EXPLORING COMMUNITY & ECOSYSTEM-BASED ADAPTATION THROUGH RESILIENCE THEORY: REFERENCING A LESOTHO CASE

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DECLARATION

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ABSTRACT

The impacts of climate change will be felt by society and the environment, triggering the need for novel adaptation strategies suited to contexts which can be depicted as a social-ecological system (SES). Community and Ecosystem-based Adaptation (CEbA) is potentially a viable solution, however, as it is a new concept, there is a need for more research to determine whether it is a viable adaptation strategy that also enhances social and environmental resilience. The purpose of this study is to investigate the potential CEbA has in enhancing livelihood and ecosystem resilience of developing rural communities, as it aims to, in the context of resource dependence and climate change. Seven generic principles for enhancing the resilience of desired ecosystem services (ES) in the face of change and uncertainty has been identified by previous research. Recent academic work has advanced sustainability science by creating context specific metrics for the seven resilience principles, which allows researchers to indirectly measure SES resilience. This research adapted these metrics to fit the Lesotho CEbA case study context. Two previously unconnected fields were integrated and applied as a new method to assess the impacts of CEbA. Six characteristics that defines a project as CEbA were found in this study. The Lesotho Climate Change Adaptation Project was then assessed against context-specific metrics of the seven resilience principles, to indirectly measure the project's impact on SES resilience. From this it was found that CEbA's characteristic methods and principles complement the seven resilience principles and that CEbA has the potential to enhance the resilience of ES as well as the resilience of the communities that are dependent on these ES. This knowledge can be used by change agents to promote the implementation of CEbA in highly resource dependent rural areas. The methods and metrics used in this project can be adapted to different contexts and be used as indicators for assessing CEbA's impact on resilience. This may help progress sustainability science and interventions aimed at helping communities adapt to climate change and enhance their resilience.

Keywords:

The seven principles of resilience, resilience, social-ecological system, Community and Ecosystem-based Adaptation, ecosystem services, Lesotho Climate Change Adaptation Project.

OPSOMMING

Die impak van klimaatsverandering sal deur die samelewing en die omgewing gevoel word. As 'n gevolg, is daar behoefte aan nuwe aanpassingstrategieë wat geskik is vir die konteks wat deur sosiaal-ekologiese sisteem (SES) weergegee kan word. Gemeenskaps- en ekosisteemgebaseerde aanpassing (CEbA) is potensieel 'n volhoubare oplossing, maar aangesien die konsep relatief nuut is, is daar 'n behoefte aan meer navorsing om vas te stel of dit 'n lewensvatbare aanpassingstrategie is wat ook sosiale en omgewingsveerkragtigheid verhoog. Die doel van hierdie studie is om die potensiaal wat CEbA het in die verbetering van lewensbestaan en ekosisteemveerkragtigheid van ontwikkelende landelike gemeenskappe te ondersoek, soos dit daarop gemik is, in die konteks van hulpbronafhanklikheid en klimaatsverandering. Sewe generiese beginsels was voorheen geïdentifiseer vir die verbetering van die veerkragtigheid van gewenste ekosisteemdienste (ES) in die lig van verandering en onsekerheid. Onlangse akademiese werk het volhoubaarheidswetenskap gevorder deur kontekssspesifieke maatstawwe vir die sewe veerkragtigheidsbeginsels te skep, wat navorsers in staat stel om SES-veerkragtigheid indirek te meet. Hierdie navorsing het hierdie maatstawwe aangepas vir die Lesotho CEbA-gevallestudiekonteks. Twee voorheen onverbonde velde was geïntegreer en 'n nuwe metode was toegepas om die impak van CEbA te evalueer. Die studie het ses kenmerke identifiseer wat 'n projek as CEbA definieer. Die Lesotho-Aanpassingsprojek vir Klimaatsverandering is geassesseer teen kontekssspesifieke maatstawwe van die sewe veerkragtigheidsbeginsels, om indirek die projek se impak op SES-veerkragtigheid te meet. Dit was hieruit gevind dat CEbA se kenmerkende metodes en beginsels die sewe veerkragtigheidsbeginsels aanvul en dat CEbA die potensiaal het om die veerkragtigheid van ES asook die veerkragtigheid van die gemeenskappe wat van hierdie ES afhanklik is, te verbeter. Hierdie kennis kan gebruik word om CEbA implementering in hoogs hulpbronafhanklike landelike gebiede te bevorder. Die metodes en maatstawwe wat in hierdie projek gebruik word kan in verskillende kontekste aangepas word en as aanwysers gebruik word vir die assessering van CEbA se impak op veerkragtigheid. Dit kan help om volhoubaarheidswetenskap en intervensies te bevorder wat daarop gemik is om gemeenskappe te help om by klimaatsverandering aan te pas en hul veerkragtigheid te verbeter.

Sleutelwoorde:

Die sewe beginsels van veerkragtigheid, veerkragtigheid, sosiaal-ekologiese sisteem, Gemeenskap- en Ekosisteem-gebaseerde Aanpassing, ekosisteemdienste, Lesotho Klimaatsverandering Aanpassing Projek.

