

Subjective resilience relates to individuals' self-evaluation of their own or their household's capabilities and capacities to handle future events. Subjective measures can capture information about risks and the impact of shocks as well as self-assessments and aspirations (Maxwell et al., 2015). It may provide a useful bottom-up tool for capturing the voice of beneficiaries. However, a careful understanding of the political economy of a situation is needed when measuring subjective resilience to overcome potential problems of reliability of self-reported resilience. Jones and Tanner (2015:15) and Béné et al. (2016:1) suggest that resilience is determined by more than tangible factors such as income or assets, but is also subjectively constructed. Subjective elements of resilience include risk perception, self-sufficiency and aspirations. People's perceptions about their ability to handle future shocks and stressors affect decisions around short-term and longer-term livelihood coping strategies, and their willingness to engage in particular types of responses (absorptive, adaptive, transformative). Subjective resilience may therefore be as important as objective resilience (Jones and Tanner, 2015:15)

According to Constas and Barrett (2013:12), two sets of metrics are required to measure resilience effectively; standard measures and context-specific measures a framework in which standard measures can be used to model dynamics of resilience that allow using across various contexts. Levine (2014:7) suggests that, instead of searching for a universal measurement of resilience, it might be more productive to focus on impact monitoring; learning about which interventions are most useful in different situations; understanding the determinants of resilience; making an investment in resilience improvement projects; and making comparative assessments of need to target resources. The technical differences between the various approaches relate largely to the choice of indicators and the ways in which they are weighted or combined.

All the models use subjective decisions rather than empirical data only or analysis of resilience in any given situation, to choose the generic indicators of resilience. Currently, subjective decision is the only way to derive such indicators, since longitudinal data for determining those characteristics do not exist, nor is there a consensus on what such data would be (Levine, 2014:8). Apart from the question whether resilience is really something that can be counted at all, there are too many critical questions to any analysis of how well people will be able to cope with. Developing a range of smaller conceptual models to help in thinking about specific issues related to resilience will probably be a more useful investment of time. The limitations of current models for measuring resilience have been ascribed to a lack of data, or they are considered still an unfinished work, still in progress (Levine, 2014:13). There are numerous methodologies at present being used to quantify resilience. As indicated by Frankenberger and Nelson (2013:14), a single technique cannot measure resilience in all contexts. Therefore, it is critical to develop a set of harmonized standards, methods, tools and indicators to guide resilience measurement for practitioners and researchers.

4.8 Conclusion

There is no single universally applicable and accepted vulnerability and resilience assessment framework or model. This is mainly because of the complexity, conceptual pluralism and multi-dimensional applicability of the terms. Therefore, to minimise the drawbacks of single framework or model-based assessment, using the combination of different frameworks is more feasible and can generate a more comprehensive and reliable outcome. Consequently, one of the critical points regarding the application of vulnerability or resilience assessment frameworks understands the context of the particular area. In addition, flexibility in terms of application and selecting feasible and fit-for-purpose frameworks are the fundamental considerations needed to be practised for theoretical and applied studies. Accordingly, the systemic approach to vulnerability and resilience to climate change-induced risks assessment enable policy- and decision-makers to understand the overall causes and solutions to cope with the challenges climate change risks.

A systems approach allows assessing vulnerability and resilience capacity at broader scale rather than an isolated and sector-based assessment. Climate change vulnerability or resilience capacity of informal settlements arises from a result of a combination of interrelated physical, socio-cultural, economic and institutional conditions. The build-up of exposure due to the concentration of population and assets increases susceptibility due to the physical condition of buildings or infrastructure, the social and economic composition of residents, and a lack of institutional capacity to cope with the hazards result in serious and irreversible losses. Therefore, the systems approach model encourages the use of hybrid techniques in order to get comprehensive insight and to address all critical factors determine vulnerability and resilience informal settlements

Despite the conceptual and methodological challenges, there are some attempts to measure resilience. The practice of measuring resilience is not free from criticism, which is linked with the limitation the frameworks to be applied universally in all circumstances. Various institutions and scholars use different models that vary in terms of purpose, scale, focus, and method of analysis and frameworks to measure the performance of different interventions and to compare resilience capacity in different geographical areas. Nevertheless, there is much overlap between different resilience measurement frameworks in terms of indicators and dimensions of resilience. Attempts to measure resilience have moved towards capacity-based approaches; with resilience understood in the context of capacity to respond to defined shocks or stresses.

Measurement of tangible factors such as assets and financial capital may not capture everything that influences resilience and the subjective perceptions of resilience and power dynamics matter too. Even though there is no universally agreed single method that can measure climate change resilience in all contexts, many of the institutions and scholars use indices as one of the analytical tools to measure and compare performances of different programmes. However, resilience measurement through indices alone is limited to using quantifiable indicators. Practically, not all climate change resilience indicators may be quantifiable. Therefore, harmonisation of the different resilience measuring models; broad-based participation of stakeholders to develop context-specific indicators; and using a combination of quantitative and qualitative indicators of climate change resilience in the given area are suggested as remedies to cope with challenges faced in the process of measuring resilience.

Chapter 5
HYBRIDISATION OF THE KNOWLEDGE SYSTEMS AS AN APPROACH TO INFORMAL SETTLEMENT RESILIENCE

5.1 Introduction

This chapter discusses the hybridisation of indigenous and scientific knowledge systems in relation to improving climate change resilience of informal settlements in the context of Africa. Firstly, indigenous knowledge systems and different perspectives about its application are reviewed and secondly, the ontological and the epistemic worldviews of indigenous knowledge system are discussed. The epistemic worldview contrasts the modernist worldview and an African philosophical worldview and knowledge system. Lastly, participatory hybrid resilience planning in the context of Africa is discussed and a conceptual framework has been developed based on the literature review.

5.2 Definitions and Concepts

Indigenous knowledge has been defined by different authors at different periods. To lay a foundation for operational definitions, some of the definitions are discussed in this section. As described by Mwaura (2008:6), indigenous knowledge is knowledge that is acquired and used over a long period by a local community and it is unique to that particular community. Usually, this knowledge is transferred from one generation to the other in traditional ways. It can be considered as part of the wider nation's knowledge system. It encompasses the skills and experiences that help people to sustain their livelihoods. Berkes (2008:1) indicates that indigenous knowledge encompasses four interrelated levels of analysis. These are local knowledge of environmental change by identifying critical indicators; the land and resource management system as applied knowledge; the social institutions that are governed by norms and cultural values; and the worldview that has its own conceptualisation and belief system.

The United Nations Educational, Scientific and Cultural Organization [UNESCO] additionally characterises indigenous knowledge as the understandings, abilities and methods of insight created by social orders with long histories of connection with their natural environment. For the indigenous community, this knowledge supports customs to decision making about basic parts of everyday life. It is the outcome of fundamental processes of complex cultural interaction, resource-use experience rituals and spiritual habits. These exceptional methods for knowing are imperative features of the world's social diversity and give an establishment to locally suitable development (UNESCO, 2002:online).

Akenji (2009:167) describes indigenous knowledge systems [IKS] as unique and innovative practices associated with local communities that are enhanced by complex environmental and social interrelationships. IKS comprise accumulations of societal practices characterised by the cultural values, capacity and methods to solve problems that are developed by local communities through critical observation of nature dynamics and inter-generational transfer of unique practice in that society (Mapara, 2009:140). As per the National Curriculum Statement (NCS) (2003:4), IKS in the South African setting denotes an assortment of information grounded in African philosophical thought and social practices that have developed over many years.

Knowledge integration [hybridisation] is the process of synthesising different knowledge frameworks or models into a common and compatible system, while the outcome of the integration process may lead to new information into a body of existing knowledge Bohensky and Maru (2011:6). Bringing indigenous and scientific knowledge together and the implication for maintaining and building socio-ecological resilience are some of the critical processes to cope with climate challenges in Africa. It is crucial to identify the relationship between knowledge integration and socio-ecological resilience. Therefore, the following critical inquiries need to be answered before materialising hybridisation of both knowledge systems. Would hybridisation really be used as a solution to capitalise on climate change-resilience capacity in the given area? Why and how will integration be undertaken? (Ramanan, 2015:1).

In addition, the integrative approach to knowledge engagement emphasises cross-cultural knowledge sharing and social learning, which has been championed by postmodern action-research advocates and progressive resilience-improvement programmes (Hill, 2006:577; Moller et al., 2009:211; Ross et al., 2009:242). Accordingly, the need to integrate indigenous knowledge with western science is recognised by many social and natural science researchers. Both scientific/modernist and indigenous knowledge systems have their own strengths and weakness, thus capitalising those strengths or problem-solving potentials through integration may help the planners to maximise synergy (Berkes et al., 2000:1251; Moller et al., 2004:2; Fraser et al., 2006:4).

5.3 Origin and Perspectives of Indigenous Knowledge (IK) Systems

Indigenous information has been generated from the close interaction between human and being and the natural world in which they live. It has been getting a great deal of consideration in the field of natural resource conservation, climate change and disaster risk management since the mid-1990s (Hiwasaki et al., 2014:1). The worldwide scientific society recognised the pertinence of indigenous knowledge and embraced it at the World Conference on Science held in Budapest, Hungary in 1999 by suggesting that scientific and indigenous knowledge ought to be incorporated especially in the field of natural environment conservation and development. The United Nations Declarations on the Right of Indigenous Peoples (ECOSOC, 2007:2), for instance, states unequivocally that "regard for Indigenous Knowledge, societies and customary practices adds to equitable and sustainable development and suitable conservation of the environment". As per Principle 22 of the Rio Declaration, indigenous knowledge plays an essential part in environmental protection, and countries are urged to strengthen indigenous culture and interests by empowering the practical advancement to ensure sustainable development (Havemann and Smith, 2007:48).

5.3.1 Ontological View of the Indigenous Knowledge System

Ontology emphasises the nature of beings and their classification is based on common features. Ontology tries to answer the following questions, such as, what are things or beings, and how things should be classified based on their relationship. Accordingly, an ontological view of an indigenous knowledge system considers the existence of the spirits that are interlinked with the physical environment (Meyer, 2008:217). With such a connection, it is accepted that there are influences between the spiritual and physical world. Therefore, indigenous knowledge integrates a spiritual orientation that human beings have an important role in the perpetuation of nature processes in the world. The ontological view also considers indigenous knowledge as native, originating and occurring naturally in a particular region (Warren et al., 1995:9).

5.3.2 Epistemic Worldviews of the Indigenous Knowledge System

The epistemology of the indigenous knowledge system is the way of knowing, transmitted across generations by storytelling. It stems from the relationships between the natural world and the spiritual arena, or between human beings and the environment (Kovach, 2005:19). This epistemic perspective of indigenous knowledge recognises the integration of subjective values and practices, with context-based information and its application in many fields. Warren (1991:1) sees indigenous knowledge as customary and local information that includes social, economic and ecological factors and exceptional to that specific culture or society. It is indigenous to a specific geographical region contrary to information created in academic institutions, research organisations and private firms.

Similarly, Flavier and Erickson (1995:479) consider indigenous knowledge systems as the premise whereupon traditional society conveys information and decides. They contend that indigenous knowledge is dynamic, and it is constantly influenced by inward inventiveness and experimentation and, in addition, by contact with outer systems. Furthermore, Berkes et al.

(2000:1251) describe the indigenous knowledge as the information produced through observation of the nearby environment and held by a particular group of communities. It is part of the social capital by which communities conserve natural capital, i.e. resources and ecological services, in order to sustain their livelihood. On top of this, the following subsections discusses modernist worldviews and African philosophical worldview of the indigenous knowledge system.

5.3.2.1 Modernist Perspective of Indigenous Knowledge Systems

The concept of worldviews has been portrayed as a mental setting that has fixed ways of seeing the world. Worldviews are associated with psychological structures that society consistently experiences to give meaning to social landscapes and to express their approaches to whatever objectives they look for. They are produced throughout a person's lifetime through socialisation and social collaboration (Olsen, et al., 1992:1). However, worldviews are normally unknowingly and uncritically taken for granted as the way things seem to be. A worldview can hold disparities and irregularities amongst convictions and values inside the perspective. Subsequently, these perspectives regularly contain incongruences. It has been proposed that in any society there is a leading worldview held by most people, although alternative worldviews exist, as perceived by some people within that particular society. Based on this, working with indigenous people will frequently require acting outside the leading perspectives found in social work globally, and especially in fourth-world domains (Olsen et al., 1992:8).

Accordingly, a modernist worldview[13] perceives indigenous knowledge as synonymous with the primitive and traditional knowledge practised by poor people that it is culturally static and historical information, rather than as a dynamic, ongoing relationship between indigenous peoples and their landscapes. It is associated with being simple, tribal, backward, traditional, static and inferior (Williams and Muchena, 1991:52). Considering indigenous knowledge as traditional is usually a practice of undermining and devaluing its importance, which does not recognise it as an alternative knowledge system (Aikenhead and Ogawa, 2007:539). Furthermore, past cross-cultural studies have taken western “rationality” and “scientism” as the benchmark criteria by which other cultures’ knowledge should be evaluated. Thus, traditional knowledge systems of indigenous peoples have frequently been portrayed as closed, pragmatic, value-laden, local, etc., indicating that they do not have the credibility of scientific knowledge systems due to their restricted practices at local level. This dichotomy explained the great divide between societies that are powerful and those that are not. The localness of

[13] ***Modernist Worldview*** in the context of this study refers, the western countries or scientific view about the indigenous knowledge system practiced in Africa.

IK has limited its contribution to development, as it is often regarded as inferior compared to "universal" scientific knowledge.

5.3.2.2 African Philosophical Worldview of the Indigenous Knowledge System

The idea of African philosophy is linked indirectly and historically to colonialism and is aimed at fulfilling the knowledge gap created because of it. It is a critical thinking associated with an indigenised African worldview (Serequeberhan, 1994:43). Simpson (2000:165) illustrates some characteristics of indigenous African perspectives by considering indigenous knowledge as a local solution for the local problem that is related to the culture, beliefs, religious ceremonies and the core survival strategy. Therefore, this knowledge system is considered as all encompassing, cyclic and subordinate upon connections with living and non-living creatures. Numerous truths are reliant upon individual practices and the relationship between the natural environment and the spiritual world (Simpson, 2000:165).

Furthermore, McKenzie and Morrissette (2003:259) clarify that indigenous African perspectives focus on the close association of human beings with the natural environment. This view perceives the indigenous knowledge system as the presence of things with the principles of survival; the demonstration of survival ways with the natural energy and cycles of the earth; every process has a role to perform to adjust itself and ensure survival of life; and this essence is comprehended as "spirit", which interfaces all things to one another and to creation.

5.4 Experimentation of the Indigenous Knowledge System

5.4.1 Empirical Success Stories of the Indigenous Knowledge System

Indigenous knowledge has been used in the fields of natural environment conservation, in anticipation of meteorological phenomena, agriculture production, traditional healing practices in Africa (Domfeh, 2007:41). Indigenous knowledge enables indigenous people to live in harmony with their surrounding natural environment for long periods. The close attachment of their livelihood with nature provides opportunities to identify any climate variations in their locality. This knowledge is acquired by long-term experience of solving local problems through local capacity (Mwaura, 2008:61). In African, local communities are confronted with different sorts of dangers associated with climate change and to handle such risks, they used to implement context-based strategies acquired from long-term experience (Nyong, Adesina and Osman, 2007:787). Mutasa (2015:1) contends that indigenous knowledge is imperative in planning for community-based climate change coping strategies. Thus, such kind of planning objectives can only be effective by involving communities that have experience of indigenous knowledge application, especially in natural resource conservation (Nyong et al., 2007:786).

The IPCC (2007:4) report notes that indigenous knowledge has a valuable basis for creating adaptation and natural resource management strategies in the light of ecological and other forms of change. United Nations University [UNU] (2012:online) likewise demonstrated Indigenous knowledge has been long acknowledged as a vital basis of information and practices in fields such as agroforestry, traditional medicine, conservation of biodiversity, communal resource management, assessment of impact, readiness and reaction for climate change and natural catastrophe. Indigenous people are critical observers of their natural habitat. Indigenous observations and understandings of meteorological phenomena are at a much better scale, have remarkable temporal ranges and examine components that may be negligible or even new to scientists. They concentrate on components essential for livelihoods' sustenance and social security and are essential for climate change resilience. The observation of indigenous people contributes essentially to enhancing climate science, by supporting that evaluation of climate change effects and policies and practices at grass-roots level.

Indigenous reactions to climate change encompass a shift into livelihood experiences and adjustments in other socio-economic conditions. The capacity to access numerous assets and depend on various modalities of land use adds to their abilities to cope with impacts of climate change at local level (UNU, 2012:online). The United Nations Framework Convention on Climate Change [UNFCC] (2013:8) also confirms the importance of indigenous knowledge in the process of identifying long-term indicators through critical observations of the changing environment. It is fundamental for grasping local-level influences of climate change and provides relevant insight into multiple alternatives solutions from the local area. This is directly associated with maximising the internal capacity to deal with hazards.

Local communities use indigenous knowledge as a basis of agricultural production, traditional food preparation, healthcare, education, natural resource conservation and disaster-risk management. They used to apply their indigenous knowledge for climate forecasting and disaster resilience by using their experience and focusing on some major environmental indicators. They use the observable characteristics of plants, insects, soil and wind direction, cloud and astronomical indicators (Mugabe, 2010:1). This knowledge is unique for that community and accumulated through experience over a long period; therefore, this knowledge is very crucial to deal with in times of complexity and uncertainty (Berkes, Colding and Folke, 2000:1251).

This knowledge can be recognised as one of the fundamental components of social capital for the poor, especially in the context of many developing countries. It facilitates the development process through encouraging contextual solutions for local challenges, including climate change risks. Baggethun et al. (2012:640) indicate that this knowledge may create favourable conditions to respond collectively to hazards and promote the resilience capacity of the socio-ecological systems. This is mainly because the local community continually accumulates various experiences that enable them to cope with the crisis. Resilience theory also recognises indigenous knowledge that is transferred over a long period by responding to disaster risks and improving the capacity to respond to shocks (Berkes and Turner, 2006:479; Folke, 2004:7). The significance of indigenous knowledge also has been recognised by the world's scientific community (Mwaura, 2008:117). However, the central question is how to transfer indigenous knowledge to the next generation without losing its importance in order to enhance climate change resilience. Bisong and Andrew (2010:479) indicate that various scholars and practitioners acknowledge indigenous knowledge as a vital option to adapt to unexpected challenges that the world would perhaps confront, including climate change calamities. Brown et al. (2012:531) emphasise the importance of supporting the practice of indigenous knowledge from Africa to the rest of the world by using the opportunity of information technology networks.

The degradation of natural resources increases from year to year in all nations because of destructive human interventions in the natural environment. These natural resources are exploited beyond their carrying capacity, causing the reduction of carbon sinks or natural forests, increased heat waves and desertification in Africa (Folke et al. 2011:719). In addition, the capacity of local government is highly limited in terms of financing and exclusively using scientific knowledge to cope with the challenges of environmental degradation caused by man-made and natural forces. Especially, in the context of Africa, the practice of indigenous knowledge has significant value when it comes to supporting the efforts of local government and other development partners. This knowledge system provides significant information that is useful to practices at micro- as well as macro-stages. This enormous system of knowledge comprises technical, environmental and community-based knowledge and skills. This knowledge has developed with time and can develop or decrease, contingent upon the local condition. Thus, the experience of using indigenous knowledge at local level enables the community to cope with uncertainties associated with climate dynamics through a number of alternative strategies.

Berkes et al. (2000:1251) argue that indigenous approaches are based on a dynamic concept of nature that manages with environmental variations rather than against it. Traditional approaches use long-time series of local observation and institutional memory to deal with infrequent (at least on human time scale) and little-experienced environmental fluctuations. This experience accrues to the indigenous knowledge that is culturally transmitted and evolves through resilience processes. Knowledge carriers, such as elders, play a crucial role in this institutional memory of ecosystem change. So do myths and ritual, by helping people to remember the rule and interpret environmental signals. Therefore, indigenous knowledge cannot be ignored in a world where it plays such an important role in disaster management, environmental conservation and the social and economic well-being of local communities (Mwaura, 2008:32).

To demonstrate some of the nation-specific successful cases of overcoming adversity through the practice of indigenous knowledge, for instance, in Swaziland, where drought and frequent floods are basic causes of catastrophes, the local communities avoid potential risk of calamities. For instance, they utilise the stature of the nests of the birds on trees to foresee the possible incidence of flooding risks. When floods are probably going to happen, the nesting of the birds is high up the trees alongside a stream and when floods are improbable, the nests are found at the bottom branches of the tree. They also utilise the seasonal cry of birds as indicator to forecast rain and fruits of wild plants to anticipate the occurrence of possible droughts. In addition, they used to observe the direction of the wind, the shape of the moon and the characteristics of animals as indicators to anticipate possible natural hazards (Domfeh, 2007:41; Mwaura, 2008:61).

The practice of using indigenous knowledge by local communities in Uganda in order to improve agricultural productivity by preparing compost from the local organic wastes can be considered as success story. They used to prepare compost from plant residue and animals wastes in order to increase the yields of crops during the anticipated drought seasons. They also used traditional pesticides made from mixtures of plant leaves to save crops from pests on the field and during storage. These practices have helped numerous indigenous people to survive within the hardship of climate change risks (Agea et al., 2008:45).

Furthermore, Bazin and Tamez (2002:120) point out that the way in which the San or !Kung collects water in the Kalahari Desert involves a lot of scientific principles. They trap moist air and then condense the water out of it. First, they dig a small pit in the sand and lay grass in it. They place half of a shell of an ostrich’s egg in the centre of the pit, open side up, like a cup. Then they stretch a transparent animal membrane (usually a bladder) over the pit, holding the edges down with stones. They put a smaller stone in the middle the membrane to weigh it down so that it sags into a cone shape. The point of the cone is aimed down into the eggshell. During the day, sunlight energy passes through the transparent membrane and heats up the grass and surrounding sand. The water in the grass and sand starts to evaporate into the air under the membrane. The pit becomes a small container of humid air. At night, the cold desert air cools down the membrane. As the humid air cools down, water condenses, running down the bottom of the membrane and dripping into the eggshell. This technique can produce up to a quarter cup of water in one night. The role of the water cycle-rainfall, evaporation and condensation are clearly present in the method of the San (Bazin and Tamez 2002:120-127).

In addition, in Papua New Guinea, Kumalu village is located in Bulolo District of Morobe Province and situated along the Snake River. The community is mainly based on subsistence living, although it has connections with a nearby gold-mining site (Mercer et al., 2009:157). Analysing Kumalu's effectiveness rankings for strategies addressing the inherent factor of 'land clearance', the selected strategy includes previous indigenous approaches along with some scientific approaches. Referring back to their environmental trend analysis, they consider that problems in land management and the loss of indigenous way of problem solving increase their vulnerability to flooding hazards. Accordingly, they decided to use past indigenous experience again and integrate this with scientific knowledge. The outcome indicates that there is significant reduction in vulnerability to flooding and landslide (Mercer et al., 2009:171).

The success stories concerning the application of indigenous knowledge in nations generally, and in Africa in particular confirm that the importance of this knowledge system. In the process of climate change resilience building through improving the natural resource conservation, forecasting meteorological phenomenon, and increasing agricultural productivity, the indigenous knowledge systems played significant role. Therefore, this evidence clarifies the importance of indigenous knowledge to improve climate change resilience of informal settlements in Africa as well as worldwide (United Nations Framework Convention on Climate Change [UNFCC], 2013; 2016:online). However, this knowledge system is not free from limitations and it cannot solve every problem associated with climate change risks (Naidoo, 2007:120). The indigenous knowledge system has its own limitations and challenges.

5.4.2 Limitations of the Indigenous Knowledge System

The previous section indicated the success stories of indigenous knowledge practice in different fields. Nevertheless, different scholars argue that indigenous knowledge has its own drawbacks. Some criticisms against indigenous knowledge are discussed in this section. One of the main critics is that not all knowledge and activities of the local community are valid and sound in relation to natural resource conservation. In some instances, the practices of indigenous knowledge have even had undesirable effects (Naidoo, 2007:120). This critic implies that the practice of indigenous knowledge may not be a solution for all climate change-related challenges. In addition, Naidoo contends that many local communities' climate change coping strategies are mainly hampered by poverty. The likelihood of escape from poverty by using modern scientific approaches may be more convincing than by using indigenous knowledge.

The above variables may cause communities to stress while competing for limited resources, such as food, space and shelter in a manner other than utilising indigenous practices.

According to Banda (2008:331), African Indigenous Knowledge System [AIKS] is considered as very rigid and unwritten, backward and superstitious. AIKS has been considered incompatible with modern society and development in a number of cases, and should therefore be relegated to the archives and museums. In some extreme cases, AIKS have been described as desperate and irreconcilable systems of thought that are unstructured, unscientific and just a myth. The assumption is that, unlike Western knowledge, which is continuously constructed, AIKS has always been there, waiting to be passed on from generation to generation; hence, it is old and not universal (Sillitoe, Dixon and Barr, 2005:13). According to Mosothwane (2007:726), IK does have limitations, although researchers have praised it for conserving the environment. Indigenous knowledge is losing ground because there is no congruence between peoples' belief systems and how they behave. Furthermore, it has been noted that the lack of an eco-centric philosophical tradition among some indigenous people has led to extensive environmental degradation. Mosothwane has also indicated that some aspects of IK should be discarded, because it does not align well with industrial development. The above section has provided an overview of the limitations of indigenous knowledge. From the discussions, it is clear that indigenous knowledge has a number of limitations, which can result in negative consequences. Therefore, it can be argued that the view of indigenous knowledge as an untainted knowledge base does not always hold. It cannot be assumed that all indigenous knowledge will necessarily provide a sustainable answer to climate change challenges in poor indigenous communities. The following section will explore the challenges of indigenous knowledge systems.

5.4.3 The Challenges of the Indigenous Knowledge System

Regardless of the significant role played by indigenous knowledge, this knowledge system faces many challenges. As indicated by UNU (2012:online), those management approaches or planning practices consider independent modernist or scientific perspectives as the sole approach to problem-solving, and confine alternative ways of coping with climate change resilience. This is reflected in policy formulation and implementation practices. On the other hand, local innovative ways of solving problems have empowered communities to survive the hardships of climate change. Despite the fact, well-financed and technically supported science-based projects dominate problem-solving approaches and limit the potential benefit of indigenous knowledge to cope with climate change risks. This knowledge system is subjected to the danger of loss, because of lack of systematic documentation and over-reliance on the intergenerational oral transmission (Tharakan, 2015:52). The influence of western education curricula, high dependency of the planning process on technology, difficulty in reconciling indigenous knowledge and scientific knowledge, and indirect impacts of the colonial legacy can be considered as the factors leading to the underutilisation of the benefits of indigenous knowledge to cope with the current climate anomalies and risks (Domfeh, 2007:41).

5.5 Theory of Hybridisation of the Knowledge Systems

Ramanan (2015:1) indicates that the western scientific approach was considered as a solution to all problems; nonetheless, it has its own weaknesses. As Ramanan describes, it has not yet been proven whether the results of many scientific innovations cause an adverse effect on the natural environment. On the other hand, the indigenous knowledge has been proven as environmentally friendly. The growing interest to protect and conserve the natural environment necessitates the hybridisation of the indigenous and scientific knowledge systems. Stephens (2000:11) argues that there are commonalities between indigenous knowledge systems and western scientific systems. These include factors such as honesty, inquisitiveness, perseverance, open-mindedness, and empirical observations in natural settings, pattern recognition, and verification through repetition, inference and prediction. Furthermore, Rahman (2000:5) explains that both knowledge systems are in a regular condition of change; and each knowledge system developed in different circumstances. Indigenous knowledge systems originated relatively independently of, and not in competition with western science. Despite their differences, or maybe because of these differences, indigenous knowledge and western science should be seen as two systems of knowledge that can complement, rather than compete with each other (Fulvio, 2006:463).

The multidisciplinary nature of an indigenous knowledge system allows the association of the natural environment with the culture in a particular area (Pierottii and Wildcat, 2000:1333). There are also arguments about the similarity between IK and science with regard to its empirical, experimental and systematic nature. However, IK differs from science in that it also encompasses social and legal dimensions, with its emphasis on networks of social relationships, not only among humans, but also between humans and other species, the land and spirits or ancestors. In other words, one of the distinctive features of IK that sets it apart from scientific knowledge is its holism. According to Drew (2005:1286), the post-positivist scientific fields have started to link science with the indigenous knowledge system by breaking the conventional perception of objectivity and specialisation in the western scientific approach of problem solving. The other argument is that, instead of focusing on their differences or dominance of one over the other, it is better to identify the interdependences of the two knowledge systems. According to Normann et al. (1996:48), the two knowledge systems are interdependent in that each needs the others' innovation and development. For instance, traditional medicine needs the technology of orthodox (scientifically proven) medicine to know more about the active components of their medicinal items. Information is also needed about toxic aspects of traditional medicine and effective dosages, especially if one considers the standardisation and formality of traditional medicines. On the other hand, orthodox medicine needs traditional medicine for survival and innovation, especially when faced with problems of diseases that cannot be cured easily.

It is argued that ways of accepting the natural world that have been shaped by diverse cultures and at different times have to be considered as knowledge systems on the same ground (Helen and David, 1995:115). The existence of complementarity between the indigenous and scientific knowledge systems strengthens the necessity of hybridisation. Scholars (Agrawal, 1995:413; Ericksen and Woodley, 2005:85; Aikenhead and Ogawa, 2007) recommend that it is vital to consider the existence of different types of knowledge systems and their epistemologies, but not to disregard their similarities. This is critical, given that IK has been recognised to be complementary to scientific knowledge (Gadgil et al., 1993). Recognising their similarities will allow devising the effective hybridisation methodologies.

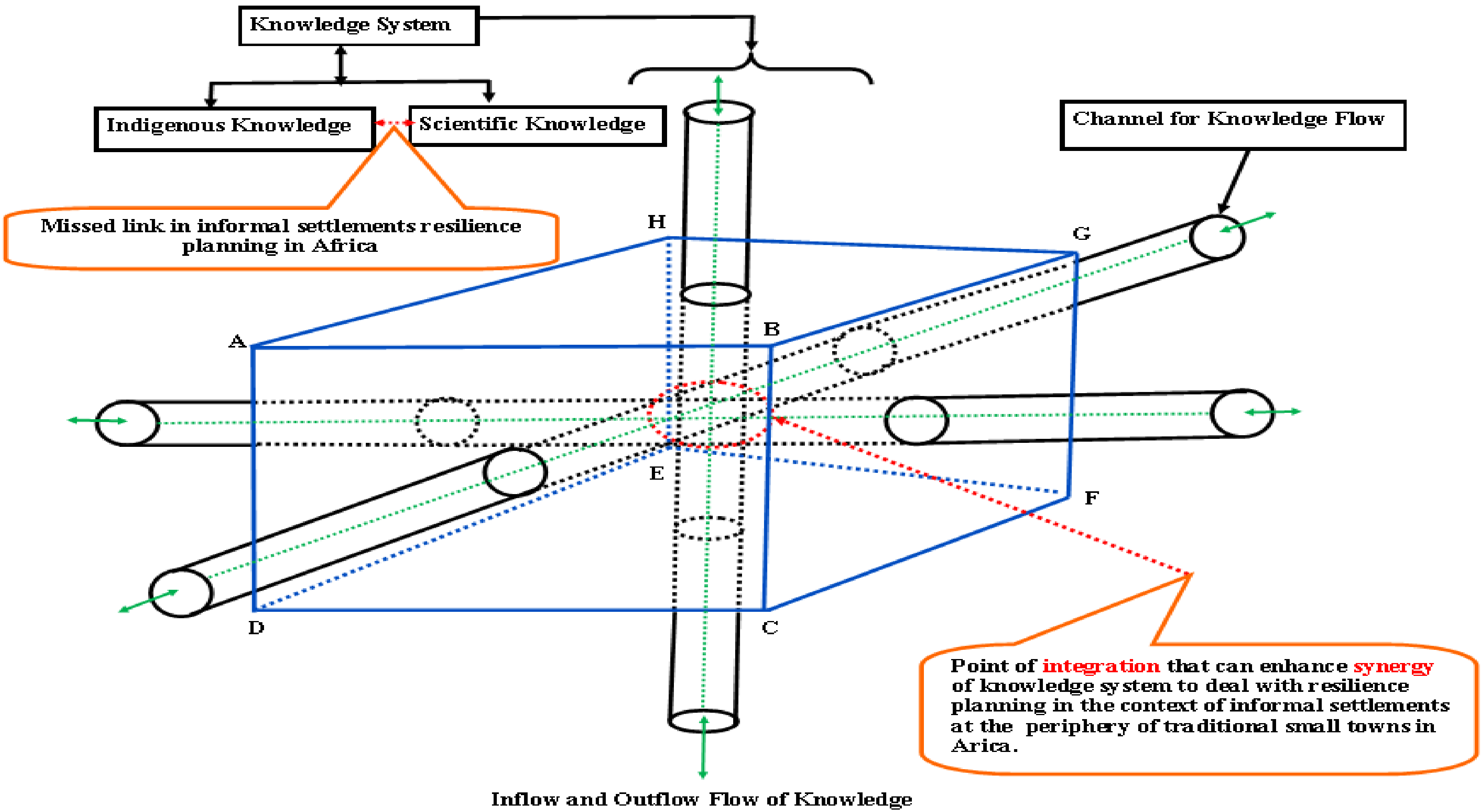
Understanding local innovation is also vitally important, as it can form the basis of the development of new, improved technologies that integrate both IK and scientific knowledge. Improved local innovations will ensure locally specific practices that will result in increased diversity and rapid adaptation by local people to keep up with dynamic environmental conditions (Bayers et al., 2006:237). Innovations that match local realities ensure relevance and efficiency, and their implementation will ensure sustainability. Wohling (2009:35) also argues that a contemporary indigenous knowledge is generally a hybridisation of multiple knowledge sources, the same can be argued for western science. Failure to recognise these facts results in underutilisation of the potential benefit of knowledge integration regarding promoting socio-ecological system resilience. Dei (2000:113) advocates hybridisation of knowledge and balancing of knowledge bases, as indigenous and western knowledge are contested in terms of boundaries and spaces.

As indicated in Folke et al. (2003:352), there are four factors for building socio-ecological resilience: first, learning to live with change and uncertainty; secondly, nurturing diversity for reorganisation and renewal; thirdly, combining different types of knowledge for learning; and fourthly, creating an opportunity for self-organisation. A resilient community is one that learns from the past, values memory and diversity, and pursues diverse strategies to meet its needs. It draws on local knowledge, which it combines with other sources of knowledge, including scientific knowledge. There are also arguments for knowledge integration relate to the ability of a socio-ecological system to withstand disturbance without change structure, function, feedbacks, identity, and to remain flexible in response to changing environmental and social contexts. The resilience view advocates the management of complexity and uncertainty in socio-ecological systems (Waker et al., 2006:online). Bohensky (2011:6), also indicates some empirical evidence for the integration of indigenous knowledge with science that enhances socio-ecological resilience.

Figure 18 depicts the conceptual architecture of hybridisation of indigenous knowledge with scientific knowledge. The cube on Figure 18 can be considered as open knowledge system or cultural system that allows inflow and outflow of energy and/or materials as well as knowledge in a certain local area. The loops indicated in all directions are possible ways of flow of knowledge through different channels. These channels allow inflow and outflow of knowledge in the given local area. The red circle at the middle of the cube depicts points of integration of scientific and indigenous knowledge systems. This is the point where the application of planning theories in Africa missed the link between the scientific and indigenous knowledge, especially in the process of climate change resilience planning of informal settlements found at the periphery of traditional small towns. The point of integration can be considered, as the maximum possible synergy will be created to solve certain local problems.

How to identify a point of integration for both knowledge systems is one of the most critical questions that have to be answered in the process of hybridisation. As indicated in Bohensky (2010:6), four critical characteristics of knowledge integration possibly make the integration more productive and maximise the benefit gained from both indigenous and scientific knowledge systems. To realise the smooth integration of both knowledge systems, consideration should be given to the social contexts and intercultural knowledge linkages. This necessitates understanding how the new integrated knowledge system contributes to the intended purpose in a particular area.

In Figure 18, the flow of knowledge may not necessarily follow a linear direction; it may follow irregular patterns. However, identifying the intersections or possible compatible areas in the planning process is critical to deal with the resilience of informal settlements. Some anthropologists believe that indigenous knowledge should be adopted by western medical, agricultural and resource management fields (Posey and Dutfield, 1997:1). Others caution that such views assume that indigenous knowledge – one extracted from its cultural context – can still be useful as applied science and society in general (Ellen et al., 2000:13). Both the knowledge systems have their own strengths and weakness. Therefore, hybridisation allows the planners to capitalise on the strengths and minimise the drawbacks (Wisner et al., 2004:9).



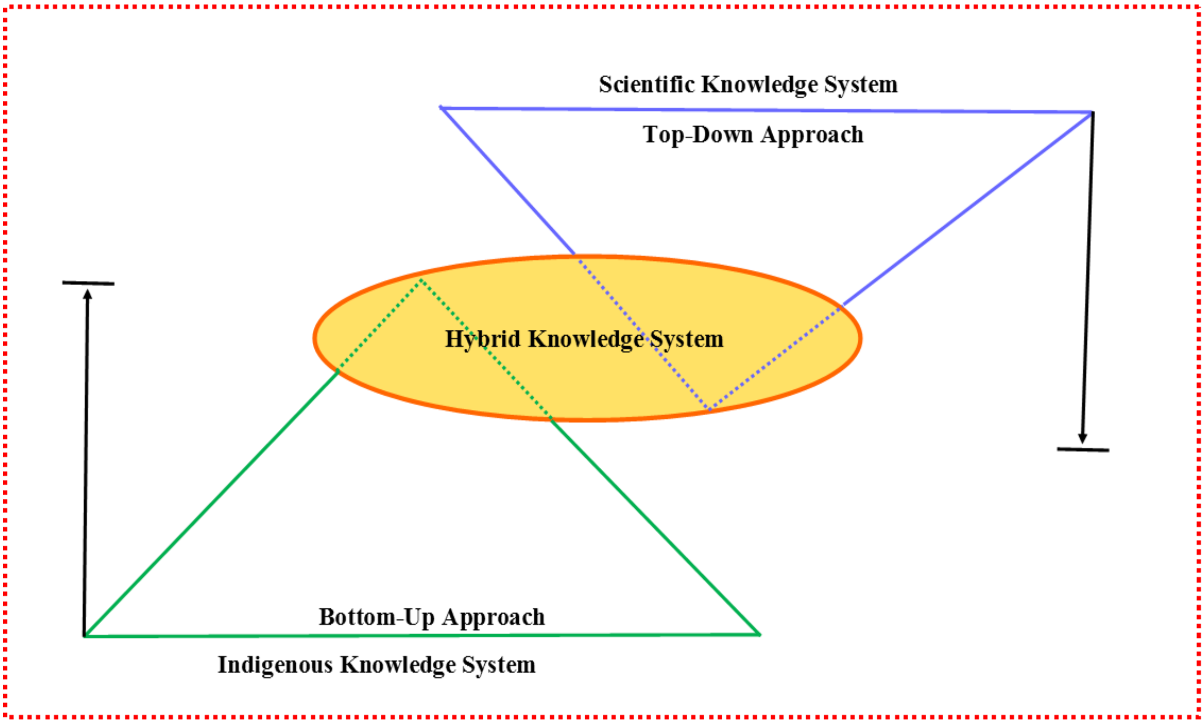
Source: Author own design, 2016

FIGURE 18: Conceptual Architecture of Hybridisation of the Knowledge Systems

As scientific evidence reveals, the practice of hybridisation is successful in many areas of the botanical and zoological sciences (James, 1998:1043). Accordingly, it is possible to experiment on the current urban planning practice in Africa, especially, in the cases of resilience planning of informal settlements found in mountainous regions of Africa. The process of successful hybridisation and fit-for-purpose models of the knowledge systems necessitates flexibility in terms of combining top-down scientific knowledge system with bottom-up indigenous knowledge systems. In addition, the overall process should consider intercultural learning and accept diversity in cultural values (Hill et al., 2008:47). Therefore, as indicated by (Brown, Dayal and Rumbaitis, 2012:531), it is essential to integrate indigenous knowledge with information communication technology. This may open the door for an innovative solution to natural environmental degradation. (See Figure 19 that reveals other ways of hybridisation of the knowledge systems).

With regard to urban planning for disaster risk reduction, there has been a recognisable movement away from top-down directives and towards bottom-up planning (Wisner et al., 2004:9; Louis 2007:130). In order to initiate bottom-up planning, participatory techniques have increasingly been used to initiate community engagement and involvement in decision making (Comfort et al., 1999:39). As the Figure 19 depicts, participatory broad-based stakeholder involvement is at the centre of successful materialisation of the hybridisation of knowledge systems, because the success of a hybridisation process and implementation of the newly derived planning model or approach are strongly dependent on the contexts and relevance to a particular community in a given area.

The central aim of hybridisation of the knowledge system is to develop new features or characteristics in the knowledge system. Application of scientific knowledge only cannot solve the problem of climate change risks in the case of small traditional towns in Africa. This is mainly because the existing reality at the grass-roots level is different from those of western settlement patterns. Therefore, local socio-ecological, cultural, environmental and economic factors need to be considered in the process of application of planning theories developed by westerns. This necessitates customisation of scientific knowledge and integration with indigenous knowledge enabled to maximise the synergy of the knowledge to solve the local problem. However, the existing reality on the ground depicts that planning practice is biased towards the application of the scientific approach (Louis, 2007:131).



Source: Author, 2016

FIGURE 19: Hybridisation of the Knowledge Systems

5.5.1 Challenges of Hybridisation of the Knowledge Systems

There are challenges with the practice of integration of both knowledge systems. As indicated in Nursey (2003:16), even in instances where both managers and indigenous communities agree to work together on resource management issues, the way forward is fraught with challenges. The main roadblock to successful management is often a lack of cross-cultural literacy, marked by a lack of trust, clear communication, knowledge and power sharing, as well as mutual respect among the stakeholders. In addition, the socio-cultural understanding of western science and how it can be better assimilated with alternative knowledge sources need to be emphasised. This gap in cross-cultural understanding makes many indigenous co-management processes difficult. One of the challenges for successful co-management is acknowledging both the indigenous and scientific knowledge to develop within culturally distinct spheres of beliefs and values (Houde, 2007:2).

In addition, for those who believe in the universality of science, the integration of the indigenous science movement and modern western science is questioned (Cobern and Loving, 2001:50), despite the recognition of the value of some indigenous knowledge contributions to the pool of scientific knowledge. In their critical remarks against the integrations of indigenous knowledge in school science, Cobern and Loving (2001:54) argue that finding value in indigenous knowledge “is not the same thing as conferring the title science and admitting indigenous knowledge of nature to the standard account”.

5.5.2 Institutionalising the Hybrid Knowledge Systems

To enhance the role of indigenous knowledge for climate change resilience, empowering the local community is one of the critical factors. However, modern planning approaches, education systems and political ideologies affect the use of indigenous knowledge negatively (Hilhorst et al., 2015:506). Competing cultural contexts can consequently hamper effective enhancement of climate change resilience because different actors relate in very different ways and scales (Berkes 2008:12). Thus, it is difficult to ensure the benefit of synergy, created through the smooth integration of different knowledge systems. As Stephenson and Moller (2009:139) explain, when political tensions develop across cultures, determining *who* makes the decision becomes more important than *what* the actual decision might be. Disempowerment may also occur through knowledge ‘validation’. IK is often compared to western science to test its ability to corroborate scientific knowledge and is typically considered a secondary choice of knowledge when quantitative scientific information is unavailable (Gilchrist et al., 2005:online). Therefore, measuring the validity of any indigenous knowledge source is important for successful natural-resource management. Accordingly, the assumptions, limitations and constraints of all knowledge systems should be considered equally (Brook and Mclachlan, 2005:9).

The creation of new institutional rules or policies more amenable to resilience enhancement strategies is more likely when actors face novel problems and crises including climate change threats (Manring, 2007:325). Cognisant of the significance of indigenous knowledge for climate change resilience is the importance of empowering the local community for natural resource management and recognising their indigenous knowledge as a coping strategy for improving resilience capacity. Practically incorporating additional supportive knowledge to improve climate change resilience is crucial, instead of only searching for scientific findings. The benefit of indigenous knowledge can be maximised by integrating it with modern technology-based science and by enhancing the capacity of traditional institutions. This also enables societies to cope with the danger of loss of indigenous knowledge in the current generation. It is essential to document and institutionalise this knowledge so as to utilise and transfer the benefits of indigenous knowledge for future generations effectively. This facilitates the involvement of the local community to participate actively in the planning, decision-making and utilisation of resources (Syafwina, 2014:573).

5.6 Participatory Hybrid Resilience Planning Model [PHRPM]

According to Watson (2009:2259), the existing urban planning systems in developing countries create some problems, such as spatial and social segregation, marginalisation of the poor, and environmental destructions. Therefore, it is argued that the planning experience should be fundamentally reviewed in order to address the urban issues in developing countries. The planning approach, especially in Africa, is directly borrowed from the western planning approach and applied without customising with African reality. Given the past dominance of the global North in shaping planning theory and practice, urban planning in many parts of the global south fails to address the urban challenges (Friedmann, 2005a:183). Therefore, new planning approaches need to be devised in order to address the challenges faced in the urban systems of the developing countries. Accordingly, pro-poor and inclusive planning approaches should be in place, especially in the context of small towns found in developing countries, including in Africa (Watson, 2009:2259).

The danger of direct application of western planning theories and practice in the context of small traditional towns in Africa has been clearly observed. Therefore, customisation of urban planning theories and practices is very crucial. In this regard, collaborative and flexible planning approaches need to be practised in the African context (UN Habitat, 2009:8). According to Healey (1996:217), collaborative or communicative planning implying a sharing of knowledge and cooperation between stakeholders or partners should result in better plans and policies that are better implemented. This planning approach opens up avenues for poor urban dwellers and other marginalised groups and promotes pro-poor planning ideas. According to Lane (2005:296), the communicative approach to planning infers a substantial role for public participation. The importance of inter-subjective communication to the communicative model is that it demands forms of participation that provide forums for dialogue, argumentation and discourse (Healey 1996:217). Public participation in communicative planning must be concerned with more than consultation and placation; instead, public participation in communicative theory is likely to involve negotiation, bargaining, and debate (Dryzek, 1990:13; Healey, 1996:218). In communicative planning, therefore, without the involvement of concerned actors, planning cannot proceed.

Healey (2003:101, in Seltzer and Mahmoudi, 2012:2) notes that communicative or collaborative planning theory recognises that all forms of knowledge systems and processes for developing the new knowledge system. Collaboration between all participants in the process encompasses citizens, planners and decision makers in the context within which plans are made. Communicative planning encourages negotiation to arrive at consensus. In this regard, the role of planners facilitates the forum in order to listen the voices of all stakeholders, including the marginalised section of the society. The communication would be a two-way rather than a top-down, technocratic approach. Therefore, in the absence of real participation of the community, planning cannot be considered as a tool to deal with urban issues (Seltzer and Mahmoudi, 2012:2). According to Garau (2012:23), however, there are critical conditions that may restrict public participation in the planning process. The complexity of some problems and the technical requirements to deal with them make public participation difficult. In such cases, public precipitation may not be considered as a remedy, for the problems need to be addressed through planning (Walters et al., 2000:6).

In line with this, communicative planning has room for hybridisation of the western planning approaches [scientific knowledge system] with the African indigenous knowledge system(Watson, 2009:2261; Innes and Booher, 2010:6).Therefore, to use the maximum potential of both knowledge systems, there must be an '*Africanised' hybrid urban planning approach* that accommodates the benefits of the indigenous knowledge system. To realise this, flexible institutions working towards hybridised and contextual planning models must be in place. This is mainly because direct application of western scientific approach in the planning process in the context of African small informal settlements is not feasible. The western scientific approach emphases on enforcing the codes, high standards, rigid regulations that could not consider the African reality at the grass root level (Watson, 2009:2261; Seltzer and Mahmoudi, 2012:2).

Therefore, the ideal participatory hybrid-planning model should consider the following integral conditions. It should accommodate the social, environmental and economic situation of the particular area; recognise the local cultural contexts that govern the knowledge system; allow broad-based stakeholder participation from inception to implementation as well as in evaluation phases; it should allow flexibility in the implementation phase; require re-engineering of previous institutional and legal frameworks designed previously biased towards western planning theories; it should allow mediation to link scientific society and indigenous people; and allow using multiple instruments and methods to get results (Seltzer and Mahmoudi, 2012:2; Friedmann, 2005a:183). Accordingly, the following sub-section discusses the level of participation in the decision-making process.

5.6.1 The Stages of Participation in Planning

The level of participation in the planning process is dependent on the type of planning (Lane, 2005:283). The complexity of the problem be addressed through planning and the required knowledge, and techniques and conceptualisation of the context determine the level of participation. However, public participation is critical to the success of implementation of any kind of planning (Watson, 2009:2261). Accordingly, by considering the problems encountered in trying to customise Arnstein's idea for developing countries, Choguill modified and included additional criteria to evaluate the level of public participation in the planning process (Choguill, 1996:431). Accordingly, the following are the ladders of public participation in the process planning or decision-making.

5.6.1.1 Empowerment

Empowerment is the highest level on the ladder of community participation. It may take the form of community members having a majority of seats or genuine specified powers on formal decision-making bodies over a particular project or programme involving community participation when municipal authorities are unable or unwilling to undertake improvements themselves. Community members are expected to initiate their own improvements, possibly with the assistance of outside organisations, demonstrating actual control of the situation and influencing the processes and outcomes of the development. These possibilities of actually controlling the situation and making allies, with governmental support, constitute the main characteristics of empowerment (Choguill, 1996:431). As Painter (1992:23) argues, real power is a critical aspect of participation and consultation. Therefore, participation can be realised in any phases of the planning and decision-making processes, from inception to implementation. The collaborative or active involvement of the community empowers them to decide on resource found at local area. The planner or decision maker plays a neutral role by facilitating community engagement to achieve the shared goal. In addition, the initiation for participation may be triggered from community side because of their legitimate right (Ecosfera, 2001:20). Accordingly, this high level of participation allows getting feedback about the implementation of the given project (Garau, 2012:23).

5.6.1.2 Partnership

According to Choguill (1996:431), partnership is the second-highest level of on the ladder of participation. The community and planners and any other decision makers share responsibilities about the projects. In this kind of participation, government involvement in the decision-making process is higher than from the case of empowerment (Lane, 2005:285; Edwards 2001:51; Teisman and Klijn 2002; Garau, 2012:25). Innes and Booher (2010:3) also demonstrate a process of collaborative involvement determines the outcome of the implementation of a certain development project. In this case, the emphasis is on the advantage of customising the plan for successful implementation.

5.6.1.3 Conciliation

Conciliation is the third-highest rung of the suggested ladder of community participation. It occurs when the government devises solutions that are eventually ratified by the people. It may take the form of appointing a few representatives of the community to advisory groups, or even decision-making bodies, where they can be heard, but also where they are frequently forced to accept the decisions of a powerful and persuasive elite. It is frequently a top-down, paternalistic approach (Choguill, 1996:435).

5.6.1.4 Dissimulation

This is the fourth rung down in the ladder. In order to achieve a semblance of participation, people are placed on rubber-stamp advisory committees or boards. The express purpose is educating them or, more frequently, engineering their support. From this level down, the government increasingly leaves the communities to themselves (Choguill, 1996:436).

5.6.1.5 Diplomacy

Diplomacy is the fifth rung down suggested in the ladder of community participation. In this case, the government, for lack of interest, lack of financial resources or for incompetence, is likely to expect the community itself to make the necessary improvements, usually with the near-heroic assistance of an outside organisation. When there is a possibility that the community by itself accomplishes real improvements, or when NGOs are involved, the government may change its attitude, frequently for tactical reasons, providing limited amounts of aid. Diplomacy may take the form of consultation, attitude surveys, public hearings, visits to the neighbourhood or meetings with dwellers. In this event, government officials pretend that they are seeking opinions on a potential project or that they are going to promote/support some kind of improvement to the neighbourhood. However, there is no assurance that new projects will be implemented, that concerns and ideas from the community will be taken into account in these projects, or that support to the community effort will be provided (Choguill, 1996:437).

5.6.1.6 Informing

This consists of a one-way flow of information from officials to the community, of their rights, responsibilities and options, without allowance for feedback or negotiation, in projects that have already been developed. It is a top-down initiative, frequently with controversial results. It is a level of manipulation and constitutes the sixth rung down of the participation ladder. (Choguill, 1996:437). This level may involve the use of information tools such as interactive websites, public meetings or focus groups (Garau, 2012:23).

5.6.1.7 Conspiracy

Conspiracy is the seventh rung down the ladder. Here, no participation in the formal decision-making process is allowed, or even considered, as the government seems to reject any idea of helping the poor. To the government, the poor communities are little more than an embarrassment. It includes cases where the reasons given by authorities for action disguise ulterior motives or may benefit other groups (Choguill, 1996:438).

5.6.1.8 Self-Management

Self-management is at the bottom of the suggested ladder of community participation. It takes place when the government does nothing to solve local problems and the members of the community, plan improvements to their neighbourhood and actually control the projects by themselves, not always successfully. Usually, although not always, communities work with the outside assistance of NGOs or the support of independent financial institutions, which seems to affect the outcome of the community effort positively. In fact, the NGOs themselves, through their extensive involvement, may well totally replace the need for government, with the exceptions of meeting the objective of changing the status quo in the political sphere (Choguill, 1996:438). In certain political contexts, however, the alliance of influential outside supporters of people's initiatives may be necessary if the community activity is to exist at all. In this case, the alliance guarantees that the hostile government exercises a diplomatic non-interference. Eventually, people's initiatives may temporarily influence the processes and outcomes of development, in the case of just a diplomatic political change, or may establish genuine empowerment in the case of change of leadership and the establishment of mechanisms of support to the communities. Thus, in the ladder of community participation suggested, in contrast to empowerment, self-management implies situations that result from lack of governmental interest in or even opposition to the poor people's demands. This seems to have been a popular approach among communities (Ecosfera, 2001:20; Choguill, 1996:438).

In the fortunate case of supportive governments, initiatives may lead to one of the three levels of participation, namely empowerment, partnership or conciliation, depending on the degree of governmental willingness and/or confidence in the community's ability to contribute to its own improvement and of the residents to initiate activities by themselves or with the support of external agencies (Seltzer and Mahmoudi, 2012:2; Innes and Booher, 2010:3). Thus, one may talk about empowerment or partnership, depending on the community's freedom to initiate activities or form alliances outside the boundaries of the governmental control, while conciliation emerges as a somewhat paternalistic approach. In this case, the level of governmental control is very high and is legitimised by good technical performance (Lane, 2005:283).