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ABBREVIATIONS & ACRONYMS

CaRe	Catchment Rehabilitation
CAS	Complex Adaptive Systems
CbA	Community-based Adaptation
CBNRM	Community-based Natural Resource Management
CEbA	Community and Ecosystem-based Adaptation
EbA	Ecosystem-based Adaptation
EES	Eco-innovation Entrepreneurship Scheme
ES	Ecosystem Services
HASHI	Hifadhi Ardhi Shinyanga
ILO	International Labour Organization
INR	Institute of Natural Resources
LCCAP	Lesotho Climate Change Adaptation Project
LHDA	Lesotho Highlands Development Authority
LTK	Local and Traditional Knowledge
NBS	Nature-based Solutions
ND-GAIN	Notre Dame Global Adaptation Index
NGO	Non-Government Organisation
SES	Social-Ecological Systems
TASS	Technology Affordability Saving Scheme
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development

CHAPTER 1: INTRODUCTION

1.1 Background information

The effects of climate change are experienced differently around the world. The world is rife with shocks as seen by the many worldwide disasters experienced in the last few years including the Covid 19 pandemic, the 2020 Australian wildfires, and the 2021 northern European floods (Canipe, Green & Hart, 2020:Wildfires, para. 1; Abnett & Mackenzie, 2021). A community in one part of the world could notice increased severity and frequency of flooding, with rises in sea levels and more extreme storms; while a community in another part of the world can experience a shortening of their rainy season, droughts lasting longer and more intense wildfires (Barnosky, Brown, Daily, Dirzo, Ehrlich *et al.,* 2014:85). Other terrible ways that communities can be affected are through water shortages; reduction of crop yields; economic losses; political strife; spread of infectious disease; pest expansion; damage to ecosystems; and extinction of species (Barnosky *et al.,* 2014:86-87). Thus, ecosystems, habitats, and species; as well as the livelihoods, lifestyles, and wellbeing of humans around the world will be affected in many ways. If trends continue their current trajectory, climate change impacts will cause further deterioration and as such, there is a need for a change of trajectory (Barnosky *et al.,* 2014:86).

As these impacts of climate change will be felt by society and the environment, it is crucial to plan. Adaptation allows for the planning of how to deal with the impacts of a changing climate, rather than reacting to the changes once they have already occurred (Ensor & Weragoda, 2009:220). A proactive approach to adaptation can allow for a degree of futuring and enable the planting of metaphorical seeds from which desirable futures can be grown. Adaptation planning has been a central focus point for international climate change negotiations (Chevallier, 2017:2). Over years of international negotiations, the concept of adaptation to climate change has evolved. In its inception, adaptation had the goal of maintaining the *status quo* through hard infrastructure-based solutions implemented in a top-down fashion, while adaptation is now more dynamic and integrative of multiple potential solutions, that include Ecosystem-based Adaptation (EbA) and Community-based Adaptation (CbA) both of which can be implemented from the bottom up (Chevallier, 2017:2).

Humans will have to adapt to the effects of climate change in many ways, and one of the most crucial of these is in how we view and interact with ecosystems and biodiversity (Barnosky *et al.*, 2014:82). Humans, and our social constructs, are linked to and dependent on natural environments, and the ecosystem services

(ES) they provide, and *vice versa*, resulting in a system described as Social-Ecological Systems, (SES) (Bouamrane, cited in, Colding & Barthel, 2019:Methods, para. 4). By understanding this system, a shift can occur where humans act as stewards of the natural environment where we are constantly adapting to an uncertain future in the pursuit of sustainability, rather than acting as masters of the natural environment that aim to reduce uncertainty in the pursuit of stability (Chapin, Carpenter, Kofinas, Folke & Abel, 2010:242). In the pursuit of sustained ES and human wellbeing, the stewardship role of the environment adopts the understanding that uncertainty and change are inevitable and need to be planned for (Chapin *et al.*, 2010:242). The goal is to adaptively manage the SES so that the entire system can thrive into posterity due to its resilience, even in the face of climate change and its effects.

As climate change will not continue smoothly and predictably, societies and natural environments will need to build an adaptive capacity to deal with this uncertainty. As such, adaptation is now used as a process of decreasing vulnerability and increasing SES resilience (Chevallier, 2017:2). Adaptation can be seen as the process that brings about SES resilience to climate change, while resilience can be viewed as the SES capacity to deal with these changes while maintaining the ability to develop sustainably (Chevallier, 2017:2; Simonsen, Biggs, Schlüter, Schoon, Bohensky *et al.*, [n.d.]:3). Resilience and adaptation are distinct and yet interlinked in this conceptualization, both aiming for the sustainability of ES and human development with the understanding that the two are interdependent and inseparable. A resilience approach to climate change aims to build the absorptive, adaptive, and transformative capacity of SES to deal with shocks and disturbances whilst maintaining desirable traits of the SES (Salomon, Quinlan, Pang, Okamoto, & Vazquez-Vera, 2019:Introduction, para. 2). Resilience thinking offers a pathway where uncertainty and change can be accepted as the norm and so planning is not focused on ensuring static stability.

The devastating effects of climate change for humans and ecosystems are felt in both developed and developing countries. The context in the global south is dire as the impoverished rural communities are often directly dependent on their ecosystems (Kumar & Yashiro, 2014: 174) (SANBI, 2017:6). These communities are more vulnerable to the effects of climate change as there is often limited access to funding and public services (Girot *et al.*, 2012:4). The impacts of climate change will be felt disproportionately in the developing world, where it has the potential to worsen poverty and reduce opportunities for sustainable development (Chevallier, 2017:2). As such, any effective and sustainable solutions to address this vulnerability and build resilience should preserve ecosystems; incorporate invaluable local and traditional knowledge (LTK); be cost-effective, and autonomous. An emerging method of integrating CbA and EbA, or Community and Ecosystem-based Adaptation (CEbA), is a potentially workable solution for poor community resilience and sustainability-building in the face of climate change.

EbA makes use of a holistic system approach to climate change adaptation by ensuring ecosystems are healthy enough that surrounding communities can increase their resilience as well as benefit from the ecosystem's goods and services (UNEP-IEMP, 2019:4). An example of EbA in practice is mangrove rehabilitation with the preservation of its biodiversity. The ecosystem goods and services from this would include buffering from coastal storms; habitat for fish; and a source of wood (Chevallier, 2019:17). On the other hand, CbA aims to empower communities to deal with the effects of climate change by building livelihood resilience, disaster risk reduction, building the capacity of institutions and society, and addressing the roots of the community's vulnerability to climate change (Girot *et al.*, 2012:7). The Ecosystems and Livelihoods Adaptation Network argues that these two approaches are more alike than they are different and that by combining the two approaches there is a better chance of yielding positive results (Girot *et al.*, 2012:15). CEbA, using ecosystems to build community resilience, is the integration of these two approaches, or the socio-ecological nexus, and as such aims to build resilience on two fronts. CEbA is an alternative pathway to development that makes use of experimentation, anticipatory thinking, radical incrementalism, and adaptive management with the aim that both people and nature can thrive in a changing world.

An innovative climate change adaptation project, undertaken in the Lesotho highlands, incorporated a CEbA approach to enhancing the resilience of communities in the face of climate change. The highlands' already experience high levels of poverty, vulnerability of livelihoods, and the deterioration of economically, socially and environmentally important wetlands and rangelands. Considering this, coupled with the increasing impacts of climate change, there is a need for a change in trajectory. The Lesotho SES is highly vulnerable to the inevitable impacts of climate change and thus the need to build resilience is high. Building resilience will aid in absorbing shocks with minimal damage to the system, adapt to changes positively and transform components of the system towards more desirable and resilient outcomes - all the while maintaining the desirable characteristics of the SES. The Lesotho Climate Change Adaptation Project (LCCA P) was started by an external party that worked to foster a more sustainable relationship between communities and their natural environment, using CEbA. The aim was to increase livelihood and ecosystem resilience to climate change, which was brought about through structured experimentation and observation over an eight-year period. This research study will look deeper into the LCCAP to see if the CEbA approaches undertaken did enhance the SES resilience.

1.2 Motivation and significance

Effective and sustainable solutions to vulnerability and risk are necessary to address climate change. As each SES will experience context specific impacts, novel solutions are needed to fit unique circumstances. The Lesotho context is typical of a highly resource dependent rural area, with its associated vulnerability to climate change due to poverty, environmental deterioration, and social isolation. Thus, solutions to decrease this vulnerability should build resilience by preserving ecosystems and enhancing community action. CEbA aims to enhance community resilience in the face of climate change, however, as it is a new concept there is a need for more research to decide whether it is a workable adaptation strategy that fosters social and environmental resilience. To assess the resilience potential of CEbA, this research will try to ascertain whether CEbA corresponds with the seven Principles for Enhancing the Resilience of Ecosystem Services (Biggs, Schluter, Biggs, Bohensky, BurnSilver *et al*., 2012). These principles are a preliminary guide to enhancing resilience of ES, upon which human wellbeing is dependent. As such, if CEbA complements these principles, it should in theory promote the resilience of ecosystems as well as the resilience of the communities that are dependent on these ES. This knowledge can then be used by change agents to promote the implementation of CEbA in highly resource dependent rural areas. Tweaking of methods and approaches used in this project can result in CEbA fitting many other contexts. Thus, if CEbA does align with the resilience principles and it has the potential to enhance SES resilience, then it is a valuable approach to dealing with climate change. This information can be useful to change agents and policy makers.