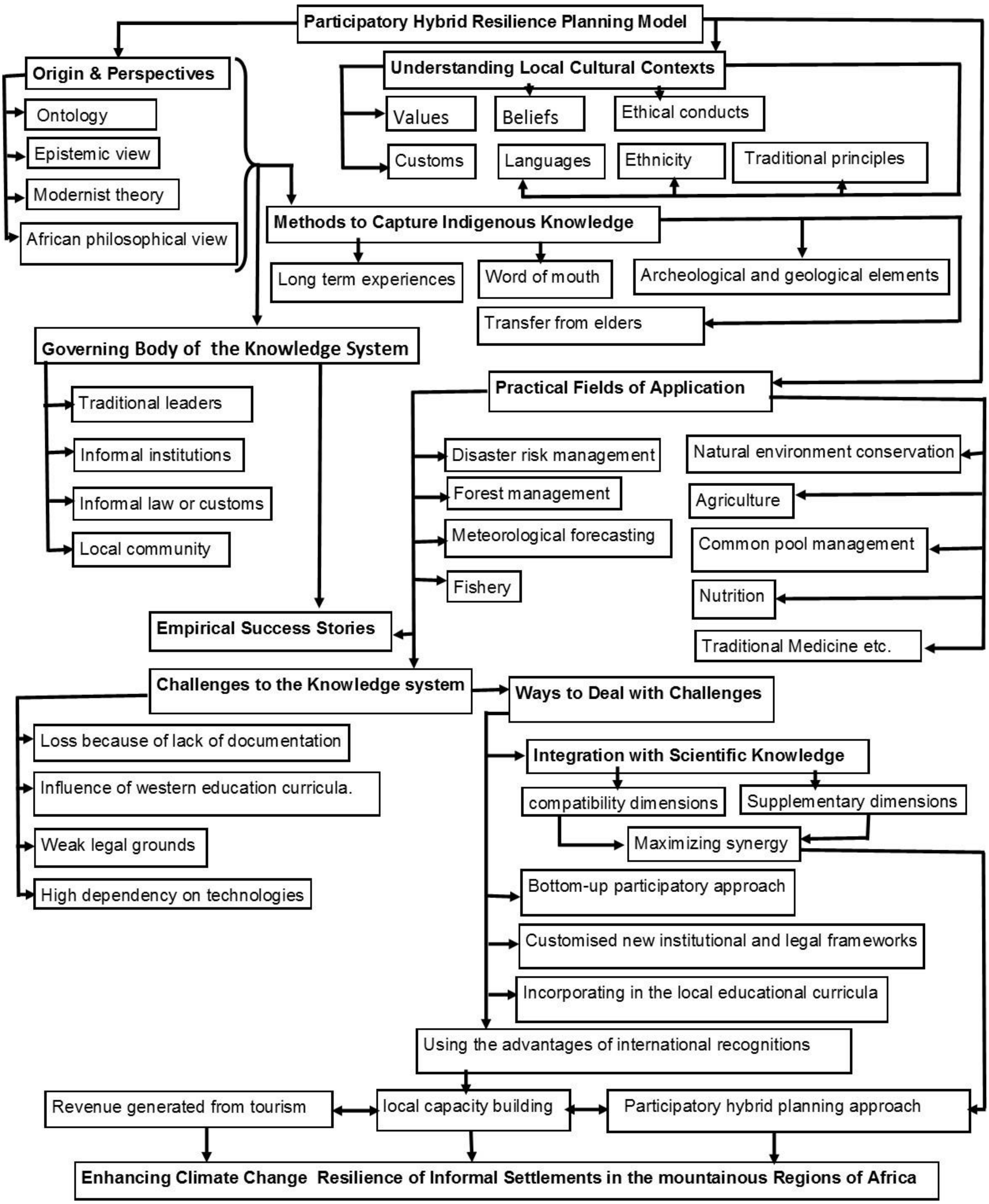
Generally, from the above discussion, it is possible to recognise that the government, planner or and other decision-makers may determine the level of community participation. The more the decision-making process encourages community participation, the higher level of possibility to achieve the goal of a certain development project. The demonstration of the level of participation indicates that empowerment and self-management are found in the extremes of participation ladder. Therefore, how the community participates in the decision-making process is critical and determines the outcome to be achieved (Ecosfera, 2001:20).

5.6.2 Conceptual Framework for Participatory Hybrid Resilience Planning Model [PHRPM]

As discussed in the above sections, one of the major challenges of resilience planning for small and traditional towns in African is how to accommodate indigenous knowledge in parallel to scientific knowledge without compromising the benefits of both systems. In many instances, Western knowledge winds up overshadowing indigenous knowledge, which is because of the recognition that it is better than the indigenous knowledge (Domfeh (2007:42). Disaster-reduction management policies of developing nations are biased to the application of scientific knowledge and overlook the significant value of indigenous knowledge in this area. Although much has been said about the benefits of ingenious knowledge, it is not institutionalised to cope with climate change risks in the context of Africa (Gaillard and Mercer 2012:93; Rist and Dahdouh, 2006:467).

The importance of this indigenous knowledge has not been well considered by policy makers and planners in order to practise in disaster risk-reduction interventions; rather, their perception and practice are biased towards the scientific knowledge system. Iloka (2016:272) argues that comprehending how local people in Africa managed to survive and adapt disasters for many years before the arrival of the western education system can be considered in the enhancement of sustainable and climate change-resilient developments. However, the challenge is the perception of indigenous knowledge systems as inferior to scientific knowledge system (Mercer et al., 2010). Therefore, the urban planners in Africa are very biased towards western planning theories and practices that are not feasible when faced with the reality of the context of Africa.

On the other hand, there have been calls for hybridisation of the indigenous knowledge and scientific knowledge systems to mitigate hazards and reduce disaster in local communities (Gaillard and Mercer, 2012:93). Accordingly, based on these principles, the following conceptual framework for hybridisation of the knowledge systems to enhance climate change resilience of informal settlement was developed.



Source: Author's Design, 2016

FIGURE 20: CONCEPTUAL FRAMEWORK FOR PARTICIPATORY HYBRID RESILIENCE PLANNING MODEL

5.7 Conclusion

The foundation for this study is grounded in the importance of the hybridisation of indigenous and scientific knowledge systems. Bridging indigenous and scientific knowledge together and the implication for maintaining and building socio-ecological resilience are some of the critical processes to cope with climate challenges in Africa. However, the modernist worldview perceives indigenous knowledge as synonymous with the primitive and traditional knowledge that practised by poor people; that it is culturally static and historical information, rather than a dynamic, ongoing relationship between indigenous peoples and their landscapes. Due to this perception, this worldview does not give recognition to the indigenous knowledge systems as an independent way of solving the social and environmental challenges. On the other hand, there is an African philosophical view of indigenous knowledge systems that encourages devising a local solution for local problems.

Using the modernist or scientific approach for planning is inadequate to deal with the complexity of climate change-related risks. Accordingly, global scientific societies have started to recognise the importance of indigenous knowledge systems and they are hybridising this knowledge with scientific knowledge. Building the climate change-resilience capacity of informal settlements requires the successful application of indigenous knowledge and its systematic hybridisation with scientific knowledge. Now, the critical question is, how to maximise the potential use of indigenous knowledge to deal with complex climate change risks that are observed in areas of informal settlements. To answer this critical question, communicative planning approaches are recommended because they allow combining bottom-up and top-down approaches as well as hybridisation of the indigenous and scientific knowledge systems. Further, there must be flexible local institutions that facilitate the hybridisation process in order to enhance the resilience capacity of informal settlements in the context of Africa.

Chapter 6
RESEARCH METHODOLOGY AND DESIGN

6.1 Introduction

Research methodology is regarded as the process of arriving at a dependable solution to a problem through objectives, planned and systematic collection, interpretation, analysis and reporting of data and information (Otokiti, 2005:13). This research methodology chapter explains the methods and techniques applied to achieve the intended objectives of the study. It comprises the research design that clarifies the plan of the research work; the sources of relevant data for this study; the sampling design and technique to determine sample size; the instruments prepared for the purpose of data collection, and the mixed approaches to data analysis; and the conceptual framework to do the study in mountainous regions of Africa.

6.2 Research Design

The research design refers to the blueprint that the research process follows in order to arrange components of the study in a logically consistent way to address the research problem (Gorard, 2013:1). To conceptualise the research problem comprehensively, the theoretical review was undertaken as baseline source of knowledge. Based on this theoretical framework, the concept of climate change resilience is conceptualised, as it is complex and research in this kind of field requires a systems approach (Nel, 2009:24; Bodenschatz, 2009:2). The research on urban resilience needs “complex thinking and complex methods” (De Roo and Joutsiniemi, 2010:90), which necessitates adopting a holistic approach (Batty, 2007:1).

The fundamental assumption of this study is that climate change resilience of informal settlements is a phenomenon that is complex, dynamic and uncertain in its characteristics and research in this area requires a systems or holistic approach. In other words, the study of climate change resilience of informal settlements needs to address the social, economic, spatial and physical and institutional variables found at the interfaces of urban and rural areas. The relevance of application of the systems approach to assess resilience capacity of informal settlements in the case study areas was to gain a deeper and holistic understanding of the interaction of factors that contribute to the vulnerability of informal settlements for climate change risks. The characteristics of informal settlements can be considered as a complex socio-ecological system. Therefore, the systems approach can solve the danger of an isolated and independent assessment of the vulnerability and resilience capacity of informal settlements for climate change-related risks. Thus, the conceptual framework of this study is developed by adopting a systems approach as a methodology to assess the climate change resilience of informal settlements in two mountainous regions of Africa. (See **Error! Reference source not found.**.)

In order to identify climate change-associated risks and vulnerability of informal settlements in the study areas, a hybrid or mixed research method was employed, which incorporated various sources of data for triangulation (survey, interview, documents, focus-group discussions and field observation). A field survey was undertaken and the data were analysed by using qualitative and quantitative approaches. Furthermore, descriptive, narrative and participatory research approaches were used to explain the situation on the ground. Since the nature of this study focuses on informal settlements found on the periphery of small traditional towns in South Africa and Ethiopia, the spatial and non-spatial characteristics of these variables have both urban and rural dimensions. Accordingly, the systems approach is used to consider informal settlement by aligning with the urban-rural system, rather than as an isolated entity.

6.3 The Philosophical Paradigm of the Research

The philosophical ground of this study can be characterised as a pragmatic research paradigm.[14] *Paradigm* refers to a worldview that describes the perception of the 'world' for its holders, the individual place in it, and the scope of conceivable connections to that world and its components (Guba and Lincoln, 1998:200). According to Powell (2001:884), in a pragmatic paradigm, the mandate of science is not to find the truth or reality, the existence of which are perpetually in dispute, but to facilitate human problem solving. As discussed in the literature review sections, the concept of resilience and vulnerability is multidimensional, multi-scale and controversial in terms of conceptual and methodological application. However, the theme of this study is how to cope with climate change-induced risks in the contexts of informal settlements in mountainous regions of Africa.

6.3.1 Ontology of the Research

The philosophical ontology of this study recognises the truth as the functional impact of thoughts. Finding logical and practical solutions for climate change-induced risks and exploring the potential benefits of indigenous knowledge to enhance climate change resilience of informal settlements form the foundation of this study. As indicated in (Gerring 2007:98), ontologically, comparative case study researchers have a tendency to have complex perspectives about the world. They consider nations, society and community as subjects of compari-

[14] ***Research Paradigm***: "a philosophical and theoretical framework of scientific school or discipline with in which theories, laws, generalizations, and the experiments performed in support of them are formulated" (Merriam Webster Dictionary, 2007).

son. Along these lines, the indicators of resilience found in the case study areas can be comparable, although some of them may not be comparable. This depends on the unique characteristics.

6.3.2 Epistemology of the Research

The study recognises many ways of thinking or doing that possibly lead to a solution. Pragmatism looks at different worldviews that are derived from lived-experience; it supports an empirical or experiential approach to gaining knowledge and practical application of theories; and it is flexible enough to accommodate other philosophical positions (Ormerod, 2006:905). Accordingly, in-depth analysis of the complex socio-ecological system, or informal settlements, by examining the overall pattern of the development process is considered as an approach to devising innovative local and feasible remedies in terms of building climate change-resilient communities. It emphasises how to solve climate change-related risks in the areas of informal settlements by integrating the indigenous knowledge with scientific knowledge. The level of application of the resilience theory in the context of informal settlements in mountainous regions of Africa is also considered. Investigating climate change impacts and building climate change resilience from the context of small traditional towns in mountainous regions of African form the central theme of this study.

6.3.3 Rationale for the Methodological Approach Operationalised

The pragmatic research permits the researcher to follow own concerns, and in addition catching the voice of others; fundamentally, it accommodates different positions and values (Owuegbuzie and Leech, 2005:375). Further, it permits to utilise a mixed approach of research methods in order to capitalise on the strengths of different research methods. Mixed methods research is the sort of research in which a scientist or group of analysts joins components of subjective and quantitative research approaches. The use of qualitative and quantitative perspectives, data gathering, analysis, deduction techniques for the broad purposes of breadth and depth of comprehension and substantiation stand in opposition to the "positivist" and "interpretive" methodologies (Johnson et al., 2007:123). Mixed methods also offer enormous potential for producing new ways of comprehending the complexities and settings of social experience, and for enhancing our abilities for social explanation and generalisation. Such an approach can draw on and augment some of the best principles of research enquiry. All the while, it can benefit approaches in which qualitative researchers have tried to develop constructivist epistemologies, and to connect with sensitive methodological issues, particularly around inquiries of interpretation and explanation (Mason, 2006:10).

Furthermore, in order to examine the complex characteristics of systems' resilience (De Roo and Joutsiniemi, 2010:90), a mixed technique of qualitative and quantitative approaches should be employed (Miller et al., 2010:3). As indicated in Cloete (2012:341), a complex and dynamic system can be better understood by identifying the characteristics of the whole system, such as its interconnectedness, processes and adaptation pattern over time by using hybrid methods. The aim is maximising validity and reliability of data and findings. Mixing both qualitative and quantitative methods has become increasingly common in the study of systems involving humans. As Creswell (2003:11) remarks, this approach enables the researcher to base knowledge claims on pragmatic grounds in a consequence-oriented, problem-centred and pluralistic way. It employs a method of inquiry that involves collecting data in a simultaneous or sequential manner, as well as the gathering of numeric information and text data so that the final data set represents both quantitative and qualitative information (Creswell, 2015:2).

Nevertheless, every approach has its own advantages and disadvantages, but one should not be a substitute for the other. However, as indicated by Bazeley (2004:141), mixed methods research should not be considered inherently valid; instead, trustworthiness and credibility must be assured through the application of rules and procedures and attention to quality criteria. Indeed, the development of quality criteria has been a concern for the mixed methods community for some time. Onwuegbuzie and Johnson (2006:48) argue that the most salient validity issues faced by mixed methods research are representation, legitimation and integration. Representation is the difficulty of representing lived experience through text and numbers; legitimation refers to the trustworthiness of inferences; and integration to the multiplicative and additive threats that result from combining methods. This leads to the root of the problem in producing high-quality mixed methods research.

The pragmatic research also encourages the use of triangulation in order to increase the confidence of the observed findings. Triangulation enhances a process of combining data from different sources to study a particular social phenomenon (Denzin, 1970 in United Nations Programme on AIDS [UNAIDS], 2010:12). (See Section 6.7.3 for further discussion on triangulation.) Accordingly, to assess the complex nature of the notion of resilience and its application in the context of informal settlements in the mountainous regions of Africa, this study operationalised a mix of theoretical, empirical and triangulation approaches to enhance reliability and validity of the research outcomes. All these research processes are materialised under the umbrella of a systems approach to analyse complex interactions of social, ecological economic and physical components in the study areas. (See the conceptual framework in Figure 24).

6.3.3.1 Comparative Case Study as a Methodology

Gerring (2007:94) characterises a case study as a spatially delimited, or an object studied at a certain period in time. It includes the kind of events that an extrapolation endeavours to clarify. This infers the case is chosen or delimited because of its potential informative value. A contextual analysis is an experimental request that researches a contemporary phenomenon inside its authentic setting, particularly when the limits between the question of study and setting are not plainly obvious. The case study approach arose out of the desire to comprehend socio-ecological interactions in both their complexity and 'natural' context. In order to emphasise the 'real-life' character of social relations, a systems approach is sought that will allow for the maximum number of contexts of each case to be taken into account (O'Brien, Eriksen, Nygaard and Schjolden, 2007:73)

Accordingly, the conditions of the two case areas were investigated with the rationale of capturing in-depth information. Contextual vulnerability to climate change-related risks and capital-based resilience capacity were assessed in each particular area. To improve climate change-resilience capacity in a certain area, assessing "contextual vulnerability" is crucial (O'Brien, Eriksen, Nygaard and Schjolden, 2007:73). This requires answering questions such as who and what are vulnerable and why? (Leichenko and O'Brien, 2008:1). Answering these critical questions needs area-specific case studies to capture data and to undertake the analysis. Cutter et al. (2010:6) propose that disaster resilience capacity is a function of social, economic, ecological, physical and institutional capital existing at a particular place and time. Analysing these capabilities in a specific place and time requires an in-depth case study.

Furthermore, the climate change-resilience capacity of a certain area is determined by the capacity of a system to resist, absorb and recover from certain climate change-related shocks (Holling, Carpenter, Kinzig and Walker, 2004:5). Comprehending the dynamic relationship among the subcomponents of informal settlements and understanding how external and internal forces lead to changes also requires in-depth case studies of a certain area and culture (Acosta-Michlik and Espaldon, 2008:554). Within the existing reality of variation in exposure and sensitivity to climate change risks, searching for enhancing resilience capacity of a certain community, place or region needs the case study method (Smit and Walden, 2006:282). Contrary to this, some scholars argue about the reliability and validity of case studies for their limitation to generalise the outcome of the study (Noor, 2008:1602; Pope and Mays, 2009:339). On the other hand, Andrade (2009:44) argues that case study methods can provide information through the understanding of incidents and processes that may not be captured by other methods.

The basic consideration of these case studies is assessing complex and interconnected variables among social, ecological and economic systems to improve climate change-resilience capacity of informal settlements in the mountainous regions of Africa. Therefore, climate change resilience planning is recognised as one of the coping strategies to the current and future challenges. To realise this, a situational analysis of the specific locations in the study areas is undertaken. The assessment of resilience capacity of the case study areas was done by using a combination of two approaches. These are *"principles to build a resilient system"* as proposed by Biggs et al. (2015:4-18) and *the capitals for disaster resilience* suggested by Cutter *et al*. (2010:7). These approaches are customised to the context of the case study areas to analyse climate change-resilience capacity. The capitals existing in the study sites are assessed against those principles to build a resilient system.

A case study itself does not constitute comparative research; good descriptions of individual cases are useful as raw material for comparisons, or as the first step in a comparative study. Therefore, comparison of case studies requires data from two or more instances to achieve the research objective. Case studies provide fine-grained analyses and allow comparability where research has been undertaken in a common framework. The cases which are compared include interactions, social meanings, contexts, social actions and cultural groups, as well as ecological and economic factors. This can be realised by a comparison of areas, groups or time periods in terms of social, ecological and economic indicators (Landman 2008:5). Comparison of the cases is realised by identifying similarities and differences among the social, economic and environmental factors. This knowledge provides the key to understanding, explaining and interpreting diverse socio-ecological and economic outcomes in terms of assessing resilience capacities in the given areas. Cross-societal similarities and differences may constitute the most significant feature of the social landscape. Hantrais (2009:109) deals specifically with multiple methods in comparative case study research, distinguishing between three approaches such as triangulation, facilitation and complementarity. Triangulation refers to using two or more different research strategies to investigate the same case so that findings or insights from one strategy can be corroborated by the other(s); specifically, quantitative and qualitative approaches are used in parallel. Facilitation denotes application of more than one approach, but one of them is dominant and different techniques may be used sequentially. For instance, a qualitative study to generate hypotheses before a quantitative study is undertaken. *Complementarity* refers to integration of different approaches rather than using in parallel or sequentially, as when researchers shift repeatedly from the one to the other.

As demonstrated in Landman (2008:5), comparison allows examining diverse phases of objects of the study. For example, in a research plan, it is represented in the ways in which samples are chosen for study in order to compare at sub-sets on a few factors while holding others consistent. At the analysis stage, distinctive areas of social groups can be compared on a variable at a similar point in time that is a cross-sectional examination, or similar areas of subjects can be compared on a variable at various focuses at the longitudinal period of time. At times, comparison happens after distribution of results, for instance, in examining the conclusions of a study from various parts of the world to consider how distinctive social orders deal with local conditions. In like manner, this study underlined the cross-sectional comparison of the instances of climate change-resilience capacity and vulnerability of informal settlements in Phuthaditjhaba (Case 1) and Karat (Case 2).

6.3.3.1.1 Justification for Using the Comparative Case Study

A comparative case study is critical to investigate the unique characteristics of each case study area. Accordingly, the comparative analysis of the cases employs objective analysis by using a composite climate change-resilience index and subjective explanation of resilience capacity of the case study areas (Frankenberger and Nelson, 2013:9). Comparison by using the resilience index provides a benchmark for measuring progress, to assess needs and targeting interventions or mitigation programmes. It provides a rationale for policy-makers to use scarce resources more strategically to maximise their effect, rather than distributing them equally across all places and programmes. In addition, it gives an opportunity to see whether the deployment resources actually make a difference in enhancing resilience or not. To minimise the problems of comparison across contexts, a combination of objective and subjective criteria to identify resilience indicators was employed (Cutter et al., 2010:12).

Comparative case studies are valuable for comprehension and clarifying how setting affects the accomplishment of an intervention and how to tailor the intercession to the particular setting to accomplish planned results better. The motivation behind this comparative study is to distinguish unique features or variables that determine climate change-resilience capacity of informal settlements in the case study areas. This comparative case study approach is preferred to assess contextual vulnerability to climate change risks and resilience capacity in case study areas. Furthermore, the aim of this comparative study is not only dealing with similarities and differences of the case study areas in terms of climate change resilience, but also identifying incomparable features that influence the process of resilience building at context-base significantly. Therefore, the researcher adopted the approach of ‘proving-by-disproving’. This means identifying unique and incomparable variables that are necessary in the process of policy and planning interventions in order to promote climate change resilience in the case study areas.

6.3.3.1.2 Justification for Selection of the Two Case Study Areas

As indicated in Peter (2011:11), in the process of comparative case studies, the case study areas can be selected based on the following criteria. These are: familiarity of the researcher with the study areas; access to the study areas; policy relevance; input for suitable planning interventions; absence of similar studies conducted in the area; convictions of the researcher, etc. In addition to these criteria, the selection for the case study area was undertaken based on the following considerations. Phuthaditjhaba and Karat towns share some similarities and contrasts regarding their geographical, social, ecological and economic features. Some of the considerations during the determinations of the case are: they are small traditional towns and the experience of traditional leadership in land administration is high; the two case study areas are located in the mountainous regions of Africa with an altitude of more than 1 640 m above sea level; and they are recognised by United Nations Education and Cultural Organisation [UNESCO] as one of the World Heritage sites because of their cultural landscapes.

According to Ragin (1987:15), in terms of selection of countries for comparative case studies, if there is little point in comparing entities that are so different that hardly any commonality can be found. Neither would it be useful to compare entities that are so similar that little difference of interest can be found. When places are selected for comparison, they should be comparable in respect of the phenomenon or theory that is the primary interest in the study. Sartori (1991:246) also stated that entities to be compared should have both shared and non-shared attributes. They should be simultaneously “similar” and “incomparable”. Therefore, the case study areas were selected purposively through a non-probabilistic sampling approach.

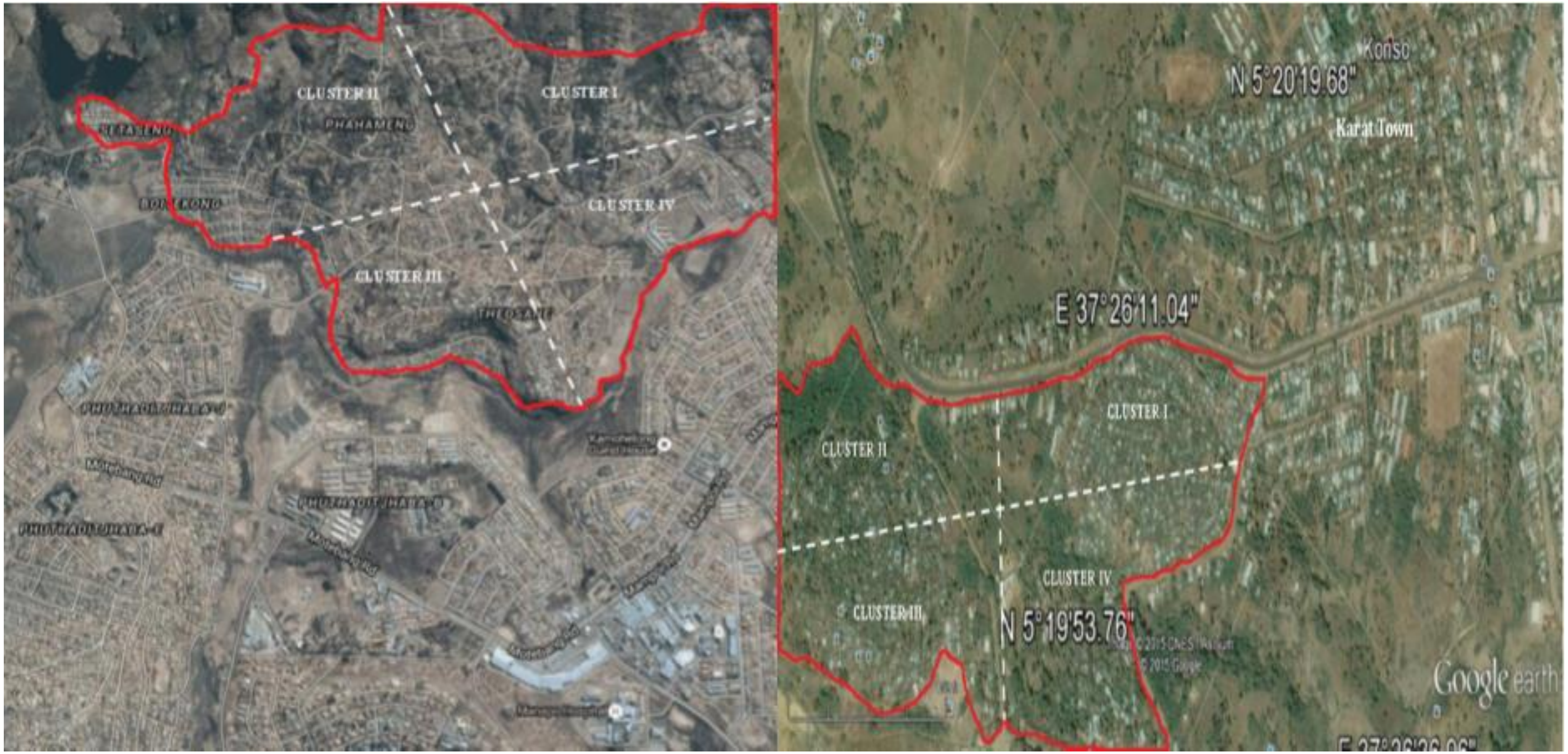
6.4 Sampling Design and Sample Size Determination

6.4.1 Sampling Design

The population of this study comprises people residing informally at the urban-rural interfaces of the mountainous landscapes of the two small towns. The selection of target households residing informally is realised by employing a multi-step combination of the cluster and simple random-sampling techniques. In order to get representative data from all study sites, the area was divided into four clusters by using the north, south, east and western directions of the towns as points of reference. The cluster sampling technique was undertaken by considering geographical distribution of the population and their vulnerability to climate change-related risks. Then, a simple random-sampling technique was used to collect data from the already identified clusters. This was undertaken by randomly choosing the respondents with the aim of giving an equal chance to be selected in the sample. Thus, the total number of households

(HH) living informally at both study sites were about 10 000 (Maluti-a-Phofung Local Municipality, 2013:26; Konso Municipality, 2014:42). In Figure 21, the red line indicates the boundary of the study sites at the periphery of Phuthaditjhaba and Karat, respectively.

Informal Settlements at the Periphery of Phuthaditjhaba (Case 1) **Informal Settlements at the Periphery of Karat (Case:2)**



Source: Adopted from Google Earth (Retrieved on 15/09/2015)

FIGURE 21: Informal Settlements at the Periphery of Phuthaditjhaba and Karat Towns

6.4.2 Sample Size Determination

Based on the Maluti-a-Phofung Local Municipality (2013:26) and Konso Municipality (2014:42), the total number of households (HH) living in the study site of Case 1 and Case 2 is about 10 000. Thus, assessment of the characteristics of the population of the study by using representative sample size can provide a valid and reliable outcome, and increase cost-efficiency and enhance effectiveness in terms of achieving the intended objectives of the study. Therefore, the sample size of 384 households (HH) from both Case 1 and Case 2 is statically calculated. (See the Equation (1) to get sample size calculated.) In other words, 192 households from Case 1 and 192 households from Case 2 were selected. Thus, each cluster has 48 households that represent the total population in the given cluster, totalling 1 250 households (5 000 HH ÷ 4 Clusters). Finally, the selection of these households from each cluster was done by using simple random sampling method (Kothari, 2004:178).

EQUATION 1: STATISTICAL FORMULA TO DETERMINE THE SAMPLE SIZE

$$\boldsymbol{n = \frac{z^2 pq}{e^2}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \boldsymbol{Equation(1)}$$

Where

$\boldsymbol{n}$ is the sample size

$\boldsymbol{z}$ is the abscissa of the normal curve that cuts off an area α at the tails;

(**1 – α**) equals the desired confidence level, e.g., 95%);

$\boldsymbol{e}$ is the desired level of precision;

$\boldsymbol{p}$ is the estimated proportion of an attribute that is present in the population and $\boldsymbol{q}$ is $\boldsymbol{1\text{-}p}$.

The value for Z is found in statistical tables that contain the area under the normal curve.

e.g. $\boldsymbol{z}$ = 1.96 for 95 % level of confidence

$$n = \frac{(1.96)^2 * 0.5 * 0.5}{(0.05)^2}$$

$$n = \frac{3.8416 * 0.5 * 0.5}{0.0025}$$

$$n = \frac{3.8416 * 0.5 * 0.5}{0.0025}$$

$$n = \frac{0.9604}{0.0025}$$

$$\underline{\boldsymbol{n = 384.16}}$$

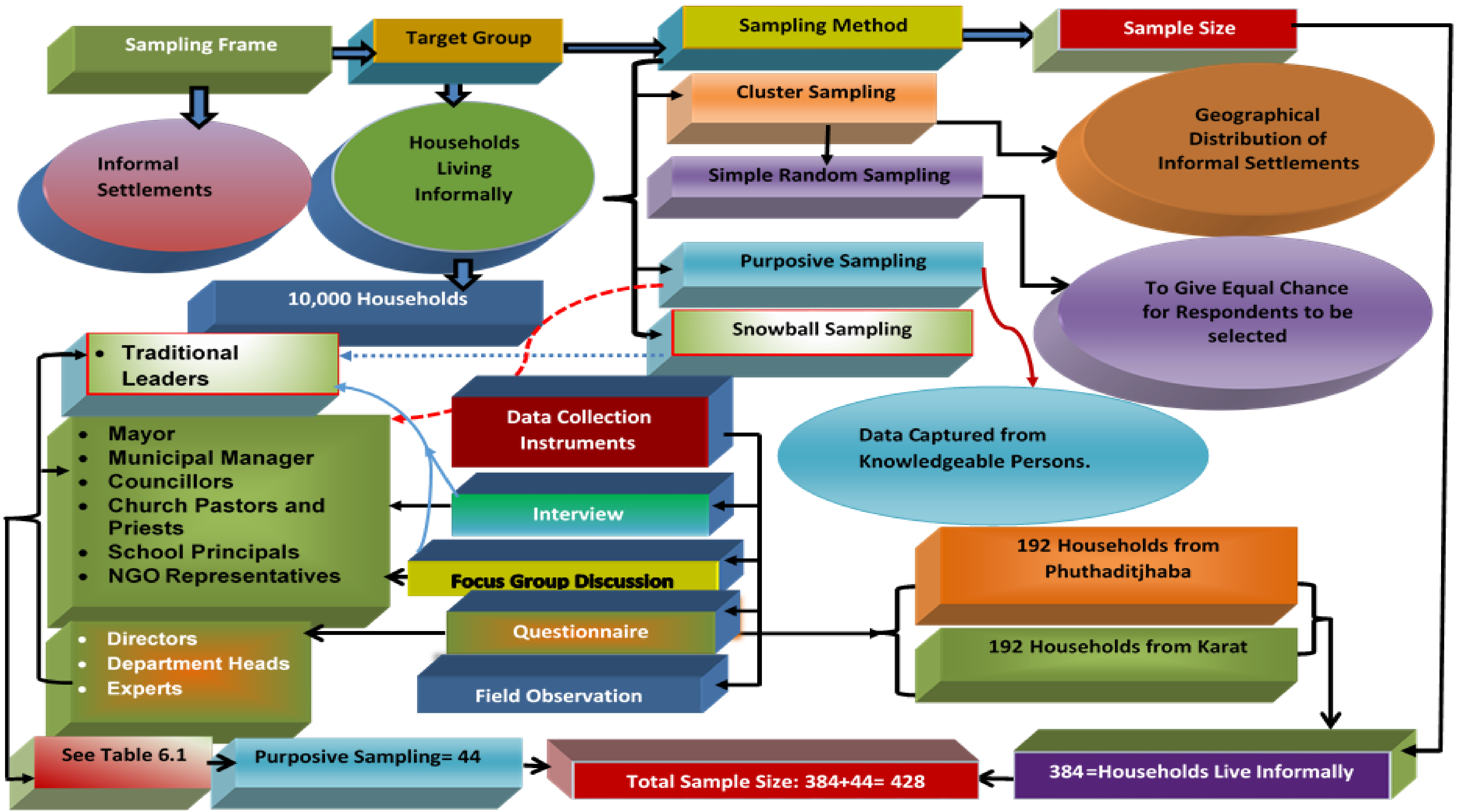
Furthermore, a purposive sampling technique was also used to capture data from professionals, informal leaders and officials working in the local government offices (See Table 6.1). To realise this, the academic background of the experts and their relevant work experience in the local government offices were considered as criteria. Informal leaders such as church leaders, school principals and NGO representatives were also included in the purposive sampling. The logic is getting relevant data from knowledgeable people and to enhance the efficiency of data collection. Additionally, the snowball sampling technique was undertaken to identify and investigate opinions of traditional leaders. The snowball sampling technique was adopted because of the cultural sensitivity and difficulty of gaining direct access to traditional leaders. Therefore, communication with these informal leaders requires consulting contact persons who have information about the culture of the traditional society. Then the traditional leaders provide the link to the next traditional leader in the study areas.

The sample size from non-probabilistic-sampling (purposive and snowball) is 44 informants from both study areas (See Table 6.1). Therefore, the total sample size selected through employing both probability and non-probability sampling technique for the purpose of this study was 428 informants (See Figure 22). Overall, a combination of the probabilistic and non-probabilistic method of sampling design and sample size determination was materialised for the purpose of this study.

TABLE 6.1: SAMPLE SIZE OF PURPOSIVE SAMPLING

Respondents	Sectoral Offices	Sample from Phuthaditjhaba	Sample from Karat	Total Sample Size	Data Collection Instruments
Mayor	Local Government Office	1	1	2	Semi-structured Interview conducted first, then make them part of focus group discussion.
Municipal Manager	Local Government Office	1	1	2	Semi-structured Interview conducted first, then make them part of focus group discussion.
Councilors	Local Government Office	2	2	4	Semi-structured Interview conducted first, then make them part of focus group discussion.
Church Pastors	Churches	1	1	2	Semi-structured Interview conducted first, then make them part of focus group discussion.
School Principals	Schools	1	1	2	Semi-structured Interview conducted first, then make them part of focus group discussion.
NGO Representatives	NGO Offices	1	1	2	Semi-structured Interview conducted first, then make them part of focus group discussion.
Traditional Leaders	Snow-ball	2	2	4	Semi-structured Interview conducted first, then make them part of focus group discussion.
Sub-Total		**9**	**9**	**18**	Semi-structured Interview conducted first, then make them part of focus group discussion.
	Local Government Offices	3	3	6	Semi-Structured questionnaire
	Finance and Economic Development	1	1	2	Semi-Structured questionnaire
Directors, Department Heads and Experts	Water Development	1	1	2	Semi-Structured questionnaire
	Urban Development and Planning	1	1	2	Semi-Structured questionnaire
	Public Safety and Transport	1	1	2	Semi-Structured questionnaire
	Culture and Tourism	1	1	2	Semi-Structured questionnaire
	Agriculture and Rural Land Development	1	1	2	Semi-Structured questionnaire
	Public Works, Roads and Transport	1	1	2	Semi-Structured questionnaire
	Education office	1	1	2	Semi-Structured questionnaire
	Health Office	1	1	2	Semi-Structured questionnaire
		1	1	2	Semi-Structured questionnaire
Sub-Total		**13**	**13**	**26**	Semi-Structured questionnaire
Grand-Total Sample Size for Purposive Sampling		**22**	**22**	**44**	

Source: Author's own (2015).



Source: Author's own (2015).

Figure 22: Schematic Representation of Sample Design and Data Collection Instruments

6.5 Sources and Types of Data

The source of data can be categorised in different ways, depending on who collects the data. Primary data ares data captured from the original source by the researcher himself for the purpose of a specific research problem, whereas secondary data are collected by another entity for some different purpose. It can, however, be used by the researcher for another purpose (Roopesh, 2013:online). However, both sources of data have their own advantages and disadvantages, and their collection needs different skills and resources (Bradford and Burke, 2005:1). According to Bradford and Burke (2005:1), primary data have the following advantages that can be captured to achieve the specific objective of the study. It helps the researcher to focus only on those data tailored to answer the research questions and best suited to answer the research problem. It will ensure originality and objectivity of the research work. Contrary to this, collecting primary data has its own drawbacks in the process of preparation and capturing the data. Relative to secondary data, collecting primary data is costlier, because it requires preparation, designing and administering the questionnaire, interviews, and survey and undertaking observations. There is also the possibility to get incorrect and biased feedbacks from the respondents that may lead to wrong findings. Primary data collection requires more human, financial, time and material resources than those of secondary data. During the fieldwork of this study, first-hand data were collected from residents settled informally in the mountainous areas around the towns and professionals and officers working in the local government of both study areas.

Secondary data can readily be obtained from different institutional archives such as national census and administrative data, literature, E-journals, magazines, surveys and publications from other organisations that were prepared to address their own problems. These data are more easily accessible and less costly than primary data. In addition, data that indicate the trends over long periods enable the researcher to recognise change over time appropriately (for instance, climate data). On the other hand, secondary data have their own weaknesses such as challenges to get the full package of information required for the intended purpose of the study (Roopesh, 2013:online). For the purpose of this study, secondary data were captured by reviewing socio-economic maps, spatial development plans, satellite images and official publications. Secondary data were also collected through review of literature pertaining to systems resilience to climate change, especially associated with resilience of informal settlement and indigenous knowledge systems. The review of the literature also focused on climate change-resilience theory and its application in the planning perspectives. To identify climate variability and change in both study areas, the last 30 years of meteorological data that indicate precipitation patterns, and maximum and minimum temperatures were collected from both national meteorology agencies of the case study areas. (See Appendix 2.) According to Roopesh (2013:online), both primary and secondary data are important in the process of research regardless of their own limitations. The type of relevant data required depends on research questions, the budget, skills and available resources. To realise the intended objectives of this study, both primary and secondary data were captured.

6.6 Data Collection Methods

Fieldwork was conducted during the 2015 and 2016 academic years. The data collection emphasised those variables and perceptions that determine an aggregate picture of climate change resilience capacity of informal settlements in Case 1 and Case 2 by obtaining information from key informants. To achieve the intended aim of the study, a combination of different data collection tools was materialised. This is realised by distributing semi-structured questionnaires to undertake survey, semi-structured interviews to capture in-depth data, target-group discussions to confirm the data collected by other tools and to generate in-depth ideas, as well as the spatial map reviews and systematic field observation to observe the physical changes linked to climate change impacts in the study areas. To provide comprehensive insight about the data collection instruments and the procedures applied for data collection during the fieldwork, this is discussed in detail in the following section.

6.6.1 Semi-Structured Questionnaire

Primary data were gathered by conveying semi-structured questionnaires and completed by informants incorporated in the sample. A pre-coded questionnaire was outlined around each dimension of capitals that are useful to build climate change-resilience capacity in the areas of informal settlements in Case 1 and Case 2 (See Appendix 4 and 5). In such manner, the researcher and four trained research assistants conveyed the coded questionnaires to the respondents amid the pilot test and the fieldwork. Respondents were asked to measure climate change resilience of the community for each variable directly or indirectly. As indicated in Bradford and Burke (2005:1), administering the questionnaires may give an opportunity for all respondents to engage fully and forward their opinions and experiences in order to address the research problem. Accordingly, the questionnaires were administered to 384 informants living in informal settlements in both Case 1 and Case 2 areas. In addition, semi-structured questionnaires were administered to 26 purposively selected directors, department heads and experts, including urban planners working in the local government offices (See Table 6.1).

To enhance data quality, at the end of each day of data collection, the researcher randomly examined and checked the completed questionnaires and reported to enumerators the next morning if there was something filled out incorrectly or not clear enough. Through this approach, consistency in terms of responses was ensured and all the questionnaires were completed by the respondents included in the sample.

6.6.2 Semi-Structured Interview

This type of interviewing is considered a valuable method for exploring the various meaning and interpretations held by interview participants in association with building informal settlements resilience to climate change-related risks. Semi-structured interviewing has been used in different studies with the aim of developing context-dependent assessments (Gerhardinger et al., 2009:93). In the viewpoint of this, the purpose of the research was explained to the informants prior to conducting an interview. These informants were selected purposely with the aim of getting the necessary information from knowledgeable persons and people who have long-term exposure to climate condition and in the given study areas. As indicated in Table 6.1, a semi-structured interview was conducted with 18 purposively selected individuals from both case study areas. In order to capture in-depth information and opinions regarding climate change risks and resilience building in the areas of informal settlements, the same interviewee was incorporated in the target-group discussions.

Once all the interviews were concluded, a long process of transcribing and capturing the interview outcome was done by the researcher and four research assistants. Interviews that were not conducted in English were simultaneously translated and transcribed by research assistants. Then, the outcome of the interview was categorised and facilitated for systematic analysis of data and extracting qualitative findings and enriching arguments. The aim of categorisation of the interview responses was to minimise and manage the possible multiple responses generated from a semi-structured interview.

6.6.3 Focus-Group Discussions

Focus-group discussion encourages interaction between members to generate information and experiences. Members show their own particular perspectives and experiences; yet they get additional information from other individuals. They tune in, ponder what is stated, and in the light of this consider their own point of view further. Members make inquiries of one another, look for clarification, remark on what they have heard and encourage others to uncover more. As the discussion progresses, individual reactions are sharpened and refined and move towards a more profound and more considered level. A focus group is in this way not a collection of individual interviews, with comments directed solely through the researcher. The focus groups are synergistic and the meeting allows sharing of information and experiences among the participants (Bloor et al., 2001:3; Bryman, 200:7).

Accordingly, a three-hour focus-group discussion was scheduled to listen to key informants such as traditional leaders, school principals, non-governmental organisations leaders, planners and local government councillors who participated in the interviews. This was deliberately arranged with the aim of triangulating and enhancing worthiness of data captured from the semi-structured interviews and focus-group discussions. Accordingly, 18 participants (9 from each case study area) were selected and attended focus-group discussions. To provide similar ground for all participants, the intended objective of the research was clearly explained and the rule of the game was set together with the participants at the beginning of discussion session.

The participants were informed of what was required, in terms of both content and process, and the amount of time needed. Detailed notes were made by the facilitators and the researcher. These were later compared and discussed to ensure that all issues raised had been recorded. The issues for discussion were introduced and participation by all was encouraged. The discussion was led by a moderator or facilitator who introduced the topic, asked specific questions, controlled digressions and stopped breakaway conversations. The researcher made sure that no one person dominated the discussion whilst trying to ensure that each of the participants made a contribution. Through this process, a focus-group discussion was successfully conducted in each of the case study areas.

TABLE 6.2: Summary of Research Methods, Techniques and Data Sources

	Research Questions	Methods to Answer Question	Techniques	Source of Data
1	What are climate change associated risks that adversely affect the livelihood of societies living informally in mountainous topographies?	**Surveying to identify risks**	Qualitative and quantitative analysis of climate change associated risks that negatively affect cultural, ecological, economic and social situations in the study areas.	***Primary data:*** Field observation to identify vulnerable people to climate change-related risks. ***Secondary data:*** Metrological, social-ecological and economic data and academic literature reviewed.
2	What is the level of damages in the areas of informal settlements that are possibly caused by climate change-related risks in mountainous landscapes?	**Descriptive analysis**	Analysis of risks and describing the possible damages in the specific locations. Systematically and selectively collecting longitudinal and cross-sectional data relevant for explaining risk.	***Primary data:*** Field observation, distributing questionnaire, and conducting interviews with vulnerable people to climate change-related risks. ***Secondary data:*** Metrological, Social-ecological and economic data and academic literature reviewed.
3	What are the determinant variables that directly affect climate change resilience capacity of informal settlements in the mountainous topography?	**Qualitative and quantitative analysis of variables**	Analysing the relationship of dependent and independent variables and explaining their influence on climate change resilience capacity of the study areas.	***Primary data:*** Field observation, distributing questionnaire, and conducting interviews with vulnerable people to climate change-related risks. ***Secondary data:*** Metrological, Social-ecological and economic data and academic literature reviewed.
4	How integration of indigenous and scientific knowledge system enhance the climate change resilience of informal settlements in mountainous regions of Africa?	**Descriptive and exploratory narratives**	Identifying and examining cultural values experienced in the study areas and their relevance to climate change resilience planning.	***Primary data:*** Field observation, distributing questionnaire, and conducting interviews with vulnerable people to climate change-related risks. ***Secondary data:*** Social-ecological and economic data and academic literature reviewed.
5	What planning approaches are more appropriate to improve climate change resilience of informal settlements in mountainous topographies?	**Participatory research approach**	Suggesting an appropriate planning approach for specific location by investigating the real situation.	***Primary data:*** Field observation, distributing questionnaire, and conducting interviews with vulnerable people to climate change-related risks. ***Secondary data:*** Social-ecological and economic data and academic literature reviewed.

Source: Author's own (2015)

6.6.4 Systematic Field Observation and the Spatial Map Review

Systematic field observation and the spatial map review were used wherever possible as a means of gaining contextual data associated with landscape changes, indicators of biophysical environment and other geographical features Field observation aims to general practical and theoretical truths about physical situations grounded in the realities. The central aim of this technique was to verify other data collection methods operationalised and to capture some unique physical features that can be used as indicators of climate change and resilience in the given case study areas (Kawulich, 2005:11). The data were captured through video and photographs cameras and by reviewing satellite images of the case study areas.

6.7 Data Analysis Methods

As discussed at the start of the methodology section, the concept of climate change resilience is complex and investigations in this kind of field requires the application of a systems approach and mixed methods of data analysis. Climate change resilience is determined by not only tangible factors such as income or assets, but also intangible factors that are built subjectively. Subjective indicators of resilience may incorporate perception of risk, aspirations and self-efficacy. People's perceptions about their ability to handle future shocks and stressors affect decisions on short-term and longer-term livelihood coping strategies and their eagerness to take part in specified types of reactions (Jones and Tanner, 2015:15; Béné et al., 2016:1).

Subjective resilience indicators, therefore, may be as important as objective resilience indicators. Consequently, data were analysed by combining qualitative and quantitative methods. Operationalisation of this mixed method of data analysis also allows the triangulation of qualitative and quantitative methods of data analysis. In this regard, the purpose is ensuring validity and reliability of the findings. The social, economic and ecological situations of the study areas were analysed to identify the vulnerability of the people to climate change risks and to investigate their resilience capacity. To realise this, data were analysed by using qualitative and quantitative techniques in a parallel and complementary manner.

6.7.1 Qualitative Data Analysis

Not everything that can be counted counts, and not everything that counts can be counted

(Albert Einstein)

Variables that were qualitative by nature were described by narration and in-depth explanations. In this case, the pattern and attributes of variables that were captured during interviews and focus-group discussions were analysed qualitatively. The cause-and-effect relationship of indicators of resilience capacity in terms of the application of indigenous knowledge is also explained by using the normative method of data analysis. This gives an opportunity to analyse different opinions and perceptions of the community regarding climate change resilience that could not be easily addressed by a quantitative method.

6.7.2 Quantitative Data Analysis

6.7.2.1 Capital-Based Analysis of Climate Change Resilience in the Case Study Areas

Despite the vast literature on the field of climate change resilience, there is significant difference about the analytical framework for measuring the concept. There are contrasts in the methods, models and metrics utilised in view of the epistemological orientations of the scholars (Cutter et al., 2014:66). Subsequently, there is little integration of methodologies in examining climate change resilience in different geographical areas. In any case, there is common comprehension among the researchers that resilience capacity is a multidimensional notion, which incorporates social, economic, human, physical, natural and institutional components (Bruneau et al., 2003:733; Cutter et al., 2010:7; Norris et al., 2008:127). In view of these discoveries, the index comprises these subcomponents that were then further characterised for analytic and comparative purposes. Since it is usually difficult to measure resilience in absolute terms, a comparison can be done by using a proxy indicator for resilience. The variables can be selected by considering the theoretical justification and the quality and accessibility of data (Cutter et al., 2014:66).

A crucial step in the creation of composite indicators is the identification of variables that are relevant, robust and representative, since the strengths and weaknesses of composite indicators are based on the quality of the variables chosen. Criteria for assuring the quality of variables are widespread within the indicators literature; yet, to date, there is no single set of established indicators or frameworks for measuring climate change resilience. Before the construction of the sub-indices could occur, a third step towards creating a suitable composite index took place. All raw data values were transformed into comparable scales utilising percentages, per capita and density functions. These forms of standardisation were essential to avoid inherent problems when mixing measurement units, since the variables were delineated in a number of statistical units, ranges and scales.

After collecting the raw variables, the data items were coded to facilitate a process of transformation, normalisation and theoretical orientation. In order to facilitate comparison of climate change resilience capacity in Case 1 and Case 2, the raw data were transformed into percentages, rates or averages. This is a necessary step to compare resilience in varying geographical locations (Cuttier et al., 2014:67). *Normalisation* refers to scaling all the variables, using one method so that all the data have comparable reference points. To realise this, the researcher used minimum-maximum scaling, a straightforward normalisation technique common in socio-ecological resilience indicators research (Tarabusi and Guarini, 2012:19). Min-max normalisation assigns a value of 0 to the minimum value and 1 to the maximum value. All other values are scaled between zero and one by subtracting the minimum value and dividing by the range. One disadvantage of using normalisation, however, is that the final score is not an absolute measurement of climate change resilience for each case study area, but rather a relative value in which case study areas can be compared. Such a relative estimation of inherent resilience capacity possibly over- or under-estimates local resilience through the normalisation process. On the other hand, it provides an easily understood comparison between places at a particular point in time. Utilising such normalised values is useful for benchmarking progress in enhancing resilience over time and across space (Cuttier et al., 2014:68).

The raw data were coded, tabulated, categorically organised, analysed and interpreted. To materialise this, data were coded and entered into Microsoft Excel Application and Statistical Package for Social Science (SPSS) software to produce descriptive and analytical results. GIS software was also used as a tool to analyse geo-spatial and non-spatial data from the case study areas. Analysis of quantitative data was undertaken by calculating indices, using frequency distribution tables, diagrams and graphs, percentages, ratios and other parameters.

6.7.2.2 Model Specifications for Quantitative Analysis of Data

Climate change-resilience capacity in the given area is directly proportional to the existence of social, economic, human, physical, natural and institutional capitals (Yoon et al., 2015:7; Cutter et al., 2010:7; Mayunga, 2007:1). Therefore, in order to measure climate change resilience capacity of informal settlements in both case study areas, this study adopted capital-based resilience measuring techniques. To materialise this, identification of the principal indicators from each capital and calculating the climate change-resilience index has been done as an integral part of the assessment.

6.7.2.2.1 Principal Climate Change Resilience Indicators Analysis

To identify the principal indicators or variables that determine resilience capacity in the given areas, there are statistical and normative methods. The aim of focusing on principal variables found in each domain of capitals is to reduce the number of variables to a manageable level. The assumption here is that not all variables have contributed equally to the resilience of the system. Therefore, the principal indicators or variables were selected by using normative and statistical methods. Identification of those major variables gives clue for the type or the strategy or intervention to be undertaken in a particular area in terms of enhancing resilience capacity. It has also the following importance in terms of ensuring resource efficiency in the informal settlements area. The limitation of resources such as financial, economic, physical and other resources is obvious in the areas of informal settlements. Consequently, to select the significant variables, the stakeholder's participation is critical to ensure efficiency and effectiveness in terms of resources utilisation to build climate change resilience.

The following are normative criteria used to identify principal indicators in this study: The theoretical and conceptual relevance of the indicators; relevance to policy of the given region or country; common understanding among the stakeholders and experts about the indicators; consider cultural values of the local community; strengthen social capital; intra and inter-sectoral influence or relationship; critical for persistence of livelihood; strategic or long-term influence over the system; unique to specific location; impact overt wide spatial area; and renewability or reversibility in terms of resource utilisation (Barnes et al., 2007:10). Further, to complement these normative criteria to identify principal indicators of resilience, the statistical method of variable selection was also used. To realise this, multiple correlation coefficient and regression model were used to measure the strength of association between variables and relationships among resilience indicators or variables (Kothari, 2004:1142).

EQUATION 2: Formula to Calculate Multiple Correlation Coefficient (R)

$$\boldsymbol{R} = \frac{\sqrt{\boldsymbol{r^2}_{\mathrm{Y}\chi1} + \boldsymbol{r^2}_{\mathrm{Y}\chi2} - 2\boldsymbol{r}_{\mathrm{Y}\chi1}(\boldsymbol{r}_{\mathrm{Y}\chi2})(\boldsymbol{r}_{\chi1\chi2})}}{\sqrt{1 - \boldsymbol{r^2}_{\chi1\chi2}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ldots\ldots\ldots..Equation(\mathbf{2})$$

<u>Where:</u>

$\boldsymbol{R} = Multiple\ correlation\ coefficent$

$\boldsymbol{r}_{\mathrm{Y}\chi1} = Correlation\ coefficient\ between\ y\ and\ x_1$

$\boldsymbol{r}_{\mathrm{Y}\chi2} = Correlation\ coefficient\ between\ y\ and\ x_2$

$\boldsymbol{r}_{\chi1\chi2} = Correlation\ coefficient\ between\ x_1\ and\ x_2$

Multiple correlation coefficient (**R**) can be any value from 0 to 1. The closer '**R'** is to one, the stronger the linear associations are. If R is equal to zero, then there are no linear associations between the dependent variables and independent variables. '**R'** is never a negative value, since the square root of this value indicates the positive root.