1.3 Purpose of study and research questions

The purpose of this study is to investigate the role of CEbA in enhancing SES resilience of developing rural communities in the face of climate change. The research aims to provide insight into whether CEbA is a viable option for enhancing livelihood and ecosystem resilience in the context of resource dependence and climate change. The key factors that were identified to guide this study were: CbA, EbA, CEbA, resilience, social ecological resilience, and principles of resilience. Preliminary reading of these topics then led to the identification of this study's research questions.

The research has three main research questions:

1. What characteristics did the LCCAP exhibit for it to be classified as CEbA?
2. Did the methods employed in the Lesotho case have the potential to enhance livelihood and ecosystem resilience?
3. Does CEbA have the potential to enhance SES resilience in the face of climate change?

In answering these questions, the research aims to highlight the role CEbA can play in resilience building, especially in rural, resource-dependent communities within developing countries. Firstly, in the literature review this research will unpack the role of CEbA in adapting to climate change and its aims to increase resilience. Integrating EbA and CbA can complement each other in achieving sustainable adaptation to climate change, however, as the concept of CEbA is new there is not much literature available. The proposed research aims to gain a thorough understanding of the integration of CbA and EbA to form CEbA and the potential CEbA must introduce resilience to communities. This will form the foundation of knowledge for when exploring the techniques that the case study implemented to be classified as CEbA. To understand the role of CEbA in enhancing resilience, the project used in the case study must conform to the characteristics that define an intervention as CEbA. As such the LCCAP will be weighed against the CEbA literature to classify the project as CEbA and from there the project can be judged on its ability to enhance resilience. Secondly, this research will provide an overview of resilience theory, with a focus on the seven resilience principles developed by Biggs *et al.* (2012). Exploring CEbA through the lens of the seven resilience principles could provide insight into whether CEbA has the potential to build SES resilience for communities to develop sustainably in a changing climate. Of special interest is where CEbA is applied to increase socio-ecological resilience of rural global south communities that exhibit high risk and vulnerability. Thirdly, a real-world case based in Lesotho, from the project "Lesotho Climate Change Adaptation Project", will be used to explore the implementation of CEbA solutions, through the seven principles of resilience, to illustrate the potential of CEbA to either enhance or undermine SES resilience. These research questions work in a stepwise manner to achieve the research aim. The research aims to explore CEbA and its potential to build SES resilience.

1.4 Research design and methodology

This thesis investigates the claimed affordances of CEbA to enhance SES resilience. It does this by looking deeper into CEbA and SES resilience literature and applying it to a case in Lesotho. The research is guided by the interpretivist philosophical paradigm, it is qualitative, empirical, and it studies existing textual data. The design makes use of mixed methods, including theory synthesis, and a case study research design. The theory synthesis focuses on integrating the previously unconnected resilience, as conceived by Biggs *et al.* (2012), with CEbA theory (Jaakkola, 2020:21). The theory synthesis includes a summary of each concept, followed by an integration of the concepts. A case study can provide an illustration of this integration in practice, grounding the integration by analysing a CEbA project case, explored through the lens of resilience. This design is used with the goal of building coherence between CEbA and resilience, as well as enhancing the existing understanding of CEbA in terms of its resilience

The data gathered for the non-empirical literature review and the empirical theory synthesis will be obtained from online journal databases like JSTOR and ResearchGate. Triangulation of methods, data and sources was applied to this study. The theory synthesis will be based on published academic literature regarding Resilience, SES, CEbA, CbA, and EbA literature. The theoretical framework on resilience used in the theory synthesis will primarily be based on the paper "Toward Principles for Enhancing the Resilience of Ecosystem Services" by Biggs *et al.* (2012). And the literature for the real-world case, the LCCAP project, is open access and can be found on the websites of two of the collaborating parties: USAID and the Institute of Natural Resources. The LCCAP in the Lesotho Highlands case was selected to illustrate integrated CEbA. The use of a case will enable more time for case exploration and thus allow for a deeper understanding of the specific case. The case data is in the form of discussion documents, infographics, fact sheets, video captured interviews, annual reports from 2010 to 2018, the project's closeout report as well as a study report on the integration of EbA and CbA for the LCCAP. Unrestricted access information will be used for the case study as far as possible as the sharing of lessons learned for the benefit of society is an important principle of CEbA. And as such the information used for the case study should be readily available to anyone with access to the internet.

1.5 Philosophy

There are four common philosophical perspectives that guide research, these are critical theory, interpretivism, deconstructivism and positivism. The perspective chosen as most appropriate to guide, inform the design and develop the methodology of this research is interpretivism with the aim of enhancing understanding. Interpretivism, with its relativist ontology and subjectivist epistemology, argues that knowledge is subjective and context-specific based on culture, experience and understanding and as such there is no single shared truth, knowledge, or reality (Ryan, 2018:9; Ritchie & Lewis, cited in Ryan, 2018:10). This project aims to interpret existing textual data on CEbA. The outcomes and activities will be analysed by the researcher according to the seven principles of resilience to assess whether the project either enhanced or undermined the SES resilience. The values and principles of CEbA and resilience align with those of interpretivism as there is an understanding of case-specific context with individual or community-specific perception of risk, wellbeing and vulnerabilities; and solutions that are context-appropriate. Although context specifics differ from project to project, general lessons can still be learned and enhance understanding regarding CEbA methods and attributes that enhance SES resilience (Salomon *et al,* 2019:Guiding governance transformation in the Anthropocene, para. 4). As such, perception, context and holistic systems thinking are especially important when aiming to build the resilience of a SES to climate change for a specific community and specific ecosystems. Understanding the people and the community as

well as the ES that support and sustain them is a prerequisite to adhering to the seven principles of resilience by guiding objectives, activities and metrics. This approach, although context-specific, subjective and interpretivist, can be used by other CEbA projects to assess or guide activities towards resilience.

1.6 Ethics

This researcher took care to understand and follow the ethical research obligation required in a research process. It is an ethical obligation of a researcher to be objective, and this researcher strived for objectivity in this research project. It is the understanding of the interpretivist paradigm, however, that a researcher always has a degree of bias as they can never truly be separate from their own values, which will thus inform the research methodology. To the fullest knowledge of the researcher, the research was undertaken with honesty and integrity. This research study was reviewed by the Research Ethics Committee: Social, Behavioural and Education Research as required by Stellenbosch University. As this project does not involve participants or the use of personal, identifiable information and the data collected is freely accessible in the public domain, the project was granted exemption from ethics review and clearance.

1.7 Chapter overviews

Chapter 1 serves as an introduction to the research project. Background information is provided, to provide context to the study. The study is briefly motivated, the significance explained, and the purpose of study and research questions are elaborated upon. Lastly, definitions, assumptions, and limitations of the study are discussed.

Chapter 2 forms the literature review, which takes an in-depth view of CEbA. The chapter defines CEbA, motivates the need for it, unpacks how it developed, and investigates some of its strengths and limitations. It then outlines the resilience framework that will be used in this study by introducing resilience theory. The rest of the chapter is dedicated to the seven resilience principles, what they mean and how they enhance or undermine SES resilience.

Chapter 3 is the methodology chapter. This chapter states the research questions and explains the research design, methodology and analysis method used in this research project. It then sets out the metric to be applied to the LCCAP case study. This chapter also addresses the limitations of this thesis and the underlying ethics and philosophy.

Chapter 4 introduces the Lesotho Climate Change Adaptation Project, which forms the case study of this research paper. It provides a background into the area's climate, its risk and vulnerabilities to climate change, and the social and ecological context of the case. Lastly, the aims and objectives of the case are discussed to understand the CEbA approaches applied to enhance the SES resilience.

Chapter 5 applies the CEbA case study to the resilience framework and metric, with the intention of uncovering whether the project methods employed adhered to the seven resilience principles and thus whether the methods enhanced or undermined resilience.

Chapter 6 is the conclusion chapter. In this chapter the research results are provided by answering the research questions. Recommendations and future research opportunities are listed and discussed. The chapter ends with a succinct summary of the research contributions.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Climate change will affect ecosystems and human wellbeing worldwide in many ways. The context in the global south is dire as the impoverished rural communities are often directly dependent on their ecosystems and so climate change has the potential to exacerbate poverty and reduce opportunities for sustainable development. Adaptation allows for the planning of how to deal with the impacts of a changing climate. Solutions to decrease climate change vulnerability should aim to enhance the SES' resilience. Resilience and adaptation are distinct and yet interlinked, both aiming for the sustainability of ES and human development with the understanding that the environment and society are interdependent and inseparable. For poor, resource dependent, rural communities with limited access to public services any effective and sustainable solution should have broad community participation, preserve ecosystems, be cost-effective, and autonomous. Thus, to uncover whether CEbA is a viable solution to enhance SES resilience and to help poor, rural communities adapt to climate, the key concepts, CEbA and resilience, had to be explored.

CEbA to climate change strives to empower communities and manage ecosystems in a manner that will enhance the SES resilience. This chapter will take a closer look into CEbA and resilience, which will divide this chapter into two major sections. The first section is aimed at understanding the integrated approach, this section will unpack EbA and CbA, then define CEbA with its major practical components highlighted, discuss its strengths and weaknesses as an approach and the section will end with how CEbA has been operationalised in previous studies. The second section is aimed at understanding resilience theory, this section will introduce the concept of resilience and place it in the context of this study, then the Seven Principles for Enhancing the Resilience of Ecosystem Services, developed by Biggs *et al.* (2012), will be introduced and explained and the section will end with how resilience has been operationalised in previous studies. These two sections will thus lay the groundwork for the research to come in following chapters.

The research aims to provide insight into whether CEbA is a viable option for enhancing livelihood and ecosystem resilience, as it aims to, in the context of resource dependence and climate change. This chapter will set the foundation for the following chapters as it introduces the potential of CEbA to assist resource dependent, poor, rural communities in adapting to climate change while at the same time potentially possessing the ability to enhance resilience of SES.