6.7.2.2.2 Calculating Climate Change Resilience Index (CCRI)

To quantify climate change-resilience capacity of the case study areas, a composite index was developed. Index numbers can be used as an average for the purpose of comparison; yet, when the units in which at least two arrangements are expressed in different ways, statistical averages cannot be utilised to compare them. In such circumstances, we need to depend upon some relative estimation, which comprises decreasing units into a common base. Once such technique is to change the arrangement into a series of index numbers. This is done when we express the given figures as rates of some specific figure on specific information. We can, subsequently, characterise an index number as a number that is utilised to quantify the level of a given phenomenon when contrasted with the level of the same phenomenon at some standard date. The utilisation of index number weights more as a unique sort of average, intended to analyse climate change resilience capacity in the given case study areas. For the development of Index, numerous strategies are accessible in literature. They vary in the way the segments of the Index are summed (Briguglio, 2003:8). The methodological decisions made amid different phases of composite index development include suppositions, subjectivity and instabilities that ought to be perceived, tended to and conveyed all through the systematic procedure (Sullivan, 2011:627; Balica, 2012b:963; Permanyer, 2012:57; Tate, 2013:526).

Nobel et al. (2006:14) indicate that the selection and application of any of these methods to assign a weight to variables will depend on various factors and the context of a particular case study situation. Thus, there is no best method to apply for weights to variables and every approach has its own weakness and strengths. To minimise the weakness and to capitalise strengths of the approaches, a combination of different approaches was used for this case study. It is realised by using the combination of objective and subjective criteria to assign weights for each variable as well as for each subsector found within the system. This weighting approach tells as variables found in the sub-sector have different significance in terms of influencing the resilience capacity. Based on this comparison of climate change-resilience capacity of the case study areas materialised. According to Noble et al. (2006:14), the three most frequently used methods in social science research are combining indicators with weights determined from theory; combining indicators with pseudo-empirically derived weights; and combining indicators with empirically derived weights. For this study, the combination of these methods was adopted in order to develop weight for each capital and variable.

A straightforward summation method cannot be used unless all these units are normalised into one standardised unit. A commonly used normalisation method is the one which adjusts the observation to take a value from 0 to 1 (Briguglio, 2003:9). Next, scores are generated and combined into an overall index. Normalisation or standardisation was done to make the indicators comparable. Once one or more indicator sets are selected, integration of the selected indicators into sub-indices and a final composite index may require data transformation by means of data or data standardisation techniques; that is, data sets measured using different scales or measurement units can be made comparable by transforming them into a common scale or measurement unit and/or by adjusting the directionality of the values by performing inverse adjustment (Abson et al., 2012:6; Kenney et al., 2012:8; Tate, 2013:526). Accordingly, the scores were normalised by taking the ratio of deviation of each observed score from the maximum value to that of range value of the variable. Summation of the normalised score (standardised score) for each variable will give the total score of each dimension (Mayunga, 2007:5).

EQUATION 3: Formula for Data Normalisation and Standardisation

$$\boldsymbol{Xnew} = \frac{\boldsymbol{X} - \boldsymbol{Xmin}}{\boldsymbol{Xmax} - \boldsymbol{Xmin}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \boldsymbol{Equation\ (3)}$$

After normalising the variables for cross-case comparisons, the researcher employed a method of aggregation in which the final climate change-resilience score represents the summation of the equally weighted average sub-index scores. In other words, the variable scores in each sub-index were averaged to reduce the influence of the different number of variables in each sub-index. These arithmetic mean scores resulted in a sub-index score for each case, and then these sub-index scores were summed to produce a final composite resilience score. Since there are six sub-indices, scores range between zero and six (0 being the least and 6 being the most resilient). The researcher chose an equally weighted index at both the sub-index and composite indicator level for three reasons. First, this simple method of aggregation is transparent and easy to understand, a criterion deemed important for potential users. Secondly, the researcher has no theoretical or practical justification for the differential allocation of importance across indicators. Thirdly, the previous practical application of equal weighting done by Nobel et al. (2006:6) to calculate index of multiple deprivations of different provinces of South Africa. While methods exist for determining weights that are subjective or data reliant, such weighting schemes do not always reflect the priorities of decision makers (Esty et al., 2005:8).

The following equation shows a proposed mathematical formula for combining indicators to generate individual Index for each form of capital. An index for a domain capital *"y"* can be calculated (Mayunga, 2007:5).

EQUATION 4: Statistical Formula to Calculate an Index of for Each Capital Domain

$$\boldsymbol{y} = \sum_{i=1}^{n} (\boldsymbol{x}_1 w_1 + \boldsymbol{x}_2 w_2 + \boldsymbol{x}_3 w_3 + \ldots\ldots\ldots\ldots\ldots \boldsymbol{x}_n w_n) \ldots\ldots\ldots\ldots\ldots Equation(\mathbf{4})$$

<u>Where</u>

$\boldsymbol{y} = Capital$

$\boldsymbol{x} = Indicator$

$\boldsymbol{w} = Weight$

$\boldsymbol{n} = Number\ of\ indicators\ or\ weight\ considered$

$\boldsymbol{i} = indicator\ number$

EQUATION 5: Statistical Formula to Calculate Composite Climate Change Resilience Index

$$\boldsymbol{CCRindex} = \frac{\sum_{i=1}^{n=6} (w_1 \boldsymbol{SC}_i + w_2 \boldsymbol{EC}_i + w_3 \boldsymbol{HC}_i + w_4 \boldsymbol{PC}_i + w_5 \boldsymbol{NC}_i + w_6 \boldsymbol{IC}_i)}{\boldsymbol{n}} \cdots \boldsymbol{Eq}.(\mathbf{5})$$

<u>Where</u>

$\boldsymbol{CCRindex} = \text{Overall Climate Change Resileince Index}$

$\boldsymbol{SC}i = Social\ Capital\ index$

$\boldsymbol{EC}i = Economic\ Capital\ index$

$\boldsymbol{HC}i = Human\ Capital\ index$

$\boldsymbol{PC}i = Physical\ Capital\ index$

$\boldsymbol{NC}i = Natural\ Capital\ index$

$\boldsymbol{IC} = Instituional\ Capital\ index$

$\boldsymbol{w} = Weight$

$\boldsymbol{n} = number\ of\ capital\ domains$

$\boldsymbol{i} = Domian\ number$

Source: (Mayunga, 2007:6).

The Score values of climate change resilience index (CCRI) range from 0 to 1; the values near to '1', indicate higher climate change resilience and lesser vulnerability to risks. On the contrary, values near to '0' indicate low resilience and higher vulnerability to risks. In this study the resilience index measures were scaled as:

[0.90 – 1.00] = Very high resilience capacity
[0.70 – 0.89] = High resilience capacity
[0.50- 0.69] = Moderate resilience capacity
[0.3-0.49] = Low resilience capacity
[0 – 0.29] = Very low resilience capacity

All things considered, index numbers have their own particular impediments with which researcher should dependably keep himself aware (Nobel et al., 2006:16; Mayunga, 2007:1). For example; index numbers are just rough markers of the resilience capacity and give just a reasonable indication of changes.

Analysis of Climate Change Risks

To calculate the climate change risk index of a particular area, there is a short path that deducts the climate change resilience index from 1 (Author's own, 2016).

EQUATION 6: Formula to Calculate Climate Change Risk Index

$$\textbf{Climate Change Risk Index} = \mathbf{1} - \textbf{Climate Change Resilience Index} \ldots\ldots\ldots\ldots \textit{Equation}\ (\mathbf{6})$$

Based on the survey results, the rating of the intensity of climate change risks was undertaken and prioritised. The rating of the intensity of the risk employed was based on 0 – 1 units of scale (i.e. 0 units means that there was no risk of climate change at the study site; 0.5 units means that the level of risk is moderate; and 1 unit means that the intensity of climate change-associated risk in the area is very high). Based on the percentage of the response rate of residents from informal settlements and experts from the local government, the level of vulnerability and intensity of the risk was prioritised. To support the above facts, the resilience capacity of each case study area was also analysed qualitatively and quantitatively. In this regard, the *disaster resilience capacities* suggested by Cutter *et al*. (2010:7) were assessed by the *principles or attributes of a resilient system* proposed by Biggs *et al*. (2015:4-18). To increase reliability and validity of the findings, the results obtained by using the combination of the above two methods were supported by interview outcomes, focus-group discussion and systemic field observations. Therefore, a combination of objective and subjective criteria was employed to identify the level of risk and resilience capacity in both case study areas.

Regression Model for Projection of Rainfall and Temperature

To project the rainfall and temperature of both case study area regression model was used. The analysis was undertaken based on the last 30 years' meteorological data captured from both case study areas.

EQUATION 7: Regression Model for Projection of Precipitation and Temperature

$$\boldsymbol{y} = \boldsymbol{\beta}_0 + \boldsymbol{\beta}_1\boldsymbol{x}_1 + \boldsymbol{\beta}_2\boldsymbol{x}_2 + \boldsymbol{\beta}_3\boldsymbol{x}_3 + \cdots\cdots\cdots\cdots\cdots \boldsymbol{\beta n x n} + \boldsymbol{\varepsilon} \cdots\cdots\cdots\cdots \; Equation(\mathbf{7})$$

<u>**Where**</u>

$\boldsymbol{y} = dependent\ variable$
$\boldsymbol{x}_1\_\boldsymbol{n} = independet\ variable$
$\boldsymbol{\beta}_0 = constant$
$\boldsymbol{\beta}_1\_\boldsymbol{n} = regression\ coefficients\ change\ in\ \boldsymbol{y}\ by\ each\ \boldsymbol{x}$
$\boldsymbol{\varepsilon} = error$

Formula to Project Population of the Case Study Areas

A projection of the population of the two case study areas was undertaken by using the exponential formula. The population growth rate for both case study was calculated based on the national censuses report of the countries (Statistics South Africa, 2011; Central Statics Agency of Ethiopia, 2007).

EQUATION 8: Exponential Equation to Project Population of the Case Study Areas

$$\boldsymbol{P_t} = \boldsymbol{P}_0(\boldsymbol{e^{rt}}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \boldsymbol{Equation(8)}$$

<u>**Where**</u>

$\boldsymbol{p_0} = initial\ year\ population$

$\boldsymbol{p_t} = poulation\ t\ years\ later$

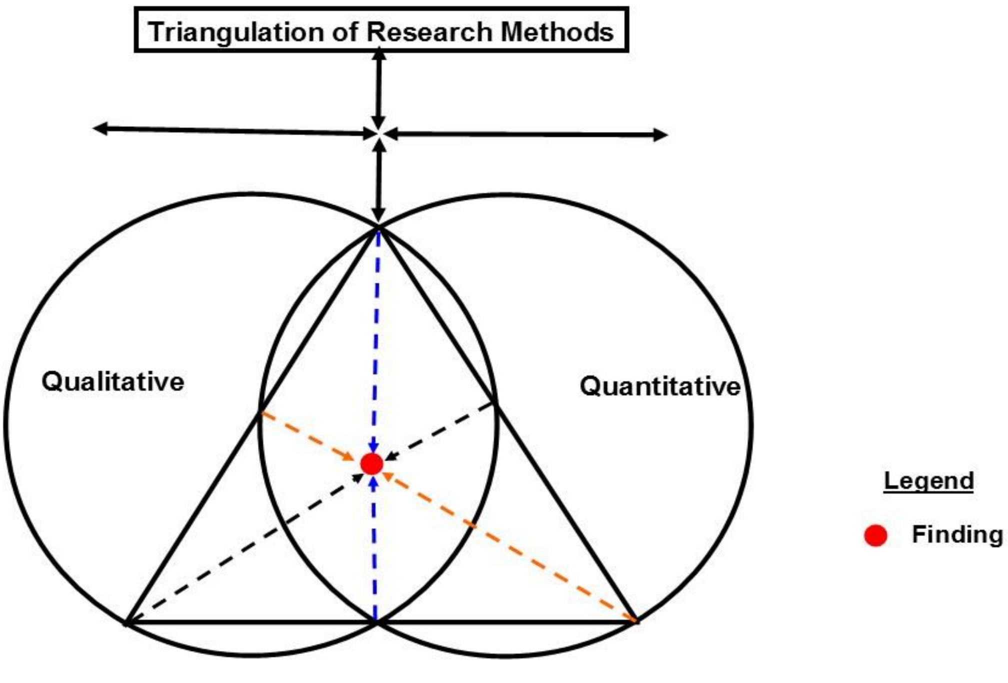
$\boldsymbol{r} = annual\ rate\ of\ population\ growth$

$\boldsymbol{e} = base\ of\ the\ natural\ logarism$

6.7.3 Triangulation of Qualitative and Quantitative Methods

Triangulation is characterised as the blend of methodologies in the investigation of a similar marvel. The triangulation analogy is derived from navigation and military techniques that practised different reference points to find the exact coordinates of the given object (Denzin, 1970, in United Nations Programme on AIDS [UNAIDS], 2010:12). Given essential application of geometry, various perspectives enable the researcher to identify more accuracy. Essentially, analysts can enhance the exactness of their judgements by gathering various types of information bearing on a similar marvel. In the social sciences, the utilisation of triangulation can be drawn back to Campbell and Fiske (1959), who built up the possibility of "multiple operationism" (Sayre, 2001:4). They contend that more than one method ought to be utilised as a part of the approval procedure to guarantee the fluctuation mirrored that of the attribute and not of the technique. In this way, the convergence or agreement between two techniques upgrades the conviction that the outcomes are substantial and not a methodological relic. Figure 23 depicts a conceptual framework for triangulation of research methods.

Denzin identifies four basic types of triangulation, namely data triangulation that indicates the use of multiple data sources in a single study; investigator triangulation that refers the use of multiple researchers to study a particular phenomenon; theory triangulation it depicts the use of multiple perspectives to interpret the results of a study; and methodological triangulation that stands for the use of multiple methods to conduct a study. Triangulation ensures convergence, corroboration and correspondence of results from different methods. In coding triangulation, the emphasis could be placed on seeking corroboration between quantitative and qualitative data. It can be supported by elaboration, enhancement, illustration and clarification of the results from one method with the results from another (Denzin, 1970, in United Nations Programme on AIDS [UNAIDS], 2010:12; Sayre, 2001:4).



Source: Author's own, 2016

Figure 23: **TRIANGULATION OF RESEARCH METHODS**

6.8 Validity and Reliability of the Study

Validity and reliability are two useful measures when defining the trustworthiness and the quality of a research study. Validity is the establishing of correct operational measures for concepts being studied, and that objective judgment is used to collect the data. Regarding reliability, it concerns the demonstration that the data collection procedures can be repeated with the same results (Yin 1994:5). Assessing the validity and reliability of a study involves examining its component parts; that is, to pay attention to the conceptualisation and the way the data were collected, analysed and interpreted (Merriam, 1998:12). If the validity is good, the study measures what it attempts to measure. The reliability deals with how trustworthy the study is and measures the method's accuracy. It shows the extent to which the researcher can confidently rely on information obtained using instrument adopted to gather data for the research work. Thereafter, data collected were subjected to reliability analysis to establish the reliability of the measures and to ensure consistent measurement among the various items in the instrument (Kullberg, 2004). By using triangulation, multiple methods of data collections and analysis, the validity and reliability are strengthened (Merriam, 1998:8).

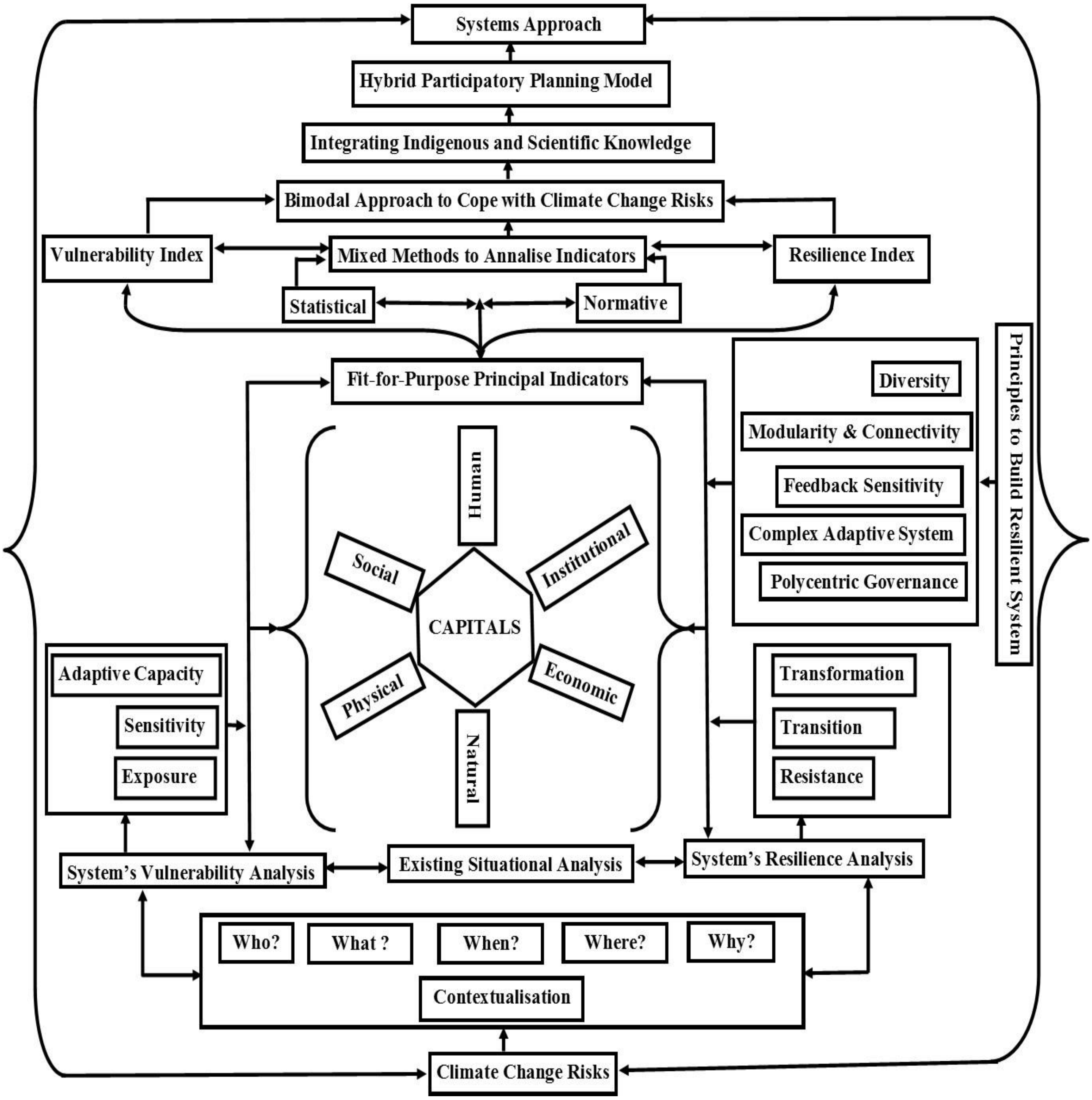
To ensure the maximum quality of responses during the preparation phase of the fieldwork of this study, a pilot test of interview guiding questions and questionnaires designed for data collection has been undertaken. Thereafter, some constructive comments from residents, experts and academicians were incorporated before the fieldwork. This feedback enabled the researcher to get valid and reliable data by considering the cultural sensitivity of indigenous people. In addition, explaining the intended objective of the research was elaborated for informants prior to conducting an interview. This also increases the confidence of informants to provide the right information about the study issues freely. Detailed discussions were conducted with the translators to have insight into the local meaning of questionnaires before distributing them to the respondents. Therefore, translators were recruited in both case study areas in order to translate into Sesotho in Phuthaditjhaba and Konsota in the case of Karat. Thus, translators, together with the researcher, helped the respondents to answer the questioners. Furthermore, triangulation of qualitative and quantitative data collected from the field was done to ensure the credibility of the research and appropriateness of the interpretation to arrive at valid and reliable findings.

6.9 Conceptual Framework for Improving Climate Change Resilience of Informal Settlements in Mountainous Regions of Africa

The conceptual framework of this study was designed by adopting a systems approach to analyse vulnerability and climate change resilience in the case study areas. The system approach is operationalised because it allows the researcher to combine or hybridise different frameworks to maximise context-specific befits and minimise the gaps observed in the application of various frameworks in an isolated manner. The holistic view of systems approach also promotes flexibility in terms of identifying capital-based indicators for resilience. In this case, informal settlements are considered as a complex resilient system. A system comprises a combination of interrelated sub-elements that mutually influence one or the other (Nel, 2009:24). The analysis of the system must be undertaken holistically instead of focusing on the single constituent. Based on this, the climate change-resilience capacity of the informal settlements should be assessed by considering those interrelated subsystems such as social, economic, natural, physical, human and institutional capitals.

The framework also advocates bimodal approaches to cope with climate change risks. This approach allows analysing vulnerability to climate change risks and at the same time to investigate resilience capacity. This approach is preferred to fill the gap observed in the application of other frameworks to deal with this complex climate change risks. To plan for improving resilience capacity, the assessment was done by analysing the vulnerability of the area or the people for climate change risks and, in this case particularly, the vulnerability of informal settlements in the mountainous regions of Africa by emphasising informal settlements found at the periphery of Phuthaditjhaba and Karat towns. It includes the investigation of risks that directly and indirectly affect socio-economic and ecological conditions of the areas. The framework clarifies how to answer the critical question of “Resilience of what, to what and for whom?” suggested by Davoudi et al. (2012:299). The analysis begins with answering the questions such as: Who is vulnerable for risk of climate change? Why vulnerable? What are the observable risks? How much is the intensity of the damage caused by climate change? Then, searching for a coping mechanism by investigating the appropriate planning approach for climate change resilience of informal settlements in the mountainous landscapes.

As Figure 24 indicates, a situational analysis of the case study areas was undertaken to identify contextualise climate change risks and resilience capacity. The capitals or capacities for disaster resilience that are recommended by Cutter, *et al.* (2010:7) were evaluated against the principles to build the resilient system suggested by Biggs *et al*. (2015:3-18). The evaluation of the capacity focused on those major variables within each capital that determine resilience capacity. This approach is preferred because of the assumption that all variables may not have the same influence on resilience capacity and focus on the critical variables to ensure efficient utilisation of limited resources, especially in the area of informal settlements. Solving one major problem may enable one to solve many minor problems. Otherwise, variables that influence resilience capacity of a certain area could be infinite. To materialise this, a mixed method of analysis used because of qualitative and quantitative nature of indicators for resilience. The cumulative climate change-resilience capacity of the study areas was then described, based on the outcomes of the evaluation. This provides an opportunity to suggest a customised and site-specific planning approach for improving resilience capacity of the study areas (See the schematic representation of the conceptual framework in Figure 24). Improving resilience capacity of informal settlements requires the understanding of the context that the community struggles for survival and has limited resource choices.



Source: Author's own, 2015

FIGURE 24: Conceptual Framework to Improve Climate Change Resilience of Informal Settlements in Mountainous Regions of Africa

The idea of how resilience might be promoted by enhancing ways of life, social infrastructure, improving adapting capacities and investments in social security measures is critical, particularly in the informal settlements. Thought of these realities is basic with a specific end goal to enhance resilience capacity of informal settlements. Along these lines, resilience capacity measuring benchmarks in the areas of informal settlements may not be similar to the standards of measuring resilience in the formal urban establishments. In other words, there is a need for a flexible and customised resilient capacity measurement framework. Otherwise, it will not be feasible with contexts of informal settlements. The framework also considers the coordination of indigenous and scientific knowledge with a specific goal to enhance resilience capacity with regard to informal settlements in Africa. By perceiving the complexity and uncertainty of climate change risks, the conceptual framework enabled the researcher to address the basic question of what local communities and stakeholders ought to do to move towards a more resilient settlement in the future. Finally, hybridised participatory and 'Africanised' planning model is proposed as a remedy to cope with these climate change risks.

6.10 Limitations of the Method Used in the Study

Although the systems approach to assess climate change resilience of informal settlements in mountainous regions of Africa has significant advantages in terms of comprehensive and detail understating of the issue, it has some drawbacks in relation to huge data requirements in respect of all capitals available in the study areas. The reality in the case of informal settlements is that there is a lack of secondary data in all sectors. Nevertheless, to cope with this drawback, intensive primary data collection was undertaken in the field. Further, the composite climate change resilience index has its own drawbacks, because it could not accommodate those qualitative factors that significantly determine resilience capacity in the study areas. For instance, the qualitative analysis of social capitals, such as social networks, informal leadership and the practice of indigenous knowledge indicated the major contributing factors and helped the local community to survive in a hostile environment in the case of Karat. On the other hand, the outcome of the analysis by using the same method in the case of Phuthaditjhaba indicated that there was limited social capital in the area. Contrary to this, the result of quantitative analysis of the social capital-resilience index in the case of Phuthaditjhaba indicated that it was higher than that of the social capital-resilience index of Karat. This can be considered as the drawbacks of the composite climate change resilience index, because it only emphasises the quantifiable variables rather than also accommodating non-quantifiable factors.

In addition, the complex and abstract nature of the climate change resilience measurement forces one to use proxy variables when facing difficulties in obtaining direct indicators for resilience. However, proxy variables may not measure the required features of climate change resilience of the given areas. This can be considered as the main drawbacks of statistical methods which lack the capacity to accommodate principal and direct qualitative variables that indicate resilience capacity in the study areas. Consequently, as these case studies were undertaken by considering the conditions of climate change resilience of informal settlements.

Chapter 7
PROFILE OF THE CASE STUDY AREAS IN THE CONTEXT OF INFORMAL SETTLEMENTS AND CLIMATE CHANGE

7.1 Introduction

This chapter analyses the profile of the case study areas and the impact of climate change-induced risks at national, regional and local scale. The empirical decision-making and planning interventions processes in relation to different perspectives are also discussed. In accordance with this, the dominant perspectives that influence the administration practice of informal settlements distinguished and practical intervention strategies to improve the resilience of informal settlements to climate change-linked risks are proposed.

7.2 Profile of Phuthaditjhaba Town

7.2.1 History and Geographical Location of Phuthaditjhaba

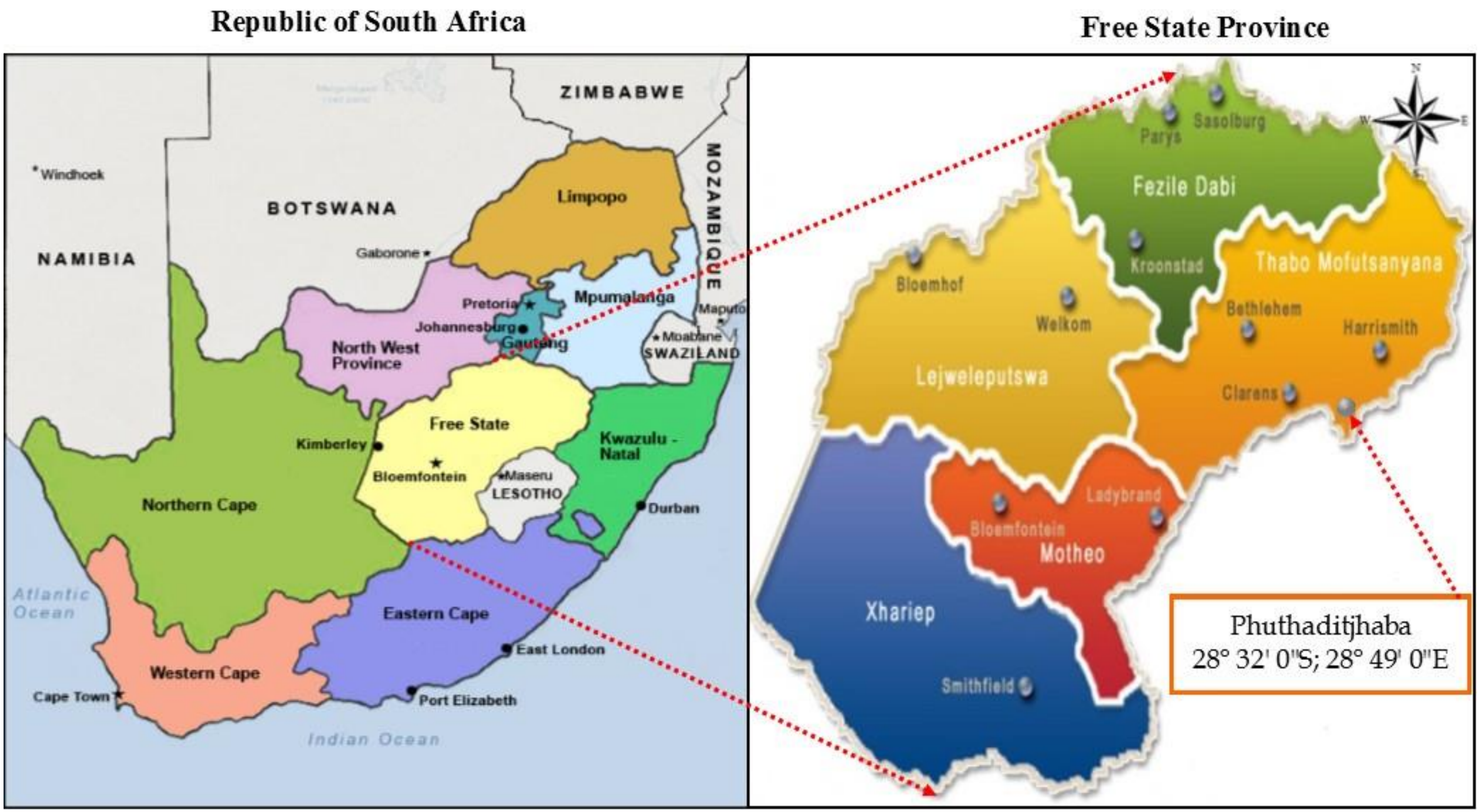
The history, emergence and development of Phuthaditjhaba is inseparably woven into politically-sanctioned racial segregation strategies of homelands creation and constrained expulsions (Murray, 1992:7). The 'self-governing' Homeland of Qwaqwa was created on 1 November 1974; soon after its declaration, the local jurisdiction estimated population was about 200 000 inhabitants. By 1980, this had bourgeoned to no less than 300 000, a population density of 484 persons per square kilometre. Most of these people were amassed in the Phuthaditjhaba area, which constitutes the biggest resettlement or 'dumping ground' in the previous Qwaqwa Bantustan (Rogerson, 1999:132).

Phuthaditjhaba's historical development occurred in the time of the 1970-80s politically sanctioned racial segregation, "intentional" evacuations, which were the result of removals from white farms and residential areas alike, across both the Free State and (the previous) southern Transvaal (Murray, 1992:8). Generally, Phuthaditjhaba can be characterised as an exemplary case of a politically sanctioned racial segregation settlement form that is hard to characterise as far as traditional meanings of what is ‘urban’ or ‘rural’. Terms like, for example; 'rural slum' or 'displaced urbanisation' apply similarly well to such settlements. Phuthaditjhaba is best comprehended as falling into that special classification of an artificial rural settlements which housed "politically-sanctioned racial segregation's shrouded urbanites" (Centre for Development and Enterprise (CDE), 1996:17). Officially, today Phuthaditjhaba is classed as "urban" with those territories that fall under tribal land proprietorship as rural (Rogerson, 1999:132).

The former name of Phuthaditjhaba town is Witsieshoek, located in the Free State Province of South Africa. Phuthaditjhaba means the meeting place of tribes in the Sesotho[15] language. It is bordered by the Elands River to the south, KwaZulu-Natal to the southeast, the Drakensberg Mountains in the north, and the country of Lesotho to the southwest. The commonly observed snow at the top of the Drakensberg Mountains surrounding the town led locals to call the region Qwaqwa (whiter than white) (Maluti-a-Phofung Local Municipality (2013:24). The geographical coordinates where the town is situated is at a latitude of 28° 32' 0"S and longitude of 28° 49' 0"E and altitude of 1 646 m.a.s.l., with a total area of 28.83 km². In 1974, the town became the capital of the Qwaqwa Bantustan, and in 1994, it reverted to being part of the Free State Province after the apartheid system was abolished in South Africa.

As the Maluti-a-Phofung Local Municipality (2013:24) reports, Qwaqwa was included in the Maluti-a-Phofung Local Municipality in 2000. It was established according to the provincial *Gazette No.14* of February 28, 2000. Currently, the Maluti-a-Phofung Local Municipality encompasses four areas, namely Qwaqwa rural, Phuthaditjhaba, Harrismith and Kestell. Phuthaditjhaba is the urban centre, which serves as the administrative capital of the Maluti-a-Phofung Municipality. The hinterlands of Phuthaditjhaba comprise rural villages of Qwaqwa established on tribal land managed by the Department of Rural Development and Land Reform. The remaining rural areas of Maluti-a-Phofung comprise commercial farms and major natures or conservation areas such as the Golden Gate National Park, Platberg, the Sterkfontein Dam and the Maluti Mountain Range (Maluti-a-Phofung Local Municipality, 2014:1).

[15] *Sesotho* is one of South African local languages spoken by the Sesotho ethnic group.



Source: Maluti-a-Phofung Local Municipality (2014); Planet Earth (2014).

FIGURE 25: Location of Phuthaditjhaba in South Africa

7.2.2 Impacts of Climate Change on the Study Region (South Africa – Free State)

The Southern African region is highly susceptible to climate change threats. Rising temperatures and rainfall variability will affect the living conditions in urban centres negatively. The western part of South Africa is expected to become hotter and frequent droughts may occur in the future, while the eastern parts the South Africa will experience storms that are more frequent. It is thus essential to identify the possible major risks of climate change in advance in order to prepare and to build resilience capacity in a particular area. In future, flooding caused by the severe storms will be the most critical challenge in some cities. On the other hand, shortage of water because of frequent droughts, an increase in the frequency of heat waves and prevalence of diseases associated with climate change are the most prominent risks of inland urban regions (Mearns and Norton, 2010:6).

Although there are variations in the results of multiscale global models, the average global temperature will increase up to 2 °C in the next decade. The potential effects on South Africa in the medium to long term will be critical and disastrous. Even in the lower greenhouse emission-scenarios case, it has been projected that by mid-century, the South African coastal area will face temperatures warmer by about 1 °C, and the interior will experience increases of about 2–3 °C. After 2050, warming is projected to increase about 3–4 °C along the coastal area, and 6–7 °C in the interior. With these rises of temperature, the biophysical situation will change completely. Parts of the country will become much drier; increased evapo-transpiration will lead to a general decline in water accessibility, altogether influencing human wellbeing, agriculture and the ecosystem in general; the expansion and magnitude of veld fires and particularly irregular weather phenomenon, for example, floods and droughts will also have critical effects; sea-level rise will affect the coastal area; and mass loss of endemic plant and animal species will significantly diminish South Africa's biodiversity (Mearns and Norton, 2010:7).

Increasing concentrations of $C0_2$ in the atmosphere, as measured at the Global Atmosphere Watch station at Cape Point show that some climate change effects are now seen to a notable degree. For instance, the ocean level around the western margin of South Africa is already rising by 1.87 mm for every year, the south coast by 1.47 mm for every year, and the east coast by 2.74 mm for every year. It is similarly confirmed that observed surface temperatures over land, and the number of cold days have changed significantly all over South Africa since 1950. Increased fire occurrence has been seen in the winter precipitation biomes and a critical decrease in precipitation since the 1950s have been seen in the southwest of the nation, with notable declines in the northeast, particularly in dry years (South Africa, Department of Environmental Affairs (2011:25). Anthropogenic climate change is probably going to have an unfavourable effect on the nation's biodiversity (Midgley and Thuiller, 2005:638). As indicated by Jonas et al. (2012:8), 40% of earthbound, 57% of stream, 65% of wetlands, 44% of estuarine, 41% of marine and 59% of coastal ecosystems are already affected or depleted. The financial cost of adapting to climate change is probably going to be considerable; yet, this cost of not adapting would be much higher.

The South African government acknowledges the concerns of the Intergovernmental Panel on Climate Change Assessment Report. The warming of the climate system is unequivocal and that is very likely increased due to anthropogenic greenhouse gas emissions (South Africa, Department of Environmental Affairs, 2011:25). Given this, it is clear that urgent universal and local measures are required to a real reduction of greenhouse gases in the atmosphere in order restrict the adverse impacts of climate change into the future. South Africa is both a contributor to and subjected to risks of, worldwide climate change given that it has an energy-intensive, fossil-fuel controlled economy and is additionally exposed to the effects of climate change (South Africa National Development Plan, 2012:23).

The nation considers the value of individual and global shared responsibilities to reduce emission of greenhouse gases. This is reflected in the Environmental Right contained in Section 24 the nation's Constitution. It has a climate change-response goal of making a commitment to the global effort to accomplish the balancing of greenhouse-gas accumulation in the atmosphere at a level that avoids hazardous effects. Preparing to adapt unavoidable potential harm of climate change through interventions that combine the social, economic and environmental resources is critical and measures need to be taken urgently. In addition, developing the emergency response capacity and prioritisation of the possible damages, particularly by considering the exposure of the poor and other vulnerable groups is essential to cope with this complex challenge (South Africa, Department of Environmental Affairs (2011:26).

The case study area, as much of the Free State Province, is dominated by grassland biome. This grassland biome is at risk under all greenhouse-emission scenarios indicated by the United Nations Framework Convention on Climate Change [UNFCCC] (Department of Environmental Affairs, 2011:72). The Maluti-a-Phofung Municipality can thus also be regarded as a particularly vulnerable area of climate change, as it is a poor area, where people will be the exposed to the effects of changing climatic conditions. The effects thereof will principally be felt on precipitation, water sources and water supply. Therefore, focus should be given to storm water management, basic water supply, flood-area control, the strengthening of engineering and community-based capacity to respond to new water supply challenges. (Maluti-a-Phofung Local Municipality, 2013:75).

Consequently, as the South African Cities Network (SACN, 2011:53) reports on the state of South African cities indicates, the notion of resilience has begun to receive consideration. The report promotes the concept of urban resilience as the ability of an area to forecast, respond and systematically adjust itself to complex challenges like environmental hazards, social issues and economic pressures. The country has also launched the National Climate Change Response White Paper in 2011, which has been designed with the aim of effectively managing climate change threats. The policy document clarifies short-, medium- and long-term strategies to enable the country to mitigate the risks related to climate change (South Africa, Department Environmental Affairs [DEA], 2011:20). However, the notion of climate change resilience of informal settlements in different parts of urban centres has still not really been addressed to the extent that the magnitude of the challenge requires. The current actions have focused on and are biased towards the resilience of the formal urban systems (SACN, 2011:54) (See Chapter 8, section 8.2.4 for a detailed climate change analysis of Phuthaditjhaba).

7.3 Profile of Karat Town

7.3.1 History and Geographical Location of Karat

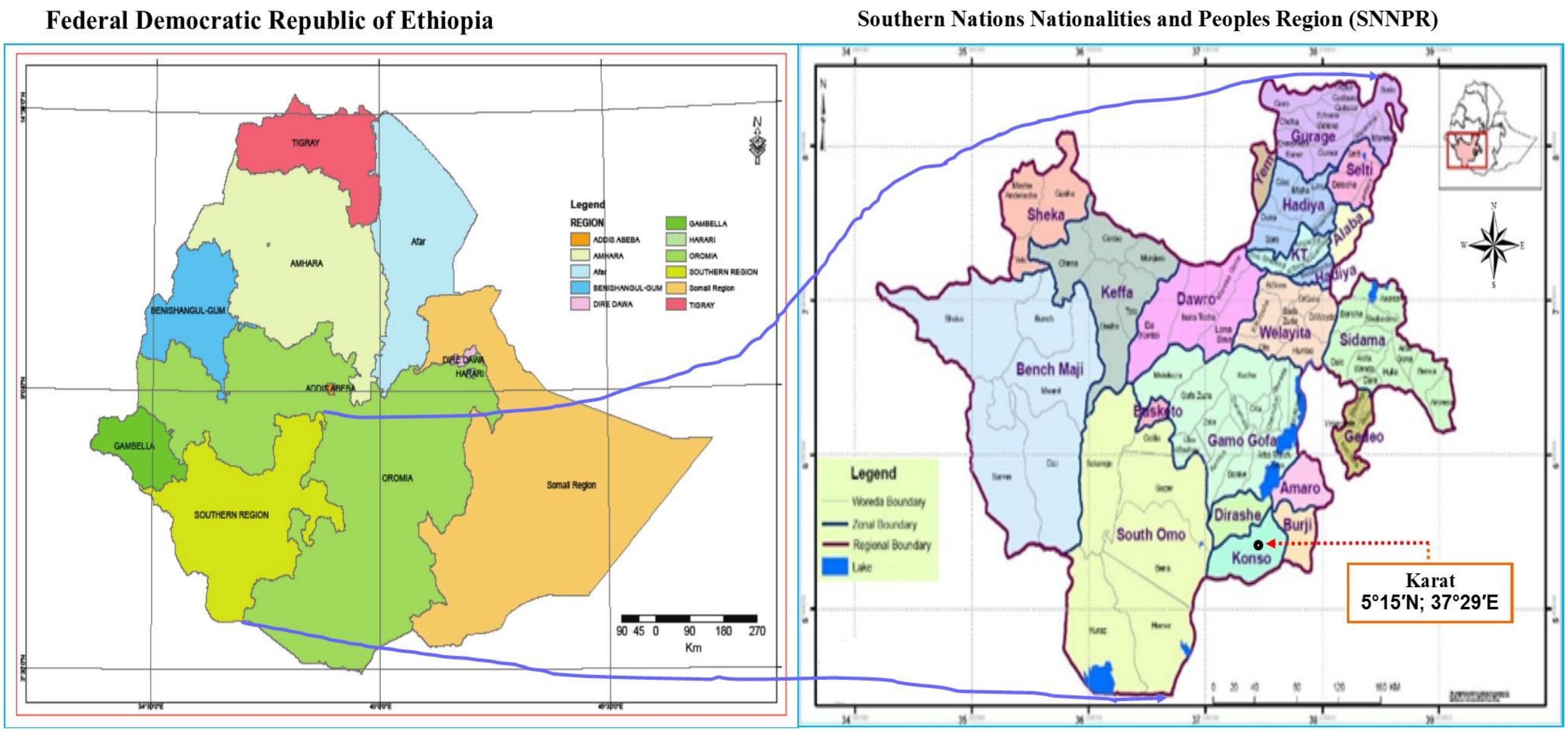
Konso became part of the Ethiopian administrative territory during the Minilik II Empire in 1897. Karat town is the administrative capital of Konso Wereda[16] found in Southern Nations Nationalities and People's Regional State (SNNPRS)[17] of Ethiopia. The people prefer to settle on top of the mountains and hillsides for defensive purposes. These settlement features are commonly observed at the periphery of Karat town as well as in the whole Konso area. The Konso cultural landscape was registered as the Ninth World Heritage Site of Ethiopia in the year 2011. The people speak an Eastern Cushitic language and they are known for terracing and intensive agriculture. The people have used their indigenous cultural tradition to cope with dry weather conditions for over 400 years (Demeulenaere, 2002:81).

The name Konso is derived from the word *Konsita,* meaning *hill farming where people are living* in stonewalled villages around the farms. Konso is situated at around 600 km south of

[16] **"Wereda"** is the lower administrative unit and it has subdivisions called "Kebeles" in the context of Ethiopia.

[17] **SNNPRS:** stands for Southern Nations Nationalities and Peoples Regional State**.** It is one of the nine regional states/provinces found in Ethiopia and located at the southern part of Ethiopia.

Addis Ababa. It is geographically located at the latitude of 5°15′N, longitude 37°29′E and an elevation of 1 650 m.a.s.l. (Watson, 2009:322). The topography of the area is characterised by rugged terrain and located within the Rift Valley Mountains. Most of the human settlements are located on the hillsides with stonewalls of four metres high. The Konso area is characterised by layers of volcanic rocks and by medium mountainous topography that ranges from 1 400–2 000 m.a.s.l.



Source: Adopted from Google Earth (11/13/2015); SNNPRS (2015)

FIGURE 26: Location of Karat in Ethiopia

7.3.2 Impacts of Climate Change in the Study Region (Ethiopia – SNNPRS)

As discussed in Chapter 2, section 2.3.4 of this study concerning the climate of the Eastern Africa, the situation varies from seasonal wetter conditions in some areas to drier in the other periods. This is mainly determined by changes in concentration of carbon dioxide in the atmosphere and changes of the temperature of the Indian Ocean. The temperatures are significantly higher in lowlands, whereas cooler conditions occur in the mountainous areas of the region in general and in Ethiopia in particular. The northern part of the Eastern Africa region received high precipitation from June to August, while the southern part of the region has higher precipitation in the December to February period tropical areas encounter two precipitation seasons with peaks in October and April (Daron, 2014b:5). As indicated by the Climate and Development Knowledge Network [DKN] (2012:online), temperature and precipitation varies over annual, decadal and multi-decadal timescales. Over the past half- century, there has been a considerable irregularity in precipitation. Parts of central Ethiopia were strangely wet in the 1970s and unusually dry in the 1980s and 1990s, while different parts of East Africa encountered the inverse trend. Temperatures over the area have increased by 1.5–2 °C on average in the last the past 50 years. The highest rises are found in the central area of the regions, especially in South Sudan where rises in the March to August period have exceeded 3 °C.

As the report of IPCC, (2014b:49) reveals, droughts and floods have been more frequent in eastern Africa in the last 30 to 60 years. Continued warming in the Indian Ocean has been shown to contribute to East African spring and summer droughts that have been more frequent over the past 30 years. According to Setegn et al. (2011:04511), projections for medium to high greenhouse gases emissions scenarios indicate that maximum and minimum temperatures over equatorial East Africa will rise and that there will be warmer days compared to the baseline of the middle and end of this century. Climate models show warming in all four seasons over Ethiopia, which may result in heat waves that are more frequent. Projections also indicate shorter spring rains in the mid-21st century for Ethiopia (Daron, 2014b:5; IPCC, 2013:18).

According to the World Bank (2008:32), Ethiopia has faced warmer weather conditions in the last century. The meteorological forecast indicates that the country will continue to face warmer climate conditions of between 0.7 °C and 2.3 °C in all periods until the 2020s and about 1.4 °C to 2.9 °C by the 2050s. The country’s economy is mainly based on rain-fed agriculture that contributes to over 40% of the Gross Domestic Product (GDP). Past meteorological reports indicate that there was high variability in the rainfall distribution. This means rainfall variability has a direct impact on agricultural productivity, as well as the country's GDP. Therefore, building climate change resilience in all sectors requires a comprehensive understanding of the possible threats and taking significant measures against these threats

Consequently, Ethiopia has designed a climate-resilient green economy strategy under the umbrella of a sustainable development goal: "sustainable cities and communities". This can be considered as a positive action in terms of recognising the issue of climate change threats. The strategy clearly recognises that the country's weather conditions will become unpredictable in the next decades with high intensity of flooding and drought in different parts. The possible impact on health, transport, agriculture, energy and industry sectors has been mentioned. Still this strategy focuses on the major formal economic and social sectors; however, it does not emphasise improving the climate change-resilience capacity of informal sectors. To facilitate the achievement of sustainable development by improving climate change resilience, it is vital to involve the whole sector that is found in the formal as well as informal systems (World Bank, 2008:40).

Concerning the SNNPRS, it is a region of vast ecological and cultural diversity ranging from arid and semi-arid conditions to cool temperate zones. Using the traditional agro-climatic classification, nearly 50% of the region falls under the Kolla region (lowland), 37% under Woina Dega (mid-altitude), and 6.5% under Dega (high altitude). Compared to the northern part of the country, the region has a wider area of forest cover. Overall, about 18% of the total area of the region is covered by shrubs, bushes and dense forests. The mean annual temperature ranges between 15–20 °C, whereas the mean annual rainfall for the region ranges from 400–2 400 mm. Drought occurs very frequently in most parts of the region (Aregay, 1999:9) (See Chapter 9 for detailed climate-change analysis of Karat).

7.4 Perspectives Matter Improving Climate Change Resilience of Informal Settlements

Discussions on informal settlements and policy over the years demonstrate a gradual shift in perceptions of informal settlements and an enhanced understanding of the challenges facing these settlements. This has prompted a shift in policy approaches and planning interventions aimed at addressing informal settlement problems. Therefore, one can track the expectations of policy interventions depending on the prevalent understanding of the informal settlement problem (UN-HABITAT, 2003:69). Most notable is the shift from the long-held view that informal settlements are unsightly, disruptive parts of the city, towards an understanding of the settlements as integral and useful components of an urban area. Subsequently, there have been changing expectations of planning interventions, whereby rather than attempt to remove or demolish settlements, state agencies are increasingly expected to improve settlements and support residents (Cities Alliance, 2014:11).

Although climate change-associated challenges in the context informal settlements are clearly discussed and understood theoretically, the piratical intervention to solve the problem do not realise at local level. This has been observed in sub-Saharan Africa (UN-HABITAT, 2003:79). Although global informal settlement discussions can be traced further back in time, literature on sub-Saharan Africa points out the emergence of the problem in the late colonial and early post-colonial period (1950s and 1960s). This era, which also coincided with the post-World War II phase, was marked by demographic change, with large masses of people flowing to urban areas (Koenigsberger, 1986:27). This rapid influx led to the demand for housing and the growth of informal settlements. During this phase, shack settlements were therefore viewed as unwanted intrusions of the rural population into the city. Freund (2007:148) notes that residents were seen as “social parasites, absenting themselves from the export-producing agrarian and mineral zones to settle in seething slum quarters”, thus triggering state intervention, which involved 'systematic round-ups and expulsions’. These forced removals and demolitions failed to kerb the rapid growth of urban population. Roddel and Skinner (1983:5) note that the initial housing policy in this era held that the enormous growth of slum and squatter settlements arose from people's inability to pay for conventional housing and that government would solve the problem by building and subsidising the necessary units. This triggered the era of state-led public housing programmes, aimed at reducing the housing deficit by increasing low-income housing stock (Koenigsberger, 1986:28).

The initial reading of informal settlements as negative facets of the otherwise formal city, however, continued to dominate state-led interventions. Whether through shack demolitions, resident relocation or mass housing programmes, the key aim of the policy was to remove these areas of 'lack' and replace them with formal, planned areas. It has, however, been recognised that, despite notable attempts, many states were unable to meet these goals. Koenigsberger (1986:28) characterises this to lack of administrative and technical manpower within state agencies, while Freund (2007:149) points to broader economic, social and political challenges in the post-colonial African countries. Nevertheless, disturbing as these slums may be to the sensibilities of the casual observer, they serve a necessary purpose. While a better organisation might reduce the need for this type of slum, it is not likely that developing nations will have either the resources or the governmental techniques that will permit a less disturbing way of handling the movement of labourers into the cities (Stokes, 1962:193).

Climate change-resilience building for informal settlements depends on the way these settlements have been perceived by officials, whether they were international development agencies or local public administrations. Many scholars point out that general attitudes towards informal settlements, slum dwellers and squatters in developing countries have usually varied from ''blind intolerance to blatant hostility'' by local officials in charge of urban management, who considered these settlements as a ''cancerous growth on the city'' (Laquian, 2005:353). In general, the practice in the context of Africa revealed that there are still different perspectives in terms of planning interventions in the area of informal settlements. For the purpose of this study, some of the perspectives, from a practical point of view, are discussed in the following sections.

7.4.1 Technocrat-Planners Perspectives (Top-Down Approach)

Informal settlements could be seen either as physical conditions, insufficient of fundamental infrastructure and administrations, or as unpredictable and changing social orders that play themselves out in complicated spatial courses of action. This point of view advocates intervention through the provision of the lacking infrastructure and services, regarding occupants as uninvolved beneficiaries of technologically composed interventions and essential concerns would associate with effectiveness. The intervention concentrates on authorising strict construction and planning standards, regulations and environmental impact assessment. The informal settlements are perceived as a cause of social and environmental problems. Therefore, thy must be demolished or subject to the standard urban planning procedures and legal measures (UN-HABITAT, 2003:79; Freund, 2007:148).

Physical planning, construction and building-design standards are essential elements in urban disaster risk management. However, as much as suitable zoning, adequate building regulations and legal tools are necessary, they can sometimes be too rigid and expensive for urban residents to employ, leading the way to an untrained informal construction sector and settlements. It was observed that the failure to analyse the costs of imposing certain zoning regulations in advance ''can easily imply that well-intended regulation will end up hurting the poor'' (Deininger, 2003:176). Evidence has shown the inverse relationship between informality and the imposition of regulations in many developing countries. The measures to meet strict land-use and building regulation are found too expensive or bureaucratically cumbersome for many, pushing more and more housing and settlements outside the regulations. Again, although some local governments develop master plans to regulate urban development and expansion, lack of consultation with cities' residents and interest groups lead to poor results in their application (Deininger, 2003:176).

7.4.2 Human Rights Advocates Perspectives

Informal settlements are seen not just as a manifestation of poor housing rights, but additionally, a symptom of a dysfunctional local government that is unable to administer the formal land and housing market (UN-Habitat, 2013: 8). Disparities and inequalities that happen daily in these settings push the people to live informally in some parts of the town. Therefore, advocators of this perspective conceived informality as the outcome of social injustice and ideological problems. Accordingly, they encourage improving the physical conditions under which residents live and to secure residents' social and political rights to the city. This can be achieved through a combination of legal reforms, institutional changes and social mobilisation (UN-HABITAT, 2005b:9).

This claim is further stretched by the 'right-to-the-city' discourse, which plans to reinforce residents' aggregate rights as citizens of the city. These rights, as indicated in the World Charter on the Right to the City include the right to work and live in fair, palatable conditions; sufficient safe housing, infrastructure and services and secured wellbeing; as well as full participation and empowerment in the decision-making process (World Charter on the Right to the City [WCRC], 2004:1). Accordingly, this perspective gives special emphasis to human rights and any planning intervention should prioritise the safety of human being. In addition, they disagree with the strict implementation of the planning standards in the area of informal settlements.

7.4.3 Political-Ideological Perspectives

The ideological constructions of informal settlements may lack an understanding of the more straightforward or micro-level processes involved in making these places. For instance, the neo-liberal perspective considers the proliferation of informal settlements is directly associated with problems in the housing market because of state-induced rigidities. State regulation and interference limits private-sector participation in the market. Therefore, the government should play an enabling role in order to facilitate financial, institutional and legal frameworks for private, sector-driven development. This is one of the dominant perspectives advocated by the World Bank (Vivien and Tito, 2006:2). The guiding principle of the neo-liberal perspective of the Bank is centred on affordability and cost recovery, which means that costs of development and operation should be recovered from project beneficiaries. The approach also promotes a reduced role of government to that of enabler or facilitator of development, and an increased role of NGOs, the private sector and other market-based players (UNHCS, 1996:209).

According to Burgess (1978), the shift denoted a change in the general comprehension of informal settlements, this view scrutinised for depoliticising the housing issue, and not to consider informal settlements as general socio-economic crises. In addition, he contended that the housing issue was a result of the capitalist ideology and failure of the government to provide infrastructure and services. Therefore, neglecting this fact may prompt the formulation of policy and planning interventions that propagated a similar arrangement that contributed to the proliferation of informal settlements. Consequently, neglecting the poor may complicate the problem (Burgess, 1978:1105). Therefore, any intervention based on this perspective is not feasible in the context of Africa, because it promotes capitalism that makes only few people wealthy. The private sector is motivated by the profit gained from the development. Therefore, the poor cannot afford the housing price in the formal market.

Contrary to the above perspective, there are Marxist perspectives that consider the challenges of informal settlements as not only the inadequacy of physical facilities, but also manifestations of social, political and economic exploitation. Therefore, this perspective encourages social mobilisation, and pay more attention to achieving equity in land markets, rather than only physical improvement. Therefore, policy makers must recognise the political nature of informal settlements resilience, develop creative strategies to recognise the power imbalance, reduce the circumstances wherein high-income stakeholders use political power to affect outcomes, and make lobbying affordable for the poor (Dafe, 2009:29).

7.4.4 Governance Perspectives (Participatory Bottom-Up Approach)

Informal settlements need to be considered from a perspective that recognises the positive aspects that represent the efforts and creativity of urban poor to cope and survive in the city. There is a need for the state to augment residents' efforts such as the facilitation of incremental self-help, including site and services and slum upgrading. Housing is a process and not a product. We need to emphasise the positive aspects of informal settlements, such as social capital and indigenous knowledge of society, the potential of solving the problem by using local resources, creativity to provide small-scale goods and services for the formal system and the reduction of social crises that may possibly happen if the people lose the place to live. However, this does not mean there is no negative externality on the formal urban system. The existing facts have forced us to focus on improving people's living standards through upgrading, rehabilitation, regularisation, provision of services and infrastructures without adversely affecting the existing nature of settlements (Huchzermeyer, 2011:16).

Informal settlements represent more than a lack of housing and infrastructure. The realities of urban poor are complex, diverse and dynamic. Informal settlements represent various elements of vulnerability, risk and insecurity, but also resilience. Intervention should be people-centred, participatory and empowering. Intervention should strengthen resilience and not create new dimensions of vulnerability. Informal settlements are not just areas of lack, poverty or deprivation, but rather as different, 'not-formal', but functional parts of the city. Informal settlement residents have the potential for political, cultural and economic creativity and dynamism. Thus any policy pertaining to informal settlements should not seek to extend the 'formal city' and its regulations to the 'informal' component; rather, it should aim at developing diverse and multiple cities (Hernandez et al., 2010:183; Mehrotra, 2010:11; Roy, 2009:7).

Participation of all stakeholders in the process-enhancing resilience is essential, including the residents of informal settlements as part of the solution for the problem they face, including climate change-related risks. Self-improvement and *in-situ* slum-upgrading arrangements depended on the belief that "urban poor have the capacities to adequately manage their own and that, given such affirmations as security of land ownership, low-interest credits, appropriate construction materials and some specialised help, they could help overhaul their own living conditions" (Laquian 2005: 362). Involving all stakeholders and empowering the poor in the informal settlements are the central aim of this perspective. This requires political commitment and checks and balances at grass-roots level. The more marginalised or socially isolated the group being helped, the more participation and associations are vital (UN-Habitat 2003: 132).

The governance perspective encourages the consideration of social issues such as poverty, inequality, environmental justice and broad-based stakeholders' participation in decision-making and space production. Therefore, it plays a significant role in shaping informal settlements' resilience to climate change risks. Scholars suggest that the impact of climate change and other risks are unevenly distributed and socially differentiated, and are therefore a matter of local and international distributional equity and justice. Policy-makers have been urged to broaden the scope of intervention towards reducing vulnerability, expanding livelihoods, and strengthening the resilience of the urban poor against short-term and long-term risks. To do this, there was a need to shift approach from the generic top-down model to one that was 'people-centred, empowering and sustainable' (IPCC, 2007:354; Tearfund, 2008:17).

Promoters of governance perspectives consider informal settlements as a broader sphere of urban management issues and do not focus on informal settlements alone. However, proponents of this approach provide practical arguments for urban management, especially for developing countries where urban informality exists on a larger scale (Urban Think Tank, 2005:23). Although this model has been criticised for its appreciation of informality, it does offer a significant shift in the informal settlement debate. It contends that the informal does not present a 'problem' that needs to be addressed, but rather a system of innovatively providing access to housing, employment, services and the city. Some of the sources also caution against viewing informal settlements through the formal/informal lens, pointing out that this only triggers intervention that seeks to formalise the informal. Rather, policy makers should strive to develop diverse and multi-faceted cities rather than attempting to extend the 'formal city' and its regulations into the irregular spaces of the so-called 'non-city' (Urban Think Tank, 2005:23; Roy, 2009:7).

The governance view would have agencies, in close alliance with the residents, intervening by communicating with and encouraging organised initiatives by residents, recognising their endeavours for improvement, acting on their demands, while also responding to their vulnerabilities. Its central concern is to build long-term capacity among the residents for on-going survival and upliftment (Huchzermeyer, 2004:47). Participation is encouraged in the identification, formulation and implementation of intervention programmes, since residents have "the best knowledge of how their settlement works, the characteristics of their community and the nature of their needs and priorities" (UN-HABITAT, 2011b:10).

In the reality of informal settlements, the vulnerability can be demonstrated as unsafe housing conditions on steep slopes and other hazard-prone areas. Eventually, the capacity to minimise risk associated with climate change and other hazards depend on the availability of resources and feasible coping strategies in a particular area. Disaster risk management is more challenging in informal settlements than the formal urban system, mainly because of a shortage of hard and soft infrastructure in these areas. The assessment of place-based hazards and vulnerability should be done by evaluating the resource capacity to cope with the current and future risk profile of the specific site (The Energy and Resources Institute [TERI], 2013:2). To reduce the risk of hazards, appropriate and site-specific disaster resilience strategies that consider physical, social, economic and natural capitals have to be devised. However, planning practice has largely focused on promoting disaster-risk management in the formal urban system. Contrary to this, the new disaster-resilience thinking advocates considering informal settlements as a sub-system of the overall urban system (Todes 2011:128). This enables planners to formulate and implement a holistic disaster-resilience plan.

Resilience planning should accommodate the changing circumstances in informal settlements, instead of just concentrating on minimum standards and designs that are mostly appropriate for modern and formal urban areas (Collins, 2009:104). In the context of Africa, it is difficult to isolate the formal urban system from the informal system, because the settlements are blended, partially formal and informal. In these urban communities, handling infrastructure demand and development backlogs are the basic issue that must be dealt with to enhance the resilience capacity of both formal and informal settlements. On top of this, the negative effects of climate changes are more serious in informal settlements in the light of the fact the poor do not have the assets that help them adapt to climate change perils (Pelling and Wisner, 2009:9). Therefore, governance systems ought to build up their abilities to oversee vulnerabilities identified with future climate change. Administration of hazard should be local and site-specific and enable feasible solutions for real problems at grass-roots level (Coaffee, 2009:239).

The above discussions indicate that policy-makers' perceptions of the ‘informal settlement problem' significantly affect what they choose to do about it. With improved understanding of the challenges of informal settlements, intervention policies may shift towards improvement. It should, however, be noted that the documented shift in global understanding of informal settlements does not automatically lead to changes in policy at country level. For instance, while it has already been established that slum upgrading is a more effective intervention approach (Cities Alliance, 2001:9), this is yet to be applied fully across the world. In sub-Saharan Africa, for instance, in-situ upgrading is still limited to 'demonstration projects', with few governments adopting these into policy frameworks (UN-HABITAT, 2003:8).

The reluctance of these states to implement support-based informal settlement interventions has already been pointed out. This is, however, not merely in the informal settlements field but has been observed in the implementation of broader urban interventions. For instance, writing on the challenges of transforming planning laws, Beresford notes that one of the key challenges is the failure to understand and incorporate the interests, concerns and needs of diverse stakeholders. Are informal settlement intervention policies plagued by similar challenges? From the discussions of various scholars, it appears that the informal settlements problem is clearly understood, as is what is expected of policy makers. However, in most sub-Saharan African cases the national-level policy transitions have not been implemented successfully (Berrisford, 2010:17).

7.5 Legal Frameworks and Climate Change Resilience of Informal Settlements

7.5.1 Spatial Planning and Informal Settlements in South Africa

The emergence and growth of informal settlements in South Africa, and the state's response to them cannot be detached from the country's historical context. The systems of segregation and apartheid that were implemented between 1910 and 1993, however, had the most profound effects on the country's social, political, spatial and economic development, ultimately affecting the housing and informal settlements sphere. For example, legislation limiting Africans' access to land forced masses of the population to look for work in cities. This led to growth in demand for housing and basic services, which was not adequately met (Republic of South Africa, 1996:28). Furthermore, policies of racial segregation and separate administrative agencies for various groups meant that former 'black' areas were under-resourced and lacking in basic infrastructure and services (Berrisford, 2010:17; Maylam, 1995:19; Mabin and Smit, 1997:193).

During the pre-1994 apartheid period, black South Africans were excluded intentionally and systematically from access to housing, infrastructure and services in urban areas (Todes, 2011:115). The properties of many people were demolished and opportunities to gain skills and participate in the economy were restricted based on race. This exclusion resulted in social segregation, spatial fragmentation, polarisation between the rich and poor, increased incidence of crime, urban sprawl and proliferation of informal settlements (Biermann, 2011:14). By considering this complex problem, the 1996 Constitution of the Republic of South Africa, Act 108, and section 26(1) issues the right for every citizen to have access to appropriate and liveable housing (Republic of South Africa, 1996:28). According to the Housing Development Agency [had] (2013:17), about 11% of the total households in South Africa reside informally. These households often do not have the security of tenure, nor access to infrastructure and services. In response to this, many acts were formulated since 1994 in South Africa with the aim of reducing social and economic disparities (Mearns and Norton, 2010:1; Pasteur, 2011:9).).

One of the acts is The Prevention of Illegal Eviction from and Unlawful Occupation of Land, Act 19 of 1998 (South Africa, 1998). This act recognises informal settlements in the peripheral area of urban centres. The fundamental considerations of this act are the legalisation of informal settlements through securing tenure, allocating resources to municipalities for upgrading and encouraging participation of residents. The act also promotes flexibility in the process of managing and legalising these areas, as well as encourages the participation of residents in the informal settlement-upgrading programme. It also provides a legal basis to claim significant engagement in the development process and recognises the historical situation that pushes disadvantaged people to settle informally (Roux, 2004:1).

In the preamble of the Spatial Planning and Land Use Management Act, 16 of 2013 (SPLUMA), it is stipulated that some of the driving forces for the formulation of this Act are informal and traditional land-use systems, which are hardly integrated with the formal spatial planning and land-use management system. Spatial planning is inadequately reinforced by infrastructural and service provision. Moreover, SPLUMA supports the incremental upgrading of informal settlements. This implies the dynamic presentation of institutional administration, designing change and land ownership rights that are set up outside existing planning law, and may incorporate any settlement or area under traditional land ownership (South Africa, SPLUMA, 2013:1). Overall, this can be considered as a positive reaction towards enhancing the livelihood of the poor living in informal settlements and accomplishing the objectives of sustainable development.

The process of policy formulation identified a number of possible approaches to deal with the challenges of informal settlements (Huchzermeyer, 2001:303). The main intervention approach (for low-income residents), however, would be a once-off capital subsidy for the provision of full tenure, basic infrastructure and housing for qualifying beneficiaries. Although this model was effective in delivering housing at a rapid pace initially, it has been strongly critiqued for a number of reasons. For instance, despite massive delivery (over a million units in 7 years), it was observed that the quality of housing built was often very poor (Pithouse, 2009:1). Furthermore, most of the new settlements could only be located on the peripheries of existing townships, far from employment areas, thus perpetuating the social and spatial marginalisation of the poor (Charlton and Kihato, 2006:252).

Parallel to legislative reform, new structures of intergovernmental relations were set with the intention of enhancing inclusive spatial planning. Therefore, Integrated Development Plans (IDPs) that require the participation of key stakeholders and institutional alignment in the development process has become the major planning tool in the post-apartheid period. However, the issues of spatial segregation and marginalised society are still not well addressed. The implementation of spatial planning criticised because it could not solve the above-mentioned problems. Spatial planning in the country is focused on solving the problem of housing and infrastructure backlogs without considering improving resilience to cope with climate change threats (Oranje and Van Huyssteen, 2011:8).

7.5.2 Urban Land Use Planning and Informal Settlements in Ethiopia

The Constitution of the Federal Democratic Republic of Ethiopia (FDRE, 1997, Article 44) indicates that all people have a fundamental right to an environment adequate for health and well-being. This article considers the fundamental right of human beings to live safely in any part of the country. Based on this, the country has formulated an urban land-use plan that guides the overall development of urban centres. The contents of planning law were modified over different periods. The land-use planning currently under execution was formulated and approved in 2012. As the Urban Planning Proclamation (2008) indicates, some of the driving forces behind the formulation of this law were uncontrolled urban sprawl and proliferation of informal settlements in urban centres. It emphasises controlling, or discouraging, informal settlements and encourages compact growth. The law also provides for upgrading and renewal of slums found at the centre of urban areas. Nevertheless, it does not mention anything about building the climate change resilience of informal settlements found at the periphery of urban centres. Therefore, the land use planning is still in favour of guiding the formal urban system, but it does not consider the socio-economic and ecological conditions of informal settlements. This causes an adverse impact on urban development.

7.6 Conclusion

In the case study areas in South Africa and Ethiopia, the notion of climate change resilience of informal settlements found in the mountainous regions has not received appropriate recognition in their legal systems. Rather, the legal acts are biased towards dealing with the challenges of climate changes in the case of the formal urban system. The study areas are highly susceptible to climate change-induced risks. The rising temperatures, rainfall variability, drought and shortage of water are among the major problems identified in the areas. Furthermore, the perspectives of diffident development actors or stakeholders matter, in order to enhance climate change resilience of informal settlements found at the periphery of small towns in Africa. The dominant perspectives in terms of policymaking and planning intervention in the process of informal settlement administration are the political ideological perspectives and technocrat planners' perspectives. However, in the context of informal settlements found at the periphery of small traditional towns in Africa, the participatory governance perspective is the most feasible and effective in terms of enhancing climate change resilience of informal settlements. This perspective empowers the poor to participate in the process of building resilience in the given area. Therefore, building climate change resilience in all sectors requires a comprehensive understanding of the possible threats and taking significant measures against these threats.

Chapter 8
PHUTHADITJHABA ANALYSIS AND DISCUSSIONS

8.1 Introduction

This chapter analyses the situation of informal settlements at the fringe of Phuthaditjhaba. The analysis emphasises the susceptibility of the residents to site-specific climate change-induced risks as well as their capacity to reduce risks associate with climate change. Accordingly, the social, economic, human, physical, natural and institutional capitals found in the area are analysed and evaluated against the principles of a resilient system.

8.2 Analysis of Vulnerability of Informal Settlements at the Periphery of Phuthaditjhaba (CASE 1)

As revealed in the conceptual framework, the analysis begins by assessing the vulnerability of the community to climate change-related risks. The following fundamental questions are answered: Who is vulnerable and why? What are the risks and the intensity of the damages on the specific sites? Resilience capacity or vulnerability of the certain communities to disaster risks, including climate change risks, is directly associated with the existence or lack of social, economic, natural, human, physical and institutional resources in that particular area (Cutter, et al., 2010:7). By materialising this concept, the capitals found in the study sites were analysed in order to identify their resilience capacity.

8.2.1 Demographics and Social Characteristics of Phuthaditjhaba

8.2.1.1 Demographics of Phuthaditjhaba and the Study Site

According to Stats SA (2012), the total population of the town in 2011 was 56 251 with an annual growth rate of 0.87% and a density of 2 288.75 inhabitants per square kilometre and with the total area of 24,58 km^2. The gender distribution of the population also indicated 45.3% males and 54.7% females. The racial composition of the town is 99% black African, 0.2% Coloured, 0.5% Indian/Asian, 0.1% white and 0.2% others.

TABLE 8.1: Population Trend and Projection for Phuthaditjhaba

Year	No.of Years [t]	Growth rate [r]	e^{rt}	Population
1996	0	0.41%	1.00	50626
2001	2	0.41%	1.01	51675
2011	4	0.85%	1.03	56251
2021	14	0.85%	1.13	61241
2031	24	0.85%	1.23	66675
2041	34	0.85%	1.34	72590
2050	43	0.85%	1.44	78361

Source: Statistics South Africa, (2012), (growth rate 1996-2001 is 0.41%/year; 0.85%/year 2001-2011).

The 2011 Census data (Stats South Africa, 2012) reveals that the average population growth of the town was 0.41% for the years 1996–2001 and 0.85% for the years 2001–2011. (See Table 8.1). This is below the average population growth rate in the Free State Province (1.1.6%) as well as at national level (2.58%). One of the major reasons for lower population growth rate is intra-country migration of the labour force from Phuthaditjhaba to other parts of the country. Concerning the establishment of informal settlements at the periphery of the town, rural-urban migration is one of the major factors for increasing population in the informal settlements.

TABLE 8.2: Age Structure and Gender Composition of Respondents at the Periphery of Phuthaditjhaba

Age Group	Male		Female		Total	
	Frequency	%	Frequency	%	Frequency	%
15-19	2	1	4	2	6	3
20-24	4	2	6	3	10	5
25-29	6	3	12	6	17	9
30-34	8	4	15	8	23	12
35-39	13	7	17	9	31	16
40-44	13	7	17	9	31	16
45-49	12	6	13	7	25	13
50-54	6	3	6	3	12	6
55-59	8	4	6	3	13	7
60-64	8	4	6	3	13	7
65+	8	4	4	2	12	6
Total	**86**	**45**	**106**	**55**	**192**	**100**

Source: Author's Field Survey (2015).

The result of a field survey undertaken at the periphery of Phuthaditjhaba town indicates the average household size as four persons. As Table 8.2 indicates, among the 192 informants, 45% are male and 55% are female. The age structure shows that 74% of the total respondents are found in the age group of 15–49 years. The remaining 26% of the total informants are found in the age category older than 50 years. This implies that the majority of the population is found in the productive age group.

8.2.1.2 Educational Status of Respondents at the Periphery of Phuthaditjhaba

In the case of Phuthaditjhaba, the South African Census Statistics of 2011 shows that 8.9% of the individuals older than 20 years are not schooled, while those older than 20 years who had the opportunity to higher education, only account for 7.9% of the population (Stats SA, 2012). The field survey (2015) indicates that of the respondents in the study, 22% are illiterate; 31% could write and read; 34% attended primary education; and the remaining 13% had secondary education. This shows that over 78% of the respondents could at least write and read. However, the survey indicates that no people are educated on tertiary level. This implies that there is a limited number of educated people in the area. (See Table 8.3)

TABLE 8.3: Educational Status of Informants at the Periphery of Phuthaditjhaba

Respondents		Educational Status				
		Illiterate	Read and Write	Primary Education	Secondary Education	Total
Male-headed household	Number	19	27	29	9	84
	% within respondents	10	14	15	5	44
Female-headed household	Number	23	33	36	14	106
	% within respondents	12	17	19	7	55
Total	Number	42	60	65	25	192
	% within respondents	22	31	34	13	100

Source: Author's Field Survey (2015).

The shortage of skilled people in the area affects the capacity to manage other types of capitals negatively in order to improve climate change resilience in the area. The survey result also depicts that male-headed household members are less privileged than their female counterparts in terms of access to education are. That means that male-headed household members are socially more vulnerable than members of the female-headed household are. In general, the study community is also characterised by poor health, education, infrastructure facilities and a high incidence of crime.

8.2.2 Analysis of Indigenous Knowledge System at the Periphery of Phuthaditjhaba

According to Akenji (2009:25), Indigenous Knowledge in South Africa has been recognised since 1994, and it has become a critical component of the restructuring of South African Science and Technology. The first National Workshop on Indigenous Knowledge in South Africa was held in 1998, with the intention of promoting African indigenous knowledge systems (Nel, 2006:99). The importance of Indigenous Knowledge was also recognised in Section 17(2) sub-section (g) of the Disaster Management Act of 2002 (Department of Local Government, 2002). The Act specifically stipulates that the electronic database developed by the National Disaster Management Centre must contain extensive information concerning disasters that have occurred or could occur in South Africa and disaster management issues, including information on Indigenous Knowledge relating to disaster management.

Moreover, the National Curriculum Statement (2003:4) also recognises the value of Indigenous Knowledge Systems in assisting problem solving in all fields. It specifically expects teachers to integrate Indigenous Knowledge Systems into their teaching. According to Rengecas (2008:3), the Cabinet approved the Indigenous Knowledge Systems Policy in 2004. This policy provides a broad basis for the recognition, understanding, integration and promotion of Indigenous Knowledge resources within South Africa. further, the 2004 policy placed the responsibility on various governmental departments to review the country's legislation and propose amendments to protect South Africa's traditional knowledge.

8.2.2.1 Forms of Indigenous Knowledge Practised by the Local Community around Phuthaditjhaba

The interviews held with the traditional leaders reveals that the community uses indigenous knowledge to improve their livelihood and to conserve the natural environment. The field survey results also indicate that 55% of the respondents agree about the existence of a strong social network and culture of working together to cope with climate change risks. Regarding the experience of traditional leadership to reduce conflict in resource utilisation, 65% of the respondents agree about this culture. More than 35% of the respondents also agree about the existence of the traditional agricultural practice to cope with climate change risks. There is also a traditional weather forecasting system to decide on the cropping season, 45% of the respondents agree about the existence of this practice on this. (See Table 8.4)

TABLE 8.4: Forms of Indigenous Knowledge Practised by the Local Community around Phuthaditjhaba

	Questions	Respondents' Feedback	
Q1.	**Forms of Indigenous knowledge practised in the local area**	**No. of Respond-ents**	**Re-spons e Rate in %**
A.	Using social capital and network to cope with climate change risks	205	55%
B.	Traditional leadership system to reduce conflict in resource utilisation	205	65%
C.	Preparation of traditional medicines from indigenous pants species	205	75%
D.	Common pool resource management (i.e. grazing land, forest, minerals , rocks, labour sharing)	205	15%
E.	Traditional and cultural food preparation	205	100%
F.	Traditional Agricultural practice to cope with climate change risks	205	45%
G.	Traditional weather forecasting systems to decide cropping season and to cope with climate change risks	205	35%

Source: Author's Field Survey (2015).

There is a similar outcome concerning the role of traditional leaders to resolve the conflicts associated with natural resource utilisation in the area. Seventy-five percent of the respondents do not agree on the existence of an effective common resource pool management (i.e. grazing land, labour sharing). The argument forwarded by the respondents in this case is degradation of natural environment at the periphery of Phuthaditjhaba because of overgrazing and the extraction of soils for moulding bricks. The outcome of focus-group discussions also confirmed that the influence of traditional leaders and/or healers is very high in terms of land administration and natural resource utilisation in the local area. They control power in the community and are consulted by all classes of people, not only on health problems, but also on other social needs and problems. People think of them first when they fall ill or have spiritual, moral, psychological or social problems.

Moreover, the outcome of an interview conducted with traditional healers and leaders also revealed the existence of climate prediction skills at the local area. For instance, the "red" moon announces the coming of drought; solar eclipses cause drought. These are some of an indicators used by traditional healers and leaders. The abundance of birds in the sky during the months of September and October is a sign of imminent rain. When the birds chirp during the farming season, it is a sign of an approaching thunderstorm. The behaviour of animals also used to predict lightning, thunderstorm and hailstorm. The restlessness and noisy behaviour of pigs can be considered as an indicator of an imminent heavy storm. Moreover, when the wind changes direction to blow from the east, it is a sign of imminent heavy rain without thunder. Fast-blowing wind from the west is a sign of imminent dry weather, which may lead to poor harvest and famine if it is prolonged. Towering darkened clouds on the west and fast-blowing wind are signs of an imminent violent hailstorm accompanied by thunder and lightning.

On the whole, the outcome of the field survey and interview indicates the existence the practice of different forms of indigenous knowledge system in the area, although many variations on the responses were observed. The existence and use of indigenous knowledge can be recognised as positive experiences towards minimising vulnerability to climate change risks. However, the responses revealed that no form of indigenous knowledge mentioned above is fully and effectively utilised regarding improving resilience capacity in the area.

8.2.2.2 Trans-Generational Transition of Indigenous Knowledge System in the Case of Phuthaditjhaba

Even though there were some experiences in terms of recognition of indigenous knowledge and its application in South Africa, the survey result on Table 8.4 revealed that there are no solid and well-organised community-based institutions and systems for the archiving, exchange and acquisition of indigenous knowledge in the local area. Therefore, the practice of indigenous knowledge systems was limited to only elderly people. However, 18% of the respondents argue that the documentation of the indigenous knowledge system is poor. About 77% of the respondents agreed that absence of institutions and systems for documentation of indigenous knowledge are a problem. This implies that the indigenous knowledge system will be lost unless some actions are taken to institutionalise this knowledge system at the local community level.

Moreover, the focus-group discussion also revealed that the practice of using indigenous knowledge is becoming limited to elderly people and it is not well-documented and institutionalised. Due to this, next generations will not have a similar practice of the knowledge system to build resilience to climate change risks. This was associated with the advancement of technology, western education system and cultural globalisation. The young generation also considers the practice of indigenous knowledge as an uncivilised tradition experienced by their ancestors rather than focusing on the benefits of this knowledge system.

TABLE 8.5: Trans-Generational Transition of Indigenous Knowledge System in the Case of Phuthaditjhaba

	Question	Respondents' Feed-back	
Q.3	**Would you indicate the level or status of documentation of the practice of indigenous knowledge system in your local area?**	**No. of Re-spondents**	**Re-sponse Rate in %**
A	Highly organised level of documentation	205	0
B	There is some practices of documentation	205	5
C	The status of documentation of the indigenous knowledge system is poor	205	18
D	No documentation at all	205	77
	Question	**Respondents' Feed-back**	
Q.4	**How do you describe the level or status of the transition of indigenous knowledge system from one generation to the other in your local area?**	**No. of Re-spondents**	**Re-sponse Rate**
A	There is high level of transition of the indigenous knowledge system to the younger generation	205	0
B	Only some of the practices are transferred to the younger genera-tion	205	0
C	The indigenous knowledge system is subjected to the danger of loss because of the poor practice of documentation	205	99
D	Not sure to describe the status	205	1

Source: Author's Field Survey (2015).

8.2.2.3 Conflict of Interest in terms of Using Natural Resources at the Periphery Phuthaditjhaba

The historical background also indicates that the traditional land administration system has been practised for a long time. The informal settlements found in the study area are still under the administration of traditional authority (Maluti-a-Phofung, 2013:6). According to the response of experts in the local government, all the land territory administered by traditional leaders is considered as informal. However, the influence of traditional leadership is very high in the area and it directly affects the development process of the formal urban system. Conflict of interest among traditional leaders and local government concerning land administration also makes the territories vulnerable to environmental degradation.

There are multiple systems in terms of land administration co-exist in South Africa particularly, in rural areas governed by traditional authority. The local government and the traditional leaders administer the land in the rural and traditional small towns in the country (Dubezane and Nel, 2016:222). To handle problems associated with the existence of this dual system of land administration, the government of South Africa framed the Spatial Planning and Land Use Management Act, 2013 (SPLUMA), effective in 2015. As indicated by Section 24 of SPLUMA, municipalities ought to exercise a single land use management scheme for the whole municipal area that clearly includes areas under traditional authority. Further, the Regulations Act explicitly excludes traditional leaders from becoming involved in land development or land use management decisions.

Nevertheless, many traditional leaders perceived that SPULUMA excludes them from their core function to land allocation, which is central to their role as a traditional authority, leading to simmering discontent (Williams, 2015, in Dubezane and Verna, 2016:225). Similarly, the land administration in the surrounding area of Phuthaditjhaba is highly influenced by traditional leaders and conflict of interests between the local government and traditional leaders is clearly observed in the area (See Survey result in Table 8.6).

TABLE 8.6: Conflict of Interests in terms of Using Natural Resources at the Periphery of Phuthaditjhaba

	Question	Respindent's Feedback	
		No. of Respondents	Response Rate in %
Q1.	What are casues of the conflicts of intersts between the the tradtional leaders and local government?		
A	Land adminstration at the peripherial area	205	99%
B	Grasaing land utilisation	205	85%
C	Contracting historical and current legal frameworks regarding resource administration	205	99%
D	Trying to enforce of planning standards in the tradtional land admistarion area	205	99%
E	Other Reseasons	205	5%

Source: Author's Field Survey (2015).

The survey result in Table 8.6 indicates that almost all respondents agree to the existence of conflict of interest between the local government and traditional leaders in terms of land administration. This trend has a negative implication for natural resource management and resilience building for climate change risks at the periphery of Phuthaditjhaba.

8.2.2.4 Integrating Indigenous and Scientific Knowledge to Enhance Resilience to Climate Change Risks in the Case of Phuthaditjhaba

As the survey result on Table 8.7 reveals, more than 65% of the respondents agreed on the existence of some practices of integration of indigenous and scientific knowledge in terms of natural resource management and identification of locally adapted crops in the area. Nevertheless, many respondents agreed that integration of indigenous knowledge with scientific knowledge was not observed including in the practice of urban planning. This practice is contrary to the policy initiatives that promote the importance of indigenous knowledge in the areas of biodiversity-management country level.

TABLE 8.7: Integrating Indigenous and Scientific Knowledge to Enhance Climate Change Resilience in the Phuthaditjhaba Area

	Question	Respondents' Feedback	
Q.1	**What are the observable practices to integrate the indigenous knowledge system with scientific knowledge system**	**No. of Respondents**	**Response Rate in %**
A.	Weather forecasting system to decide cropping season and to cope with climate risks	205	5%
B.	Mixed cropping system and rotation to cope with drought or other climate change- related risks	205	85%
C.	Natural environment conservation i.e. forest, spring water, etc.	205	86%
D.	Identification of drought resistant plants and crops species	205	65%
E.	Applying indigenous knowledge in urban planning practice	205	0%
F.	Terracing to conserve soil and water	205	5%
G.	Preparation of traditional medicine from indigenous plant species	205	15%
H.	Other areas?	205	0%

Source: Author's Field Survey (2015).

Generally, from the above discussions, it is possible to recognise the attention given to the practice of indigenous knowledge in South Africa at policy level. Nevertheless, the existing reality at grass-roots level indicates that the use of indigenous knowledge as an input for urban planning or within disaster risk reduction and climate change resilience building in the traditional areas is limited. This is mainly because of the absence of institutions working towards strengthening indigenous knowledge system at the community level.

8.2.3 Spatial Analysis of the Periphery of Phuthaditjhaba

Phuthaditjhaba area is dominated by sedimentary rocks and the soil found near the Drakensberg Mountain range is susceptible to water erosion (Hoffman, Todd, Ntshona and Turner, 1999:8). The Drakensberg Mountain range is registered as a World Heritage site because the area has the following peculiar features: It is the centre of endemic montane plant species; mountains with high altitudes of up to 3 482 m.a.s.l. with exceptional beauty and spectacular sceneries; for the cultural heritage as it is home to the greatest outdoor gallery of rock paintings; and because the area is the most important water catchment area for South Africa, as well as Lesotho (Maluti-a-Phofung Local Municipality, 2014:10). The Golden Gate Highlands National Park can be considered as a comparative advantage to benefit from the tourism industry. Nevertheless, the town can be portrayed as lacking infrastructure and services. Around 68% of the households in the area do not have access to piped water in their home units; around 70% are without access to flush toilets; and around 11% are without access to electricity power (Stats SA, 2012). The poor road networks and weak drainage systems are indicators of the lack of infrastructure in the area. Furthermore, the mountainous landscape makes the cost of infrastructure provision high and the local government has limited capacity to cover these costs. The proliferation of informal settlements around the periphery of the town is also an indication of poor infrastructure and service provision. Additionally, there is a serious problem when it comes to purification and distribution of water in the town (Maluti-a-Phofung Local Municipality, 2014:10).

Source: Adopted from Google Earth (Retrieved on 15/09/2015).

FIGURE 27: Informal Settlements at the Periphery of Phuthaditjhaba

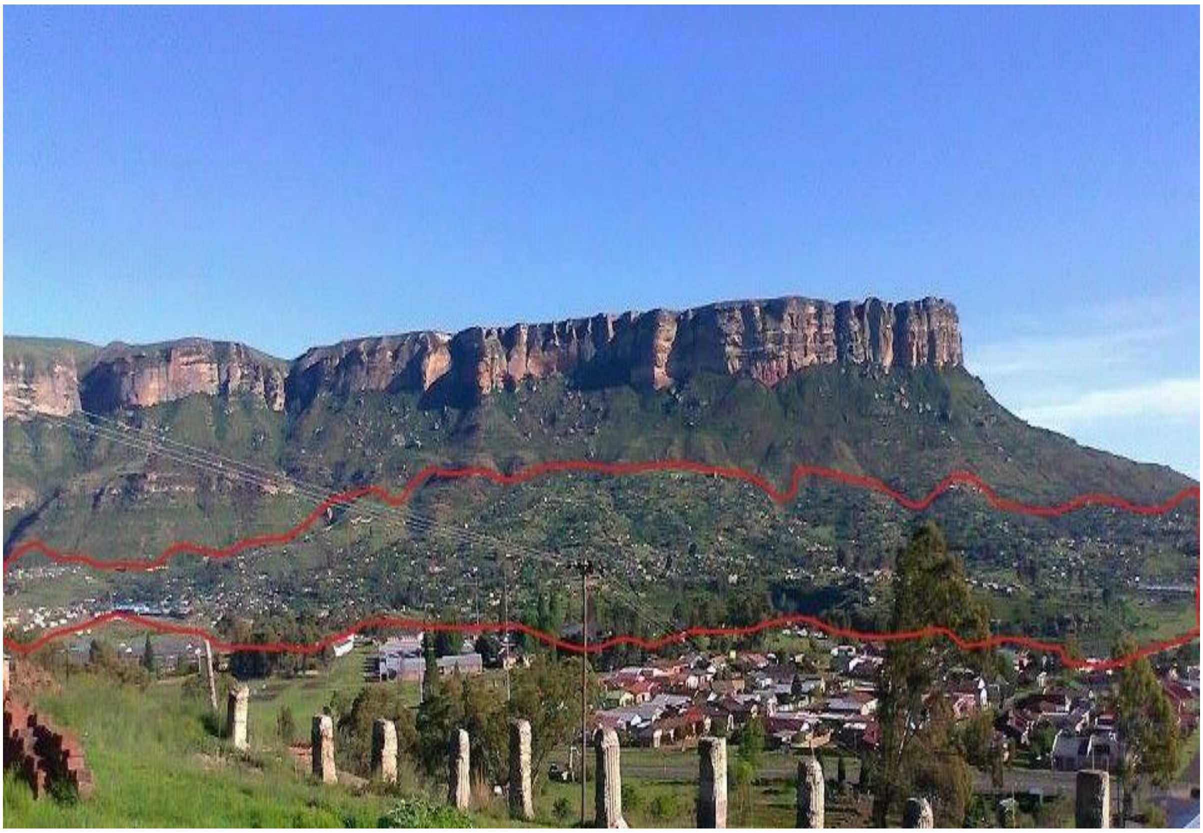
The study site is found in the northern direction of Phuthaditjhaba. The *Mabolela* and *Bochabela* informal settlement sites are located on the hillsides of the Drakensberg Mountains, at an altitude of 1 646 m.a.s.l. The topography of the study site is characterised by irregular terrain and rocky slopes with greater than 20% (Free State Provincial Spatial Development Framework, 2013). The area outlined in red in Figure 27 depicts the study site at the periphery of Phuthaditjhaba town. From the field observation, it is evident that the physical characteristics of the landscape in the area restrict the overall development of the town. Concerning the reasons for informal settlements at the periphery of the town, the officials and experts working in the local government have the following perceptions: more than 60% of the respondents agreed that the major causes of informal settlements at the periphery of Phuthaditjhaba are speculation in land market, failure of the municipality to address the demand for land and housing, failure of the formal market system to address the needs of the poor, uncontrolled rural-urban migration, and historical exclusion because of apartheid (See Table 8.8).

TABLE 8.8: Causes of Informal Settlements at the Periphery of Phuthaditjhaba

Causes of Informal Settlements in Phuthaditjhaba	Number of Respondents	Rate of Response
Speculation in land market	13	65%
Failure of municipality to address the demand for land and housing	13	85%
Failure of the formal market system to address the needs of the poor	13	75%
Rural–urban migration	13	65%
Historical exclusion because of apartheid	13	62%

Source: Survey result from officials and experts (2015).

Regarding the administration of informal settlements in the study site, 75% of the officials and experts prefer to demolish informal settlements or relocate the informal settlers rather than recognising the community's right to live there and improving their resilience capacity at the existing place. Although legalisation such as The Prevention of Illegal Eviction from and Unlawful Occupation of Land, Act 19 of 1998; the Local Government: Municipal Systems Act, 2000; Local Government: Municipal Integrated Development Planning Regulations, 2001; Local Government Gazette 2001; SPLUMA, 2013 and others issued at different periods were not practically applied as per the objectives (HDA, 2013:18), the existing planning practice and perceptions of professionals are not aligned with the historical reality that drives the society to live informally. They consider the informal settlements as a constraint to development and due to this they fail to provide infrastructure and services in the area.



Source: Author’s Field Observation (2015).

FIGURE 28: Informal Settlements at the Bottom of Drakensberg Mountains

As indicated in section 8.2.2.3, the surrounding area of Phuthaditjhaba is administered by traditional authority. According to officials in the local government, there is a conflict of interest between tribal and local municipal councils in terms of accessing land and guiding the development in the area. This opens the door for many rural-urban migrants to settle informally on the outskirts of the town. This is typical of informal settlements in former homeland towns in South Africa (Duma, 2015; Nhlapo, Kasumba and Ruhiiga, 2011). Because of conflict of interest between the municipal and traditional authorities, the area lacks infrastructure and service facilities to improve the living conditions of the society. Furthermore, the issue of natural environment conservation has not received appropriate attention and migrants settle in the area prone to environmental hazards. Thus, they are more vulnerable to climate change risks, for example, flooding from storm water runoff after heavy rainfalls that may also cause rockfalls onto the residential houses found at the bottom of the mountain. The risk to human life and various structures ca be serious unless preventive measures are promptly taken (See Figure 28).

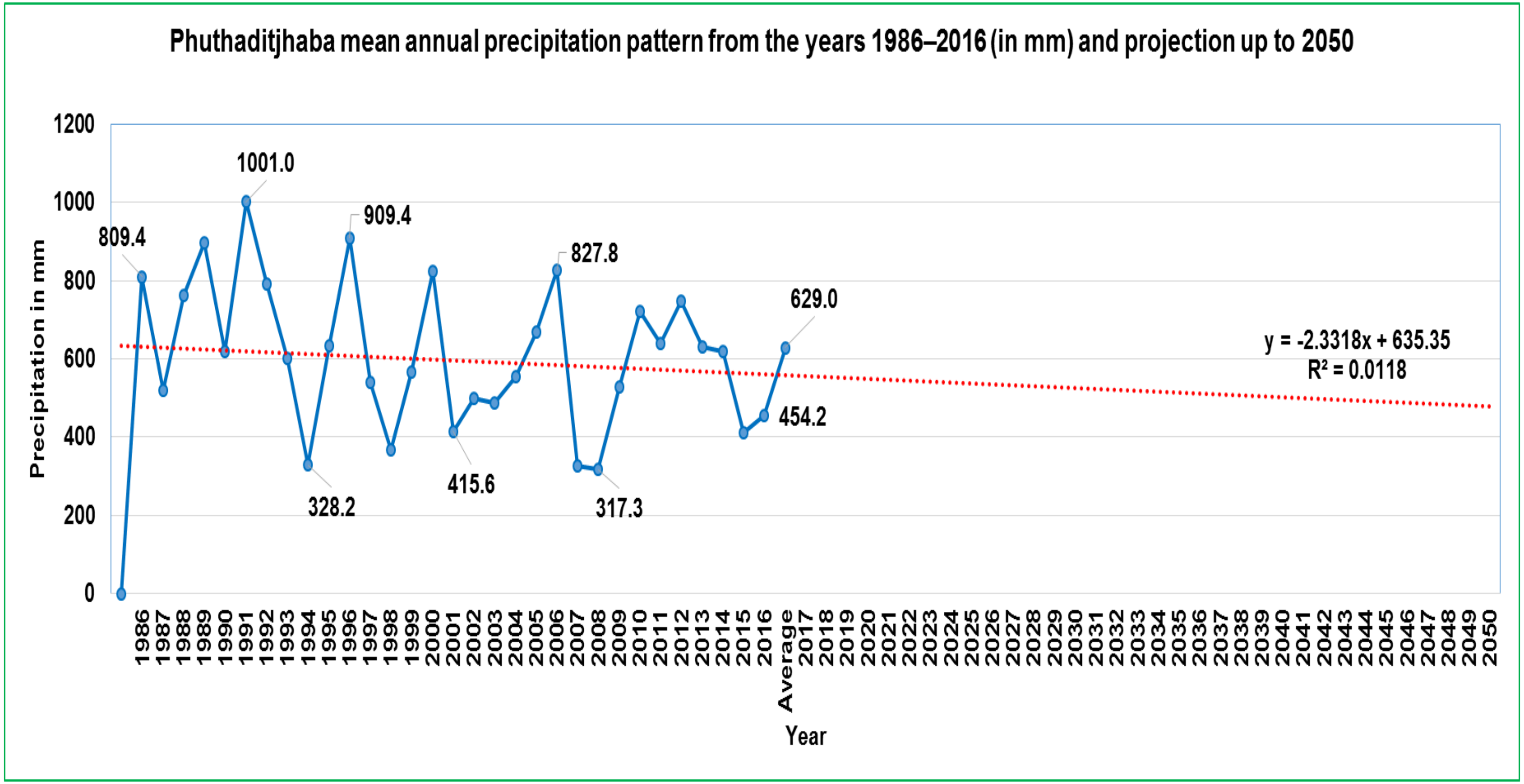
8.2.4 Ecological Features at the Periphery of Phuthaditjhaba

8.2.4.1 Precipitation Pattern

The Maluti-a-Phofung Municipality falls within the summer-rainfall region with the rainy season lasting from October to March. Snowfalls are common in this area. The mean annual precipitation for Maluti-a-Phofung Municipality areas varies between 650 and 850 mm, with averages varying from approximately 450 to 550 mm in the eastern areas to 850 mm in the Drakensberg Mountains and higher-lying areas (Maluti-a-Phofung Local Municipality, 2013:74). The mean annual rainfall distribution varies from 300 mm to about 900 mm in the southeastern part of the mountains near Phuthaditjhaba (Berg and Manley, 2003:1). The area is vulnerable to climate change-associated risks. This is mainly because of mountainous terrain and the sedimentary soils that are susceptible to soil erosion caused by rain, as well as because of weak infrastructure provided in the area. According to Sullivan (2011:630), the Phuthaditjhaba area is highly vulnerable to risks in the water sector due to climate change risks. The research done by Sullivan indicates that the Water Vulnerability Index of the area ranges from 70 to 80. This can be considered as the observable evidence of climate change risk in the study area.

The last three decades' meteorological data indicate that the mean annual rainfall for Phuthaditjhaba was 629 mm. The highest mean rainfall of 1 001.1 mm was registered in the year 1991. The lowest mean rainfall of 317.3 mm was registered in the year 2008. The rainy season ranges from September to April with heavy storms, and winters are cool with irregular snow. (See Table 2.1, Appendix 2.) The meteorological[18] data were captured from the Agricultural Research Council Institute for Soil Climate and Water (ARCISCW), South Africa (2016). The red line in Figure 29 demonstrates that the trend of mean precipitation pattern in Phuthaditjhaba in the past 30 years. This trend line indicates that there has been declining precipitation and the projection of rainfall, likewise showed that the declining precipitation pattern. This can be recognised as one of the indicators of climate change in this study area (See Figure 29).

[18] **Nearest Station**: Qwaqwa: UNIQWA; **Station ID**: 30426; **Latitude:** -28.48287; **Longitude:** 28.82522; **Altitude:** 1699; **Date**: 01/01/1986-31/08/2016



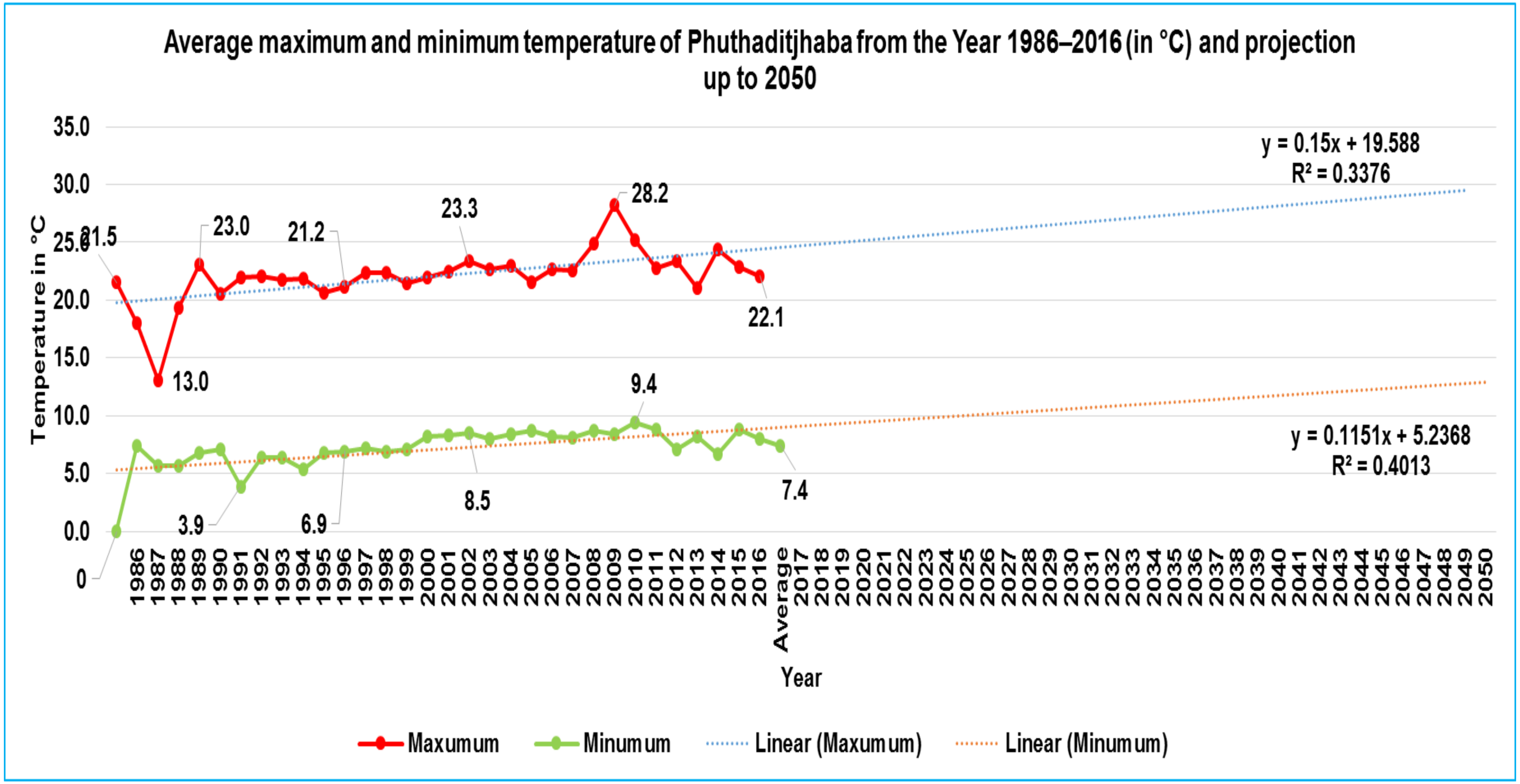
Source: Agricultural Research Council Institute for Soil Climate and Water (ARCISCW), South Africa (2016) (See Tables 2.1, Appendix 2)

FIGURE 29: Annual Average Precipitation Pattern of Phuthaditjhaba from the Year 1986-2016 and Projection up to 2050

From the responses of the residents in the informal settlements, it was noted that heavy seasonal rainfall has demolished their houses. Other risks relate to wind and rockfalls. The area experiences a windy season from August to December with greater average wind speeds than the rest of the year. Heavy thunderstorms accompanied by strong winds cause soil erosion and rockfalls from the mountain slopes. This cumulative effect of climate change-related risks makes the people living in the informal settlements susceptible to hazards.

8.2.4.2 Range of Temperature

According to Maluti-a-Phofung Local Municipality (2013:74), average temperatures at broader municipal level vary from 14 °C to 32 °C during summer, to 4 °C to 20 °C during winter. In the case of Phuthaditjhaba, specifically, the last 30 years' meteorological data indicate that the average maximum and minimum annual temperatures are 22.1 °C and 7.4 °C, respectively (South Africa Agricultural Research Council Institute for Soil Climate and Water [SAAR-CISCW], 2016). (See Tables 2.2 and 2.3, Appendix 2.) The trend and projection lines show that the average temperature in the area is rising. This can be perceived as one of the indicators for climate change in Phuthaditjhaba area. (See Figure 30) In addition, there were incidences of veld fires during hot seasons that damaged biodiversity and caused soil erosion at the periphery of the town.



Source: Agricultural Research Council Institute for Soil Climate and Water (ARCISCW), South Africa (2016) (See Tables 2.2 and 2.3, Appendix 2)

FIGURE 30: Annual Average Temperatures of Phuthaditjhaba from the Year 1986-2016 (in °C) and Projection up to 2050

8.2.4.3 Vegetation Features

According to Mucina and Rutherford (2006:19), the vegetation in the Phuthaditjhaba area falls within the Drakensberg grassland bioregion. The grasslands are classified in five vegetation types, namely: Eastern Free State sandy grassland; Basotho montane shrub-land; northern Drakensberg highlands grassland; Drakensberg-Amathole Afromontane fynbos and Lesotho highland basalt. There are extensive grazing lands at the periphery of Phuthaditjhaba. The residents are experienced, with mixed livestock production and crop production. The urban sprawl is now engulfing the grazing lands at the periphery (Free State Provincial Spatial Development Framework, 2013:5).

Source: Author's Field Observation (2015).

FIGURE 31: The Grasslands at the Periphery of Phuthaditjhaba

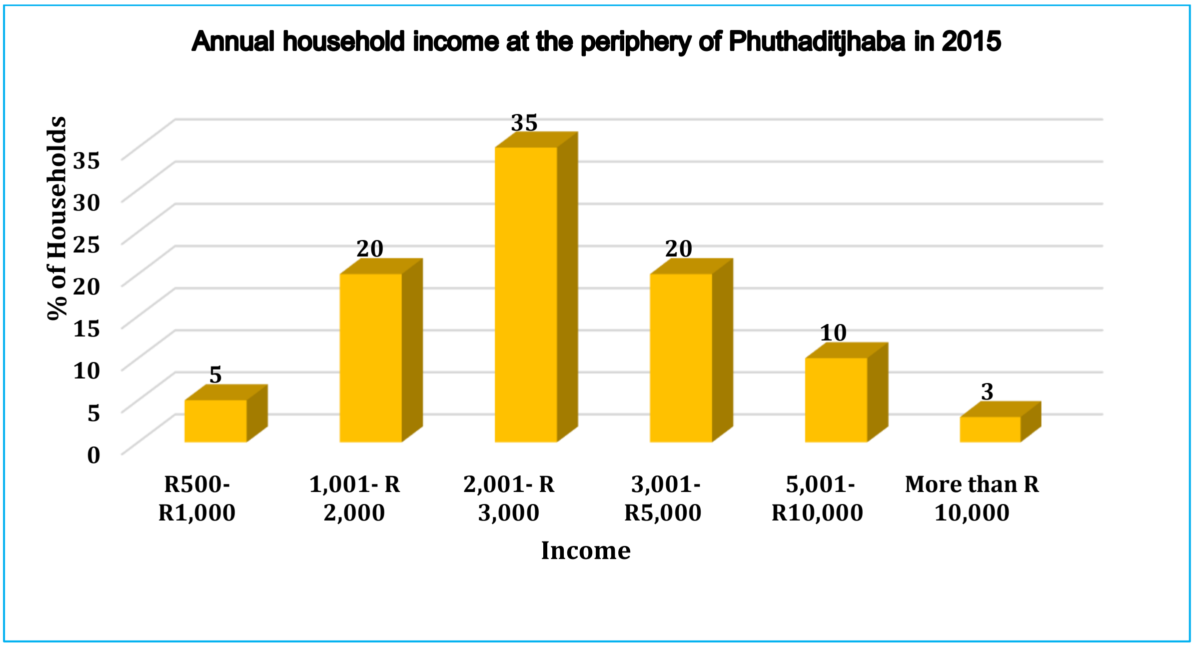
The periphery of the Phuthaditjhaba built-up area is characterised by environmental degradation due to overgrazing (Chingombe and Taru, 2013). Although the area is the most crucial water catchment area for the people of South Africa, the impact of drought causes a shortage of water that severely affects the amount of water available in the area (Maluti-a-Phofung Department of Water, 2015). The field observation during the study also depicts that the impact of overgrazing is high on communal land and it causes soil erosion in the area (See Figure 31). The survey result captured from residents of informal settlements also showed that the impact of climate changes is clearly observed in the area. Reduction of local plant species, increases in temperature, fluctuations in rainfall and a serious shortage of water, and increased incidence of drought are manifestations of the impact of climate changes. Therefore, a focus should be given to managing resources and supply of water and storm water utilisation.

8.2.5 Economic Characteristics

The Maluti-a-Phofung Local Municipality is one of the poorest areas in the Free State Province, where about 60% of households generate an income of less than R1 650 per month. Over 80% of the Maluti-a-Phofung Local Municipality population lives in Qwaqwa (Stats SA, 2012). Internal economic migration is one of the common demographic characteristics in the area. The gender distribution is also evidence of the migration of male workers from the area. The gender ratio over the year 2001 to 2011 has increased nationally, provincially and in the district. However, it indicated a decrease at the Maluti-a-Phofung local area. This is mainly because the area lacks manufacturing, construction and mining industries that can possibly accommodate the existing labour force in the area. Due to this, much of the local labour force migrates to other parts of the country in search of employment.