2.2 Community and Ecosystem-based Adaptation

2.2.1 Background into EbA and CbA

The following section provides a background for CbA and EbA, the two climate change adaption approaches that make up CEbA. EbA uses the services gained from biodiversity and ecosystems as a strategy for communities to adapt to climate change (Chevallier, 2017:3; Prabhakar, Scheyvens & Takahashi, 2019:3). This strategy requires ecosystems to be in a healthy state, which is achieved through sustainable management practices, nature conservation, and restoration activities (Chevallier, 2017:3; Prabhakar *et al.*, 2019:3; Coll Besa, 2015). It aims to sustainably merge climate change adaptation with ES and benefits for society, thereby contributing to community resilience in the face of uncertainty and change (Chevallier, 2017:3; Midgley *et al.*, cited in South African National Biodiversity Institute, 2017:55; Prabhakar *et al.*, 2019:3). EbA makes use of holistic systems approach to climate change adaptation by ensuring ecosystems are healthy enough for surrounding communities to increase their resilience as well as benefit from the ecosystem's goods and services (Chevallier, 2017:3; UNEP-IEMP, 2019:4). An example of EbA in practice is mangrove rehabilitation with the preservation of its biodiversity, to adapt to an increase in coastal storm frequency and intensity due to climate change. Under the correct conditions, mangroves can keep up with the rising of sea levels, another projected impact of climate change (UNEP, 2016:100). The ecosystem goods and services from mangrove EbA would include habitat for fish; nursery for coastal species, including corals; soil stabilization; and diversified options for livelihoods of the locals (Chevallier, 2019:17; UNEP, 2016:100). Since 1994, mangroves have been planted along 8 961 ha of the Viet Nam coastline to protect the coastal communities from the typhoons and coastal flooding that is projected to be exacerbated by climate change (UNEP, 2016:100). The mangroves primarily act as a wind and wave breaker, additionally, the local population has benefited from oyster aquaculture in the mangroves and the carbon sequestration has aided global climate change mitigation efforts (UNEP, 2016:100).

CbA aims to increase the ability of members within rural communities to prepare, on an individual, household, and community-wide scale, for the impacts of climate change. It allows communities to identify their vulnerability and needs in terms of climate change (Chevallier, 2017:3). The community will then plan, set priorities, and implement solutions to increase their resilience based on their local knowledge and capacity (Chevallier, 2017:4; Coll Besa, 2015). This is done through a community-led participatory process (Wendo, 2019). As such the community is empowered to choose their own projected pathway, on their terms, thus ensuring self-reliance rather than dependence on an external aid programme. CbA aims to empower communities to deal with the effects of climate change by building livelihood resilience, disaster risk reduction, building the capacity of institutions and society, and addressing the roots of the community's

vulnerability to climate change (Girot *et al.*, 2012:7; Chevallier, 2017:3). An example of a real-world CbA project was done in Sri Lanka, where a participatory assessment process in a community highlighted that crop failure of fertilizer-dependent hybrid rice varieties due to floods and salinization were the main threats to the locals' livelihoods (Ensor & Weragoda, 2009:227). This was addressed by training farmers to develop sustainable farming practices and to undertake their own research into rice crop varieties, thus using and building on the local knowledge (Ensor & Weragoda, 2009:228,229). This led to the reintroduction of a diverse range of traditional varieties of rice; the creation of communication networks between farmer groups themselves as well as between farmer groups and government departments and research institutes; and co-learning between these collaborating groups. Consequently, it increased the capacity of the locals to adapt to future changes (Ensor & Weragoda, 2009).

EbA's focus is on ensuring the healthy functioning of ecosystems with principles based on the 2002 World Summit on Sustainable Development, which include: maintaining ecosystem health through conservation keeping in mind the ecosystem's time and spatial scales, and participatory management of the ecosystem that makes use of traditional, local and scientific information sources (Girot *et al.*, 2012:9; Wendo, 2019:1). CbA is a human rights-based approach to adaptation with guiding principles including equality, special needs of marginalized groups, open participation, empowerment, and accountability (Girot *et al.*, 2012:5; Chevallier, 2017:4). The focus is on people and as such outlines who has the right to manage the ecosystems and who should receive the benefits from these ecosystems. In other words, EbA has a focus on the ecological dimension of people's vulnerability (Woroniecki, Wamsler, & Boyd, 2019:6) whereas CbA's focus is on the social and developmental dimension of people's vulnerability with an explicit reliance on local inclusion and participation (Forsyth, 2013:441; Chevallier, 2017:4). By combining these foci there is a better chance of addressing more components that build social-ecological resilience. The two approaches agree on open participation and the use of LTK, however, their focus on how best to increase the adaptive capacity of communities differs. If the two approaches are used in combination, the strengths of each strategy can complement the other to produce a more holistic pathway to resilience. Another benefit of combining the approaches is that many of the shortcomings of each individual approach can be addressed. The social aspects of EbA can be improved by the incorporation of CbA's human development focus, just as CbA can benefit from the ecological knowledge that comes with EbA (Chevallier, 2017:6). Thus, when used in combination, the strengths of each strategy can complement the other to produce a stronger and more beneficial strategy, both environmentally and socially.