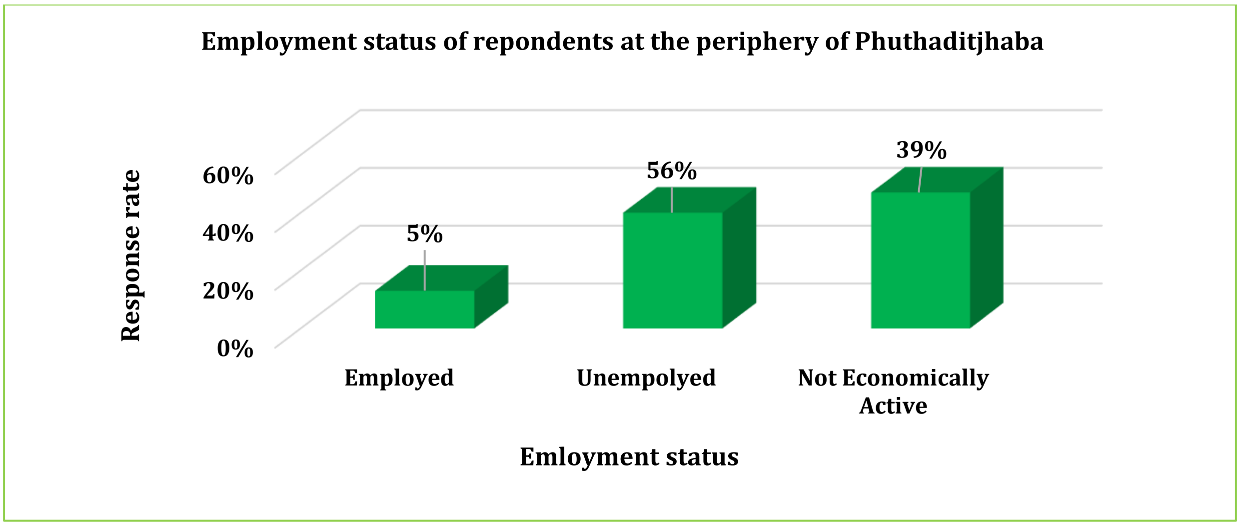
The percentage of the economically active age group 15 to 64 years increased from 4.9% to 5.3% (Stats SA, 2012). On the other hand, the percentage of older age group above 64 years rose from 60.6% to 62% in the years 2001 and 2011, respectively. This implies an increase of dependency ratio, and people that are more elderly are dependent on the economically active age groups. The average economic growth rate of the area is 1.9% per annum, which is slightly lower than the provincial growth rate of 2.1% and the national growth rate of 3.3% per annum. The economy of the area is less diversified and concentrates on community services that account for more than 54% of Gross Value Added (GVA). The manufacturing, construction and agricultural sectors are very limited in the area. Therefore, the economy of the area is vulnerable to external factors such as climate change risks and price fluctuations. There are also limited employment opportunities in the area with an unemployment rate of about 52% (IHS Global Insight, 2013:2), indicating that there is limited income-generation capacity, no savings and no investment to accumulate assets.

The South Africa index of Multiple Deprivation for 2011 is weighted by using a combination of four domains of deprivation, such as material deprivation, employment deprivation, education deprivation and living environment deprivation (Nobel et al., 2013:18). According to Noble et al. (2013), 36.8% of the population of QwaQwa live with material deprivation; 56% with employment deprivation; 22.8% with education deprivation; and 61.4% with environmental deprivation. In terms of income poverty, 74.9% of the population live in the lower poverty line (R604), and 83.4% in the upper poverty line (R1 113). This level of income poverty is higher than that of the average income poverty in all other homelands, which is 73.4% and 81.7%, respectively, and from all South Africa, which is 55.7% and 64.6%, respectively. This is manifested by a lack of infrastructure and service facilities to attract manufacturing and other investments; low household income; the high youth unemployment rate of up to 52%; and subsistence living conditions (Stats SA, 2012). High levels of unemployment, coupled with low incomes, make the residents of informal settlements vulnerable to the risks of climate change in the area. As the survey result reveals in Figure 32, about 90% of the residents in informal settlements earn less than R10, 000 per year and about 39% of the residents are economically dependent on those employed, while 56% are unemployed.



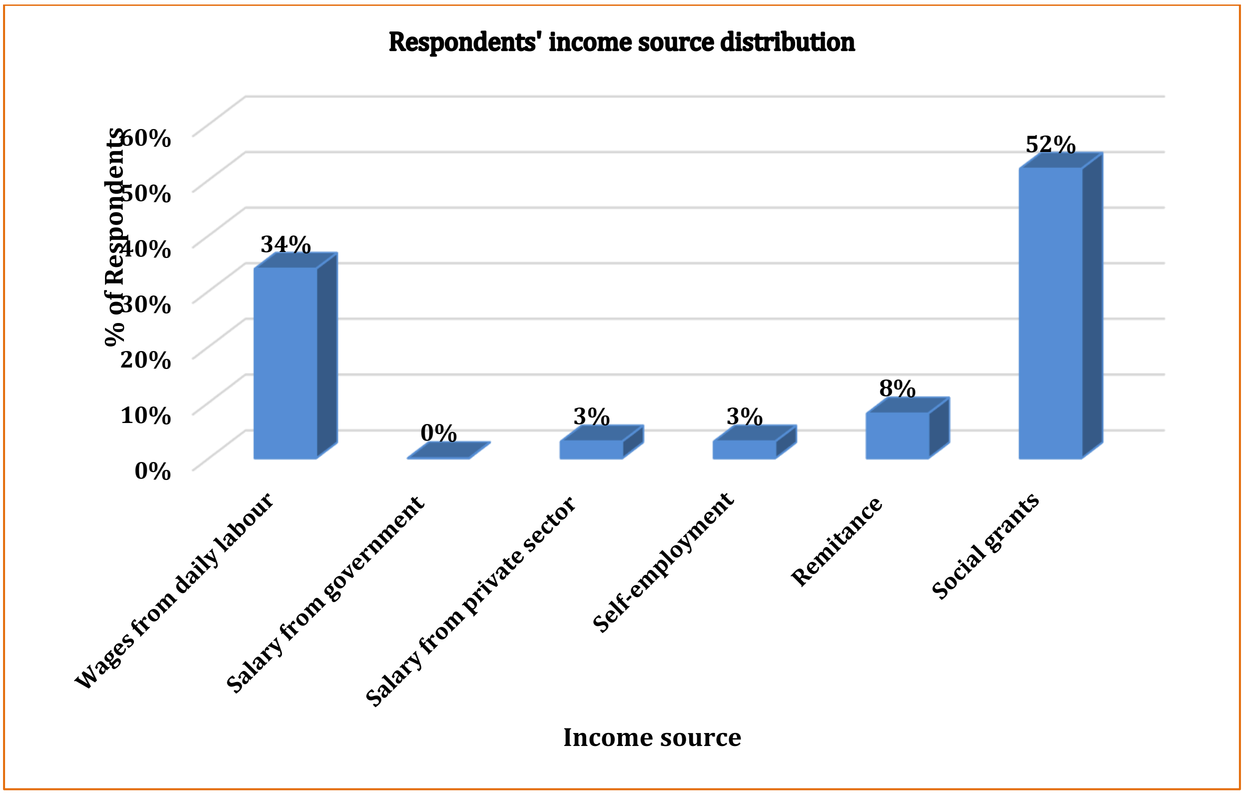
Source: Author's Field Survey (2015). See Table 1.1, Appendix 1

FIGURE 32: Annual Household Income at the Periphery of Phuthaditjhaba in 2015



Source: Author's Field Survey (2015). See Table 1.2, Appendix 1

FIGURE 33: Employment Status at the Periphery of Phuthaditjhaba in 2015



Source: Author's Field Survey (2015). (See Table 1.3, Appendix 1)

FIGURE 34: Respondents' Income Source Distribution at the Periphery of Phuthaditjhaba in 2015

The survey result also indicates that 52% of the respondents are dependent on social grants and 34% are dependent on wages from casual daily labour. As Figure 32 shows, almost 90% of the residents live below the subsistence level. This implies that the residents have a shortage of financial and economic capital to deal with disaster risks. This is confirmed by Stats SA

(2012). A higher level of unemployment indicates that there is limited income-generation capacity with no savings or investments to accumulate assets arising from the high level of poverty in the area. Because of this, significant numbers of the productive workforce migrate to other parts of the country. However, the area also attracts many poor people from the surrounding rural areas who have no option other than living informally in environmentally sensitive areas. Although, the existence of Golden Gate National Park 7 km from the town, the Drakensberg Mountain range and World Heritage site makes Phuthaditjhaba a point of destination for many tourists, the town does not use this comparative advantage of natural and cultural sites (Chincombe and Taru, 2013:3) that could possibly attract more tourists to generate revenue and would enable the local government to provide better infrastructure and service facilities and to leverage employment for the local community.

8.3 Intensity of Climate Change-Induced Risks at the Periphery of Phuthaditjhaba

The residents living informally on the periphery of the town are vulnerable to climate change-associated threats because of social, spatial, ecological and economic conditions. Lack of resources and weak coping mechanisms exacerbate the severity of the dangers. Based on the survey results, water shortages due to rainfall variability, soil erosion, flash flooding, rock falls from hillsides, extremely cold winters, seasonal damaging winds, hot summers and veld fires are the most observable climate change-induced risks in the study area. The high level of poverty in the area makes the residents more vulnerable to these risks (Stats SA, 2012). Table 8.9 depicts the relative severity of the risks in the study site. The results indicated on the table are derived from the percentages of responses from the residents of informal settlements and experts from the local government office about the existing climate change-induced risks.

As Table 8.9 indicates, the climate change-induced risks are arranged based on their level of severity. Where more than 80% of the respondents agree that the intensity of risk is high, it is considered as a serious problem that needs urgent coping strategies in the study site.

TABLE 8.9: Respondents' Feedback about Climate Change-Induced Risks at the Periphery of Phuthaditjhaba

Climate Change-Induced Risks	Number of Respondents	Intensity of Risks		
Direct Climate Change Risks		**High**	**Medium**	**Low**
Shortage of water	205	100%		
Severe thunderstorms	205	95%	5%	
Flash flooding	205	85%	15%	
Cold winters	205	85%	15%	
Seasonal strong and damaging wind	205	75%	25%	
Hot Summer	205	65%	35%	
Veld fire	205	55%	45%	
Lose of biodiversity	205	95%	5%	
Indirect Climate Change-Linked Risks				
Soil erosion	205	100%		
Raockfalls from hillsides	205	90%	10%	
lose of grazing land	205	90%	10%	
Decrease in soil fertility	205	90%	10%	

Source: Computed from Field Survey, 2015

To confirm the results captured from the survey of residents and experts, focus-group discussions were held. The outcome also confirmed the same results. Accordingly, any coping strategy should consider the major threats in the area. The strategy should give priority to improving housing quality and income levels of the community, implement afforestation schemes and create wind breaks, provide drainage systems and further real solutions for other risks.

8.4 Analysing Climate Change Resilience Capacity at the Periphery of Phuthaditjhaba

Evaluation of climate change-resilience capacity of a certain area requires comprehending complex and interlinked variables in the social, ecological and economic system. Based on this, instead of using a single instrument to analyse resilience in a certain area, it is preferable to use a combination of different analytical tools. In this case, the aim is to obtain a more reliable outcome in terms of assessing climate change-resilience capacity. Accordingly, evaluating existing resilience capacity of a certain area is a point of departure to plan and improve the situation. Thus, the combination of two approaches is realised in order to evaluate resilience capacity of informal settlements at the periphery of Phuthaditjhaba. The analyses of resilience capacity of the study sites have been done by a matrix of the two approaches. These are ***"principles to build a resilient system"*** that are proposed by Biggs *et al*. (2015:3-18) and *"capitals for disaster resilience"* suggested by Cutter et al. (2010:7).

The principles to build a climate resilient system are to 1) maintain diversity and functional redundancy; 2) manage connectivity and independence of system components; 3) manage major variables and feedbacks; 4) foster complex adaptive systems thinking; 5) promote participation and polycentric governance systems. On top of this, the capitals for climate change resilience adopted for this study are social capital, economic capital, natural capital, human capital, physical capital and institutional capital. These approaches are customised to analyse climate change-resilience capacity of the case study sites. The capitals existing in the study sites are examined against these principles.

TABLE 8.10: Matrix of "Principles of a Resilient System" and "Capitals for Climate Change Resilience" in the Case of Periphery of Phuthaditjhaba

Principles/Attributes of Resilient System	Capitals for Climate change resilience					
	Economic	Human	Social	Physical	Natural	Institutional
Diversity and functional redundancy	*	*	*	*	*	*
Connectivity and independence of system components	*	*	*	*	*	*
Major variables and feedbacks	*	*	*	*	*	*
Complex adaptive system thinking	*	*	*	*	*	*
Promoting participation and polycentric governance systems	*	*	*	*	*	*

Source: Author's own (2015).

Principle 1: Maintain Diversity and Functional Redundancy

Diversity and functional redundancy of economic capital: The report of Stats SA (2012) indicates that the dominant economic sector in Phuthaditjhaba is community service, which accounts for more than 54%. As indicated in section 8.2.5 above, in terms of income poverty, more than 74.9% of the population of Phuthaditjhaba live below the poverty line (i.e. they earn less than or equal to R604 per year) and 56% of the population live with employment deprivation (Nobel et al., 2013:18).

In addition, the survey undertaken during the study depicts that 52% of residents in the informal settlements are dependent on social grants and 34% are dependent on wages from casual daily labour as a source of income. The diversity of income and employment opportunities can be considered as indicators of resilience. However, there is a limited employment opportunity in the area. Due to this, many local labourers migrate to other parts of the country to search for employment opportunities. Therefore, the community of the study site is vulnerable to climate change risks and the high cost of basic needs. As indicated in IHS Global Insight (2013:2), the rate of unemployment is about 52%. The high level of unemployment leads to limited income generation capacity and lesser economic capital. This is one cause for the high level of poverty in the area. The more limited economic capital in the area, the less climate change-resilience capacity will be in the area.

Diversity and functional redundancy of human capital: In the case of Phuthaditjhaba Stats SA (2012) indicates that 8.9% of the individuals aged older than 20 years are not schooled, while those of age older than 20 years who had an opportunity for higher education account for only 7.9% of the population. The educational status of informants in the study site indicates that 22% are illiterate, 31% can read and write, 34% attended primary education and the remaining 13% attended secondary education. This shows that more than 78% of the respondents could at least read and write (See Table 8.3). This can be taken as an opportunity to promote environmental education at community level. The existence of cheap labour in the study site can also be recognised as a positive factor to enhance resilience capacity. However, the outcome of the interviews with officials revealed that the municipality does not use the advantage of the existing labour force for natural environmental conservation works.

Diversity and functional redundancy of social capital: The land at the periphery of the town has been administered by traditional leaders for a long time. Traditional leadership plays a prominent role in the area, directly affecting the development process of the formal urban system. The informal settlements found in the study site are still under the authority of the traditional authority. As shown in the outcome of the interview held with traditional leaders, the community has the practice of conflict resolution through traditional approaches and indigenous knowledge of traditional healing by using indigenous plants. However, in terms of natural environment conservation, the community do not utilise their social capital effectively, especially in the process of administering communal resources such as grazing lands. This is seen in the existence of over-grazing and veld fire outbreaks in the communal land. The study site is also characterised by poor health, education and infrastructure facilities and a high crime rate (Maluti-a-Phofung, 2013). This affects the climate change resilience capacity of the community at the study site negatively.

Diversity and functional redundancy of physical capital: The area is characterised by poor infrastructure facilities such as poor road layout, drainage systems and housing. As the report of Stats SA (2012) depicts, 68% of the households in Phuthaditjhaba lack access to piped water in their dwelling units, 70% are without access to flush toilets, and 11% are without access to electricity. Noble et al. (2013:18) also confirm that 61.4% of the population live with environmental deprivation. According to the interviews with officials in the municipality, the steep slopes with a gradient of over 20% and irregular terrains make the cost of infrastructure provision very high and the local government cannot afford these costs. The proliferation of informal settlements around the periphery of the town is also an indication of poor infrastructure and service provision in the area. As the report of Maluti-a-Phofung Local Municipality (2014:10) reveals, there is also a serious problem when it comes to the purification and distribution of water in the area.

***Diversity and functional redundancy of natural capital*:** Availability of tourist attractions nearby Phuthaditjhaba such as Golden Gate National Park, the Sterkfontein Dam and the Drakensberg Mountain ranges can be considered as potential tourist-attraction natural capitals. The attractive scenery, endemic montane plant species, an altitude of up to 3 482 m.a.s.l., and the fact that the area is the most crucial water catchment area for South Africa, are comparative advantages the town can use to boost its economic activities and extend its infrastructure. As indicated in Mucina and Rutherford (2006:19), the coverage of vegetation in the Phuthaditjhaba area is characterised by the Drakensberg grassland bioregion. However, natural environment conservation has not enjoyed an appropriate priority in the area. Due to this, environmental degradation is commonly observed at the periphery of the town. Table 8.11 shows the landscape capacity recovering from climate change-induced risks. The figure is derived from the rate of responses from officials and experts from the local government offices and the residents living in the study site. The rate of restoration capacity of the landscape in the study site is categorised by three levels: *High, Medium* and *Low*. This is undertaken to identify the level of climate change-induced risk in the site and to prioritise the risks to take the necessary intervention just in time.

TABLE 8.11: Respondents' Feedback about the Landscape Capacity to Recover from Climate Change-Induced Risks at the Periphery of Phuthaditjhaba

Climate Change-Induced Risks	Number of Responndents	Landscape Capacity to Recover from Risk					
Direct Climate Cahnge Risks		**High**	**%**	**Medium**	**%**	**Low**	**%**
Shortage of water	205			96	47	108.65	53
Irregualr thunderstorm	205			14	7	190.65	93
Drought	205			154	75	51.25	25
Flash flooding because of erratic rainfall	205					51	25
Extremely cold winters	205	51	25	154	75		
Seasonal strong and damaging winds	205			21	10	184.5	90
Hot summer	205	51	25	154	75		
Veld fire	205	27	13	178	87		
Indirect Climate Change-Linked Risks							
Soil erosion	205			21	10	185	90
Rockfalls from hillsides and landslides	205			12	6	192.7	94
Decrease in soil fertility	205			33	16	172.2	84
Lose of grazing land	205			41	20	172.2	80

Source: Author's Survey Result (2015).

As indicated in Table 8.11, soil erosion and infertility because of over-grazing, shortages of water because of rainfall variability, the outbreak of veld fires and rock falls from hillsides are the most critical problems observed in the study site. Therefore, the people residing informally in environmentally sensitive areas are vulnerable to these climate change-induced risks at the periphery of the town. The urban sprawl in the area negatively affects these natural resources, namely grazing land and the proliferation of settlements in environmentally sensitive areas.

Diversity and functional redundancy of institutional capital**:** The availability of different rules, regulations, programmes, policies and governance structures helps authorities to deal with climate change-related risks. One of the major policy documents to deal with climate change threats is the *National Climate Change Response White Paper* (South Africa, 2011) that was formulated to address the risks associated with climate change. There is also legalisation designed to address the issue of informal settlements in the country (See empirical legal frameworks on Chapter 7, section 7.5). However, the notion of climate change resilience of informal settlements has still not been addressed as the magnitude of the challenge. Rather, the legal acts seem to be biased to solve the challenges of the formal urban systems.

In addition, institutional capital is also determined by the level of coordination among the key stakeholders to promote climate change-resilience capacity in the particular area. Based on the outcome of the focus-group discussion, there was weak coordination among key actors in order to deal with environmental degradation at the periphery of Phuthaditjhaba. In addition, there is a big gap at the implementation phase of those policy and legislation at grass-roots level. One of the reasons for this, in the case of Phuthaditjhaba, is conflict between traditional leaders and local council.

Principle 2: Manage Connectivity and Independence of System Components

Connectivity and independence of economic capitals: Strong connectivity between the subsystems of economic capital is essential to withstand and/or restore climate shocks. For instance, linkages among economic sectors, employment opportunities and income sources in a particular area can be taken as determining factors to improve resilience capacity. Based on this fact, the dominant source of employment opportunity in the case of Phuthaditjhaba is community service, which accounts for 54% of employment opportunities (Stats SA, 2012). Due to lack of employment opportunities, people migrate to another part of the country. This implies that there is weak connectivity among subcomponents of the economic system in the area. Therefore, the community living in the study site is easily vulnerable to climate change risks because of lack of this economic capacity.

Connectivity and independence of human capital*:* This refers to assigning the right skilled manpower at the right place. The human structure at local government offices indicates that there is a shortage of manpower, especially in the departments like urban planning, infrastructure and water development departments. This affects environmental conservation works in the area negatively. In addition, the focus-group discussion revealed that even the existing human resources in the local government offices are not working in a coordinated manner.

Connectivity and independence of social capital: As the survey result in The interviews held with the traditional leaders reveals that the community uses indigenous knowledge to improve their livelihood and to conserve the natural environment. The field survey results also indicate that 55% of the respondents agree about the existence of a strong social network and culture of working together to cope with climate change risks. Regarding the experience of traditional leadership to reduce conflict in resource utilisation, 65% of the respondents agree about this culture. More than 35% of the respondents also agree about the existence of the traditional agricultural practice to cope with climate change risks. There is also a traditional weather forecasting system to decide on the cropping season, 45% of the respondents agree about the existence of this practice on this. (See Table 8.4)

depict, there is a weak social network, especially for natural environment conservation. In addition, they agree on that there is weak common resource pool management, particularly with respect to grazing lands. About 70% of the respondents agree with these perspectives. This implies that connectivity of social capital is weak, which increases the vulnerability to risks associated with climate changes.

Connectivity and independence of physical capital: This is related to landscape and infrastructure connectivity and independence. In the study site, there is a gully between the built urban area and informal settlements at the bottom of the Drakensberg Mountain at the northern side of Phuthaditjhaba. This makes the cost of infrastructure development high and affects landscape connectivity negatively. On the other hand, concerning connectivity of infrastructure subsystems such as water, electricity, telecommunication and roads, keeping the independence of these components has its own advantages to enhance resilience capacity. In this case, it is better to differentiate those lifelines structurally (Biggs et al., 2015:6). When components of a system are independent in terms of supplying services, the probability of failure in the process of service provision becomes less, which strengthens the resilience of the system. For instance, if the water supply is dependent on more than one source of power, the possibility of disconnection of water due to natural or manmade damages will be reduced. The more independent system components become, the more resilient the system is. Therefore, when designing certain infrastructure and services, proactive thinking is crucial to enhance resilience. In this regard, the municipality considered the study site as an informal area administered by traditional leaders; thus, independent facilities are not provided. Therefore, the level of vulnerability to climate threats will be high unless the responsibility of both authorities is clarified.

Connectivity and independence of natural capital: Regarding the natural resource utilisation, this attribute is customised to the community's dependency on limited natural capitals. In the context of informal settlements at the periphery of Phuthaditjhaba, there is excessive quarrying of stones for the construction of houses and over-grazing, which cause environmental degradation. To deal with this problem, environmental impact assessment for the quarry site should be employed by involving stakeholders and the grazing capacity of the area should be controlled.

Connectivity and independence of institutional capital: As the outcome of focus-group discussion reveals, there is weak coordination among institutions regarding climate-improving resilience capacity at the study site. This can be confirmed by conflict of interest between the political decisions and professional decisions to solve some community problems at the periphery. Institutions should coordinate to create synergy and to become efficient and effective in the process of achieving development goals. This can be realised without jeopardising the purpose of the establishment. As the outcome of focus-group discussion also depicts, institutions at local level prefer to work independently because of cumbersome administrative procedures. This affects the natural environment conservation at the study site adversely.

Principle 3: Manage Variables and Feedbacks

Managing variables and feedback of economic capital: Identification of the average household income level, the profile of economically active and not active or dependent, employed and unemployed people in the area should be done. The community in the study site is characterised by a high percentage (90%) of the households that have an income less than R10 000 per annum, an unemployment rate of 56%, and about 39% of the residents are dependent or not economically active. (See Figure 32, Figure 33 and Figure 34). This economic profile reveals that the community experiences living conditions below acceptable subsistence levels; thus they are vulnerable to climate change-related and other disaster risks. Managing economic variables and feedback are crucial to taking the appropriate interventions towards improving resilience capacity of the study site. However, from the interviews with officials of the municipality, the local offices do not have appropriate records of the economic profile of the community at the study site. This is mainly because the area is considered as illegal and administered by traditional leaders. This affects the possibility of improving the livelihood and climate change resilience capacity of the community in the study site badly.

Managing variables and feedback of human capital: Keeping the records of skilled and unskilled labour force in a particular area is necessary, because it enables authorities to determine the cost of labour and capacity to manage all other capitals in the area. In the case of Phuthaditjhaba, Stats SA (2012) states that 8.9% of the individuals aged over 20 years are not schooled, and only 7.9% of the population older than 20 years received higher education. This implies that there is a limited number of educated people in the area. In other words, the capacity to manage other capitals to improve climate change resilience in the area is low.

Managing variables and feedback of social capital: Established networks of cooperation in society can serve as a channel that conveys information about the influences of climate change at a certain area. In the context of the study site, the survey results revealed that the social bonds or culture of working together to conserve the natural environment is very weak. The interviews held with the traditional leaders reveals that the community uses indigenous knowledge to improve their livelihood and to conserve the natural environment. The field survey results also indicate that 55% of the respondents agree about the existence of a strong social network and culture of working together to cope with climate change risks. Regarding the experience of traditional leadership to reduce conflict in resource utilisation, 65% of the respondents agree about this culture. More than 35% of the respondents also agree about the existence of the traditional agricultural practice to cope with climate change risks. There is also a traditional weather forecasting system to decide on the cropping season, 45% of the respondents agree about the existence of this practice on this. (See Table 8.4)

This holds true for communal land management and is evidenced by environmental degradation at the periphery of Phuthaditjhaba. When comparing the status of the social network of Phuthaditjhaba to that of Karat, the experience of the community at the periphery of Karat is better as seen in collaborative societal work of terracing to conserve soil and water for long periods to adapt to periodic droughts in the area. The stronger the societal network in the area, the less the chance of the community becoming susceptible to climate change-related risks.

Managing variables and feedback of physical capital: The quality and coverage of infrastructure facilities should be recorded clearly. The status of infrastructure should be updated continuously. The state of infrastructure at the study sites "*Mabolela*" and *"Bochable"* at the periphery of Phuthaditjhaba is very poor. As confirmed by local officials, the cost of infrastructure provision at this site is very high. The steep slopes make the area susceptible to soil erosion and falling of stones from the top of the mountain. The field observation reveals that there no remedial measures are taken by both the municipality and traditional leaders in order to deal with the environmental degradation at this site. The risk of climate change will thus increase, unless prompt interventions, such as afforestation of the lower slopes of the mountain and restricting the settlements on environmentally sensitive sites are implemented.

Managing variables and feedback of natural capital: The level of accumulation of renewable and non-renewable natural resources should be registered and documented appropriately. Any change in the status of resources should be updated and documented. As the outcome of the interview with officials from the local government revealed, the status of natural resources is poorly recorded, especially at the periphery of the town where the land is administered by traditional leaders. This is mainly because the area is considered as informal areas. This implies that the area may be losing important non-renewable resources because of conflicting interests between the local government and the traditional leaders.

Managing variables and feedback of Institutional capital: This refers to the existence of relevant policies and institutional structures that facilitate smooth flow of information and promote coordination among the key stakeholders in order to improve resilience capacity in the area. The acts associated with informal settlements administrations does not encourage the demolition of informal settlements without considering the historical backgrounds of the settlements. In the context of the study site, the result of the focus-group discussion indicates that the reality on the ground does not reflect the rules and regulations. The horizontal and vertical institutional linkages are not well administered. This is seen by conflicting interventions taken by different departments to solve problems such as the provision of electricity and water without considering the guiding plan, affecting the development process negatively, because it is irregular and not aligned with the plan.

Principle 4: Foster Complex Adaptive Systems Thinking

Foster complex adaptive systems thinking to enhance resilience capacities**:** Promoting resilience capacities in a certain area requires comprehending complex interactions of major variables of economic, social, human, physical, natural and institutional capitals. This opens the door for flexibility to manage unprecedented changes. Accordingly, the agenda of climate change resilience of informal settlements should be handled in a flexible manner, rather than implementing rigid standards set for the design and provision of infrastructure and buildings in the formal urban system. The outcome of the interviews with officials revealed that they prefer the displacement of residents or demolishing any informal settlements that interfere with the formal plans. This implies that the actors still do not understand the historical causes of informal settlements in the study site (See Table 8.8).

Therefore, producing skilled human resources that can manage flexibly and recognise the issue of informality is very important. Also, the implementation of legislation should be done flexibly by considering the context of that particular area while enhancing the use of traditional knowledge by harmonising with the institutionalised system. However, the result of the focus-group discussion revealed that any interventions undertaken by the local government are in favour of the formal urban system, rather than accommodating the issues of informal settlements. This implies that understanding the complex interaction between the formal and informal urban system is still in its infancy. Furthermore, concerning the physical situation of housing in the study site, it was clear that houses are built from poor-quality construction materials that expose the residents to risks of climate extremes. To solve this problem, the low-cost housing programmes should also be implemented in this area. This will avoid the possible social and economic problems caused when the settlements are demolished, and enable the local community to improve their resilience capacity.

Principle 5: Broaden Participation and Promoting Polycentric Governance

This principle encourages the involvement of key stakeholders in the process of development and decentralised system of governance. It also promotes participation of people found at the grass-roots level in the process of resource utilisation and decision making. This enables authorities to come up with local solutions to local problems. In the context of the study site, the outcome of the focus-group discussion showed that the existence of a conflict of interest among traditional leaders and local municipal councillors makes it difficult to realise broad-based participation and devolution of decision-making power at grass-roots level. The studies undertaken by Dubezane (2015), Mbense (2015) and Seikonyela (2014) in the previous homeland areas of South Africa support this argument. Any development projects have to be done based on in integrated intervention approach. The synergy created among all the projects should enable authorities to assure the efficiency of resource utilisation. Coordinating the local and scientific knowledge, agricultural products with agro-processing and other small-scale industries and market opportunities can enable the community to ensure efficient and effective utilisation of all kinds of resources. Based on this principle, the study area missed this kind of integration in the development process and much still has to be done to enhance climate change resilience.

8.5 Conclusion

The vulnerability of informal settlements found in the peri-urban community of Phuthaditjhaba town was analysed by using aggregates of different instruments, specifically, the study site that includes the *Mabolela* and *Bochabela* informal settlements. The analysis reveals that the area is vulnerable to climate change-induced risks such as shortage of water, extremely cold weather during winter, strong and damaging winds, rock falls from the mountains, and flash flooding caused by heavy rainfall. This result in damages to informal settlements found at the bottom of the Drakensberg Mountain and soil erosion, reducing the fertility of the rapidly degrading soil; hence, subsistence agriculture of the community. Together these risks make the people living informally in this area susceptible to accidental damages.

Regarding the land administration at the periphery of Phuthaditjhaba, the traditional authority has a stronger influence than the local government. Due to this, there is a conflict of interest between the traditional leaders and local municipal councillors because of overlapping responsibility in the process of land administration. This affects the overall urban development in the area negatively and exacerbates the vulnerability of informal settlements, because the area lacks an appropriate road layout, drainage systems and other social facilities. Therefore, to improve climate change resilience of informal settlements through conserving the natural and manmade resources in this area, there must be a flexible and contextualised legal framework that promotes negotiation between traditional leaders and local government.

Concerning the practice of indigenous knowledge, the local community has experience of conflict resolution through traditional leadership. The practice can be recognised as a positive factor to enhance resilience capacity at the study site. However, the experience of indigenous knowledge faced the challenge of loss because of limited documentation and that fact that it is not transmitted to the younger generations. Therefore, integration of the indigenous and scientific knowledge systems in the area is limited. With respect to the economic circumstance of the local community, over 52% of the families are dependent on social grants as a source of income. This is insufficient to sustain their livelihoods and hampers them from adapting to climate change and other hazards. However, the Golden Gate National Park and Drakensberg Mountain ranges near Phuthaditjhaba town and the attractive traditional culture of the society, as well as the registration of the region as a World Heritage site can be used as a destination of tourists. This can be used as an opportunity to generate revenue from the tourism sector and allocating a budget for infrastructure provision in the informal areas in order to enhance their climate change resilience.

Chapter 9
KARAT ANALYSIS AND DISCUSSION

9.1 Introduction

This chapter encompasses the analysis and discussion of the circumstances of informal settlements at the periphery of Karat. The analysis focused on place-based climate change-induced risks, the vulnerability of local community for these risks, and the status of resilience capacity in this particular study site. To materialise this, a capitals-based analysis of vulnerability and resilience capacity of informal settlements around Karat were operationalised. Accordingly, the social, economic, human, physical, natural and institutional capitals were investigated, based on the principles or attributes of resilient systems.

9.2 Analysis of Vulnerability of Informal Settlements at the Periphery of Karat (CASE 2)

The community's vulnerability to climate change risks is directly linked to the availability and management of resources and coping strategies implemented in that particular area (Cutter et al., 2010:6). The people living informally in the western part of Karat town are susceptible to climate change-induced risks. Therefore, an analysis of existing resource capacities was undertaken in the following sections.

9.2.1 Demographics and Social Characteristics of Karat and the Study Site

9.2.1.1 Demographics of Karat and the Study Site

The community is characterised as diverse indigenous eastern Cushitic in origin. They settled on hilltops for defensive purposes and in an effort to avoid tropical diseases such as malaria that are prevalent in the lowlands (Tadesse, 2010:54). The community around Karat town is well known for its intensive agricultural and terracing practices on the hillsides and fortified villages. According to the CSA report (2007:73), the total population of Karat town was 10 470 people and 1 689 households; of this, 49% were males and 51% were females. The age structure and gender composition of the population are integral demographic features that indicate the social and economic situation of households. They determine the availability of the productive labour force and the ratio of the economically dependent population. The field survey done in the informal settlements at the periphery of Karat town indicates that the average household size of the respondents is six persons. This household size is greater than that of national and regional averages, which are 4.8 and 4.7 persons per household, respectively.

The population pressure increases from time to time in the study site (see Table 9.1). This has an impact on the depletion of natural resources such as forest, water and land. The density of the population is 2,445 inhabitants per square kilometre (CSA, 2007). The area is densely populated and overcrowded, which affects the emergency measures during the occurrence of hazards negatively.

TABLE 9.1: Population and Trend and Projection of Karat

Year	No.of Years [t]	Growth rate [r]	e^{rt}	Population
2005	0	3%	0	9823
2007	2	3%	0.06	10470
2011	4	3%	0.12	11805
2021	14	3%	0.42	15935
2031	24	3%	0.72	21510
2041	34	3%	1.02	29035
2050	43	3%	1.29	38035

Source: Central Statistical Agency of Ethiopia (2007), (population growth rate is 3% per year)

Analysis of the age structure of the respondents indicates that 70% of the household members are between the age of 15 and 49 years, whereas only 8% are above 65 years. This means the dependent age group within the sample household is about 8% without including the age group below 15 years. This implies that households face challenges in covering daily expenses and assuring savings. The gender composition of the informants in the area indicates that 73% of the total respondents are male and 27% are female. Of this, 95% of the sample households are headed by men and the remaining 5% are headed by women.

TABLE 9.2: Age Structure and Gender Composition of Respondents at the Periphery of Karat

Age Group	Male		Female		Total	
	Frequency	%	Frequency	%	Frequency	%
15-19	4	2	3	2	7	4
20-24	6	3	3	2	9	5
25-29	8	4	6	3	14	7
30-34	21	40	6	12	27	52
35-39	23	12	9	17	32	29
40-44	17	9	6	3	23	12
45-49	16	8	6	3	22	11
50-54	11	6	3	2	14	7
55-59	11	6	3	2	14	7
60-64	12	6	3	2	15	8
65+	12	6	3	2	15	8
Total	**141**	**73**	**51**	**27**	**192**	**100**

Source: Author's Field Survey (2015).

9.2.1.2 Educational Status of Respondents at the Periphery of Karat

According to a CSA (2007) report, the literacy rate of Karat people is 39.7%. The survey result depicts a similar result. Concerning the literacy status of respondents in the informal settlements, 60% were illiterate; 19% could read and write; 16% had primary education; and 5% secondary education (See Table 9.3).

TABLE 9.3: Educational Status of Respondents at the Periphery of Karat

Respondents	Educational Status					
		Illiterate	Read and Write	Primary Education	Secondary Education	Total
Male-headed household	Number	81	23	25	6	47
	% within respondents	42	12	13	3	73
Female-headed household	Number	34	13	6	4	17
	% within respondents	18	7	3	2	27
Total	Number	115	36	31	10	192
	% within respondents	60	19	16	5	100

Source: Author's Field Survey (2015)

The majority of the community follow a traditional lifestyle. Lack of education, health and other infrastructure facilities are commonly observed features in the study site. The survey result indicates that female-headed households are less educated than male-headed households are, which implies that they are more disadvantaged in terms of using social and economic facilities.

9.2.2 Analysis of Indigenous Knowledge System at the Periphery of Karat

The indigenous knowledge in Ethiopia have been practised for more than 1 700 years, though the documentation of this knowledge system is weak (European Conference on Information System [ECIS], 2010:2). Despite the presence of rich indigenous practices associated with knowledge creation and sharing, present-day Ethiopia faces some challenges with regard to its administration of knowledge. One of the issues is that the nation has lost knowledge of what empowered its previous civilisation. The unawareness of this indigenous knowledge has dispossessed the nation specifically, and the world in general, of its knowledge base. The traditional practices have been understudied and to a great extent undocumented, making it hard to consolidate them with logical information framework (Nkrumah 2003:13).

However, the World Bank (2005:6) indicates that the indigenous knowledge in Ethiopia related to medicinal plants, social insurance and rangeland management have been studied and documented to a certain extent. Unfortunately, the manner in which this knowledge is developed and the role of knowledge generation is not well understood or documented. Despite this fact, experience of indigenous knowledge system does exist in some parts of the country, including the study area. The 1997 Constitution of the Federal Democratic Republic of Ethiopia provides opportunities for self-determination and cultural identity promotion for indigenous people. This paves the way for the people to practise their indigenous knowledge system. For instance, the Konso cultural landscape was registered as one of the World Heritage sites by UNESCO in 2011. This indicates the existence of the practice of indigenous knowledge systems in the study area, although it is not well documented and institutionalised.

9.2.2.1 Forms of Indigenous Knowledge Practised by the Local Community around Karat

The Konso people have been known for their intensive agricultural practice and experience of indigenous knowledge in the field of natural environment conservation for more than 400 years (Watson 2009:322; Tadesse, 2010:45; Demeulenaere, 2002:81). The survey results on Table 9.4 confirm the use of indigenous knowledge in different development activities.

TABLE 9.4: FORMS OF INDIGENOUS KNOWLEDGE PRACTISED BY THE COMMUNITY AROUND KARAT

	Questions	Respondents' Feed-back	
Q1.	**Forms of Indigenous knowledge practised in the local area**	**No. of Respondents**	**Re-sponse Rate in %**
A.	Using social capital and network to cope with climate change risks	205	100%
B.	Traditional leadership system to reduce conflict in resource utilisation	205	100%
C.	Preparation of traditional medicines from indigenous pants species	205	100%
D.	Common pool resource management (i.e. grazing land, forest, minerals, rocks, labour sharing)	205	100%
E.	Traditional and cultural food preparation	205	100%
F.	Traditional agricultural practice to cope with climate change risks	205	100%
G.	Traditional weather forecasting systems to decide cropping season and to cope with climate change risks	205	100%

Source: Author's Field Survey (2015).

A strong social network was built over time that enables them to work together socially, such as building individual houses, stone walls, terracing, labour sharing for communal works, farming, construction of micro-ponds and ensuring local security. The outcome of the focus-group discussion also revealed the existence of the strong social bond among the community members, as seen in the community's cooperative working culture and experience of traditional leadership over many years. They engage in natural environment and conservation through this social network. The local community participates in the process of conservation of the natural habitat by using the technique of terracing. The experience of terracing in Konso area has universal acknowledgment. The local community settled on the ridges and is experienced regarding a rigorous agricultural production system on the hillsides. This practice enables them to cope with the challenges of seasonal drought occurring in the area.

Source: Author's field survey, (2015).

FIGURE 35: Terracing in the Hinterlands of Karat

The community uses public open spaces for the purpose of traditional governance, community discussions and rituals in their villages. The practice of working together was common in farming, terracing and construction of micro-ponds. Tribal and ritual leaders of the society known as "*Paqola*"[19] previously had the power to administer lands and other natural resources (Watson, 2004). However, the land administration role shifted to the state in 1994 when the control of all urban and rural lands moved to the state. Individuals only have a use right on the land. The role of "*Paqolas"* shifted to the mobilisation of the community for other development works, leading rituals and conflict resolution. These rituals and conflict resolution processes are managed by traditional leaders and local elders in the open spaces arranged for social meetings.

The outcome of interviews conducted with traditional leaders showed that predicting the weather is an important aspect of the indigenous knowledge in the local area. They have ways and means of predicting and foreseeing impending events, calamities and disasters. In order to decide on the cropping season and to cope with climate risks, the traditional weather forecasting system and the role of predicting events is left to the elders, families or clans that specialise in that art. The art of traditional rainfall prediction, however, is masked in mystery and is considered as a gift for a few. The potential person to inherit the art is identified in good time and is taken through the process of learning the art. The community relies largely on intensive agriculture and uses the information to make decisions that include mixed cropping

[19] "*Paqola*" is the name given to tribal and ritual leaders of the Konso people in Ethiopia.

of maize, beans and millet; planting of cassava and potatoes; and drying and storing of food for use during drought periods. The indigenous knowledge on disaster forecasting and early warning depends on sharp observation of the characteristics of animals, bird migrations and areas of nests, characteristics of insects, moon cycles, stars, vegetation, trees, strength and bearing of winds, state of clouds, air and water temperatures, earth movements and spiritual bodies. Furthermore, the existence of snakes and different reptiles, as well as other wild animals around estates looking for water and nourishment forecast a dry season. If the birds delay their migration to the area, it indicates the possibility of poor seasonal rainfall. The birds usually make more nests when a wet season is expected, and fewer nests when a poor rainy season is expected, during which they migrate from their usual nesting places. If these birds become too greedy and cannot be satisfied with food, regardless of how much they are fed and fly over one another other in competition for the food, it is an indication of a pending drought.

The community also used to plant drought- resistant trees and crops, such as *Moringa stenopetala*, sorghum, tubers, maize, millet, teff and other cereals. *Moringa stenopetala* has a nutritional and medicinal value that is found almost in all households' yards in the study area. It is used to prepare traditional medicines, along with other indigenous plant species to treat human beings as well as livestock. The community also manages common resource pools such as forests, grazing land, spring water, labour sharing and other resources. To adapt to climate change impacts, the society practises a mixed agricultural production system.

9.2.2.2 Trans-generational Transition of Indigenous Knowledge in the Case of Karat

As the survey result on Table 9.5 reveals, there are no well-established local community-based institutions and systems for the documentation, exchange and acquisition of indigenous knowledge in the local area. This is one of the major causes for limited utilisation of the indigenous knowledge by elderly people. There are some experienced in terms of recording of indigenous knowledge and its application. However, 80% of the respondents agree that only small fraction of the surviving indigenous knowledge systems has been documented, due to the absence of institutions and systems for documentation of the IKS. This implies that the knowledge system may be lost and the younger generation may not benefit from it in order to cope with climate change risks.

TABLE 9.5: Trans-Generational Transition of Indigenous Knowledge in Karat Area

	Question	Respondents' Feedback	
Q.2	**Would you indicate the level or status of documentation of the practice of indigenous knowledge system in your local area?**	**No. of Respondents**	**Response Rate in %**
A	Highly organised level of documentation	205	0
B	There is some practices of documentation	205	5
C	The status of documentation of the indigenous knowledge system is poor	205	80
D	No documentation at all	205	70
	Question	**Respondents' Feedback**	
Q.3	**How do you describe the level or status of the transition of indigenous knowledge system from one generation to the other in your local area?**	**No. of Respondents**	**Response Rate**
A	There is high level of transition of the indigenous knowledge system to the younger generation	205	0
B	Only some of the practices are transferred to the younger generation	205	4
C	The indigenous knowledge system subjected to the danger of loss because of the poor practice of documentation	205	95
D	Not sure to describe the status	205	5

Source: Author’s Field Survey (2015).

The outcome of the focus-group discussion also revealed that the practice of using indigenous knowledge is becoming limited to the elderly people and it is not well documented and institutionalised. Therefore, the younger generation does not have the same knowledge as that of previous generations as they are influenced by the modern education system. The field survey result on Table 9.5 also confirms that the knowledge system is becoming limited to the elderly people.

9.2.2.3 Conflict of Interest in terms of Using Natural Resources at the Periphery of Karat

The survey results (see Table 9.6) reveal that more than 90% of the respondents agree that there is a conflict of interests among the community, as well as between the traditional leaders and local government regarding natural resource utilisation. Conflict of interests among the community is commonly observed in boundary disputes, grazing land, forest and spring water utilisation. Traditional leaders govern the process of mobilisation of the local community for the conservation of natural environment. When conflict arises within the community, they mediate to solve the problem. The community living informally at the periphery of Karat is still characterised by this culture and their livelihood system is commonly linked with indigenous knowledge.

TABLE 9.6: Conflict of Interest In relation to Using Natural Resources at the Periphery of Karat

	Question	Respindent's Feedback	
		No. of Respondents	Response Rate in %
Q1.	What are casues of the conflicts of intersts between the the tradtional leaders and local government?		
A	Land adminstration at the peripherial area	205	75%
B	Grasaing land utilisation	205	65%
C	Contracting historical and current legal frameworks regarding resource administration	205	99%
D	Trying to enforce of planning standards in the tradtional land admistarion area	205	99%
E	Other Reseasons	205	25%

Source: Author's Field Survey (2015)

The focus-group discussions also confirmed the existence of a conflict of interest between the traditional leaders and local government. For example, in the case of Ethiopia, since 1994, the state has control over land ownership, and the community only has a use-right on the land. Nevertheless, practically, the traditional leaders want to administer land ownership in their local area. This conflict of interest in land administration may have an adverse impact in terms of building resilience for climate change risks. The more conflicts of interests are observed in the local area, the less the possibility of building resilience to cope with climate change risks, because the resources will not be used in a sustainable manner.

9.2.2.4 Integrating Indigenous and Scientific Knowledge to Build Resilience to Climate Change Risks the Case of Karat

There were some practices of integrating indigenous and scientific knowledge. For instance, mixed cropping systems and rotation to cope with drought to increase the productivity of the land is commonly practised by the local community and agricultural extension workers. More than 75% of the respondents confirm the existence of this practice. The community has experience of terracing to conserve soil and water; natural resource conservation and identification of drought-resistant plants and animal breeds. On the other hand, 95% of the respondents agree that there is limited integration between the knowledge systems in areas of weather forecasting and traditional medicine preparations (See Table 9.7).

TABLE 9.7: Integrating Indigenous and Scientific Knowledge to Enhance Climate Change Resilience in Karat Area

	Question	Respondents' Feedback	
Q.1	**What are the observable practices to integrate the indigenous knowledge system with scientific knowledge system**	**No. of Respondents**	**Response Rate in %**
A.	Weather forecasting system to decide cropping season and to cope with climate risks	205	5%
B.	Mixed cropping system and rotation to cope with drought or other climate change- related risks	205	75%
C.	Natural environment conservation i.e. forest, spring water, etc.	205	76%
D.	Identification of drought resistant plants and crops species	205	78%
E.	Applying indigenous knowledge in urban planning practice	205	0%
F.	Terracing to conserve soil and water	205	90%
G.	Preparation of traditional medicine from indigenous plant species	205	2%
H.	Other areas?	205	0%

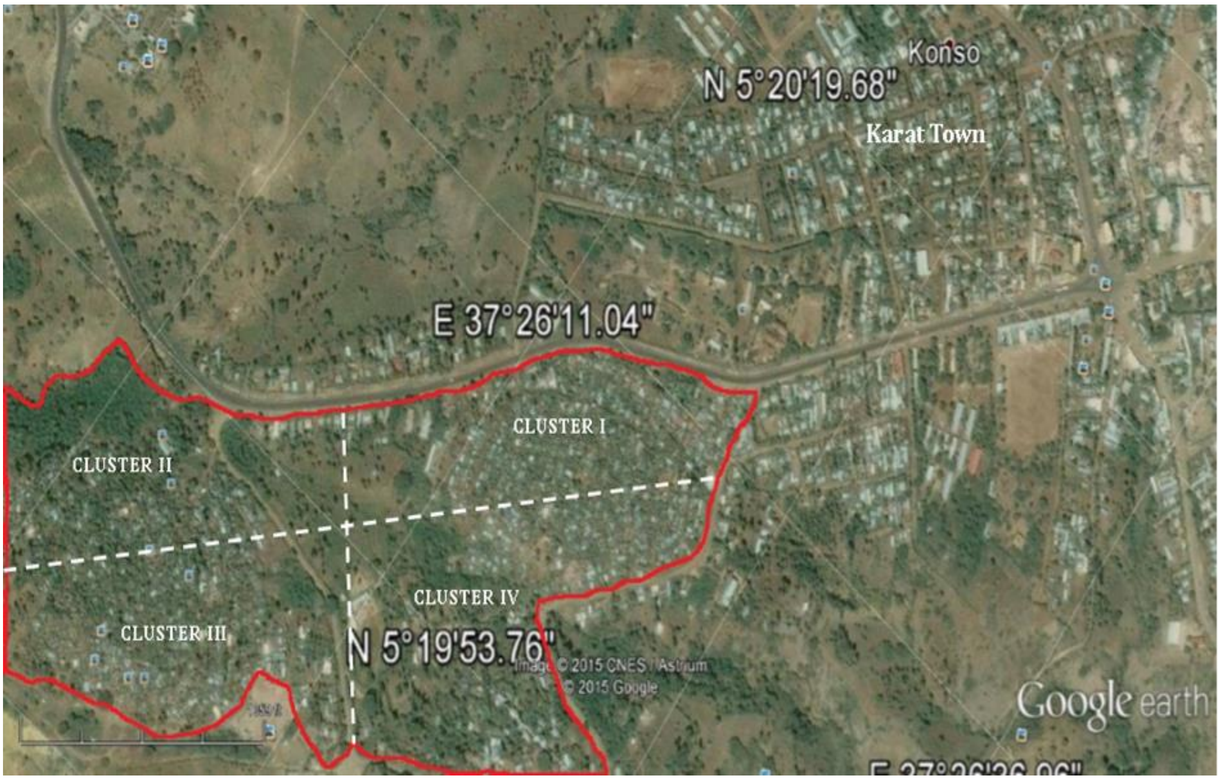
Source: Author's Field Survey (2015).

An interview conducted with experts from Konso information and culture offices revealed that there was a huge gap in integrating indigenous and scientific knowledge in urban planning practice. This is associated with the absence of institutions at grass-roots level, organised for facilitating the integration process and the epistemological differences between the two knowledge systems.

9.2.3 Spatial Analysis of the Periphery of Karat

The settlements are densely populated and more than 5 000 households live in this informal settlement area. According to CSA (2007), the average crude density in the case of Konso is 103.9 inhabitants per square kilometre. However, in this informal settlement, the population is even more dense and lacks adequate infrastructure. Figure 36 shows the area demarcated in red as the study site found in the western direction of Karat town. The informal settlements are situated on the top of hills about 1 650 m.a.s.l. The rural hinterlands found near the town are sources of agricultural production that support the community as an economic base. The settlements' characteristics are very susceptible to environmental degradation such as soil erosion and deforestation.

According to Mulat (2013:3), there are six major soil types in Karat areas: Eutric Regosols, Lithosols, Chromic Vertisols, Eutric Nitosols, Chromic Luvisols and Eutric Fluvisols. The type of soil varies from place to place and altitude. An unpublished research report of the Konso agricultural office revealed that 35% of the soil is sandy; 30% is clay and the remaining 35% is loamy soil. In general, the soil in the area can be described as shallow and infertile. This makes the soil susceptible to water and wind erosion and limits the productivity of agriculture in the area. As indicated in Förch (2003:3), the soil of the area has a volcanic origin. It is very fragile and can easily be exposed to erosion. Steep slopes, rocky terrain and irregular rainfall make conservation work of soil and water in the area very challenging. The UNESCO World Heritage Center list of world heritage sites in Ethiopia (online) reveals that the Konso cultural landscape comprises stonewalled terraces and fortified settlements in the mountainous topography of Konso. The people have their own cultural living traditions established for more than 400 years (21 generations) to adapt to dry and fragile climate conditions. The landscape manifests shared values of the society, social capital and indigenous community knowledge. There are also wooden statues to represent heroes of the members of the community that can be used as a confirmation of their own traditional practice for different generations.



Source: Adopted from Google Earth (Accessed 15/09/2015).

FIGURE 36: Satellite Image of Informal Settlements at the Periphery of Karat

Though the area has attractive natural and cultural landscapes, the periphery of Karat still lacks appropriate road networks and drainage systems, as well as faces a shortage of water and economic infrastructure. This prevents the town from generating revenue from the tourism industry (Karat Town Municipality, 2014). The community in the informal settlements lives in crowded traditional houses made from grass and wood (Figure 37). The survey results captured from the residents indicates that these traditional houses have the capacity to balance extremes of hot and cold weather conditions. The existence of indigenous plants near the housing is also a positive practice of environmental conservation. For instance, the *Moringa stenopetala* tree has multipurpose benefits such as traditional medicinal value and food value. It is drought resistance and keeps the moisture in the area. The survey outcome also showed that more than 80% of the respondents have been living in the study site for more than 30 years. They understand the impacts of climate change, mainly because of frequent droughts in the area. Therefore, an emphasis has been given to soil and water conservation through terracing.

Source: Field observation (2015).