CbA often makes use of EbA or nature-based solutions (NBS) to climate change-related issues. An example of this is through a community-led wetland rehabilitation to reduce the effects of flooding on the community

members. EbA projects also often make use of CbA principles, with many scholars agreeing that enhancing adaptive capacity and SES resilience requires full community collaboration and co-management, where the community and project team or government agree on duties as well as benefits pertaining to an area or resource (Borrini-Feyerabend, Pimbert, Farvar, Kothari & Renard, 2004:69; Seddon, Hou-Jones, Pye, Reid, Roe, 2016:5). An example of this is when EbA projects build the information sharing and learning capacity of communities by creating or strengthening communication networks between communities and other institutions, like government departments, research centres, and businesses, through effective collaboration. As such, EbA and CbA often overlap. At a local level, CbA and EbA are often indistinguishable from one another with communities acting as stewards of ecosystems and undertaking activities that combine both approaches in the hopes of yielding the best adaptation strategy in the given context (Reid, 2014: 2; Prabhakar *et al.*, 2019:2;).

2.2.2 Defining CEbA

CEbA is an integration of EbA, which was first introduced at the United Nations Framework Convention on Climate Change in 2008 (Geneletti & Zardo, 2016:38), and CbA, which was first documented in 2006 (Girot *et al.*, 2012:7) and is thus a new concept. CEbA can be considered a range of adaptation measures that include EbA strategies and CbA processes (Coll Besa, 2015). The integration of EbA and CbA requires the assimilation of core principles from both strategies. Simply, through correct governance, locals are empowered to build their own resilience to climate change and restore, manage and preserve ecosystems that provide adaptive goods and services as well as co-benefits (Girot *et al.*, 2012:4). Although the principles for CEbA are constantly evolving, they consistently make use of human rights and ecosystem principles along with activities that will have the greatest impact on vulnerable communities (Girot *et al.*, 2012:7). CEbA encourages collaboration between multiple sectors and groups; promotes transdisciplinarity; and aims for synergistic outcomes to enhance community resilience on multiple fronts.

The integration of EbA and CbA results in super additive synergy, where the whole of the parts (CEbA) is greater than the sum of the parts (EbA and CbA), as the outcome is enhanced by the interaction of the components (Corning, cited in Duguma, Minang & Van Noordwijk, 2013:The Synergy Concept: A Theoretical Perspective, para. 3). CEbA integrates EbA and CbA as it subscribes to the belief that humans and ecosystems are SES and cannot be dealt with in isolation (Chevallier, 2017:2). With the understanding that humans cannot survive in isolation of the natural environment, CEbA focuses on ecosystem function, biodiversity, human communities, and livelihoods (Lewis & Oosthuizen, 2014:8). It has a long-term and

holistic outlook towards adaptation to climate change and realizes the need for healthy functioning of ecosystems as well as the empowerment of local communities to forge their own resilient adaptive pathways. Thus, CEbA principles are not just focused on human beings, but all species and their ecosystems. There is also an understanding that the social (cultural and socio-economic) and power relations' (institutional and governance) contexts cannot be ignored when addressing climate vulnerability (Girot *et al.*, 2012:6; Lewis & Oosthuizen, 2014:15; Reid, 2014:4). In this holistic approach to adaptation, the healthy functioning of each component interacts beneficially to produce a whole greater than just the sum of its parts. This holistic approach is represented in the way professionals, practitioners, and researchers describe how CEbA should progress. The following section explains how this theory should unfold.

2.2.3 CEbA in practice

The need to make use of a CEbA approach is borne from a SES's risk and vulnerability to climate change. This risk and vulnerability should be a principal component to the planning of actions to build adaptive capacity and social-ecological resilience (Reid, 2014:2). To build social-ecological resilience using a CEbA approach, there is a need to understand the practical application of CEbA and how this will look in the real world. Girot *et al.,* (2012:16,17) defined how CEbA should ideally look by focusing on NBS, community-based efforts, ecosystem health, collaborative governance, social and environmental resilience, and the documenting as well as sharing of lessons learned (see Figure 1 below). The following paragraphs will look closer into the various aspects that characterize CEbA in practice.

A definite component of CEbA is the promotion of proactive rights-based, CbA that provides social security and builds resilience for the community in the long term by reducing vulnerabilities and addressing adaptation needs (Girot *et al.*, 2012:17). Community resilience should be built alongside ecosystem resilience and increase the adaptive capacity of the natural surroundings. A major way to build ecosystem resilience is by reducing the external stressors that undermine the functionality and health of the system (Roberts *et al.*, 2012:178). Another way of increasing resilience is through promoting the health and flexibility of the natural systems through community-based conservation efforts (Girot *et al.*, 2012:17). CEbA should also aim to implement NBS for disaster risk reduction and increased local resilience to climate or weather-related disasters (Girot *et al.*, 2012:17; Roberts, Boon, Diederichs, Douwes, Govender *et al*, 2012:174). The reliance on ecosystems for adaptation and resilience requires the understanding that ecosystems are dynamic and complex, adaptive systems (CAS), which are thus also subject to a changing environment (Girot *et al.*, 2012:16).