FIGURE 37: Picture of Informal Settlements at the Periphery of Karat

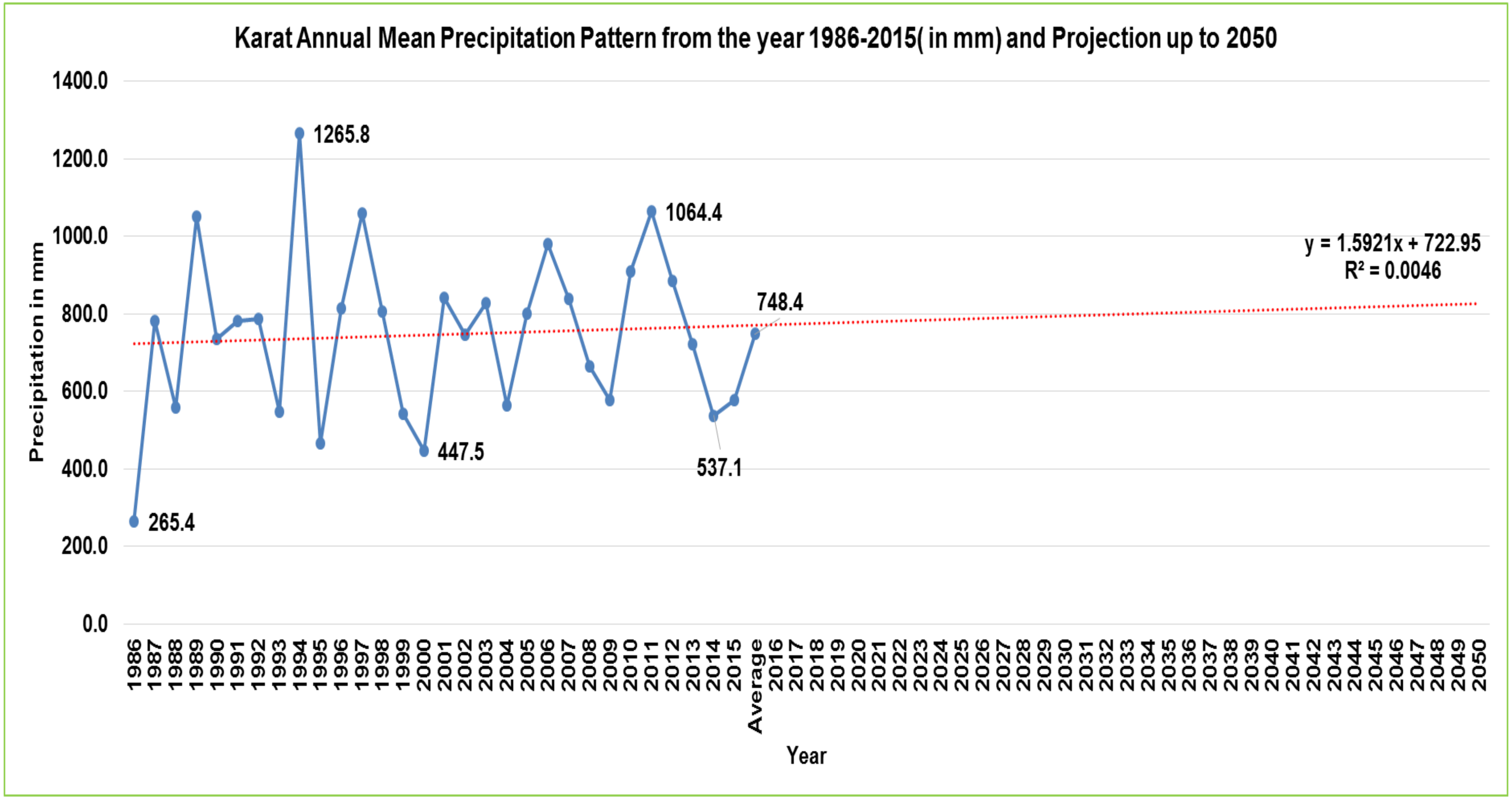
9.2.4 Ecological Features at the Periphery of Karat

Karat town and its hinterlands are characterised ecologically as dry-arid zones. The feature of the area can be described as volcanic sedimentary region and a relief of mountainous landscapes, which ranges from 1 400 to 2 000 m.a.s.l. (Tadesse, 2010:52). According to the Konso Agriculture and Rural Development office, the Konso area is categorised into two agro-ecological zones. These are an arid agro-ecological zone that accounts 70%, and tropical sub-humid zone that accounts 30% of the total area. The soil characteristics vary from one location to the other; however, 35% of the soil is sandy, 30% is clay and the remaining 35% is loamy soil. The people have long-term experience of conserving natural resources, particularly soil and water in the area. It is clearly observed that this practice of terracing helps them to reduce land degradation. This has enabled them to live on fragile soil and within irregular rainfall conditions (Watson, 2009:26). The field observation also witnessed that this cultural land-scape helps them to conserve the natural environment. However, the outcome of the focus group discussion indicated that contrary to their long-term terracing practices, climate change adversely affects livelihoods of the community now. This can be described by the prevalence of frequent droughts within every two to three years that make them very vulnerable to a short-age of food and water because they are very dependent on rain-fed agriculture.

9.2.4.1 Precipitation Pattern

The rainfall[20] distribution of Karat town and its hinterlands over the last 30 years and the pro-jection up 2050 indicate significant variation in average annual rainfall. The data includes the period from 1986 to August 2015. The rainfall in this period indicates that the area has a bi-modal rainfall pattern with a longer rainy season from March to May and a shorter rainy season from September to November. December and January are dry seasons (see Table 2.4, Ap-pendix 2). The irregularity of rainfall distribution is clearly observed seasonally and annually.

[20] Meteorological data were captured from National Meteorological Institute of Ethiopia (NMIE). (2015). **Nearest Station**: Konso; **Station ID**: **Latitude**: 5°15′N; **Longitude:**37°29′E; **Altitude:**1650 m.a.s.l.; **Date:** 01/01/1986-31/12/2015



Source: National Meteorology Institute of Ethiopia (2015) (See Table 2.4, Appendix 2).

FIGURE 38: Karat Annual Mean Precipitation Pattern from the Year 1986 to 2015 (in mm) and Projection up to 2050

As shown in Figure 38, the red trend line describes that a slight increase in average annual precipitation has been observed in the last three decades. A relatively higher precipitation was observed in the years 1989, 1994, 1997, 2006 and 2011. In the last 30 years, the average annual rainfall of the area is about 748.4 mm. In addition to these facts, the focus-group discussion indicated that the community clearly understands the irregularity of rainfall patterns over the past decades. The local community associates the cause of this variation with increasing deforestation due to rising population pressure in the area. According to the Konso Department of Agriculture (2015), the high level of variability of perception pattern affects agricultural production adversely and the area has become susceptible to periodical droughts. To adapt to this climate change impacts, the local community tries to conserve water resources through building small ponds in the villages (See Figure 39). However, the intensity of droughts demands further improvements in the climate change resilience of the area.

Source: Author's Field observation (2015).

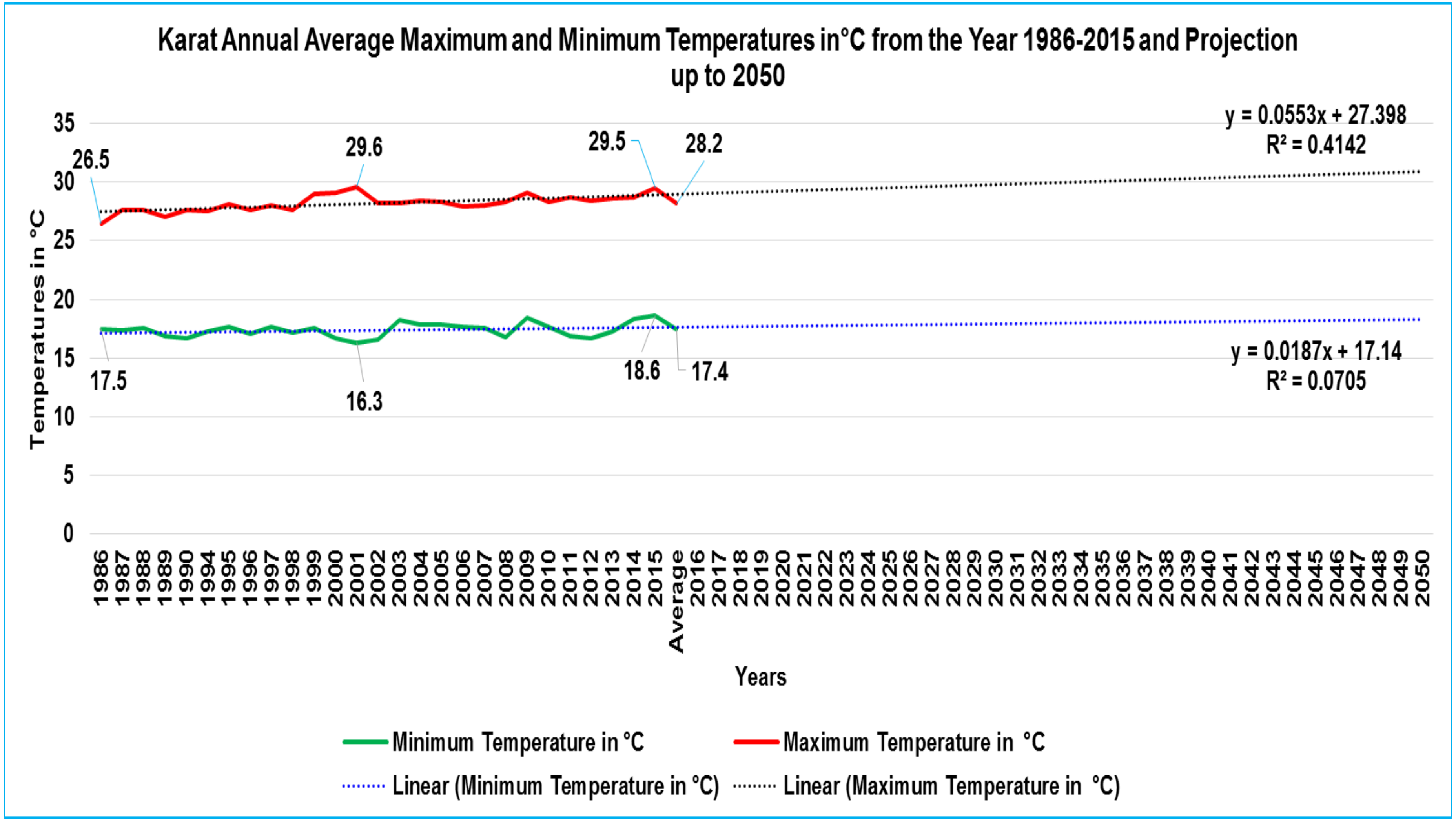
FIGURE 39: Water Conservation Practice at the Periphery of Karat

Based on the traditional agro-ecological zone classification, the area can be classified as a *'Kola'* agro-climate zone. This is hot and semi-dry weather found at altitude ranges from 500–1500 m.a.s.l. It accounts for 70% of the weather conditions of the area. The second classification is the "Woina Dega" agro-climate zone. This cool and sub-humid area is found in the mid-altitude of 1 500–2 300 m.a.s.l. It accounts for the remaining 30% of the weather conditions observed in the area (Watson, 2009:323). About 70% of the total population of Konso live in a "*Kola*"[21] agro-ecological zone (Konso Department of Agriculture, 2015). In general, the ecology of the Konso area is characterised by rugged terrain, stony soils, hot temperatures and high population density. This can cause soil erosion, shortage of water, declining agricultural productivity and a shortage of other resources.

9.2.4.2 Range of Temperature

The trend line since 1986 and the projection up to 2050 demonstrates that there was a temperature increase, and it may increase in average in the future. The average annual maximum and minimum temperatures of Konso area were 28.2 °C and 17.4 °C, respectively. As depicted in Figure 40, the last 30 years' temperature trend shows a slight rise in both maximum and minimum temperatures. In general, the area experiences hot weather. This leads to high evapotranspiration and a dry season that influences the agricultural production system in the area unfavourably. The details of monthly and annual average temperatures of the area are indicated on Table 2.5 and 2.6 in Appendix 2.

[21] "**Kola"** means hot and semi-arid agro-ecological zone.



Source: National Meteorology Institute of Ethiopia (2015) (See Tables 2.5 and 2.6, Appendix 2)

FIGURE 40: Average Maximum and Minimum Temperatures of Karat from the Year 1986-2015 and Projections up to 2050 (in °C)

9.2.4.3 Vegetation Features

The coverage of forests and grasslands is declining at the hinterlands of Karat. This is mainly because of deforestation to expand agricultural land and over-grazing (See Figure 36). The area is commonly covered by trees like *Moringa stenopetala, Accia abysinica* and other drought-resistant crops such as sorghum, tubers, maize, millet, teff and other cereals. Sorghum is the most crucial cereal crop, followed by maize and millet. The people produce a local drink from sorghum and maize called ***"Cheqa"***,[22] a traditional brew commonly used by the majority of the local community. To adapt to the challenge of frequent drought, the people used to practise mixed agricultural systems in the area. However, the focus-group discussion revealed that agricultural productivity is still declining.

9.2.5 Economic Characteristics

The economic base of the Konso area is dependent on intensive agriculture (Watson, 2004: online), practised by using traditional techniques of terracing on the steep slopes. Like other small urban settlements in the rural area of Ethiopia, the population of Karat town is dependent on the agricultural productions in the hinterland. Mixed farming, that is, crop production and livestock rearing, is the major income generation system practised by hinterland households. The environment is favourable for agricultural crops such as sorghum, maize, teff, haricot beans, millet, wheat, barley, cotton, coffee and other root crops (Konso Department of Agriculture, 2015). The crop production system is mainly dependent on the rain-fed agricultural system. However, the area has been affected adversely by frequent droughts in the past decades. This decreases agricultural productivity and causes food insecurity in the area. The droughts force the local people to practise their adaptation strategy by using their traditional knowledge (Tadesse, 2010:45). Terracing and diversification of the type of crops, growing drought-resistant, multipurpose trees such as *Moringa stenopetala* are the major adaptation strategies to combat frequent drought in the area.

Since Karat town is settled on the route to pass commodities from Kenya to Arbaminch-Addis Ababa, small emerging commercial activities are also observed. The existence of this main route can be taken as a comparative advantage for market opportunities for agricultural products, but the area cannot produce surplus agricultural products because of periodic droughts. Therefore, the people live with subsistence agriculture and in chronic poverty conditions (Konso Department of Agriculture, 2015).

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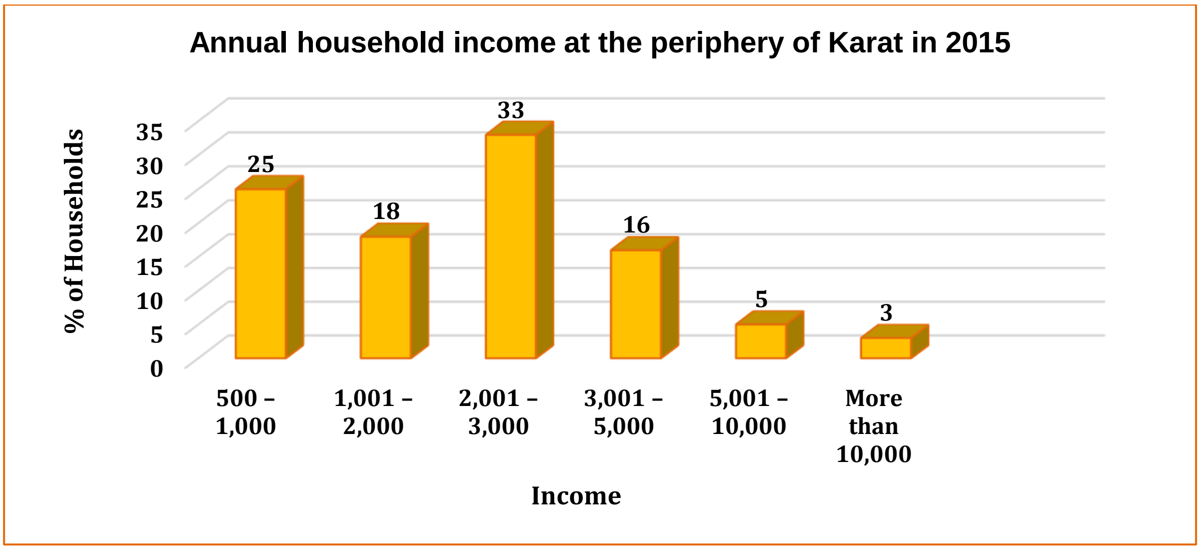
[22] ***"Cheqa"*** is the type of traditional drink made from sorghum and maize commonly used by Konso people.

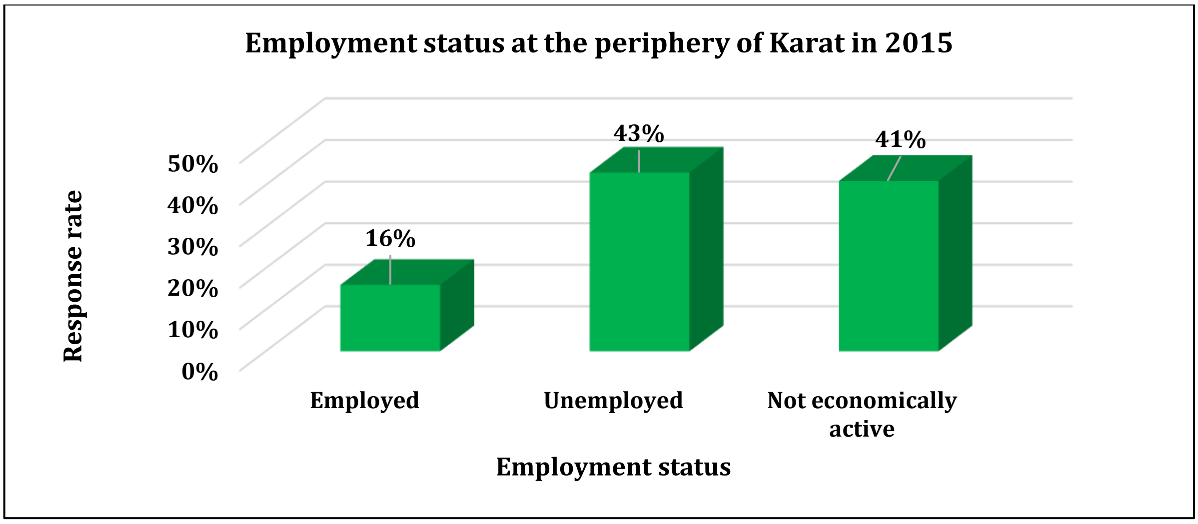
The cultural and natural landscapes of Konso were registered as a World Heritage site by UNESCO in 2011. Due to this, the area attracts many tourists from different parts of the world. However, it is difficult to exploit the economic benefit from this tourism industry, as a shortage of infrastructure facilities and service affect the area negatively. The survey results indicate that more than 95% of employment opportunities are created by the agricultural sector. On the other hand, less than 5% of the society generates their income from micro-scale weaving, blacksmithing, handcrafts, traditional drinks and honey production. The people are accustomed to keeping livestock as a means of building assets and for the consumption of milk and butter. However, this sector also faces problems such as shortage of grazing land and water. As illustrated in Figure 41, more than 95% of the households living in informal settlements earn less than 10 000 Birr;[23] 41% of the informants are economically dependent and 43% are unemployed. In addition, 55% of the respondents are dependent on daily casual labour as a source of income. This indicates that more than 95% of the households face subsistence living conditions. This makes them easily susceptible to the risk of periodic drought incidents.



Source: Field survey (2015).

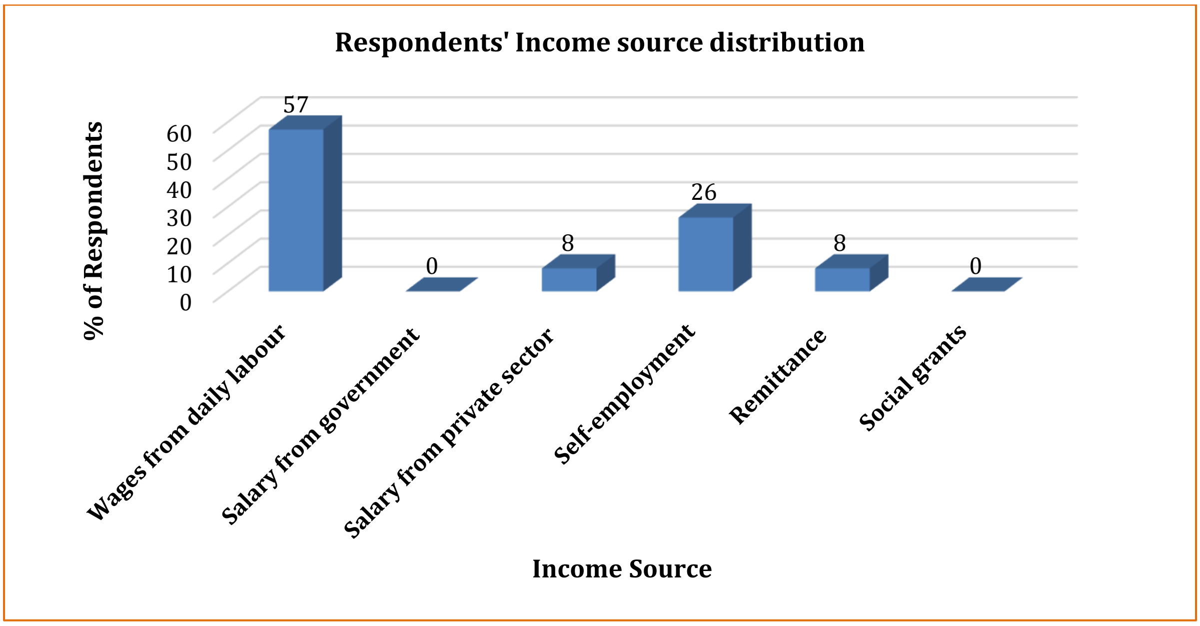
FIGURE 41: Annual Household Income at the Periphery of Karat in 2015

[23] ***Birr****: Ethiopian Currency, 1 Birr equivalent to 1.5 Rand during the study period in 2015.*



Source: Field survey (2015).

FIGURE 42: Employment Status at the Periphery of Karat in 2015



Source: Field Survey (2015) (See Table 3.1, 3.2 and 3.3, Appendix 3)

FIGURE 43: Respondents' Income Source Distribution at the Periphery of Karat in 2015

As the interviews conducted with officials indicated, the area also generates some revenue from the tourism sector. The cultural landscapes, long history of terracing, fortified villages and the community's indigenous lifestyle is the major attractions. However, tourism infrastructure and service facilities are still limited in the area. According to the interviews conducted with local officials, some people benefit from the Productive Safety Net Programme (PSNP). The programme focuses on the construction of local roads, building terracing and other agricultural activities on the farms. Those found in the productive age group, more than 60% of the inform-ants, generate their daily wage from Karat and use a traditional saving and credit system named "*Equb*".[24] Furthermore, seasonal migration is also practised as a means of generating additional income, through off-farm activities such as road construction in the nearest area. These can be considered as positive factors in terms of diversifying income sources of the local community. However, limited income-generation opportunities, coupled with the high unemployment rate (43%) and a high dependency ratio, still make the households vulnerable to climate change-associated risks and these negatively affect their resilience capacities.

9.3 Intensity of Climate Change-Induced Risks at the Periphery of Karat

The intensity of the climate change-related risk analysed is based on the combined survey result from residents living in the study site and experts working in the local government offices. Table 9.8 depicts the comparative intensity of the risks in the study site. The survey reveals that more than 80% of the respondents recognise the severity of potential climate change-induced risks such as drought, shortages of water and food, reduced agricultural productivity, the prevalence of weather-related tropical diseases and heat weaves because of increasing temperature in the study area. On the other hand, the community's long-time practice of terracing has played a significant role in terms of reducing soil erosion possibly caused by erratic rainfall.

The secondary data captured from the National Metrology Institute of Ethiopia also confirmed the experience of hot weather conditions in the study area (see Table 2.5, Appendix 2). To validate the survey outcome, triangulation has been done by incorporating outcomes of the interviews and focus-group discussions. The results complement one another and support the validity of the result captured by means of the survey. Identification of the magnitude of the risk in this particular site enables planning to improve climate change-resilience capacity. Therefore, a climate change-resilience strategy has to emphasise the highly severe risks prioritised (See Table 9.8).

[24] ***"Equb"*** is a traditional and informal saving and credit system widely practised in different parts of Ethiopia.

TABLE 9.8: Respondents' Feedback about Climate Change-Induced Risks at the Periphery of Karat

Climate Change-Induced Risks	Number of Respondents	Intensity of Risk		
Direct Climate Change Risks		High	Medium	Low
Drought	205	100%		
Shortage of water	205	100%		
Shortage of food	205	95%	19%	
Prevalence of weather-induced tropical diseases. i.e. malaria	205	98%	2%	
Reduced agricultural productivity	205	100%		
Heat waves because of increasing temperature	205	82%	18%	
Lose of biodiversity		95%	5%	
Flash flooding because of erratic rainfall	205		62%	38%
Veld fires	205		12%	88%
Strong and damaging winds	205			100%
Extremely cold temperatures	205			100%
Indirect Climate Change-Linked Risks				
Soil erosion	205		13%	87%
Land slide or rockfalls	205		6%	94%
Lose of grazing land	205		15%	85%

Source: Field Survey Result (2015).

9.4 Analysing Climate Change Resilience Capacity at the Periphery of Karat

To analyse climate change-resilience capacity of the study site, a combination of two approaches such as the "*principles of resilient system*" and "*disaster resilience capitals*" is applied. The approaches are customised with the existing reality of informal settlements at the periphery of Karat town. The matrix of the principle of a resilient system and capacities for climate change resilience are indicated in Table 9.9.

TABLE 9.9: Matrix of "Principles of the Resilient System" and "Capitals for Climate Change Resilience" in the Case of Periphery of Karat

Attributes or Principles of Resilient System	Capitals for Climate Change Resilience					
	Economic	Human	Social	Physical	Natural	Institutional
Diversity and Functional Redundancy	*	*	*	*	*	*
Connectivity and Independence of System Components	*	*	*	*	*	*
Major Variables and Feedbacks	*	*	*	*	*	*
Complex Adaptive System Thinking	*	*	*	*	*	*
Promoting participation and polycentric governance systems	*	*	*	*	*	*

Source: Author's own (2015).

Principle 1: Maintain Diversity and Functional Redundancy

Diversity and functional redundancy of economic capital: More than 95% people at the periphery of Karat generate their income from agricultural products. The remaining portion of the community (less than 5%) generate their income from small-scale weaving, blacksmithing, handcrafts, the sale of traditional drinks and wages from daily labour at Karat. This implies that the majority of the income source is limited to one sector. The more limited the sources of income to one sector, the more vulnerable people are to climate stress, and so become less resilient. Though the area is susceptible to periodic droughts, there are no micro-insurance and credit facilities to compensate for losses in agricultural production. This exacerbates the vulnerability of the local community to climate change-related risks.

Diversity and functional redundancy of human capital: The availability of a cheap labour force can be considered as a positive input to improve climate change resilience. However, the survey outcome indicates that 60% of the informants are illiterate, which means that there is a limited number of skilled manpower in the area (See Table 9.3). Also, the interviews conducted with local government officials revealed that the shortage of skilled manpower is one of the constraints to address the environmental problems. Availability of skilled labour gives an opportunity to use environmentally appropriate small-scale technologies.

Diversity and functional redundancy of social capital: The working culture of the people and their strong social network, as well as the existence of different forms of indigenous knowledge to conserve the natural environment can be recognised as positive indicators for improving resilience capacity. However, more than 90% of the respondents agree that indigenous knowledge is not well documented and transferred to the younger generations (See

Table 9.5). Therefore, their applications become limited to only the elderly people. Institutionalising the application of indigenous knowledge is crucial in the context of the study site, because it supports the efforts of the local government to improve climate change-resilience capacity.

Diversity and functional redundancy of physical capital: Since Karat is small and situated in a remote area of the country, the provision of infrastructure is very limited. If infrastructure facilities such as local roads, water and other services are appropriately provided, the area can achieve a comparative advantage in terms of attracting tourists. On the other hand, it is possible to consider the experience of terracing to conserve soil and water as a positive contributor to improve resilience capacity. Furthermore, this principle promotes the existence of different infrastructure facilities that provide similar functions, for instance, availability of biogas, solar systems, hydroelectricity and wind power to serve the same area. If one facility fails, it is possible to use the alternatives. Informal settlements at the peripheral area of Karat can be characterised as having very poor infrastructure provision. In other words, in terms of infrastructure provision, the area is less resilient and continues to be susceptible to climate change-induced risks.

Diversity and functional redundancy of natural resources: The ecological condition is favourable for the production of diversified agricultural products and growth of different indigenous plants, i.e. *Moringa stenopetala* that is drought resistant and has medicinal and nutritional value for the local community. It is commonly found in the gardens of households in the study area and helps the community to manage environmental shocks. However, the existing agricultural production system totally depends on rainfall conditions. The last 30 years' meteorological data indicate an irregular rainfall distribution (See Figure 38).This contributes directly to the reduction of agricultural productivity. The results of the vulnerability analysis of informal settlements at the periphery of Karat revealed that the community is vulnerable to drought, shortages of food, water and heatwaves because of increasing temperature and weather-linked topical diseases. However, if the natural resources and other capitals are appropriately managed, it is possible to minimise the risk of climate change. Table 9.10 depicts the landscape capacity for restoration from climate change-induced risks in the study site. The result is derived from the survey response from experts working in local government and inhabitants living in the informal settlements. The rate of restoration capacity of the landscape in the study site is categorised by three levels, i.e. *High, Medium* and *Low*. This is employed to identify the level of climate change risk in the site and to prioritise the risks to take the necessary intervention at the right time.

TABLE 9.10: Respondents' Feedback about the Landscape Capacity to Recover from Climate Change-Induced Risks at the Periphery of Karat

Climate Change-Induced Risks	Number of Respondnets	Landscape Capacity to Recover					
		High	%	Medium	%	Low	%
Direct Climate Cahnge Risks							
Perodic drought	205			27	13	178	87
Shortage of water and food	205			72	35	133	65
Prevalence of weather-induced tropical diseases. i.e. malaria	205			170	83	35	17
Reduced agricultural productivity	205			82	40	123	60
Heat waves because of increasing temperature	205			47	23	158	77
Flash flooding because of erratic rainfall	205	185	90	21	10		
Strong and damaging winds	205	127	62	68	33	12	6
Veld fires	205	133	65	72	35		
Indirect Climate Change-Linked Risks							
Soil erosion	205	185	90	10	5	10	5
Land slide or rockfalls	205	160	78	39	19	6	3
Decrease in soil fertility	205	47	23	137	67	18	9

Source: Computed from Field Survey, 2015

As Table 9.10 shows, the landscape capacity to recover from climate change-induced risks is very limited. More than 60% of the respondents agree that there is very limited resilience capacity to cope with periodic drought, shortage of food and water, reduced agricultural productivity and prevalence of weather-induced tropical diseases. On the other hand, there is positive feedback about resilience capacity of the landscape in terms of controlling flash flooding caused by erratic rainfall, soil erosion and landslides. This resilience capacity is directly associated with the community's long-term experience of indigenous knowledge to make terracing and stone walls in the local area. In general, the landscape resilience capacity is very limited, relative to the intensity of existing climate change-induced risks.

Diversity and functional redundancy of institutional capital: The existence of a climate-resilient green economy strategy in Ethiopia can be considered as a positive factor to improve capacity. In addition, various proclamations have been formulated to address the issue of informal settlements in a different part of Ethiopia (See Chapter 7). However, these legal frameworks are biased towards the formal urban system and have not stressed improvement of climate change resilience of informal settlements. Furthermore, in the context of the study site, the experience of indigenous knowledge that was practised for more than 400 years (Watson, 2009:26) can be taken as a positive factor to improve resilience capacity in the area. However, the danger is the probability of loss of the indigenous knowledge because of weak institutionalisation practices. The focus-group discussion also confirms that the coordination among government, NGOs and other actors is very weak. This is evidenced by the duplication of similar work by different actors. Therefore, aligning the development goals of the area with the plans of all stakeholders is important in order to cope with the prevailing climate change-associated risks in the area.

Principle 2: Manage Connectivity and Independence of System Components

Connectivity and independence of system components of economic capital**:** Connectivity among economic capitals helps the local community to cope with disaster risks. The interconnectivity among the economic basis, employment opportunities and income generation sources contribute positively to enhancing resilience capacity in a certain area. Accordingly, in the context of this study, site agriculture is the major source of employment and income for the community (CSA, 2007). The employment opportunity is only seasonal and because of this, the labour force migrates to other nearby areas in search of jobs. This implies a weak connectivity between the economic capitals, which may affect their resilience capacity negatively.

Connectivity and independence of system components of social capital: The survey result revealed that almost all respondents agree to the existence of strong social networking and the culture of working together, as well as the experience of the application of indigenous knowledge for environmental conservation in the study site. These components of social capitals can be recognised as positive factors for promoting climate change-resilience capacity in the area. However, the young generations are not fully utilising the benefits of indigenous knowledge because they are influenced by the modern educational system.

Connectivity and independence of system components of human capital**:** Availability of the skilled human resources in the area is one of the major determining factors to deal with the threats of climate change. As the interview result depicted, there is a shortage of manpower at the local government offices. This influences the environmental conservation work and building resilience capacity at grass-roots level negatively.

Connectivity and independence of system components of *physical capital*: This principle encourages connectivity and independence of infrastructure facilities at the right place. For instance, the water and telecommunication service should not entirely depend on electricity, because the failure in one subsystem affects the whole system. The survey result showed that since the study site is considered by the local municipality as an informal settlement, these facilities are not provided at all. Therefore, the area will continue to be vulnerable to climate stresses unless adequate infrastructure is provided.

Connectivity and independence of system components of natural capital: In the context of natural resource utilisation, this principle is customised as the community's dependency on limited natural capitals. For example, the people in the informal area depend on forests for wood for fuel and construction of houses. This causes deforestation, which leads to soil erosion and a decline in agricultural productivity. To reduce the community's dependency on limited forest resources, it is possible to provide biogas, solar systems and other affordable energy sources for the local community. Therefore, the community must be encouraged to use bricks made from local available soils and stones for the purpose of construction of traditional houses. This may help to reduce the intensity of deforestation in the area.

Connectivity and independence of system components of institutional capital**:** Similar to the previous study site, the outcome of the focus-group discussion showed that there is week collaboration among institutions concerning improving climate change resilience at the study site. This can be confirmed by conflict of interests between the political decisions and professional decisions to solve some community problems at the periphery. Institutions at local level prefer to work independently because of long administrative procedures. This limits the capacity of institutions from fully addressing the problems of climate changes.

Principle 3: Manage Major Variables and Feedbacks

Managing major variables and feedbacks of economic capital: The profile of the economic condition of the specific area should be clearly identified. For instance, recording of household income levels, the source of employment opportunities and economic bases should be done periodically. As the survey result revealed, more than 95% of households earn less than 10 000 Birr[25] per annum, and about 57% earn their income from daily casual labour. There is also a high unemployment rate of more than 43% and a high dependency ratio that is about 41% in the study site (see Figure 41, Figure 42 and Figure 43). This implies that in terms of these economic variables, the community's climate change-resilience capacity is weak. All these important variables are not well documented at the local government office. This may negatively affect the interventions taken in order to improve resilience capacity of the community living in the study site.

Managing major variables and feedbacks of social capital: The society's strong cultural network enables the smooth flow of information throughout the community. Therefore, possible forecast climate risks can be easily communicated to the community. This enables the community to design adaptive strategies proactively. The greater the flow of information

[25] South African **Rand** was equivalent to **1.5** Ethiopian **Birr** during the study in 2015.

through the backward- and forward-moving societal channel, the greater the resilience to climate stresses. In the context of informal settlements at the periphery of Karat town, this can be recognised as a positive factor to improve resilience capacity. However, these factors should be institutionalised and supported by information and communication technologies.

Managing major variables and feedbacks of human capital: The capacity to manage all other capitals is directly influenced by the existence of human capital in a particular area. In the context of Karat town, the interviews revealed that there is a shortage of skilled manpower in the area. The survey result in the study site also confirmed this fact; about 60% of the respondents are illiterate; 19% can read and write; 16% attended primary school; and only 5% attended secondary school. These figures clearly reveal the shortage of skilled labour force in the area. To cope with these challenges, adult education modalities need to be implemented in the study site and periodic records of the status of the community's educational level should be well documented.

Managing major variables and feedbacks of physical capital: The quality and coverage of infrastructure facilities should be clearly recorded. The status should be updated throughout the years. Concerning the study site, the result of the field observation reveals that there is poor infrastructure coverage in the area. The outcome of the interview conducted with Karat municipal officials shows that there is no appropriate record-keeping system. Therefore, this may affect the intervention from different actors in order to improve climate change-resilience capacity in the area.

Managing major variables and feedbacks of natural capital: The level of accumulation of renewable and non-renewable natural resources should be appropriately registered and documented. Any change in the status of resources has to be updated and documented. In this regard, this practice is still not implemented in the study area. Due to this, there is no exact information about the level of deforestation and depletion of other natural resources. Therefore, all stakeholders should champion the installation of reliable information centres at least at Karat town municipal level.

Managing major variables and feedbacks of institutional capital: The existence of different policies and institutions in a certain area may not be a guarantee for improving climate change-resilience capacity. One of the most crucial aspects is the successful implementation of those legal frameworks. To realise this, institutional coordination and flexible implementation of the laws are very essential. The outcome of the focus-group discussion reveals that there is weak coordination among development actors at local level. Flexibility in the implementation phase of the policy is important, especially in the informal settlements. Their real context should be recognised and special treatment is needed. Otherwise, the community may be affected negatively by a policy aimed at a positive development process.

Principle 4: Foster Complex Adaptive Systems Thinking

Fostering a complex adaptive systems thinking is a cross-sectional principle that should be realised in the process of enhancing climate change-resilience capacity in a particular area. This necessitates understanding complex interrelation and adaptive capacities of economic, social, human, physical, natural and institutional capitals. Therefore, to strengthen the resilience capacity of informal settlements, the legal frameworks need to be implemented flexibly by considering the contexts of informal settlements. In the case of this study site, incorporating indigenous knowledge in the process of improving the adaptive capacity of the local community is important. For instance, the traditional housing that is made from woods and grass enables the local community to adapt to weather extremes. Furthermore, terracing to conserve soil and keep moisture, mixed agricultural practices and plantation of *Moringa stenopetala* to adapt to droughts may enhance climate change resilience. Therefore, harmonising the indigenous knowledge with institutional knowledge enables the community to promote an adaptive capacity in the local area. However, as the outcome of the focus-group discussion revealed, the severity of drought still requires improving their adaptive capacity more. In terms of developing customised environmental conservation skills and knowledge, educational facilities are still not fulfilled. Environmental education and skills development schemes should consider the real environmental situation in a particular area, although the majority of the workforce at the study site is unskilled labour. This implies that the majority of the community follow a traditional lifestyle. The local community also focuses on natural environment conservation by experiencing indigenous knowledge. Contrary to this, deforestation and over-grazing are challenges in the area. Therefore, upgrading environmental management knowledge is necessary.

Principle 5: Broadening Participation and Polycentric Governance Systems

This principle encourages the involvement of key stakeholders in the process of development and a decentralised system of governance. The assumption is that a community found at grass-roots level understands the real problem better than the government body found at the top. The principle encourages a bottom-up approach. This enables the community to come up with local solutions to local problems. In the context of the study site, the outcome of the focus-group discussion indicates that the local government still does not involve the traditional leaders fully. However, these leaders have still been highly influential in the area. Furthermore, it is of critical importance that the youth and women participate in the local development process. For instance, the youth can help to strengthen the experience of terracing and women can protect their area by reducing deforestation for providing wood for fuel. Without considering and empowering the community, this section of community improving climate change-resilience capacity in the area will be very challenging.

9.5 Conclusion

The study area is vulnerable to climate change risks such as droughts, rainfall irregularity and increasing temperatures. This results in a reduction of agricultural productivity and a shortage of water and food. Therefore, in order to adapt the frequent droughts in the area, the local community used to practise indigenous knowledge planting drought-resistant trees, building traditional terracing and stone walls. *Moringa stenopetala* has medicinal and nutritional value. This enhances their resilience capacity in the face of hardships caused by drought. The traditional housing made from woods and grass also helps them to balance extremes of weather conditions. In addition, the existence of a strong social network governed by traditional leaders helps them to conserve the natural environment and minimise climate change threats. The community's working culture and experience of different forms of indigenous knowledge to conserve the natural environment can be considered as positive factors for improving climate change resilience. However, in terms of the practice of integration of the indigenous and scientific knowledge systems, there is significant experience.

In addition, the study site is characterised by poor infrastructure and social facilities at grass-roots level. Due to this, the local community could not fully exploit the comparative advantage of attracting tourists to cultural landscapes and heritage sites. Therefore, residents in the informal settlements have not been benefiting from the tourism industry as required. Thus, lack of infrastructure and other social facilities negatively influences their climate change resilience capacity. The existence of traditional savings, a credit system like *"Equb*" and community involvement in the PSNP helps them to diversify their income. A small-scale traditional production system such as weaving, blacksmithing and handcrafts helps some of the community members to generate an additional income. However, this practice still requires technical support from the local government and NGO to up-scale and benefit all residents in the informal settlements.

Chapter 10
COMPARATIVE ANALYSIS OF CASE STUDIES AND SUMMARY OF FINDINGS

10.1 Introduction

This chapter provides a comprehensive insight into the comparison of the case studies in terms of climate change-resilience capacity. Further, it summarises the major findings of the two case studies. The comparison of climate change-resilience capacity was undertaken by focusing on those comparable indicators. This is mainly because some of the climate change-resilience indicators are unique to the specific place and culture. For instance, cultural values, beliefs and perceptions of people about climate change risk and the way they cope with this challenge are highly context-based and incomparable. To realise this, the combination of objective and subjective criteria was employed to select resilience indicators in the case study areas. Objective criteria are more useful to analysis quantitative indicators or variables. On the other hand, subjective criteria are more meaningful to select non-quantifiable indicators, but significantly determine resilience capacity in the given area. This approach of selection of indicators is preferred because objective criteria only to select the indicators of climate change resilience capacity may not fully address the factors associated with perceptions, cultural values, beliefs and other social opinions. However, these indicators are important to determine climate change-resilience capacity in the case study areas.

10.2 Comparison of the Case Studies (Case 1 and Case 2)

The fundamental assumption in the process of comparing climate change resilience of both case study areas is that there are unique characteristics of each case study area that may be incomparable, for instance, cultural values, perceptions and beliefs. Therefore, the comparison only focuses on those variables commonly observed in both case study areas. The other consideration is that the climate change-resilience capacity of informal settlements is lower than the resilience capacity of the formal urban system. Accordingly, climate change-resilience capacities of the study areas were weighted from zero units up to one unit. Zero units indicate that the climate change-resilience capacity of the given area is very low. In other words, the area is highly vulnerable to climate change associated risks and damages. One unit means the highest climate change-resilience capacity, which makes the area less susceptible to climate change-related risks. One unit is considered as a perfect or an ideal climate change-resilience capacity, even in the case of the climate change resilience capacity of the formal urban systems. The other important consideration is that the climate change-resilience capacity of informal settlements is at least below the moderate level of climate change-resilience capacity (i.e. below 0.5 units). At this point, climate change-resilience capacity is equivalent to the risks related to climate change. This means there are no damage to human beings, natural environments or on other physical properties.

10.2.1 Capital-Based Analysis of Climate Change Resilience Index of Case1 and Case 2

Climate change risk resilience (CCRR) of a certain area is a function of the existence of economic (E), human (H), social (S), physical (P), natural (N) and institutional (I) capital. These capitals must be evaluated based on the attributes of a resilient system. Mathematically it can be expressed like this:

$$\boldsymbol{Climate\ Change\ Risk\ Resilience}\ (\boldsymbol{CCRR}) = \text{f}(\boldsymbol{EC}, \boldsymbol{HC}, \boldsymbol{SC}, \boldsymbol{PC}, \boldsymbol{NC}, \boldsymbol{IC})$$

Therefore, based on the evaluation of capitals found in each case study area through the attributes of a resilient system, the resilience index for each capital was calculated on the scale of 0 up to 1 units. To calculate resilience index, equal weighting has been assigned to sub-components of capitals as well as for all capitals. The value of weight assigned to each component indicates that the relative significance of each indicator contributes to resilience. For the purpose of this study, equal weighting is assigned (i.e. 17%, this is obtained by dividing 100% by six capitals) for all components. As indicated in the methodology section, this weighting system is preferred because of three major reasons. First, this method of weighting is transparent and easy to understand. Secondly, there is no theoretical or practical justification for the differential allocation of importance across indicators. Third, the existence of previous practical application of equal weighting done by Nobel et al. (2006:6) to calculate an index of multiple deprivations in different provinces of South Africa.

TABLE 10.1: Capital- Based Indicators for Climate Change Resilience

Capitals	Indicators	Unit	Description
Social Capital	Social Networks	number	Number of informal social networks created
	Social Trust	number	Number of informal social organisations to create synergy and information flow
	Productive Safety Nets Programmes	number	Number of safety net programs to provide support for the community
	Indigenous Knowledge	number	Areas of application of indigenous knowledge
Economic Capital	Per capita Income	$	Household income per year
	Rate of Employment	%	The number of employed people divided by total population of the area
	Dependency Ratio	ratio	Number of individuals economically dependent on the employed one (I.e. Age > 65 years and Age <15 years
	Per capita saving	$	Amount of saving by households per year
	Wages per day	$	Amount of money paid for daily labour
	Investment	$	Amount of money invested by households per year
	Informal micro-finance and Insurance	$	Availability of micro-finance
	Insurance schemes for emergency service	$	Amount of money allocated for emergency and risk reduction or sharing
Human Capital	Adult literacy rate	%	Percentage of adult population literate per the total population of the area
	Enrolment Rate	%	Number of people enrolled at the at the right age for education from the total population of the area
	Life expectancy	number	The average years of individual can survive in the given area
	Skilled labour	number	Availability of skilled labour in the area
	Unskilled Labour	number	Availability of unskilled labour in the area
	Population density	Number/Km²	Number of population per hectare
	Fertility rate	%	Number of births per year

Capitals	Indicators	Unit	Description
Physical Capital	Road and drainage construction	$	Budget allocated for road and drainage construction per Km^2
	Housing construction	$	Amount of money required to build individual house
	Terracing to conserve soil and water	$	Amount of money required to build terracing to conserve soil and water
	Flood and wind break structures	$	Amount of money required to build flood and wind break structures
	Stonewalls for security purpose	$	Amount of money required to build stone walls to keep safety and security
Natural Capital	Forest conservation	$	Cost of fuel woods per year
	Availability and access to water	$	Community water consumption per year
	Access to land	m^2	Availability of fertile land for agricultural production
	grazing land	m^2	Availability of grazing land in the area
	Soil Conservation	$	Amount of soil saved from erosion per year (increased production)
	Sands, rocks and other construction materials	$	Cost of construction material if they trnaspored from other places
	Drought resistant local trees and crops species	$	Incerased prodicutivity because of adaptable crop breeds
Instituional Capital	Policy to cope with climate change risks	number	Aviability of policy documents that are formulated to cope with climate change risks
	Rules and Regulations to conserve natural environment	number	Special rules and regulations to protect environmentally sensitive areas
	Emergency facilities	number	Number of cars for emergency works
	Organisations to Integrate Indigenous and scientific knowledge systems	number	Special organisations established to integrate indigenous knowledge and scientific knowledge
	Informal micro-finance and Insurance institutions	number	Avaibility of informal micro-fiance and insurance institutions at communoty level

Source: Author’s own (2015)

On top of this, variables selection was undertaken based on two considerations; first, a justification based on the extant literature on its relevance to resilience, and secondly, availability of consistent quality data from national data sources[26] and other secondary sources since 2007. This delimitation of the period is set because the latest national census in Ethiopia was undertaken in 2007 and in South Africa in 2011. Therefore, to facilitate the comparison between the two case study areas within a similar period, projections of some variables were undertaken based on the growth rate of the last national census of the respective countries. Table 10.1 describes identified capital-based climate change resilience indicators that are common to both case study areas.

10.2.1.1 Climate Change Resilience Index (CCRI) for Informal Settlements at the Periphery of Phuthaditjhaba (Case 1)

The analysis of resilience index for each six capital revealed some variations in terms of climate change resilience capacity in the study area (i.e. resilience index for social capital is 0.056; economic capital is 0.040; human capital is 0.031; physical capital 0.028; natural capital is 0.056, and institutional capital is 0.056). Thus, the composite climate change-resilience index for Case 1 is 0.044. This is obtained by adding index-values of each capital and dividing them by six (See Table 10.2). This implies that the resilience capacity is very low. In other words, climate change-related risk is very high.

The climate change risk index can be calculated by deducting the resilience index from 1.

$$\boldsymbol{Climte\ Change\ Risk\ Index = 1 - Composite\ Resilience\ Index}$$

$$\boldsymbol{Climte\ Change\ Risk\ Index = 1 - 0.044}$$

$$\underline{\boldsymbol{Climte\ Change\ Risk\ Index = 0.956}}$$

This result depicts the higher probability of the danger of climate change risk in the areas of informal settlements at the periphery of Phuthaditjhaba. The lower the resilience capacity, the more the vulnerability of the community for climate change risks. This result is complementary to the qualitative discussions undertaken in Chapters 8 and 9. The major climate change-associated risks in the case of Phuthaditjhaba are irregular, heavy, windy rainfall, increasing temperature and the shortage of water.

[26] The data were captured from the census result of Statics South Africa, 2011 and Central Statistics Agency (CSA), Ethiopia, 2007; from research findings of the previous studies; and from official publications.

TABLE 10.2: Climate Change Resilience Index (CCRI) for Case 1

Capitals	Indicators/Variables	Unit	Raw Data	Normalised/ Standardised data(ND)	Weight (W)	ND*W	Resilience Score
Social Capital	Social Networks	number	3.00	1	0.17	0.1667	
	Social Trust	number	3.00	1	0.17	0.1667	
	Productive Safety Nets Programmes	number	2.00	0	0.17	0	
	Indigenous Knowledge	number	2.00	0	0.17	0	
Sub-Index					0.17	**0.3334**	**0.056**
Economic Capital	Per capita Income	$	397.73	1.000	0.17	0.1667	
	Rate of Employment	%	44.00	0.109	0.17	0.018210184	
	Dependency Ratio	Ratio	0.62	0.000	0.17	0	
	Wages per day	$	2.73	0.005	0.17	0.000885742	
	Per Capita saving by using Informal micro-finance	$	132.58	0.332	0.17	0.055393296	
	Economic growth	%	2.00	0.003	0.17	0.0005793	
Sub-Index					0.17	**0.241768522**	**0.040**
Human Capital	Literacy rate	%	78.00	0.033	0.17	0.005455605	
	Life expectancy	number	59.60	0.025	0.17	0.004120368	
	Skilled labour	number	150.00	0.064	0.17	0.010680446	
	Population density	Number/Km²	2300.00	1.000	0.17	0.1667	
	Fertility rate	number	2.82	0.000	0.17	0	
Sub-Index					**0.17**	**0.186956418**	**0.031**

Capitals	Indicators/Variables	Unit	Raw Data	Normalised/ Standardised data(ND)	Weight (W)	ND*W	Resilience Score
Physical Capital	Road and drainage construction	$	145455.00	0.014	0.17	0.002404335	
	Housing construction	$	9090909.1	1.000	0.17	0.1667	
	Terracing to conserve soil and water	$	27272.73	0.001	0.17	0.000233754	
	Flood and Wind Breaks structures	$	29090.90	0.002	0.17	0.000267147	
	Stonewalls	$	14545.46	0.000	0.17	0	
Sub-Index					0.17	**0.169605237**	**0.028**
Capitals	**Indicators/Variables**	**Unit**	**Raw Data**	**Normalised/ Standardised data(ND)**	**Weight (W)**	**ND*W**	**Resilience Score**
Natural Capital	Forest conservation	$	14545.45	0.000	0.17	0	
	Availability and access to water	$	300000.00	0.126	0.17	0.021072384	
	Access to land	m^2	640000.00	0.277	0.17	0.046171337	
	grazing land	m^2	1280000.00	0.560	0.17	0.093416425	
	Soil Conservation	$	109090.91	0.042	0.17	0.006979388	
	Sands, rocks and other construction materials	$	2272727.28	1.000	0.17	0.1667	
	Drought resistant local trees and crops species	$	43636.36	0.013	0.17	0.002147504	
Sub-Index					0.17	**0.336487038**	**0.056**
Institutional Capital	Policy to cope with climate change risks	number	6.00	0.250	0.17	0.041675	
	Rules and Regulations to conserve natural environment	number	8.00	0.750	0.17	0.125025	
	Emergency facilities	number	9.00	1.000	0.17	0.1667	
	Organisations at the grass root level to solve problems of informal settlements	number	5.00	0.000	0.17	0	
Sub-Index					0.17	**0.3334**	**0.056**
Composite Resilience Index							**0.044**

Source: Author's computation from secondary data (2015).

10.2.1.2 Climate Change Resilience Index (CCRI) for Informal Settlements at the Periphery of Karat

As indicated in Table 10.3, the analysis of resilience index for each six capital also revealed that some differences in terms of resilience capacity of capitals in the study area (i.e. resilience index for social capital is 0.051; economic capital is 0.037; human capital is 0.030; physical capital 0.028; natural capital is 0.033, and institutional capital is 0.051). Thus, the composite climate change resilience index for Karat (Case 2) is 0.038. This implies that the lower climate change=resilience capacity in the case study area and the higher probability of adverse effects of climate change related-risks.

TABLE 10.3: Climate Change Resilience Index (CCRI) for Case 2

Capitals	Indicators/Variables	Unit	Raw Data	Normalised/ Standardised data(ND)	Weight (W)	ND*W	Resilience Score
Social Capital	Social Networks	number	12.00	1.000	0.17	0.167	
	Social Trust	number	9.00	0.500	0.17	0.083	
	Productive Safety Nets Programmes	number	6.00	0.000	0.17	0.000	
	Indigenous Knowledge	number	8.00	0.333	0.17	0.056	
Sub-Index					0.17	**0.306**	**0.051**
Economic Capital	Per capita Income	$	227.27	1.000	0.17	0.167	
	Rate of Employment	%	16.00	0.068	0.17	0.011	
	Dependency Ratio	Ratio	0.52	0.000	0.17	0.000	
	Wages per day	$	0.63	0.000	0.17	0.000	
	Per Capita saving by using Informal micro-finance	$	54.55	0.238	0.17	0.040	
	Economic growth	%	2.00	0.007	0.17	0.001	
Sub-Index					0.17	**0.219**	**0.037**
Human Capital	Literacy rate	%	39.70	0.015	0.17	0.003	
	Life expectancy	number	61.48	0.024	0.17	0.004	
	Skilled labour	number	100.00	0.040	0.17	0.007	
	Population density	Number/Km^2	2445.00	1.000	0.17	0.167	
	Fertility rate	number	3.00	0.000	0.17	0.000	
Sub-Index					0.17	**0.180**	**0.030**

Capitals	Indicators/Variables	Unit	Raw Data	Normalised/ Standardised data(ND)	Weight (W)	ND*W	Resilience Score
Physical Capital	Road and drainage construction	$	90909.10	0.000	0.17	0.000	
	Housing construction	$	2727273	1.000	0.17	0.167	
	Terracing to conserve soil and water	$	116364	0.010	0.17	0.002	
	Flood and Wind Breaks structures	$	98181.82	0.003	0.17	0.000	
	Stonewalls	$	93654.43	0.001	0.17	0.000	
Sub-Index					0.17	**0.169**	**0.028**
Natural Capital	Forest conservation	$	12000000.00	1.000	0.17	0.167	
	Availability and access to water	$	75000.00	0.000	0.17	0.000	
	Access to land	m^2	640000.00	0.047	0.17	0.008	
	grazing land	m^2	1280000.00	0.101	0.17	0.017	
	Soil Conservation	$	436364.00	0.030	0.17	0.005	
	Sands, rocks and other construction materials	$	170454.60	0.008	0.17	0.001	
	Drought resistant local trees and crops species	$	196364.00	0.010	0.17	0.002	
Sub-Index					0.17	**0.200**	**0.033**
Institutional Capital	Policy to cope with climate change risks	number	2.00	0.000	0.17	0.000	
	Rules and Regulations to conserve natural environment	number	6.00	0.667	0.17	0.111	
	Emergency facilities	number	3.00	0.167	0.17	0.028	
	Organisations at the grass root level to solve problems of informal settlements	number	8.00	1.000	0.17	0.167	
Sub-Index					0.17	**0.306**	**0.051**
Composite Resilience Index							**0.038**

Source: Author's computation from secondary data (2015)

The climate change-risk index in the case of Karat is 0.96. That is obtained by using the flowing formula.

$$\boldsymbol{Climte\ Change\ Risk\ Index = 1 - Composite\ Resilience\ Index}$$

$$\boldsymbol{Climte\ Change\ Risk\ Index = 1 - 0.038}$$

$$\underline{\boldsymbol{Climte\ Change\ Risk\ Index = 0.962}}$$

This result depicts the higher probability of the danger of climate change risk (i.e 0.962) in the areas of informal settlements at the periphery of Karat. As the outcome of the qualitative discussion in the previous chapter indicates, climate change risk, such as periodic drought, increasing temperature, lower agricultural productivity, shortage food and the prevalence of tropical diseases such as malaria are commonly observable climate change-associated risks in the case of Karat. The result of quantitative analysis of the climate change risks index also confirms this fact (i.e. 0.962). The higher the climate change risk, the lower the resilience capacity to cope with the challenge and the more the community is vulnerable to risks.

10.2.1.3 Comparison of Capital-Based Climate Change Resilience Index of Case 1 and Case 2

This section compares climate change-resilience capacity of Case 1 with Case 2 by using a summary table and resilience index graphs. Although some possible variations in terms of scaling the resilience capacity are expected, for the purpose of this study, the resilience index values are scaled in the following ranges.

<u>Where Resilience Index Value</u>:

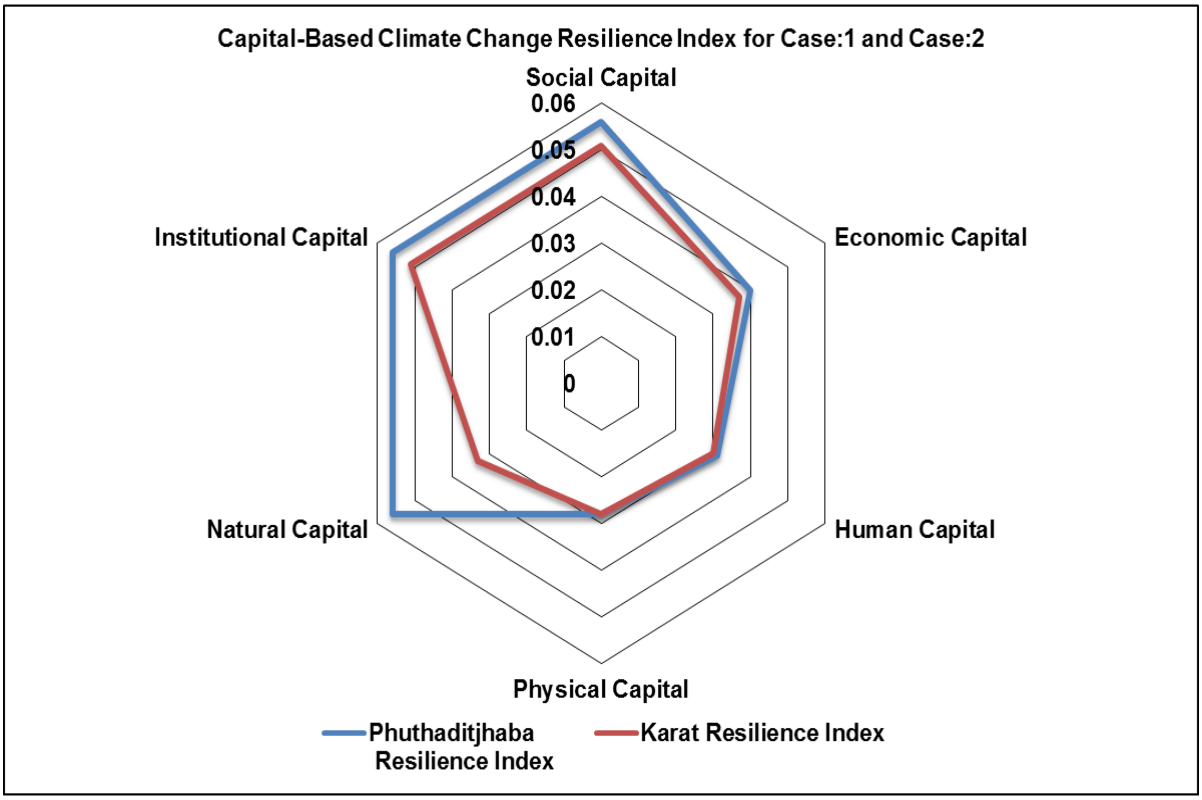
[0.90 – 1.00] = Very high resilience capacity
[0.70 – 0.89] = High resilience capacity
[0.50- 0.69] = Moderate resilience capacity
[0.3-0.49] = Low resilience capacity
[0 – 0.29] = Very low resilience capacity

TABLE 10.4: Capital- Based Climate Change-Resilience Index for Case 1 and Case 2

Capitals	Phuthaditjhaba Resilience Index	Karat Resilience Index
Social Capital	0.056	0.051
Economic Capital	0.040	0.037
Human Capital	0.031	0.030
Physical Capital	0.028	0.028
Natural Capital	0.056	0.033
Institutional Capital	0.056	0.051
Composite Resilience Index	**0.044**	**0.038**

Source: Author's computation from secondary data (2015)

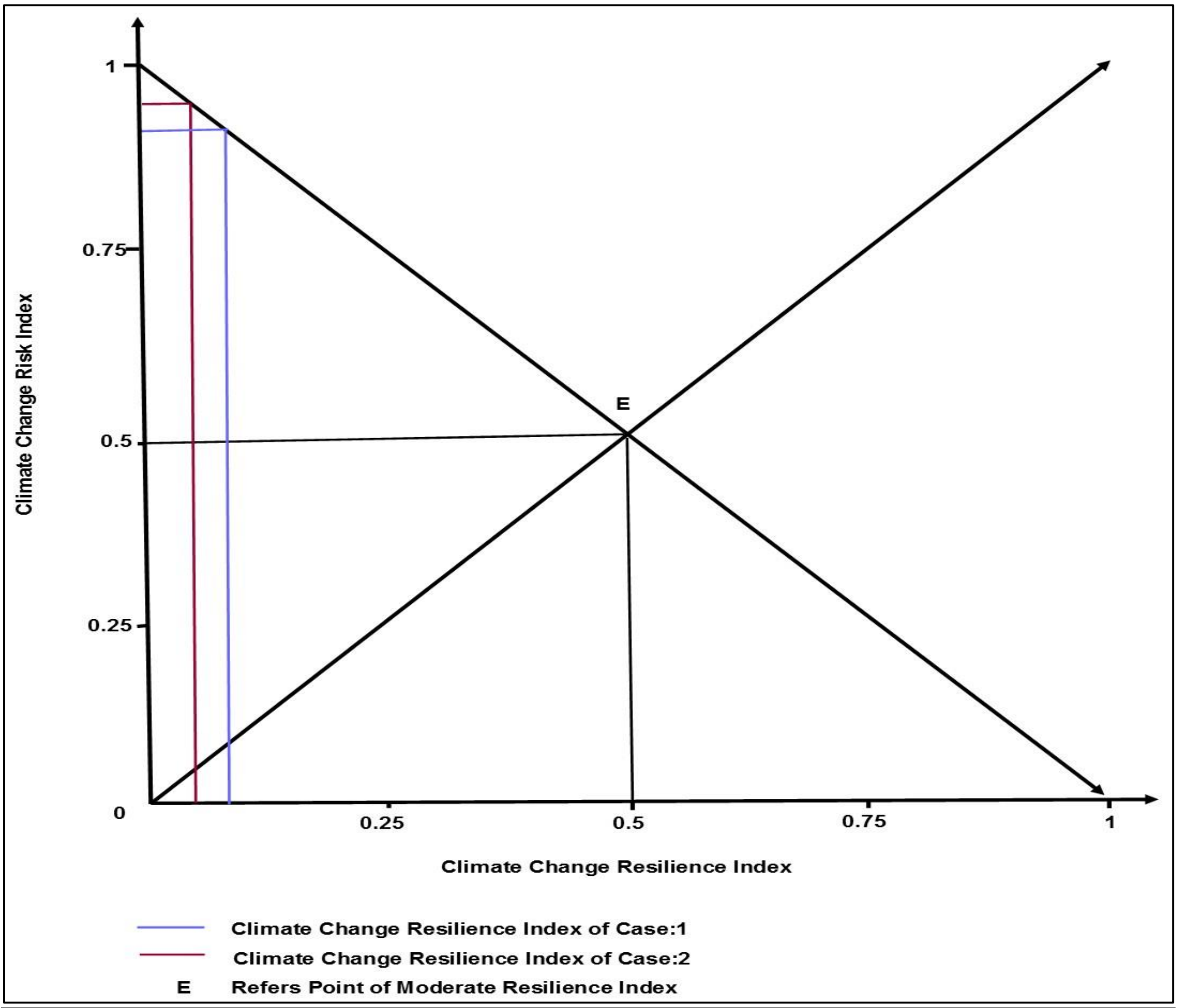
As Table 10.4 revealed, cumulative resilience index of Phuthaditjhaba (i.e. 0.044) is somewhat greater than that of the Karat (i.e. 0.038). Regarding the value sub-indices of capitals, Phuthaditjhaba has a greater resilience index in all sub-capitals except the physical capital, which is equal in both cases. Nevertheless, in terms of social capital, the outcome of the qualitative discussion in Chapter 8 indicates that Karat has stronger social capital than Phuthaditjhaba. The justification for this is the experience of using indigenous knowledge and social networking in the environmental conservation that was significant in the case of Karat. Contrary to this, the quantitative result indicates that the social capital resilience index of Phuthaditjhaba (0.056) is a somewhat greater than that of Karat (0.051). This unexpected result is maybe due to the weakness of the resilience-index calculation model, especially in terms of recognising qualitative indicators that have a significant contribution to social capital resilience.



Source: Computed from Table 10.4 (2015)

FIGURE 44: Capital-Based Climate Change-Resilience Index for Case 1 and Case 2

The comparison of the overall climate change-resilience index in Table 10.4 reveals that the two case study areas have better residence capacity in terms of social, institutional and natural capital. On the other hand, in terms of physical, economic and human capital, the result of the index shows that significant gap. This can be considered as critical signals in order to identify priority and strategic areas in the policy and planning intervention. Thus, in relative terms, improvements in the physical, economic and human capitals in both case study areas need to be emphasised to cope with already identified climate change-related risks. Also, other capitals also need further improvement because the probability of climate change risks in the informal settlements are very high (i.e. above 0.956) and this is beyond the current coping capacity of the case study areas.



Source: Author's computation from Table 10.4 (2015).

FIGURE 45: Graphical Representation of Climate Change Resilience Capacity of Phuthaditjhaba and Karat

As Figure 45 depicts, climate change resilience capacity and climate change-related risks are inversely proportional. When the climate change-resilience capacity increases, the risks induced by climate change start to decline. The letter **"E"** describes the point of moderate resilience capacity. This point can be reached when climate change-resilience capacity is equivalent to the level of climate change-related risks. At this point, the assumption is that no human beings or property was damaged. Concerning the study sites, the climate change-resilience index of Phuthaditjhaba is 0.044, whereas the climate change-resilience index of Karat is 0.038 (See Figure 45). From this, it is possible to recognise that there is limited climate change-resilience capacity in both cases. In other words, the possibility of incidence of climate change-related risks is more than 0.95 (95%) in both cases. This indicates that the two case study areas are highly vulnerable to climate change-related risks. In terms of assessing the climate change-resiliency capacity, the two case study areas have their own strengths and weaknesses. Therefore, the outcome of this comparison should be considered as a point of departure to deal with climate change-associated risks, because the estimation that indicates the levels of climate change resilience capacity may vary in terms of different time and space scales.

10.3 Summary of Key Findings

10.3.1 Key Findings in the Case of Informal Settlements at the Periphery of Phuthaditjhaba

The impacts of climate changes already observed in Phuthaditjhaba area are manifested by increasing temperatures during summer, fluctuations in rainfall and a serious shortage of water, increased incidence of drought, strong and damaging winds, flash flooding that causes soil erosion and rock falls from hillsides, and reduction of biodiversity including local plant species. These are the most-felt climate change-induced direct and indirect risks in the study site at the bottom of the Drakensberg Mountain.

The major causes of informal settlements at the periphery of Phuthaditjhaba are a combination of the following factors, namely speculation in land, failure of the municipality to address the demand for land and housing, failure of the formal market system to address the needs of the poor, uncontrolled rural-urban migration and historical exclusion because of apartheid. Actors from the local government side prefer to demolish informal settlements or relocate the informal settlers rather than recognising the community’s right to live there and improving their resilience capacity at the existing place. This perception affects the practice of planning towards improving climate change resilience in the study site negatively. The existing planning practice and perceptions of professionals are not aligned with the historical reality that drives the society to live informally. They consider the informal settlements as a constraint to development and due to this, they fail to provide infrastructure and services in the area.

There is also an overlap of responsibility between the traditional authority and local councillors thus open the door for conflict of interest, especially in the process of land administration. This affects environmental conservation and the overall development process negatively. Degradation of the natural environment at the periphery of Phuthaditjhaba due to over-grazing and excessive extraction of soils for moulding bricks are observable human-induced risks that exacerbate the overall climate change risks. The community, under traditional leadership, has not utilised their social linkage effectively in order to administer communal resources. This can be confirmed by overgrazing beyond the carrying capacity of the natural environment and the outbreak of veld fires on the communal land.

Lack of disaster resilience capacities such as economic, social, human, physical, natural and institutional capacities and weak coping strategies exacerbate the severity of the risks in the study site. The disaster risk reduction measures, preparedness plan, early warning system and trained manpower in the communities are missing. Although communities are able to identify risks that they face, there is nothing much to do without the support of local authorities. Lack of appropriate road layout and drainage systems aggravates the damage caused by runoff in the study site. During emergencies, lack of open spaces and alternative routes can pose a major risk as rescue and evacuation would be hampered. There is the possibility of rock falls from hillsides that would be much worse for emergency services, as the internal roads are narrow and a complicated network of water pipes and electric wires is installed along narrow internal roads. This would create problems during rescue operations.

The community in the study site experiences below-subsistence living conditions and they have a low economic capacity to cope with climate change risks. The World Heritage Site status of the Golden Gate National Park and Drakensberg Mountain ranges around Phuthaditjhaba as well as the cultural heritage of the community, in general, attract many tourists to the area. The income generated from this tourism sector can be utilised for providing infrastructure and services at the periphery of Phuthaditjhaba. However, the local government could not utilise this comparative advantage found in the area effectively. Lack of infrastructure and service facilities to attract manufacturing and other investments to the area also causes a higher rate of unemployment (about 56%) and lower household income.

The absence of local institutions that enhance the benefit of indigenous knowledge to improve climate change-resilience capacity is one of the contributing factors for loss of this knowledge system and difficulty in integrating with the scientific knowledge, especially in the natural environment conservation and urban planning practice in the areas of informal settlements. Ignorance about informal micro-finance schemes and non-engagement of the local government in the affairs of informal settlements also contribute to a lower climate change-resilience capacity in the study site. These growing pressures transform underlying factors of vulnerability into unsafe conditions, eventually lowering the overall resilience of the community. Hence, each of these issues needs systematic and careful attention in order to build the resilience of the community.

10.3.2 Key Findings in the Case of Informal Settlements at the Periphery of Karat

The incidence of periodic drought, shortage of water and food, the prevalence of weather-induced tropical diseases, such as malaria caused by a mosquito, sleeping sickness (African trypanosomiasis) caused by the tsetse fly, reduced agricultural productivity, heat waves because of increasing temperatures are the major climate change-induced risks already detected in the Karat area. The Informal settlements at the periphery of Karat are susceptible to these climate change-induced risks and environmental degradations because they are situated at the top of hills. The residential site is densely populated because of limited land at the top of hills. This makes them vulnerable to fire outbreaks and diseases caused by climate change.

The experience of a long-term strong social network and capital to conserve the natural environment helps them to survive in a hostile environment. The practice of traditional leadership, coupled with the experience of indigenous knowledge in the process of environmental conservation, contributes positively to adapt to harsh environmental conditions. The traditional leaders play a community mobilisation role in the process of natural environment conservation. The cultural landscapes, long history of terracing, fortified villages and the community's indigenous lifestyle is the major attractions for the tourism sector. These cultural landscapes and the society's traditions attract many tourists to the area, although there are limited infrastructure facilities in the area. The community also tries to adapt to periodic droughts through planting drought-resistant trees (i.e. *Moringa stenopetala*) and by using a mixed cropping system. *Moringa stenopetaa* has medicinal and nutritional values. In addition, the traditional and cultural housing that is made from woods and grass enables them to balance the extremes of the weather conditions that could in different seasons. These cumulative climate change-resilience strategies enable them to survive in the face of drought hardship.

Agriculture is the dominant economic base in the study area. However, the agricultural production system is mainly dependent on rainfall in the area. The last three decades' meteorological reports reveal that irregular seasonal and annual rainfall distribution was observed in the study site. This affects agricultural productivity adversely and causes a shortage of food and water. Deforestation for the purpose of construction of traditional housing, wood for fuel, expansion of agricultural land and overgrazing are also causes of soil erosion and the decline of agricultural productivity in the study site.

Limited income-generation opportunities, coupled with a high unemployment rate and high dependency ratio make the households still vulnerable to climate change-associated risks and these are negatively affected their resilience capacities. However, the community has practised the traditional saving and credit system like "*Equb*", and being involved in the Productive Safety- Net Programme (PSNP) helps them to build assets and improve climate change-resilience capacity. There is a small-scale traditional production system in the form of weaving, blacksmithing and handcrafts, which helps some of the community members to generate an additional income.

The people in the Konso area are well known for their long-time indigenous knowledge system in natural environment conservation, terracing, mixed agricultural system, traditional medicines, traditional weather forecasting and other practices. However, the outcome of the investigation revealed that this knowledge system was not appropriately documented and transferred to the younger generation. Therefore, its application is limited to the elderly and subjected to loss. Lack of institutional capacity at local level to integrate the indigenous knowledge with scientific knowledge also hampers the potential benefit that could be gained to cope with climate change risks in the informal settlements area. The urban planning approach in the study area is strongly influenced by the formal procedures and standards suggested by the western planning theories. The top-down approach dominates the planning process. This approach is not feasible for enhancing the climate change resilience capacity of informal settlements at the periphery of Karat. Therefore, an "Africanised", indigenous and integrated planning model needs to be designed and implemented in order to minimise the risks of climate change and to improve the resilience capacity of communities living in the informal settlements found in the mountainous topography.

10.4 Conclusion

This resilience index can be more meaningful when it is used for the comparison of the status of the given area at a different period or comparisons of different cases at different geographical areas during the same time scale. The outcome of quantitative analysis is complementary to that of the outcome of the qualitative analysis in terms of identified resilience capacity and climate change-related risks. The triangulation of the data analysis methods confirms the lower resilience capacity and high climate change-related risks in the case study areas. These findings indicate the necessity of urgent coping mechanisms in order to reduce the possible losses. Consequently, to cope with this very high climate change risks in these areas, improving those capital-based indicators is critical. This can be realised by a broad-based participation of all stakeholders. This comparative study identifies the unique environmental, spatial, social and economic features that determine resilience capacity of both case study areas. Climate vulnerability and resilience are differentiated geographically and socially, reflecting conditions, processes, driving forces and interacting factors that vary, depending on the spatial scale and local context. Thus, one of the major challenges of composite index development is to select indicators that are appropriately matched and most relevant to the spatial scale of vulnerability and resilience assessment, and that enable decision-makers to realise tailor-made interventions across different geographical areas.

Therefore, local and contextual resilience capacity should not be compared directly with the cases found in geographically different places. Comparison of resilience capacity is more meaningful in terms of planning interventions when it will be realised for a particular context and over a different period. This is mainly because the unique nature of the typical area, culture, the type of risks and vulnerabilities vary from place to place. Therefore, comparing a particular situation with its own cases by using longitudinal data could give a more meaningful outcome. The resilience capacity of Case 1 and Case 2 in this study also needs to be recognised within this perspective, and the result of resilience index should not be interpreted as that one study site in a given country is better in terms of resilience capacity than another study site in another country. In this study, the composite resilience index is developed only to identify the status of a particular case relative to the existing climate change risks in that particular area.

In general, the outcome of the analysis indicates that the two case study areas are highly susceptible to climate change risks and they have limited resilience capacity. Therefore, planning interventions should focus on those capital-based indicators to enhance resilience capacity in the areas of informal settlements in mountainous regions of Africa.

Chapter 11
CONCLUSION AND RECOMMENDATIONS

11.1 Conclusion

The philosophical paradigm of the research can be categorised as a pragmatic approach. Given the complexity of the research field, employing the mixed method of data analysis is considered as the most feasible approach. To measure and to assess resilience capacity in the case study areas, the combination of the "*characteristics of a resilient system*" and "*capital-based resilience assessment approach*" was operationalized. This method was preferred with aim of filling the gap and minimising the weakness possibility observed if a single method of data analysis was employed. Therefore, a combination of qualitative and quantitative methods and triangulation of the finding from both methods was realised. This comparative study identifies the unique environmental, spatial, social and economic features that determine resilience capacity of both case study areas. Climate vulnerability and resilience are geographically and socially differentiated, reflecting conditions, processes, driving forces, and interacting factors that vary depending on the spatial scale and local context. Therefore, local and contextual resilience capacity should not be directly compared with the cases found geographically different places. Comparison of resilience capacity is more meaningful in terms of planning interventions when it will be realised for a particular context and over the different time period. Any policy and planning intervention should be context specific by identification of unique resilience features in particular area rather than using a one-size-fits-all approach.

Accordingly, the study adopted a systems approach to problem-solving. The conceptual and methodological complexity of climate change resilience assessment necessitates operationalising the holistic methods. Using this approach enables identifying complex interactions of factors contributing to vulnerability and resilience of informal settlements for climate change risks. Therefore, climate change resilience of informal settlements observed from the systems point of view. A system encompasses an interconnected, complex, and functionally related components. Due to this characteristic of the system, a change in one part of the system may affect the whole system negatively or positively. Therefore, small changes in one sub-component can have a significant consequence for the system as a whole. The theory of system's resilience emphasises on the capacity of the social-ecological components to function normally in the face of hazards through maintaining adaptive and transformative capacity across the spatial and temporal scales. Therefore, the ability to persistence, transition, and transformation are the core elements of resilience. Accordingly, this study operationalises the concept of evolutionary resilience because this school of thought considers the complexity, dynamics and uncertainty of climate change in the areas of informal settlements. This implies that the past planning trends can no longer be used as a remedy for uncertain future climate change risks in the areas of informal settlements. Comprehending the importance of a system's internal linkages, its ability to absorb shocks and how these attributes vary from one stage to another, enables the planners to analyse the resilience capacity of a system. However, the past urban planning interventions in the study areas have been realised by isolating informal settlements from the formal urban system and the rural areas. This approach has a negative impact in the process of building resilience in the areas of informal settlements. Therefore, the impacts of climate change-induced risks in the areas of informal settlements may have a direct adverse effect on the formal urban system, because of this complex interrelations. Any planning strategies should accommodate the climate change risks in the areas of informal settlements.

The system approach to assessing climate change resilience is allow bridging the small traditional towns and rural areas in the context of Africa. This approach to improving climate change resilience considers the level of exposure, sensitivity and adaptive capacity of inhabitants in the informal settlements. Therefore, the urban planning interventions need to focus on identifying the level of vulnerability and resilience capacity in the given area. The interactions among the sub-components of the overall social-ecological system were assessed. The social, economic, physical, human, natural, and institutional capitals are considered as the components of the urban-rural system. The complex interactions and interrelations among these components determine climate change resilience capacity in the area. Accordingly, the system's capacity to resist and adapt climate change risks, and transform to the new 'normal' functional and structural condition depend on the diversity, flexibility and connectivity of these capitals found in the study areas.

In the context of this study, the social networks, income sources and employment opportunities, availability of labour force, infrastructure and services, conservation of natural resources and the existence of climate change policy are the major factors that leverage and augment the resilience capacity in the study areas. The social networks among the inhabitants of informal settlements can be used as a medium to communicate climate change information effectively. The local community can use the indigenous knowledge that is accumulated for long period of time in order to cope with the risks of climate change. Accordingly, a community that has access to information in relation to climate change will have better adaptive capacity than the others because they have opportunities to respond proactively. The people live in the informal area can also generate the income by producing small scale cultural goods and services. In this case, the local government should support the efforts of the local community by creating the enabling environment. Incremental housing upgrading and improving the road and drainage systems also can contribute to enhancing resilience in the study areas. On the whole, to organise these efforts of the local community and enhancing resilience capacity, there must be flexible and customised institutional and legal frameworks. These frameworks should encourage using the internal potential of inhabitants of informal settlements and the external support from the development partners.

In addition, understanding the complexity of social-ecological systems requires the practice amalgamation of multiple knowledge systems. The role of indigenous knowledge to promote climate change resilience capacity also needs to be recognised. This is mainly because local governments in the case study areas have limited capacity to cope with complex climate change-related risks. The practice of this knowledge may facilitate and supplement the collective response to disaster risks and fill the gap that could not be addressed only by applying scientific approach to augment the resilience capacity of the informal settlements. Therefore, enhancing climate change resilience capacity of informal settlements requires recognition of indigenous knowledge at the formulation and implementation phases of the policy and plans. In addition, Integration of indigenous knowledge with science will enhance informal settlements resilience because of the synergy created between the knowledge systems. In this regard, it is crucial to identify dimensions of integration of the knowledge system. Since the two knowledge systems have their own cultural setting and epistemological variations, it is essential to understand complementary and supplementary dimensions of the knowledge systems. Hybridisation of the two knowledge systems could be successful in the natural resource conservation and resilience planning in the informal settlements in mountainous regions of Africa. The most critical consideration in the process of hybridisation of the two knowledge systems is identifying feasible dimensions of integration because complete integration of the knowledge systems may not be practical (See Chapter 5 Figure 18). Accordingly, building institution that facilitate the integration of the knowledge systems at the grass root level is crucial.

11.1.1 Research Objectives Achieved

Objective 1: To analyse the vulnerability to climate change induced-risks of societies living informally in the mountainous landscapes. This objective was achieved by undertaking a theoretical examination of the concept of vulnerability and by identifying appropriate assessment framework in the context of informal settlements. There is no single universally applicable and accepted vulnerability and resilience assessment framework or model. This is mainly because of the complexity, conceptual pluralism and multidimensional applicability of the terms. Therefore, to minimise the drawbacks of single framework or model using the combination of different frameworks is more feasible and can generate a comprehensive and reliable outcome. Consequently, one of the critical points regarding the application of vulnerability or resilience assessment frameworks is understanding the context of a particular area. In addition, flexibility in terms of application and selecting feasible and fit-for-the purpose frameworks are the fundamental considerations need to be practiced for theoretical and applied studies. Therefore, to analyse vulnerability of informal settlements in the mountainous regions of Africa, a bimodal approach of assessment was operationalized. This is assessing vulnerability in relation to climate change resilience capacity and in terms of the intensity of climate change risks at specific case study area. The outcome revealed that vulnerability to climate change risks of informal settlements is directly associated with deficiency of capitals to build resilience in the areas.

Objective 2: To analyse determinant indicators or variables that influence climate change resilience capacity of informal settlements in mountainous topographies. To achieve this objective capital-based climate change resilience capacity assessment of informal settlements was employed. The fundamental understanding in capital-based resilience capacity evaluation formulated based on identifying the status of social, economic, human, physical, natural and institutional capitals in the case study areas. Accordingly, each capital has a principal indicators or variables for resilience capacity in the given area. Then, those determinant indicators of climate change resilience were identified by using statistical and normative approaches. Finally, based on these variables, composite climate change resilience index of informal settlements in Phuthaditjhaba and Karat was developed.

Objective 3: To examine the integration of indigenous and scientific knowledge systems in order to enhance climate change resilience of informal settlements in mountainous regions of Africa. This objective has been achieved through theoretical and practical assessment of the benefits of integration of indigenous and scientific knowledge in the context of the two case study areas. In this regard, to maximise the potential use of indigenous knowledge in order to enhance climate change resilience of informal settlements found in the traditional small towns in Africa, “hybridisation” of this knowledge system with scientific knowledge was considered as the most feasible strategy for resilience planning.

Objective 4: To propose appropriate planning approaches to promote climate change resilience of informal settlements in mountainous landscapes. This objective was achieved by suggesting practical resilience planning approach in the context of informal settlements in mountainous regions of Africa. Accordingly, indigenous and hybridised climate change resilience planning need to be developed for informal settlements found in the traditional small towns in Africa. In this case, the past urban planning approach has been highly biased to the western urban planning theory and direct implementation in the context of informal settlements in Africa could not be feasible. This is because western planning theory focuses on enforcing standards, building codes, rules regulations and ordinances that cannot accommodate the African reality. Therefore, 'Africanised' indigenous and hybridised resilience planning is suggested to cope with the current and future challenges of climate change-induced risks in the informal settlements.

11.1.2 Synthesis of the Study

The outcome of investigation regarding the climate change resilience capacity of both case study areas indicated that there is limited resilience capacity. This is confirmed by triangulation of composite climate change resilience index and qualitative analysis of resilience capacity in the case study areas. The limited climate change resilience capacity is mainly because of lack of physical, economic and human capitals relative to other forms of capitals. However, still other forms of capitals are limited in the areas. Therefore, informal settlements in the mountainous regions of both case study areas are susceptible to the adverse impacts of climate change-induced risks. Consequently, systematic coping strategies need to be materialised. Otherwise, the adverse impact of climate change will increase in these areas. The projections of weather conditions revealed that there will be increasing temperatures and declining and irregular rainfall in both case study areas. As the IPCC (2014b:133) report concluded, that until 2050 the risk of climate change will not decline all over the world, even in a lower CO_2 emission scenario. This is because of the past emission impacts on the atmosphere, land and ocean. The severity of the risks is high, especially in the poor countries and people live in impoverished condition in informal settlements.

Therefore, the planning approach should be participatory, flexible, and customised to the situation of the given area. Participatory planning approaches empower residents of informal settlements to decide their own fate. Flexibility of planning standards, building codes and other regulations is critical in the implementation phase in the context of informal settlements. However, the current planning standards and building codes are highly influenced by western countries planning theories. Therefore, customization of the resilience building planning approach by incorporating indigenous knowledge, especially in the areas of natural environment conservation and resilience planning is crucial in cases of informal settlements found at the periphery of traditional small towns in Africa.

Accordingly, this study is grounded on an African indigenous knowledge system that encourages local solutions for local problems. This means, building the resilience capacity of informal settlements to deal with climate change risks requires a successful application of indigenous knowledge. There are some idiomatical expirations in Ethiopia that encourage contextual solution for local problems. *“Ye Agerun Serdo Be Ageru Bere”.* The literal translation of this idiom is *“Cultivating local grassland by using local ox”.* In this idiom, the ox adapts to the local hardships and can cultivate the land successfully for the intended purpose. This provides lessons that encourage the use of internal capacity to solve ones’ own problems. Another idiom is *“Wof Ende Ageru Yichohal”* this idiomatical expression can be literally translated as *“Birds sing as uniquely just as their local area*”. From this expression, it is possible to capture crucial lessons in the application processes of planning theories that are devised by western countries but modified in the context of traditional small towns or informal settlements in Africa. Therefore, customization of the planning theories to the reality on the ground is critical for enhancement of climate change resilience capacity of informal settlements in mountainous regions of Africa.

In the context of the African urban system, direct applications of those western countries planning principles is challenging and it has an adverse effect on the overall wellbeing of people, even in the case of the formal urban system. A variety of disciplines agree that informal settlements account for the majority of housing in many cities of global South including Africa. The settlement condition of African traditional small towns can be characterised as informal settlements. The level of poverty is high and do not allow achieving planning principles set by western planners. In Africa, planning education is also influenced by western curricula, therefore the knowledge of planners is biased to western views. This can be evidenced by the perception of most planners working in the local government offices about informal settlements. Most of them still encourage demolition and relocation in order realise state funded development projects. This perception negatively affects the local people and their right to live. To minimise the risk of climate change in informal settlements, understanding the reality on the ground is critical. Therefore, an ‘Africanised’ or indigenous planning that encourages understanding of the local context is needed. The new planning approach for Africa should encourage integration of indigenous knowledge with scientific knowledge. It should also promote flexibility from inception to implementation phases of the plan. Accordingly, Hybridised Resilience Planning Model [HRPM] for Africa informal settlements is necessary.

11.2 Recommendations

11.2.1 Recommendation for the Case of Informal Settlements at the Periphery of Phuthaditjhaba

To cope with the highest climate change-risk scenario in the case of informal settlements at the bottom of Drakensberg Mountain, different alternatives are suggested. The first alternative is relocating the inhabitants of informal settlements to alternative settlement areas found at the periphery of Phuthaditjhaba and restricting informal settlements and keeping the area protected. To relocate the inhabitants from the informal settlements facilitating the project of Reconstruction and Development Programme [RDP] can be considered as one of the alternatives to find a solution to the problem. The source of the budget could be the government and/or other development partners working towards reducing the risk of climate change. If a practical application of this alternative is not feasible, the second alterative could be upgrading the quality of housing and local road layout and drainage system, as well as installing water and electricity lines at least at community level. This possibly minimises the risk of flash flooding that could happen during thunderstorms. To reduce the risk of rock falls from the hillside that may be caused by flash flooding and extensive erosion of soil at the top-hillsides of the mountain, planting trees and building, protective structures at the bottom of the mountain are critical. Otherwise, the damage to human life and other structures will be high.

To cope with the risks possibly caused by extremes of weather conditions such as strong and damaging wind, thunderstorms, extremely cold winters and hot summers, improving housing quality, establishing windbreak structures and tree-belts by identifying major wind direction are critical measures that have to be operationalised urgently in the areas of informal settlements. The local government should allocate a budget to improve infrastructure and service conditions in informal settlements, rather than focusing only on the formal urban system, because any negative externality from the informal settlements directly affects the living conditions in the formal urban system. Therefore, inclusive thinking is very critical to achieve the broader sustainable development goals in the area.

To diversify the income sources and employment opportunity for the inhabitants in the informal settlements, small-scale enterprises and entrepreneurship should be encouraged by providing technical and financial support. This minimises the risk of dependency on only social grants as a source of income. This could be realised by a cooperation of local government, NGOs and other civil society organisations. The more diversified income sources and employment opportunity in the area, the more climate change resilience can be created in the area. Therefore, the local economic development programme should focus on establishing and attracting labour-intensive investments in order to improve the overall wellbeing of the local community, including inhabitants of the informal settlements. Further, the comparative advantage of the existence of the Golden Gate National Park and attractive Drakensberg Mountain ranges should be used to generate revenue from the tourism sector. Then, benefitting the inhabitants of informal settlements at the periphery of Phuthaditjhaba through providing infrastructure and promoting small-scale enterprises to create employment opportunities for the local community may help the effort of improving climate change resilience in the area.

To avoid conflict of interests among the traditional leaders and local municipal councillors regarding the land administration at the peripheral area of the town, providing flexible and contextually applicable legal frameworks at local government level is crucial. This legal framework should recognise the historical background of the specific location, the level of political influence of traditional leaders, and the community's culture and preference to sustain their livelihood. This legal framework should reserve room for negotiation between traditional leaders and local government in terms of flexibly managing the land issue in the informal area. Since the traditional leadership in the area has a long history, appreciating the strength of this leadership and closely working with them to mobilise the community for natural environment conservation would be very important and may contribute positively to improving climate change resilience in the informal settlements in the area.

11.2.2 Recommendation for the Case of Informal Settlements at the Periphery of Karat

To enhance the climate change resilience, special emphasis has to be given to growing drought-tolerant trees and crops and strengthening the practice of terracing and micro-ponds to conserve water and soil. Using organic wastes as a fertiliser to improve agricultural productivity, such as making compost, can easily be prepared from waste disposals from the nearest Karat town. This enables them to contain moisture and humidity of arable land in the face of the hardships of drought. To minimise deforestation and soil erosion in the area, consideration ought to be given to building up and utilising alternative energy sources, such as biogas and solar systems. Keeping in mind the adaption of the extremes of climate conditions, improving the quality of traditional housing made from woods and grass and supplanting them with bricks made from mud and locally available soil should be done. In this process, an environmental impact assessment also ought to be given emphasis in order to limit the adverse effect of environmental degradation. This helps to minimise the risk of deforestation possibly caused by housing construction. To cope with the risk of periodic droughts occurring in the area, introducing informal micro-finance and insurance services is essential. In this regard, society's strong bond and traditional leadership help to administer this service in a sustainable manner.

In order to promote the significant role of indigenous knowledge to improve climate change resilience, recognition should be given to informal socio-cultural institutions governed by traditional leaders at community level. The strong social bond and network and the experience of using different forms of indigenous knowledge have to be capitalised on, strengthening resilience capacity of the society, using social networks as a channel to transmit climate information. This technique is possibly effective, because it directly aligns with people's beliefs and lifestyle. Special emphasis has to be given also to institutionalise indigenous knowledge and use local resources in order to advance the society's resilience capacity and withstanding climate change-induced risks. Aligning the development goals of the area with the plans of all stakeholders is critical in order to cope with the prevailing climate change-associated risks in the area.

To diversify the income sources of the community, supporting the traditional saving and credit system "*Equb*" by providing technical support to the community at the grass-roots level is fundamental, as well as encouraging the community to involve in Productive Safety Net Programmes (PSNP) for alternative income sources that empower them to sustain their livelihoods. With a specific objective of scaling up and strengthening the traditional small-scale production systems, such as weaving, blacksmithing, and handicrafts, technical and financial support ought to be given to the community by government and NGOs.

Improving infrastructure and service facilities to exploit the potential benefit from the tourism sector is necessary. Since the area is registered as one of the world heritage sites, it will attract more tourists if the required services are fulfilled. Then, the community living informally in the area will benefit directly from the revenue generated from this sector, using the comparative advantage of tourism attraction centres found in the area for the purpose of generating revenue and allocating the budget to provide infrastructure and services in the informal areas. To minimise the density of the population at the top of hills, attracting new establishments by providing infrastructure and services at the lowland areas also requires attention.

11.2.3 General Recommendation and Lessons for Africa

Climate change-resilience building must be placed within with local contexts that are shaped by an understanding of priorities and a tailored approach to the specific spatial and time scale.

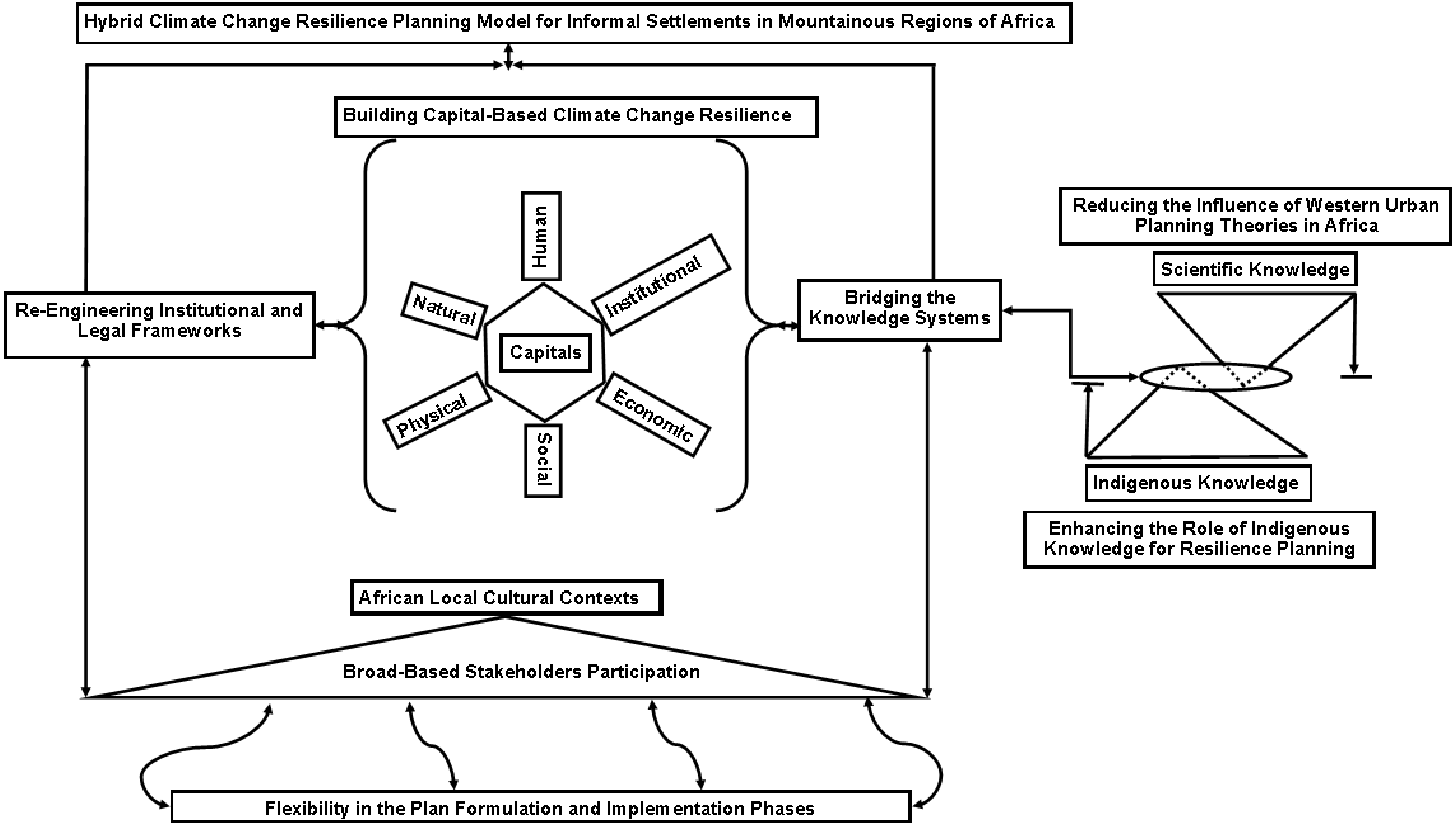
Observing vulnerability to climate change risks with the lenses of resilience assessment frameworks enables the planners to understand the concepts in and in-depth and holistic manner. Therefore, in the context of informal settlements in the mountainous regions of Africa, a customised Hybrid Climate Change Resilience Planning Model (HCCRPM) must be formulated and implemented. This planning model should accommodate the social, environmental and economic situation in a particular area, integrate all man-made and natural capitals found at the local area, and advocate a step-by-step and flexible infrastructure and service provision in the areas of informal settlements. In addition, it has to recognise the local cultural contexts that govern the indigenous knowledge system and allow broad-based stakeholders' participation from inception to implementation, as well as in evaluation phases of the climate change-resilience plan. Therefore, flexibility in at levels of the planning process needs to be the critical consideration and the process should allow to using multiple instruments and methods to enhance the resilience of informal settlements to climate change risks. Accordingly, all these processes require the re-engineering of the previous institutional and legal frameworks that were biased towards western urban planning theories. The new, customised institutions should play the role of mediation to link scientific society with the indigenous people (See Figure 46).

Devising micro-level or site-specific climate change-resilience strategy is very critical, because the different areas have their own unique characteristics that require contextual and feasible solutions. Policy and planning interventions to improve climate change resilience capacity should consider spatial, cultural, social, economic and ecological heterogeneity and context of informal settlements in a particular area, in other words, advocating a "bottom-up approach" to identify the real situation on the ground. This enables the local community to decide on and benefit from the resources available at grass-roots level and make them part of the solution. The government should create the enabling environment to the local communities to respond quickly and adapt to extreme weather conditions by using their social networks as a channel to flow climate information. To build up a sense of belongingness of local community in the process of natural environment conservation, the development partners ought to support distinctive benefit schemes at local level, promoting climate change risk-based education and empowering those vulnerable people. This can be realised through broad-based stakeholder involvement in the resilience planning process. The participation should incorporate local and national government, the private sector, planners, ecologists, sociologists and other civil society organisations, traditional leaders, and inhabitants from the formal and informal settlements.

Effectively using the advantage of the cheap labour force in most African cases to conserve the natural environment and promoting small-scale labour-intensive enterprises in the areas of informal settlements helpful to enhance resilience. This creates an opportunity for the local community to diversify their income source and improve their climate change resilience capacity by establishing tailor-made, informal micro-finance and insurance services that consider the traditional living situations of the society to help them cope with climate change-induced risks, thus promoting alternative living conditions in the informal areas through diversifying financial, human, physical and social capitals available in the areas. This can be realised by identifying the resources available at the local area and from other development partners.

To enhance the governance of climate change and cope with environmental challenges, improving the local capacity through capacity building, providing resources, establishing new institutions, enhancing good governance, and enhancing local decision-making power are important. To realise this, practical participation of the local and regional governments, stakeholders and development partners, traditional leaders and the poor living informally in the area is imperative. Furthermore, institutionalising the experience of indigenous knowledge and linking with scientific knowledge are more feasible in the context of traditional living conditions. However, this process requires especial attention and engagement of the government, private sector, academic institutions and traditional society. In line with this, establishing an institution at the local level to flexibly manage the issues of informal settlements and improve their climate change resilience is critical.

In this regard, the legal framework that gives authority for this institution and encourages traditional leaders' participation in the decision-making processes at the local level should be in place. The creation of enabling legislations that promote flexible institutions and recognise the benefit of hybridising the indigenous and scientific knowledge is critical for enhancing the resilience of informal settlements to climate change risks. Traditional systems of governance and social networks also need to get recognition, because they facilitate the successful implementation of climate change resilience planning in the given area. These will improve the ability to manage diversity and share resources collectively while dissipating climate change risks and reinforcing innovative capacities. The local government can also use the informal social networks as an opportunity to communicate climate change risks and to cope with the threats.



Source: Author's Design, 2016

FIGURE 46: Hybrid Climate Change Resilience Planning Model for Informal Settlements in Mountainous Regions of Africa

Mainstreaming climate change resilience programmes in all development endeavours through involving in educational curricula, forums and awareness raising campaigns is also essential. The action must be started now, at least to mitigate the negative impacts of climate change related risks. Identifying and mapping specific areas by the intensity of climate change associated risks and making intervention based on the contexts are essential. Planning for climate change resilience ought to include better administration of climate change-associated risks in all sectors, by all stakeholders, with locally feasible techniques. Another hazard administration culture is required, which incorporates climate change-induced dangers within a long-run development planning to enhance informal settlement resilience. Therefore, capacity building should involve the community most vulnerable to climate change risks in the informal settlement areas. Further, in order to enhance resource efficiency and effectiveness, there must be institutional integration and coordination in the process of climate change resilience planning of informal settlements.

11.3 Implication for Policy and Practice

The general policy guideline should promote an integration of indigenous knowledge with scientific knowledge in order to implement resilience planning for informal settlements in the mutinous region of Africa. This requires the establishment of new African and local institutions that facilitate an integration of the two knowledge systems and work as a bridge between the indigenous and scientific community. Consequently, development partners and actors should be involved in capacity building programmes by providing financial and technical support for these newly designed institutions. The issue of climate change risks has already been recognised at national level in both case study areas. However, there is a big gap in relation to the practical application of climate change resilience programmes at grass-roots level, especially in the areas of informal settlements. For instance, the importance of indigenous knowledge systems in the areas of biodiversity conservation and natural resources conservation has been recognised at policy level in both nations. However, because of weak institutional frameworks at the local level, this knowledge is subjected to the danger of loss. Therefore, how to implement the existing policies at the grass-roots level needs especial consideration. To cope with these challenges, intensive capacity building programmes are necessary for local institutions and local communities.

The past planning guidelines in both nations were biased towards the formal urban planning procedures that are highly influenced by western urban planning theories and technocrat urban planners. In addition to the lack of technical and finical capacity at the local level, this is one of the major problems that hamper the implementation of urban planning in the context of the two case study areas. For instance, the *Spatial Planning and Land Use Management Act*, 2013 (SPLUMA) formulated in South Africa, does not clearly recognise the role of traditional leaders in land administration. Consequently, the existing reality in the study site indicates that the influence of traditional leaders is still high. This negatively influences the implementation of the plan at local level. This implies that there is a gap between policy at national level and practice at local level. Therefore, for successful implementation of policy and planning guidelines, understanding the reality at grass-roots level is crucial. In the context of both case study areas, climate change resilience was embedded in the practice of indigenous knowledge and expertise, diversified resources and livelihoods, informal social institutions and networks, as well as cultural values and attitudes. Therefore, the policy response to climate change risks should support and enhance indigenous ways of coping strategies. Accordingly, the researcher proposes that a customised Hybrid Climate Change Resilience Planning Model [HCCRM] needs to be materialised in the context of traditional small towns in mountainous regions of Africa. The policy guidelines should be enforced by institutionalising this new approach to climate change resilience planning. Generally, the government and the public should take responsibility to enhance climate change resilience of informal settlements by recognising the reality on the ground. Accordingly, more serious focus should be on policy implementation, rather than having a decoration of policies on paper that are not implemented successfully.

11.4 Implication for Further Research

For the purpose of this study, the combination of different assessment frameworks was materialised in order to investigate climate change risks, vulnerability and resilience of informal settlements in mountainous regions of Africa. The approach of using a combination of different assessment framework was preferred to minimise the gap and drawbacks possibly observed in the process of examining these issues by using a single framework. As the case studies were limited to two informal settlements found at the periphery of traditional small towns in Eastern and Southern Africa, to develop universally applicable and acceptable climate change-resilience assessment framework requires ranges of heterogeneous geographical areas. Accordingly, this research paves the way for a new research area that could possibly devise a universally applicable, flexible and fit-for-purpose climate change-resilience assessment framework.

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Appendix 1
FIELD REVIEW TABLES – PHUTHADITJHABA

TABLE 1.1: ANNUAL HOUSEHOLD INCOME IN 2015 AT THE PERIPHERY OF PHUTHADITJHABA

Range of Income	Number of Households	Annual Household Income
<R500	13	7%
R500 – R1,000	10	5%
R1,001 – R 2,000	38	20%
R2,001 – R 3,000	67	35%
R3,001 – R5,000	38	20%
R5,001 – R10,000	19	10%
More than R10,000	6	3%
Total	**192**	**100%**

TABLE 1.2: EMPLOYMENT STATUS OF RESPONDENTS IN 2015 AT THE PERIPHERY OF PHUTHADJIDABA

Status of Employment	Number of Households	Response Rate
Employed	25	13%
Unemployed	77	40%
Not Economically Active	90	47%
Total	192	100%

TABLE 1.3: INCOME BY SOURCE OF HOUEHOLDS AT THE PERIPHERY OF PHUTHADITJHABA IN 2015

Income Type	Number of Households	Percentage of Income
Wages from daily labour	65	34%
Salary from government	0	0%
Salary from private sector	6	3%
Self-employment	6	3%
Remittance	15	8%
Social grants	100	52%

Appendix 2
PHUTHADITJHABA AND KARAT RAINFALL DISTRIBUTION AND TEMPERATURES

TABLE 2.1: PHUTHADITJHABA ANNUAL AND MONTHLY RAINFALL DISTRIBUTION IN THE YEAR 1986-2016 (IN MM)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Total
1986	127.9	65.2	101.4	80.5	0	30.5	0	61	10.5	142.1	105.5	84.8	**67.5**	**809.4**
1987	67.4	76	69.2	46.2	3.3	7	3.5	71.8	160.7	14.9	0	0	**43.3**	**520.0**
1988	158.9	229.7	270.9	33.5	17	3.5	0	0	0	0	0	49	**63.5**	**762.5**
1989	174.7	278.2	58.5	39.3	19	29.8	0	3.5	0	51.8	193.8	48.4	**74.8**	**897.0**
1990	45.1	127	67.7	100	14.9	6	0.6	14.2	2.5	50.6	39	152.6	**51.7**	**620.2**
1991	201.9	224	126.5	0	0	20.5	0	0	43.7	159.7	104.7	120	**83.4**	**1001.0**
1992	91	210	106	34	0			88	0	52	183.5	26	**79.1**	**790.5**
1993	124	139.9	160	60.5	0	6	0	16.5	0	83	12	0	**50.2**	**601.9**
1994	0	30	8.5	40	31	0	0.8	2	10.7	35.6	31.3	138.3	**27.4**	**328.2**
1995	84.5	94.5	84.3	22.7	1.6	7.9	0	3	9.9	30.4	143.7	151.9	**52.9**	**634.4**
1996	187.5	185.8	74.9	31.4	38.2	0	16.9	5	17.2	164.8	46.4	141.3	**75.8**	**909.4**
1997	69.2	16.5		62.2	64	33	23.9	14.9	49	59.6	126.8	22.2	**49.2**	**541.3**
1998	57.5	109	90.2	10	0	0	0	0	9.6	45.8		44.8	**33.4**	**366.9**
1999	42.8	56.7	65	13.1	14.7	5	0	0		46.3	92.8	230.6	**51.5**	**567.0**
2000	196.6	138.3	207.1	3.3	0.3	5.9	0.3	0.6	58.4	84.1	68.0	61.9	**68.7**	**824.8**
2001	59.3	108.6	81.8	34.0	6.6	0.5	8.5	27.4	0.6	2.1	0.4	85.8	**34.6**	**415.6**
2002	21.4	41.4	21.8	40.0	43.8	19.3	4.8	89.0	23.6	44.4	13.4	136.2	**41.6**	**499.1**
2003	83.5	131.1	51.5	9.3	8.2	6.7	0.1	8.6	13.0	24.7	106.4	45.1	**40.7**	**488.2**
2004	95.1	98.5	77.9	19.6	0.0	21.6	5.8	4.9	14.4	38.2	68.6	110.5	**46.3**	**555.1**
2005	178.9	57.8	87.3	36.7	11.2	0.5	0.0	31.1	13.4	115.5	101.5	36.2	**55.8**	**670.1**
2006	169.3	142.7	101.9	47.5	9.8	0.1	1.2	50.0	21.7	67.0	100.3	116.3	**69.0**	**827.8**
2007	60.2	24.6	36.4	35.8	1.7	15.6	0.4	0.0	37.0	113.2	1.2	1.5	**27.3**	**327.6**
2008	1.2	1.6	4.1	2.5	18.3	21.6	1.3	3.1	4.3	27.4	154.9	77.0	**26.4**	**317.3**
2009	44.7	74.7	53.3	24.6	26.7	35.3	1.8	12.2	11.2	86.9	71.9	85.3	**44.0**	**528.6**
2010	193.3	13.0	59.2	54.6	3.8	6.6	0.0	0.0	0.8	55.1	148.8	187.5	**60.2**	**722.6**
2011	193.6	114.8	52.6	36.1	20.2	18.6	22	13.2	5.2	49.6	18.9	94.4	**53.3**	**639.1**
2012	92.6	59.8	132.1	0	0	47.7	0	3.2	113.8	132.1	31.0	134.4	**62.2**	**746.7**
2013	117.4	95.3	36.3	66.0	28.7	1.0	0.0	8.9	3.1	91.2	77.5	105.9	**52.6**	**631.2**
2014	222.1	106.4	2.0	26.2	0.0	0	0	11.3	8.6	26.1	173.7	43.7	**51.7**	**620.1**
2015	94.1	44.7	131.9	0.3	0.5	7.4	18.3	0.3	13.5	22.6	30.7	47.5	**34.3**	**411.7**
2016	113.5	125.7	59.2	40.6	27.4	15.2	72.4						**64.9**	**454.2**
Average	**108.7**	**103.9**	**82.6**	**33.9**	**13.3**	**12.4**	**6.1**	**18.1**	**22.6**	**63.9**	**77.5**	**86.0**	**52.8**	**629.0**
Total	**3369.1**	**3221.4**	**2479.5**	**1050.6**	**410.9**	**372.8**	**182.5**	**543.6**	**656.3**	**1916.8**	**2246.8**	**2579.0**		

Source: Agricultural Research Council Institute for Soil Climate and Water (ARCISCW), South Africa (2016).

TABLE 2.2: MAXIMUM TEMPERATURE OF PHUTHADITJHABA IN THE YEAR 1986-2016(IN °C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1986	24.84	24.61	25.69	21.26	20.82	14.55	16.88	19.44	21.29	21.2	21.7	25.91	**21.5**
1987	28.11	28.21	26.1	24.21	21.74	15.79	16.43	16.45	17.31	21.56	0	0	**18.0**
1988	26.51	25.45	23.63	20.18	19.55	16.76	0	0	0	0	0	24.04	**13.0**
1989	26.93	23.86	24.74	11.41	8.36	2.99	22.08	20.9	21.59	21.96	22.04	25.25	**19.3**
1990	27.81	25.71	24.46	22.03	20	17.87	18.24	19.2	23.24	24.25	27.33	26.22	**23.0**
1991	26.9	25.7	23.33	24.96	20.98	16.1	18.02	20.31	21.86	22.24	25.87	0	**20.5**
1992	28.95	28.94	26.18	25.13	21.25	17.6	18.08	0	23.61	24.32	22.59	27.33	**22.0**
1993	27.66	24.41	24.5	21.58	20.06	15.84	17.86	18.85	24.2	22.26	23.19	24.71	**22.1**
1994	23.87	23.72	24.1	21.79	20.36	14.92	16.12	18.33	23.26	22.34	25.24	27.53	**21.8**
1995	26.85	27.03	24.31	20.58	18.27	16.62	16.2	19.41	24.61	23.14	23.4	22.44	**21.9**
1996	25.37	23.89	23.16	20.01	17.87	16.49	11.86	16.15	22.5	22.88	22.15	25.35	**20.6**
1997	24.9	27.08	22.05	19.6	16.55	15.25	16.03	20.11	21.38	21.85	22.93	26.41	**21.2**
1998	25.22	26.01	24.52	24.05	19.22	19.14	16.69	18.8	23.09	23.55	23.85	23.95	**22.3**
1999	25.89	26.86	25.87	22.79	19.01	17.13	17.5	19.27	20.85	22.41	27.36	23.37	**22.4**
2000	22.72	24.11	23	19.94	19.5	18.1	16.8	20.8	20.6	23.3	22.3	26	**21.4**
2001	27.2	24.8	25.1	20.7	20	18.4	16.1	20.1	20.4	23	22.8	25	**22.0**
2002	26.5	25.4	26.3	24.4	20.2	15.5	16.3	18.4	21.3	25.1	24.8	25	**22.4**
2003	26.8	26.8	24.9	24	20.9	15.5	22.8	17.8	22.1	26.8	24.8	26.7	**23.3**
2004	25.9	25.4	23.7	22.6	21.4	17.5	15.3	20.6	20.9	24	28.1	26.1	**22.6**
2005	26.3	26.1	23.7	21.2	20.8	18.8	19.4	21.1	24.5	23.8	24.5	26	**23.0**
2006	25.2	24.7	22	20.9	16.3	17.4	19	16.6	22.4	23.7	24.2	26.6	**21.6**
2007	27.2	28.6	25.8	22.6	20.6	16.4	17.6	20.2	25.3	19.9	23.7	23.9	**22.7**
2008	24.9	25	23.4	21.5	19.6	17.2	17.1	20.6	22.5	25.9	25.8	27.1	**22.5**
2009	28.1	25	24.4	22.4	19.7	17.2	25.2	23.2	26.1	27.2	30.7	30.2	**24.9**
2010	31.5	34.6	34.4	25.4	29	24.6	27.6	26.8	26.4	25.4	26.5	26.5	**28.2**
2011	34.3	36.3	36.5	24.1	19.04	16.7	14.68	18.77	23.91	24.49	26.47	26.79	**25.2**
2012	27.95	27.26	25.45	21.92	21.6	15.7	17.81	20.29	19.9	23.32	26.7	25.5	**22.8**
2013	26.9	28	25.8	21.8	20.5	19.5	18.6	19.5	24.3	24.8	25.3	25	**23.3**
2014	28.5	0	26.5	23.2	22.9	18.44	16.69	18.9	24.31	24.24	22.65	25.84	**21.0**
2015	26.08	27.25	23.86	23.7	23	17.3	17.8	23.7	23.3	28	27.7	31	**24.4**
2016	28	27.9	26.9	23.8	20	18.3	16.5	21.4					**22.9**
Average	**26.9**	**25.8**	**25.3**	**22.1**	**20.0**	**16.8**	**17.3**	**18.6**	**21.9**	**22.9**	**23.1**	**24.2**	**22.1**

Source: Agricultural Research Council Institute for Soil Climate and Water (ARCISCW), South Africa (2016).

TABLE 2.3: MINIMUM TEMPERATURE OF PHUTHADITJHABA IN THE YEAR 2000-2016 (IN °C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1986	11.59	10.6	12.24	9.63	4.67	1.62	-0.15	2.88	6.65	8.66	9.41	11.4	**7.4**
1987	12.72	13.99	11.72	9.26	4.3	0.62	-0.14	2.2	5.23	8.02	0	0	**5.7**
1988	14.28	14.45	12.67	8.41	3.82	2.82	0	0	0	0	0	11.33	**5.6**
1989	12.89	13.19	10.04	6.59	3.65	-1.01	2.92	4.51	3.19	4.87	8.91	11.3	**6.8**
1990	13.53	11.5	10.55	8.6	3.04	-1.45	-0.45	1.59	5.19	9.07	11.1	13.03	**7.1**
1991	14.03	13.76	11.19	5.2	1.96	0.26	0	0	0	0	0	0	**3.9**
1992	12.34	11.72	8.73	6.7	1.15	-0.29	-1.78	2.08	6.99	7.76	9.3	11.85	**6.4**
1993	11.91	11.84	10.35	5.92	1.99	-2.48	-0.73	0.75	4.31	10.37	10.2	12.05	**6.4**
1994	12.43	11.84	10.06	5.27	-0.08	-1.25	-5.34	0	3.62	5.74	9.72	12.02	**5.3**
1995	13.49	13.88	11.2	6.9	2.03	-2.14	0.21	-0	4.98	9.12	11.34	10.73	**6.8**
1996	13.56	13.21	9.65	6.2	4.14	-0.23	-1.08	2.05	4.25	9.05	9.85	12.44	**6.9**
1997	13.75	12.87	12.77	5	1.92	1.88	-0.24	2.11	6.88	8.39	9.4	11.94	**7.2**
1998	13.09	13.46	11.18	6.25	1.6	-1.14	-0.04	0.83	5.43	9.07	10.96	12.39	**6.9**
1999	13.91	13.33	11.86	7.43	3.8	-1.48	-1.08	-0.1	4.24	7.98	11.57	13.45	**7.1**
2000	12.15	13.81	13.33	7.01	3.8	1.6	0.81	4.05	6.6	10.9	10.8	13.3	**8.2**
2001	13.5	12.9	12.3	9.64	4.59	2.04	0.31	2.47	6.3	10.7	11.8	13.3	**8.3**
2002	14.1	13.3	12.6	8.42	4.36	1.25	1.16	6.37	7.1	10.3	9.96	13.4	**8.5**
2003	14.2	14.7	10.9	6.2	-0.8	-0.3	1.2	2.61	8.1	13.6	12.1	13	**8.0**
2004	14.6	14.1	12.3	8.51	4.01	0.06	-0.3	5.29	5.3	9.83	13.3	13.8	**8.4**
2005	14.6	14.1	11.7	8.61	4.09	2.75	0.59	6.35	8.3	9.97	11.8	11.9	**8.7**
2006	15	15	11.4	8.66	2.27	-0.2	1.55	2.95	6.3	10.6	11.5	13.2	**8.2**
2007	13.5	13.4	11.5	8.2	2.42	1.64	0.62	3.5	9.2	9.81	11.4	12.4	**8.1**
2008	13.7	14.1	11.8	6.92	5.7	1.68	1.5	4.54	6.4	10.6	13	14.3	**8.7**
2009	14.9	14.4	11.9	7.83	4.76	3.3	-0.1	3.24	7.2	10.4	10.1	13.5	**8.4**
2010	16.4	16.3	10.4	10.7	6.42	1.07	3.77	3.7	8.7	9.99	12.2	13.2	**9.4**
2011	16.3	22	22.3	10.8	3.17	0	-4.58	-0.5	5.17	8.08	10.18	12.33	**8.8**
2012	13.56	13.33	10.39	5.08	2.72	-0.14	-1.89	2.28	5.45	9.46	11.9	13.4	**7.1**
2013	14.2	13.5	12.2	6.71	2.62	1.75	3.4	3.84	7.1	8.66	11.2	13.1	**8.2**
2014	12.14	13.05	11.9	6.39	3.95	-1.47	-2.52	1.26	4.9	7.75	10.26	12.17	**6.7**
2015	12.69	11.66	11.02	7.48	4.91	3.97	2.77	5.28	8.6	11.3	10.9	14.8	**8.8**
2016	14.8	14.3	12.5	9.91	5.07	2.27	1.67	3.49					**8.0**
Average	**13.7**	**13.7**	**11.8**	**7.6**	**3.3**	**0.5**	**0.1**	**2.6**	**5.7**	**8.7**	**9.8**	**11.8**	**7.4**

Source: Agricultural Research Council Institute for Soil Climate and Water (ARCISCW), South Africa (2016).

TABLE 2.4: KARAT ANNUAL AND MONTHLY RAINFALL DISTRIBUTION (IN MM)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Total
1986						81.0		17.0	18.0	15.0	65.2	69.2	**44.2**	**265.4**
1987	21.5		97.3	238.5	214.3	19.1	3.3	9.4	47.3	112.5		18.0	**78.1**	**781.2**
1988	20.8	17.0	32.1		54.3	72.5	77.8	47.4	142.2	68.6	14.1	11.6	**50.8**	**558.4**
1989	38.3	97.9	121.1	158.7	218.0	22.7	34.6	32.9	105.8	108.1	17.5	96.2	**87.7**	**1051.8**
1990	11.5	145.9	178.4	157.8	73.8	10.4	10.0	11.9	41.1	50.8	28.2	16.9	**61.4**	**736.7**
1991	35.5	37.4	148.6	95.1	166.6	46.3	0.0	49.2	24.3	72.3	67.9	37.4	**65.1**	**780.6**
1992	7.9	23.3	59.7	159.5	138.3	68.5	42.6	4.9	92.4	112.1	38.6	38.4	**65.5**	**786.2**
1993	107.5	169.9	1.8	0.0	106.3	0.0	1.0	1.6	14.9	90.1	29.6	24.7	**45.6**	**547.4**
1994	549.6	4.2	81.8	171.1	137.1	16.7	29.7	69.3	15.7	109.3	64.6	16.7	**105.5**	**1265.8**
1995	10.2	7.1	31.1	171.7	31.8	87.7	22.8	1.4	44.1	55.8	0.0	3.2	**38.9**	**466.9**
1996	32.7	24.0	161.1	205.4	74.0	76.7	19.8	35.8	94.9	80.6	10.1	0.0	**67.9**	**815.1**
1997	5.8	0.0	52.6	259.1	74.8	22.3	79.3	28.2	15.0	229.7	229.7	64.2	**88.4**	**1060.7**
1998	122.9	125.5	45.1	118.3	123.9	53.9	1.5	23.0	40.1	120.7	32.2	0.0	**67.3**	**807.1**
1999	7.6	3.5	148.5	106.0	4.9	12.4	31.5	41.8	38.3	68.3	11.6	66.9	**45.1**	**541.3**
2000	0.0	0.0	28.3	87.1	98.2	5.0	10.3	18.3	17.9	76.8	37.5	68.1	**37.3**	**447.5**
2001	33.2	4.1	98.4	352.0	0.0	0.0	19.8	63.1	50.3	137.8	81.2	1.9	**70.2**	**841.8**
2002	43.0	15.7	86.9	112.0	77.9	14.0	0.0	3.4	43.1	92.9	28.2	228.7	**62.2**	**745.8**
2003	3.8	14.2	80.2	231.6	210.4	25.7	27.2	85.0	30.1	41.4	44.0	35.3	**69.1**	**828.9**
2004	33.4	13.0	54.2	112.6	123.3	4.9	6.2	0.3	56.3	42.1	83.5	33.2	**46.9**	**563**
2005	25.0	2.4	81.8	145.0	273.4	9.5	19.4	16.2	61.8	109.9	57.6	0.0	**66.8**	**802**
2006	3.1	65.9	142.2	177.5	41.9	32.0	5.0	100.3	14.6	141.2	181.8	75.4	**81.7**	**980.9**
2007	13.4	3.8	55.1	154.7	84.2	77.6	12.3	115.6	181.7	71.2	70.2	0.0	**70.0**	**839.8**
2008	3.7	4.3	43.2	123.3	68.6	10.1	44.8		144.9	192.7	29.0	0.8	**60.5**	**665.4**
2009	44.4	16.3	61.5	82.6	93.4	23.3	11.9	1.4	51.1	63.2	90.3	38.8	**48.2**	**578.2**
2010	44.0	56.6	163.1	220.1	180.3	24.9	18.5	23.2	57.9	73.9	26.1	20.2	**75.7**	**908.8**
2011	0.0	24.8	62.7	79.9	177.0	68.9	50.5	50.5	61.0	137.6	281.0	70.5	**88.7**	**1064.4**
2012	0.0	2.6	36.2	217.3	55.5	17.6	66.6	46.9	180.9	128.1	79.0	54.5	**73.8**	**885.2**
2013	18.4	11.1	77.9	85.3	151.1	20.0	11.1	55.0	113.7	53.4	115.2	8.6	**60.1**	**720.8**
2014	1.9	83.6		52.5	114.2	59.9	31.2	41.3	37.7	114.8			**59.7**	**537.1**
2015	0.0	15.9	59.8	233.9	99.9	125.1	43.8						**82.6**	**578.4**
Average	**42.7**	**35.4**	**81.8**	**153.9**	**112.7**	**37.0**	**25.3**	**35.5**	**63.3**	**95.5**	**67.2**	**39.3**	**65.8**	**748.42**
Total	**1239.1**	**990.0**	**2290.7**	**4308.6**	**3267.4**	**1108.7**	**732.5**	**994.3**	**1837.1**	**2770.9**	**1813.9**	**1099.4**		

Source: National Meteorology Institute of Ethiopia (2015)

TABLE 2.5: MAXIMUM TEMPERATURE OF KARAT IN THE YEAR 1985-2015(IN °C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1986						23.8		25.9	24.8	27.5	28.6	28.2	26.5
1987	29.5	29.8	28.4	26.8	25.2	24.6	25.5	27.0	28.6	27.8		30.1	27.6
1988	30.3	31.0	31.5	27.4	24.8	25.3	24.1	25.8	26.3	26.7	28.5	29.3	27.6
1989	29.8	29.0	28.8	26.1	25.5	25.3	24.1	27.2	26.8	25.7	27.6	28.2	27.0
1990	29.0	29.0		26.1	27.3	26.5	26.5	26.6	29.0	28.4			27.6
1994		31.9	30.6	27.7	24.9	25.6	24.7	25.3	28.4	26.7	27.2	29.4	27.5
1995	30.7	31.0	29.3	27.2	27.4	26.6	25.5	26.5	27.4	27.6	28.1	29.7	28.1
1996	29.9	31.6	28.7	26.1	26.2	24.0	25.1	26.8	26.8	27.3	28.5	30.1	27.6
1997	31.1	32.2	31.8	25.9	26.0		25.9	27.4	29.2	25.9	25.5	26.6	28.0
1998	27.4	28.4	29.9	29.3	26.8	25.7	24.7	25.3	27.9	27.1	28.5	30.4	27.6
1999	31.7	32.7	29.4		28.4	27.9	25.1	27.3			29.4	28.9	29.0
2000	31.2	32.4	32.6	29.7	26.7	27.0		26.9	27.7		27.4	28.9	29.1
2001	31.7	31.5	29.4	25.3								30.1	29.6
2002	30.0	32.0	29.5	28.4	26.4	26.4	27.0	27.2	28.3	27.3	28.8	27.6	28.2
2003	29.0	31.9	31.3	27.7	25.8	25.6	25.5	25.9	28.2	29.5	29.4	29.0	28.2
2004	29.9	30.9	31.5	27.2	26.9	26.7	26.9	27.9	28.4	27.9	27.5	29.0	28.4
2005	30.3	32.0	30.7	29.1	25.3	25.7	25.8	27.4	27.8	27.3	28.3	30.4	28.3
2006	31.2	31.1	29.4	26.6	27.7	27.1	26.3	26.0	27.7	27.4	26.6	27.4	27.9
2007	29.5	31.4	31.5	28.6	26.9	25.4	25.9	25.2	26.3	27.5	28.3	29.8	28.0
2008	31.2	31.8	31.1	27.9	27.2	26.8	25.5	26.9	27.7	26.1	27.2	29.8	28.3
2009	30.3	31.5	32.1	28.0	27.6	28.3	26.9	28.1	29.1	28.5	29.9	28.7	29.1
2010	29.7	30.8	28.9	27.9	26.3	26.3	25.8	26.9	28.0	28.4	30.2	30.4	28.3
2011	31.5	32.3	32.0	31.4	27.4	26.7	27.2	26.7	27.7	28.3	25.9	27.4	28.7
2012	30.6	32.2	32.4	28.1	26.4	26.9	25.4	27.1	27.2	27.5	28.0	29.5	28.4
2013	30.9	32.8	30.7			26.2	26.4	26.3	28.1	27.5	27.9	29.6	28.6
2014	32.0	30.6		29.3	28.1	27.8	27.1	27.4	28.1	27.5			28.7
2015	31.6	32.8	32.4	28.3	27.5	26.8	27.1						29.5
Average	30.4	31.3	30.6	27.8	26.6	26.2	25.8	26.7	27.7	27.5	28.1	29.1	**28.2**

Source: National Meteorology Institute of Ethiopia (2015)

TABLE 2.6: MINIMUM TEMPERATURE OF KARAT IN THE YEAR 1985-2015 (IN °C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1985	7.0	8.6	9.6	11.3	10.5	10.0	10.0	9.7	9.6	9.0	8.2	7.0	9.2
1986											17.6	17.4	17.5
1987	17.5	18.4	18.5	17.9	17.0	16.4	16.3	16.3	17.1	17.4	17.5	18.1	17.4
1988	18.9	19.5	20.0	17.6	17.6	16.6	15.9	16.8	16.6	17.0	17.2	17.2	17.6
1989	17.5	17.6	18.1	17.0	16.4	15.9	16.1	17.0	16.4	16.5	16.9	16.9	16.9
1990	17.0	17.6	17.5	16.9	16.9	15.9	15.4	16.2	16.7	16.6			16.7
1994		19.4	18.8	18.1	17.0	16.9	16.4	16.2	17.1	16.8	16.8	17.0	17.3
1995		18.9	18.7	18.2	18.1	16.8	16.9	16.9	16.9				17.7
1996		19.2	18.1	17.2	17.2	16.2	15.8	16.4	16.6	16.7	17.0	17.8	17.1
1997	19.1	19.5	19.9	17.1	16.6		16.6	17.0	17.6	16.9	17.1	17.1	17.7
1998		17.8	18.9	18.8	17.5	16.6	16.4	16.2	16.7	16.7	16.7	17.0	17.2
1999	17.4	18.4	17.6		19.4	18.7	16.0	16.4			17.1	17.1	17.6
2000	17.8	18.5	18.5	17.2	16.8	16.4		15.8	15.9		15.1	14.9	16.7
2001	16.2	15.5	16.1	14.0			16.1	18.2	20.4	14.2	15.0	17.6	16.3
2002	17.4	18.9	17.2	15.8	14.3	13.9	13.8	16.8	17.4	17.2	18.2	18.0	16.6
2003	18.1	20.1	19.9	18.3	17.7	17.7	17.4	17.0	17.9				18.2
2004		19.2	19.2	17.5	17.3	17.0	16.8	17.5	17.4	17.6	17.5	18.3	17.8
2005	18.6	20.4	19.6	18.9	17.2	17.2	16.5	16.9	17.1	17.1	16.2	17.6	17.8
2006	19.4	19.4	18.3	17.4	18.1	17.2	17.4	16.8	17.1	17.5	17.0	17.0	17.7
2007	17.9	19.0	19.1	18.8	18.1	17.4	17.0	16.4	16.7	17.1	17.3	16.8	17.6
2008	18.0	17.9	17.8	16.8	16.4	15.6	15.8	17.5	16.3	16.0	16.3	17.5	16.8
2009	18.5	20.1	20.1	18.6	17.8	17.6	16.5	17.5	18.3	18.3	18.5	18.7	18.4
2010	18.4	20.0	18.2	18.5	17.9	17.2	16.4	16.4	16.9	17.3	18.0	17.1	17.7
2011	18.1	17.9	18.6	18.5	17.0	16.9	16.3	16.0	16.6	16.4	15.6	14.8	16.9
2012	15.5	16.5	17.0	15.7	17.6	17.7	16.8	17.0	16.6	16.7	16.8	16.4	16.7
2013	17.2	18.3	17.8			17.1	16.9	16.7	17.3	17.5	17.1	17.2	17.3
2014	19.0	19.2		18.7	18.1	17.9	17.8	17.7	17.9	18.0			18.3
2015	18.5	19.9	20.3	18.1	18.2	18.2	17.0						18.6
Average	17.4	18.4	18.2	17.3	17.1	16.6	16.2	16.5	16.8	16.6	16.6	16.7	**17.0**

Source: National Meteorology Institute of Ethiopia (2015)

Appendix 3
FIELD REVIEW TABLES – KARAT

TABLE 3.1: ANNUAL HOUSEHOLD INCOME AT THE PERIPHERY OF KARAT IN 2015

Range of Income in Ethiopian Birr	Number of Households	Annual Household Income (%)
500 – 1,000	48	25
1,001 – 2,000	35	18
2,001 – 3,000	63	33
3,001 – 5,000	31	16
5,001 –10,000	10	5
More than 10,000	6	3
Total	192	100

TABLE 3.2: EMPLOYMENT STATUS OF HOUSEHOLDS AT THE PERIPHERY OF KARAT IN 2015

Status of Employment	Number of Households	Percent
Employed	31	16
Unemployed	83	43
Not economically active	79	41
Total	192	100

TABLE 3.3: DISTRIBUTION OF INCOME BY SOURCE AT THE PERIPHERY OF KARAT IN 2015

Income Type	Number of Respondnets	Percentage of Income by Source
Wages from daily labour	109	57
Salary from government		0
Salary from private sector	15	8
Self-employment	50	26
Remittance	15	8
Social grants		0
Total	**192**	**100**

Appendix 4
QUESTIONNAIRE FOR DIRECTORS, DEPARTMENT HEADS AND EXPERTS

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS·UV
NATURAL AND AGRICULTURAL SCIENCES
NATUUR- EN LANDBOUWETENSKAPPE

Dear Respondent

Good day! The aim of this questionnaire is to collect data for conducting a **PhD study** in the title of *Improving the Resilience of Informal Settlements in Mountainous Regions of Africa*. Accordingly, your willingness to provide genuine information is crucial to the success of this study. The final outcome of this study will be used for academic and policy formulation purposes as well as to undertake informed decision-making at local and national level. I greatly appreciate your participation in the valuable contribution you can make towards this study. Please note the following ethical considerations before signing below.

1. You will remain anonymous and your name will not be used in any research findings. Here coded names for instance 'participant A, B.', etc. will be used.
2. Your identity will not be disclosed unless you agree.
3. You have the liberty not to answer specific questions or to withdraw at any stage.
4. Your participation is entirely voluntary.
5. You may choose not to answer any question (s).
6. There will be no remuneration for participating in this research.
7. Your signature below indicates your consent to participate in this study.

Thank you in advance for your cooperation!

Name (optional): ______________________

Signature: ___________________________

Date: _______________________________

CODE: __________________________

PART I: GENERAL INFORMATION

1. Department_____________________________________
2. Position____
3. Educational Status_____________________________
4. Work Experience ______________________________
5. Nationality_______________________________________

PART II: SETTLEMENT CHARACTERISTICS	
Instruction: Answer by using tick sign (√) in the box, you can choose one or more.	
2.1 How do you indicate characteristics of informal settlements in this town?	Characteristics
They are growing	
Growth and service provision is managed by municipality	
Poor infrastructure and basic services provision	
They adversely affect the living conditions of residents in the formal urban system	
Any comments?	
2.2 What do you think about the causes of informal settlements in this town?	Causes
Speculation in Land	
Failure of municipality to address the demand for land and housing	
Failure of the formal market system to address the needs of the poor	
Rural Urban Migration	
Historical Exclusion	
Any Comments?	
2.3 In your opinion what are the most appropriate responses by government to improve the living conditions of people in informal settlements?	Responses
Facilitating housing construction by residents	
Provision of basic infrastructure: water, sanitation, roads and storm-water	
Relocating residents of informal settlements	
Demolition informal settlements because it negatively affects the urban development	
Any comments?	

2.4 Who is responsible authority to allocate land for residents in this town?	Authority	
Local Municipality		
Tradtional leaders		
Both		
Any comments		
	Yes	No

2.5 Is there any conflict of interest among traditional leaders and local municipality in terms of land and the management of other resources?		

2.6 If the answer for question Number 2.5 is "Yes", how these problems affect the development of the town?

____

____

2.7 Do you have any suggestions to deal with this problem?

____

____

PART III: SOCIAL CHARACTERISTICS

Instruction: Answer by using tick sign (√) in the box, you can choose one or more.

3.1 What forms of Indigenous Knowledge is used by the local communities to deal with the different problems they encounter locally?	Indigenous Knowledge
Communal behavior to solve the problems (Social capital)	
Local cultural values to deal with challenges	
Tradtional leadership to reduce conflict in resource utilisation	
Indigenous plants and traditional medicines	
Common resource pool management (i .e grazing land, forest, minerals, rocks, environmental conservation etc….)	
Traditional food preparations	
Traditional agricultural practice	
Traditional weather forecasting systems	

Any comments?

____

____

3.2 Which of the following applicable regarding community-based institutions and systems for documentation, exchange, and acquisition of traditional knowledge in your town?	Institutions and systems
Institutions and systems for knowledge documentation and exchange are present and functioning well.	
Institutions and systems for knowledge documentation and exchange present but could be strengthened.	
Some knowledge documentations and exchange takes place but needs to be strengthened.	
Only a small fraction of surviving indigenous knowledge has been documented.	
No documentation of existing indigenous knowledge takes place	
3.3 Which one of the following is applicable regarding transition of traditional knowledge of conserving the natural environment from one generation to the other?	Transition of traditional knowledge
Key concepts and practices known to all community members, including youth.	
Key concepts and practices known only to adults and elders.	

Traditional knowledge lost.	
Any comments?	
3.4 Are cultural traditions related to the use of natural resources and protection of biodiversity continued by young people, e.g. festivals, songs, etc.?	Cultural traditions
Cultural traditions practiced by all community members including youth	
Cultural traditions practiced only by adults and elders.	
Not practiced.	
Any comments?	
3.5 Does the community have free access to lands, territories, natural resources, and sacred and ceremonial sites?	Free Access
Community has access to its land and resources and autonomy in their management.	
Community has access to its land and resources and partial autonomy in their management, but its autonomy needs to be strengthened and recognised by outside groups.	
Community has limited access to its land and resources and limited decision power over their management.	
Community has neither access to nor decision on land management	
Any comments?	
3.6 Are there any sources of conflict of interest among the community, particularly in the informal settlement areas?	Sources of Conflict
Common resources i.e grazing lands, forest, clean water etc	
Boundary disputes	
Utilisation of water, sanitation, electricity and other resources	
Conflict among traditional leadership and government authorities	
Any comments?	
3.7 What are conflict resolution strategies used by the society to deal with the above mentioned conflicts?	Conflict resolution
Arbitration by Forma court	
Arbitration by local government and councilors	
Mediation by tradtional leaders	
Combination of the above strategies	
Any comment?	
3.8 What is your view about informal settlements in relation to development of the formal urban system?	Informal settlements
Informal settlements negatively affect the town’s development	
They are source of crime and social pathology	
They contribute positively by reducing housing demand and land prices	
It is innovative ways of survival for the poor section of society	
Any comments?	
3.9 In what way is indigenous knowledge useful and being used for planning and managing the overall development of the town? ____ ____	

PART IV: ECOLOGICAL CHARACTERISTICS	
Instruction: Answer by using tick sign (√) in the box, you can choose one or more.	
4.1 What are abundantly existing natural endowments in the town and nearby areas?	Natural Endowments
Minerals (e.g. Gold, Platinum, coal, shale gas, diamond, or any other)	
Forests	
Grazing Land	
Spring Water	
Arable land	
Building materials (clay, gravel and building stone)	
Any other?	
4.2_What types of natural disasters are known to occur in this area?	Natural Disasters
Severe thunderstorms with hail	
Soil erosion and decreasing fertility of soil	
Drought	
Wide-spread flooding	
Flash-flooding	
Earthquakes	
Land-slides and rock falls	
Heavy snowfalls that cut off the area	
Bush/veld fires	
Windstorms, tornadoes etc	
Heatwaves	
Any others?	
4.3 have any major environmental changes been observed in this local area that could be related to global climate change?	Environmental changes
Higher annual temperature	
Flooding	
Soil erosion	
More frequent land slides	
Drought or lack of rainfall	
Any other?	
4.4 What are the main factors that contribute to social and environmental disturbances in this area?	Disturbances
Over-grazing	
Deforestation for agricultural land expansion and for Fuel wood consumption	
Effluent discharges into scarce and stressed water resources	
Destructive Mining practice	
Expansion of urban areas into arable land or indigenous	

Any Comments?	
4.4 How do you indicate the land use management and environmental conservation practice?	Land use and Environmental Conservation
Well-connected and effective	
There is a practice but to a limited extent	
The practice is not at all	
Difficult to determine	
Any comments?	

4.5 How do you rate the landscape capacity in terms of recovering from extreme environmental and climate changes-related stresses?					
Stresses	Rate of recovery				Description (if any)
	High	Medium	Low	Difficult to determine	
Flash Flooding					
Drought					
Over-grazing					
Wild fire					
Soil erosion					
Heavy wind					
Shortage of Water					
Decrease in soil fertility					
Land slide					
Deforestation					

4.6 What are the major risks negatively affect the living condition of residents in informal settlements?	Risks
Heavy rainfall that cause flooding, damage housing, infrastructure and loss of life	
Landslides damage infrastructure, loss of access, damage to buildings and settlements	
Strong wind that possibly demolish settlements	
Any other risks?	

PART V: ECONOMIC CHARACTERISTICS	
Instruction: Answer by using tick sign (√) in the box, you can choose one or more.	
5.1 What are the major economic base (employment and source of Income) of this local area?	Employment and Income Source
Small scale manufacturing	
Agriculture	
Service sector	

Government grant	
Mining and Quarrying	
5.2 What are the possible sources of income for residents of informal settlements?	Sources of Income
Wages from casual daily labour	
Salary from government	
Salary from private sector	
Self-employment	
Support from families from elsewhere	
Social grants	
Any comments?	
5.3 How do you characterise economic condition of residents of informal settlements?	Economic condition
High unemployment rate	
Very low income generation opportunities	
High dependency ratio	
Subsistence living condition	
They produce small scale goods andservices	
Any comments	

Part VI: Legal Framework	
Instruction: Answer by using tick sign (√) in the box, you can chose one or more.	
6.1 Would you mention the recent legal framework or act that deal with management of informal settlements in the town?	
6.2 What measures/Actions this act promotes regarding informal settlement management?	Measures/Actions
Facilitating housing construction by residents	
Provision of basic infrastructure: water, sanitation, roads and stormwater line	
Relocating residents of informal settlements	
Demolition informal settlements because it negatively affects the urban development	
It empowers municipality to control all lands	
It empowers tradtional leaders to control land found in the peripheral area	
Any comments?	

Key: 0= No risk; 10= very low risk; 50= Moderate risk; 100= very high risk

PART VII: VULNERABILITY TO RISK ANALYSIS FRAMEWORK													
7.1 Instruction: Indicate by making circle intensity of risk													
No	Types of Risk	Rating Intensity of Risk											
1	Flash flooding	0	10	20	30	40	50	60	70	80	90	100	

2	Land slide/rock fall/mud-slide	0	10	20	30	40	50	60	70	80	90	100		
3	Soil erosion	0	10	20	30	40	50	60	70	80	90	100		
4	Veld fire	0	10	20	30	40	50	60	70	80	90	100		
5	Heat wave	0	10	20	30	40	50	60	70	80	90	100		
6	Extremely cold temperature	0	10	20	30	40	50	60	70	80	90	100		
7	Strong and damaging wind	0	10	20	30	40	50	60	70	80	90	100		
8	Shortage of Water	0	10	20	30	40	50	60	70	80	90	100		
9	Crime	0	10	20	30	40	50	60	70	80	90	100		
10	Poor sewerage and drainage system	0	10	20	30	40	50	60	70	80	90	100		
11	Poor Road Network/Layout	0	10	20	30	40	50	60	70	80	90	100		
12		0	10	20	30	40	50	60	70	80	90	100		other

7.2 Would you prioritise the risks that exist in the areas of informal settlements based on their level of severity? (You can refer 7.1 above).

1st:___________________________________

2nd:__________________________________

3rd:__________________________________

4th: __________________________________

5th: __________________________________

1.3 What measures should the communities take to deal with the existing risks?

7.4 Do you have any suggestions for managing the risks mentioned above in informal settlements in a sustainable manner?

Appendix 5
QUESTIONNAIRE FOR RESIDENTS OF THE STUDY AREAS

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS·UV
NATURAL AND AGRICULTURAL SCIENCES
NATUUR- EN LANDBOUWETENSKAPPE

Dear Respondent

Good day! The aim of this questionnaire is to collect data for conducting **PhD study** in the title of *Improving the Resilience of Informal Settlements in Mountainous Regions of Africa*. Accordingly, your willingness to provide genuine information is crucial to the success of this study. The final outcome of this study will be used for academic and policy formulation purposes as well as to undertake informed decision-making at local and national level. I greatly appreciate your participation in the valuable contribution you can make towards this study. Please note that the following ethical considerations before signing below.

1. You will remain anonymous and your name will not be used in any research findings. Here coded names for instance 'participant A, B,' etc. will be used.
2. Your exact location and privacy will be kept secret, with the only general area located will be indicated in research findings.
3. Your identity will not be disclosed unless you agree.
4. You have the liberty not to answer specific questions or to withdraw at any stage.
5. Your participation is entirely voluntary.
6. You may choose not to answer any question (s).
7. There will be no remuneration for participating in this research.
8. Your signature below indicates your consent to participate in this study.

Thank you in advance for your cooperation!

Name (optional): ______________________

Signature: ____________________________

Date: ________________________________

PART I: DEMOGRPHIC CHARACTERISTICS
Instruction: Answer by using tick sign (√) in the box
1.1 Gender: Male ☐ Female ☐
1.2 Age: under 15 ☐ 15-30 ☐ 1-45 ☐ 46-60 ☐ over 65 ☐
1.3 Place of birth: ___________________________
1.4 Household sise: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5-8 ☐ 0ver 8 ☐
1.5 Educational Status: Illiterate ☐ Read and Write ☐ Primary school ☐ Secondary school ☐
1.6 Nationality: South African ☐ Lesotho ☐ other ☐
PART II: SETTLEMENT CHARACTERISTICS
Instruction: Answer by using tick sign (√) in the box
2.1 How long have you lived in this settlement? 1-5 years ☐ 6-10 years ☐ 11-20 years ☐ More than 20 years ☐

2.2 How do you indicate characteristics of informal settlements in this town?	Characteristics	
They are growing		
Growth and service provision is managed by municipality		
Poor infrastructure and basic services provision		
They adversely affect the living conditions of residents in the formal urban system		
Any comments?		
2.3 Who is responsible for allocating land for residents in your local area?	Responsible	
Local municipality		
Tradtional leaders		
Both		
Comments?		
2.4 In your opinion what are the most appropriate responses by government to improve the living conditions of people in informal Settlments	Responses	
Facilitating housing construction by residents		
Provision of basic infrastructure: water, sanitation, roads and storm-water		
Relocating residents of informal settlements		
Demolition informal settlements because it negatively affects the urban development		
Any comments?		
2.5 Are there any conflicts of interest among traditional leaders and local municipality in terms of land and other resources management?	Conflict	
	Yes	No

Comments?				
2.6 If the answer for question Number 2.5 is “Yes” What do you suggest to solve this problem? ____ __________________				
PART III: SOCIAL CHARACTERISTICS				
Instruction: Answer by using tick sign (√) in the box, you can choose one or more.				
3.1 Forms of Indigenous Knowledge is used by the local communities to deal with the different problems they encounter locally.	Response			
	Yes	No	Undetermined	
Communal behaviour to solve the problems (Social capital)				
Local cultural values to deal with challenges				
Tradtional leadership to reduce conflict in resource utilisation				
Indigenous plants and traditional medicines				
Common resource pool management (i.e. grazing land, forest, minerals, rocks, environmental conservation etC.)				
Traditional food preparations				
Traditional agricultural practice				
Traditional weather forecasting systems				
Any comments? ____ __				
3.2 Which of the following applicable regarding community-based institutions and systems for documentation, exchange and acquisition of traditional knowledge in your town?	Institutions and systems			
Institutions and systems for knowledge documentation and exchange are present and functioning well.				
Institutions and systems for knowledge documentation and exchange present but could be strengthened.				
Some knowledge documentations and exchange takes place but needs to be strengthened.				
Only a small fraction of surviving indigenous knowledge has been documented.				
No documentation of existing indigenous knowledge takes place				
3.3 Which one of the following is applicable regarding transition of traditional knowledge of conserving the natural environment from one generation to the other?	Transition of traditional knowledge			
Key concepts and practices known to all community members, including youth.				

Key concepts and practices known only to adults and elders.	
Traditional knowledge lost.	
Any comments?	
3.4 Are cultural traditions related to the use of natural resources and protection of biodiversity continued by young people, e.g. festivals, songs, etc.?	Cultural traditions
Cultural traditions practiced by all community members including youth	
Cultural traditions practiced only by adults and elders.	
Not practiced.	
Any comments?	
3.5 Does the community have free access to lands, territories, natural resources, and sacred and ceremonial sites?	Free Access
Community has access to its land and resources and autonomy in their management.	
Community has access to its land and resources and partial autonomy in their management, but its autonomy needs to be strengthened and recognised by outside groups.	
Community has limited access to its land and resources and limited decision power over their management.	
Community has neither access to nor decision on land management	
Any comments?	
3.6 Are there any sources of conflict of interest among the community, particularly in the informal settlement areas?	Sources of Conflict
Common resources i.e. grazing lands, forest, clean water etc…	
Boundary disputes	
Utilisation of water, sanitation, electricity and other resources	
Conflict among traditional leadership and government authorities	
Any comments?	
3.7 What are conflict resolution strategies used by the society to deal with the above mentioned conflicts?	Conflict resolution
Arbitration by Forma court	
Arbitration by local government and councillors	
Mediation by tradtional leaders	
Combination of the above strategies	
Any comment?	
3.8 What is your view about informal settlements in relation to development of the formal urban system?	Informal settlements
Informal settlements negatively affect the town’s development	
They are source of crime and social pathology	

They contribute positively by reducing housing demand and land prices	
It is innovative ways of survival for the poor section of society	
Any comments?	
3.9 In what way is indigenous knowledge useful and being used for planning and managing the overall development of the town? ____	

PART IV: ECOLOGICAL CHARACTERISTICS

Instruction: Answer by using tick sign (√) in the box, you can choose one or more.

4.1 What are abundantly existing natural endowments in the town and nearby areas?	Natural Endowments
Minerals (e.g. Gold, Platinum, coal, shale gas, diamond, or any other)	
Forests	
Grazing Land	
Spring Water	
Arable land	
Building materials (clay, gravel and building stone)	
Any other?	

4.2 What types of natural disasters are known to occur in this area?	Natural Disasters
Severe thunderstorms with hail	
Soil erosion and decreasing fertility of soil	
Drought	
Wide-spread flooding	
Flash-flooding	
Earthquakes	
Land-slides and rock falls	
Heavy snowfalls that cut off the area	
Bush/veld fires	
Windstorms, tornadoes etc.	
Heat waves	
Any others?	

4.3 have any major environmental changes been observed in this local area that could be related to global climate change?	Environmental changes
Higher annual temperature	
Flooding	
Soil erosion	

More frequent land slides	
Drought or lack of rainfall	
Any other?	
4.4 What are the main factors that contribute to social and environmental disturbances in this area?	Disturbances
Over-grazing	
Deforestation for agricultural land expansion and for Fuel wood consumption	
Effluent discharges into scarce and stressed water resources	
Destructive Mining practice	
Expansion of urban areas into arable land or indigenous	
Any Comments?	
4.4 How do you indicate the land use management and environmental conservation practice?	Land use and Environmental Conservation
Well-connected and effective	
There is a practice but to a limited extent	
The practice is not at all	
Difficult to determine	
Any comments?	

4.5 How do you rate the landscape capacity in terms of recovering from extreme environmental and climate changes-related stresses?					
Stresses	Rate of recovery				Description (if any)
	High	Medium	Low	Difficult to determine	
Flash Flooding					
Drought					
Over-grazing					
Wild fire					
Soil erosion					
Heavy wind					
Shortage of Water					
Decrease in soil fertility					
Land slide					
Deforestation					

4.6 What are the major risks negatively affect the living condition of residents in informal settlements?	Risks
Heavy rainfall that cause flooding, damage housing, infrastructure and loss of life	
Landslides damage infrastructure, loss of access, damage to buildings and settlements	
Strong wind that possibly demolish settlements	
Any other risks?	

PART V: ECONOMIC CHARACTERISTICS	
Instruction: Answer by using tick sign (√) in the box, you can choose one or more.	
5.1 What are the major economic base (employment and source of Income) of this local area?	Employment and Income Source
Small scale manufacturing	
Agriculture	
Service sector	
Government grant	
Mining and Quarrying	
5.2 What are the possible sources of income for your households?	Sources of Income
Wages from casual daily labour	
Salary from government	
Salary from private sector	
Self-employment	
Support from families from elsewhere	
Social grants	
Any comments?	
5.3 How do you characterise economic condition of residents of informal settlements?	Economic condition
High unemployment rate	
Very low income generation opportunities	
High dependency ratio	
Subsistence living condition	
They produce small scale goods andservices	
Any comments	
5.4 How many of the members of households have a job opportunity? 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ All ☐	

5.5 Would you indicate the estimation of the amount of your monthly expenditure for your households?	Expenditure
R500- R1,000	
R1,001- R 2,000	
R2,001- R 3,000	
R 3,001- R5,000	
R 5,001- R10,000	
More than R 10,000	

Key 0= No risk; 10= very low risk; 50= Moderate risk; 100= very high risk

PART VI: VULNERABILITY TO RISK ANALYSIS FRAMEWORK													
6.1 Instruction: Indicate by making circle intensity of risk													
No	Types of Risk	Rating Intensity of Risk											
1	Flash flooding	0	10	20	30	40	50	60	70	80	90	100	
2	Land slide/rock fall/mudslide	0	10	20	30	40	50	60	70	80	90	100	
3	Soil erosion	0	10	20	30	40	50	60	70	80	90	100	
4	Wild fire	0	10	20	30	40	50	60	70	80	90	100	
5	Heat wave	0	10	20	30	40	50	60	70	80	90	100	
6	Extremely cold temperature	0	10	20	30	40	50	60	70	80	90	100	
7	Strong and damaging wind	0	10	20	30	40	50	60	70	80	90	100	
8	Shortage of Water	0	10	20	30	40	50	60	70	80	90	100	
9	Crime	0	10	20	30	40	50	60	70	80	90	100	
10	Poor sewerage and drainage system	0	10	20	30	40	50	60	70	80	90	100	
11	Poor Road Network/Layout	0	10	20	30	40	50	60	70	80	90	100	
12		0	10	20	30	40	50	60	70	80	90	100	other

6.2 Would you prioritise the risks that exist in the areas of informal settlements based on their level of severity? (You can refer 6.1 above).

1st: ______________________________

2nd: ______________________________

3rd: ______________________________

4th: ______________________________

5th: ______________________________

6.3 What measures should the communities take to deal with the existing risks?

____

____

_____

6.4 Do you have any suggestions for managing the risks mentioned above in informal settlements in a sustainable manner?

____

____

_____

APPENDIX 6
INTERVIEW QUESTIONS CONDUCTED WITH MAYOR, MUNICIPAL MANAGER, COUNCILLORS AND INFORMAL LEADERS

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
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NATURAL AND AGRICULTURAL SCIENCES
NATUUR- EN LANDBOUWETENSKAPPE

Dear Respondent

Good day! The aim of this interview is to collect data for conducting **PhD study** in the title of *Improving the Resilience of Informal Settlements in Mountainous Regions of Africa*. Accordingly, your willingness to provide genuine information is crucial for the success of this study. The final outcome of this study will be used for academic and policy formulation purpose as well as to undertake informed decision making at Local and National level.

Thank You Very Much for Your Time and Information!

How do you indicate characteristics of informal settlements in this town?

What do you think the cause of informal settlements in this town?

Is there any contradictory working condition among traditional leaders and local municipality in terms of land and other resources management?

If the answer is "yes", how these problems affect the development of the town?

1. What are conflict resolutions strategies are used by the society to deal with conflicts?
2. What is your perception about informal settlements in relation to development of the formal urban system?
3. What are the major ecological changes observed in this local area related with climate changes?
4. What are abundantly existing natural endowments in the town and nearby areas?
5. What are the possible risks may adversely affect the living condition of residents of informal settlements in this town?
6. What is the major economic base (employment opportunity and source of Income) of this local area?

APPENDIX 7
WORKING DEFINTIONS OF VULNERABILITY

Working definitions: Vulnerability is...	Source
The degree of loss to a given element at risk or a set of elements at risk resulting from the occurrence of a natural phenomenon of a given magnitude and expressed on a scale from 0 (no damage) to 1 (total damage	(UNDRO, 1979:online)
The conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards	(UNISDR, 2004:online)
The characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from impacts of a hazard	(Blaikie, 1994:5)
The intrinsic and dynamic feature of an element at risk that determines the expected damage/ harm resulting from a given hazardous event and is often even affected by the harmful event itself. Vulnerability changes continuously over time and is driven by physical, social, economic and environmental factors	(Birkmann, 2006:55)
The degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change	(Schneider et al. 2007:779; Füssel, (2006:301)
The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.	**IPCC, (2014:127)**

APPENDIX 8
WORKING DEFINTIONS OF RESILIENCE

	Author (year)	Subject area	Definition
1	Alberti et al.(2003)	Agricultural and biological sciences; environmental science	". . . the degree to which cities tolerate alteration before reorganizing around a new set of structures and processes" (p. 1170).
2	Godschalk (2003)	Engineering	". . . a sustainable network of physical systems and human communities" (p. 137).
3	Pickett et al. (2004)	Agricultural and biological sciences; environmental science	". . . the ability of a system to adjust in the face of changing conditions" (p. 373).
4	Ernstson et al. (2010)	Environmental science; social sciences	"To sustain a certain dynamic regime, urban governance also needs to build transformative capacity to face uncertainty and change" (p. 533).
5	Campanella (2006)	Social sciences	". . . the capacity of a city to rebound from destruction" (p. 141).
6	Wardekker et al. (2010)	Business management and accounting; psychology	". . . a system that can tolerate disturbances (events and trends) through characteristics or measures that limit their impacts, by reducing or counteracting the damage and disruption, and allow the system to respond, recover, and adapt quickly to such disturbances" (p. 988).
7	Ahern (2011)	Environmental science	". . . the capacity of systems to reorganize and recover from change and disturbance without changing to other states . . . systems that are "safe to fail" (p. 341).
8	Leichenko (2011)	Environmental science; social sciences	". . . the ability . . . to withstand a wide array of shocks and stresses" (p. 164).
9	Tyler and Moench (2012)	Environmental science; social sciences	". . . encourages practitioners to consider innovation and change to aid recovery from stresses and shocks that may or may not be predictable" (p. 312).
10	Liao (2012)	Environmental science	". . . the capacity of the city to tolerate flooding and to reorganize should physical damage and socioeconomic disruption occur, so as to prevent deaths and injuries and maintain current socioeconomic identity" (p. 5).
11	Brown et al. (2012)	Environmental science; social sciences	". . . the capacity . . . to dynamically and effectively respond to shifting climate circumstances while continuing to function at an acceptable level. This definition includes the ability to resist or withstand impacts, as well as the ability to recover and re-organize in order to establish the necessary functionality to prevent catastrophic failure at a minimum and the ability to thrive at best" (p. 534).
12	Lamond and Proverbs (2009)	Engineering	". . . encompasses the idea that towns and cities should be able to recover quickly from major and minor
			disasters" (p. 63).
13	Lhomme et al. (2013)	Earth and planetary sciences	". . . the ability of a city to absorb disturbance and recover its functions after a disturbance" (p. 222).
14	Wamsler et al. (2013)	Business management and accounting; energy; engineering; environmental science	"A disaster resilient city can be understood as a city that has managed. . . to: (a) reduce or avoid current and future hazards; (b) reduce current and future susceptibility to hazards; (c) establish functioning mechanisms and structures for disaster response; and (d) establish functioning mechanisms and structures for disaster recovery" (p. 71).
15	Chelleri (2012)	Earth and planetary sciences; social sciences	". . . should be framed within the resilience (system persistence), transition (system riseal change) and transformation (system reconfiguration) views" (p. 287).

16	Hamilton (2009)	Engineering; social sciences	"ability to recover and continue to provide their main functions of living, commerce, industry, government and social gathering in the face of calamities and other hazards" (p. 109)
17	Brugmann (2012)	Environmental science; social sciences	"the ability of an urban asset, location and/or system to provide predictable performance – benefits and utility and associated rents and other cash flows – under a wide range of circumstances" (p. 217).
18	Coaffee (2013)	Social sciences	". . . the capacity to withstand and rebound from disruptive challenges . . ." (p. 323).
19	Desouza and Flanery (2013)	Business management and accounting; social sciences	"ability to absorb, adapt and respond to changes in urban systems" (p. 89).
20	Lu and Stead (2013)	Business management and accounting; social sciences	". . . the ability of a city to absorb disturbance while maintaining its functions and structures" (p. 200).
21	Romero, Lankao and Gnatz (2013)	Environmental science; social sciences	". . . a capacity of urban populations and systems to endure a wide array of hazards and stresses" (p. 358).
22	Asprone and Latora (2013)	Engineering	". . . capacity to adapt or respond to unusual often radically destructive events" (p. 4069).
23	Henstra (2012)	Social sciences	"A climate-resilient city . . . has the capacity to withstand climate change stresses, to respond effectively to climate-related hazards, and to recover quickly from residual negative impacts" (p. 178).
24	Thornbush et al. (2013)	Energy; engineering; social sciences	". . . a general quality of the city's social, economic, and natural systems to be sufficiently future-proof" (p. 2).
25	Wagner and Breil (2013)	Agricultural and biological sciences	". . . the general capacity and ability of a community to withstand stress, survive, adapt and bounce back from a crisis or disaster and rapidly move on" (p. 114).
26	Resilience Alliance (2010)	Environmental science; social sciences	the system's ability to absorb disturbances, both short and sudden shocks, as well as slow long pulses while adapting to changes within its environment. p. 5
27	UNISDR(2004)	Environmental science; social sciences	Resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions [8]

Source: Sara, Joshua, and Melissa (2016)

APPENDIX 9
EMPERIAL FRAMEWORKS TO MEASURE RESILIENCE

Name of Framework
Frameworks Applied to Measure Resilience
Rockefeller Foundation's Asian Cities Climate Change Resilience (ACCCRN)
Assessments of Impacts and Adaptations of Climate Change (AIACC) Sustainable livelihood approach
Action Research for Community Based Adaptation (ARCAB)
ARUP's City Resilience Framework (ARUP)
UK Department for International Development Building Resilience and Adaptation to Climate Extremes and Disasters framework (BRACED)
UNDP Community-Based Resilience Analysis (CoBRA) Framework
Constas and Barrett's Principles of Resilience Measurement for Food Insecurity (Constas and Barrett)
Mayunga's Capital-Based Approach to Community Disaster Resilience (Mayunga)
Feinstein International Center's Livelihood and Resilience Framework (Feinstein)
International Institute for Sustainable Development's Climate Resilience and Food Security (IISD)
UN Food and Agriculture Organisation's (FAO) Self-evaluation and Holistic Assessment of Climate Resilience of farmers and pastoralists framework (SHARP)
International Institute for Environment and Development's Tracking Adaptation and Monitoring Development (TAMD)
Technical Assistance to NGO's (TANGO) Livelihood Framework
Characteristics of a Disaster Resilient Community (Twigg, 2009)
UN/ISDR Disaster Resilience Scorecard for Cities (UN/ISDR)
USAID Measurement for Community Resilience (USAID 2013)
USAID Coastal Resilience (Indian Ocean Tsunami Warning System Program) (USAID 2007)

Appendix 10
ETHICAL CLEARANCE

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS·UV
NATURAL AND AGRICULTURAL SCIENCES
NATUUR- EN LANDBOUWETENSKAPPE

Faculty of Natural and Agricultural Sciences

04-May-2015

Dear Mr Tamirat Melore

Ethical Clearance: Planning for Improving Resilience of Informal Settlements in the Mountainous Regions of Africa: Comparative Case Studies in Qwa Qwa-Phuthaditjahba in South Africa; and Konso-Karat in Ethiopia

Study Leader/Supervisor: Nel, Verna

Principal Investigator: Mr Tamirat Melore

Department: Urban and Regional Planning (Bloemfontein Campus)

This letter confirms that a research proposal with tracking number: **UFS-HSD2015/0023** and title: **'Planning for Improving Resilience of Informal Settlements in the Mountainous Regions of Africa: Comparative Case Studies in Qwa Qwa-Phuthaditjhaba in South Africa; and Konso-Karat in Ethiopia'** was given ethical clearance by the Ethics Committee.

Please ensure that the Ethics Committee is notified should any substantive change(s) be made, for whatever reason, during the research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the Ethics Committee on completion of the research. The purpose of this report is to indicate whether or not the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the Ethics Committee should be aware of.

Note:

This clearance is valid from the date on this letter to the time of completion of data collection.

Progress reports should be submitted annually unless otherwise specified.

Yours Sincerely

Prof. Neil Heideman

Chairperson: Ethics Committee

Faculty of Natural and Agricultural Sciences