Ideally, CEbA should have good governance with collaborative management between institutions and communities (Girot *et al.*, 2012:17; Roberts *et al.*, 2012:182,186). This will require greater consideration into the specific projects' institutional, governance and policy context (Roberts *et al.*, 2012:174; Reid, 2014:4). Communities should be placed at the centre of planning and remain central during the implementation and monitoring of solutions (Girot *et al.*, 2012:17; Reid, 2014:2; Chevallier, 2017:4). Effort should be placed on promoting participation and partnerships by building trust between actors and building the capacity of local actors to participate (Reid, 2014:4). This will aid the integration of knowledge types, build on community innovation, and promote co-learning between groups (Girot *et al.*, 2012:17; Roberts *et al.*, 2012:173). A community's ability to respond in times of change is dependent on their intentional learning and knowledge integration from various sources (Faulkner, Brown, & Quinn, 2018:Table 1, para. 5). The planning, implementation, and monitoring stages should be well documented as the gathering of evidence are important for demonstrating the effectiveness of the CEbA approach (Reid, 2014:3). The accumulation of compelling arguments and the sharing of lessons learnt can aid other projects and can also aid in securing funding for projects (Girot *et al.*, 2012:17). CEbA has the potential to be low cost, especially in rural areas, but as it is not no-cost, there is a need for funding (Roberts *et al.*, 2012:182; Girot *et al.*, 2012:14). Funding will need to be acquired for change agents to implement interventions that are not free, or to upscale interventions or to secure participation from locals who require incentives.

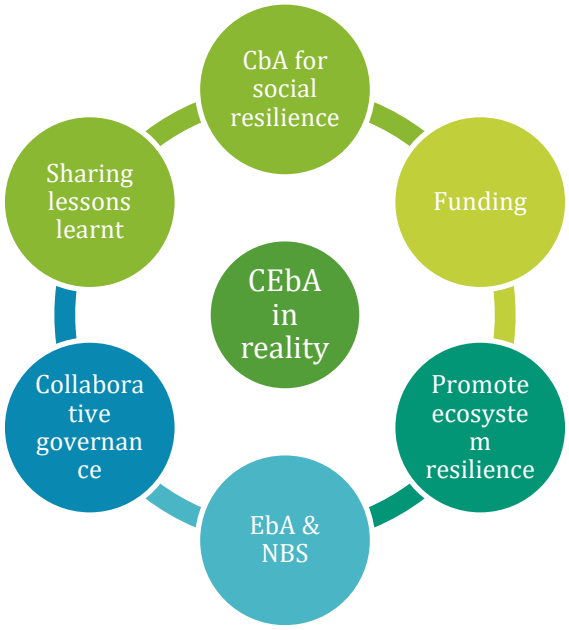

Figure 1: CEbA (adapted from Girot et al., 2012:16,17).

2.2.4 Strengths and limitations of CEbA

CEbA encourages co-learning between the environmental and social disciplines, it thus could address weaknesses within the two parent strategies and build on their strengths. CEbA also has strengths, resulting in an approach with many benefits and strengths. Stakeholder buy-in and sense of project ownership are enhanced by the participatory and collaborative nature of CEbA which strives for the inclusion of LTK and scientific knowledge in the project, as well as respecting established local rules and customs. By making use of the area and community's strengths, it is low cost and thus appropriate for rural developing world contexts. The co-benefits arising from the project have the potential to generate additional income and revenue streams, as well as enhance the SES resilience and wellbeing of the stakeholders. The strengths and benefits of CEbA promote the uptake and use of such methods, however, the adaptation approach is not without issues. CEbA has inherent limitations and challenges, including spatial and time scale; the complex and adaptive nature of ecosystems; the difficulties of participation; and trade-offs. These limitations and challenges need to be understood. The following section first discusses CEbA's strengths and benefits and then its limitations and challenges as well as how to lessen the severity of said limitations and challenges.

CEbA makes use of multiple knowledge types to inform its participatory adaptation process. This is a strength as projects then benefit from multiple ways of knowing and sources of information, thus providing a fuller picture. Scientific knowledge informs CEbA on climate projections, successful ways to adapt to a changing climate, and much more. Indigenous, LTK is just as important to the success of CEbA (Reid, 2014:3). This knowledge can include information on the area's climatic and social history; community experimentation and implementation of green corridors, rewilding, ecosystem rehabilitation, conservation farming, Community-based Natural Resource Management (CBNRM); and NBS to problems such as floods, droughts, storms, and environmental degradation. If this knowledge is shared it can reduce risk and vulnerability not only to its community but also to other communities with similar problems. Information regarding the values, taboos, religions, cultures, social structures and power relations of the people are important to know, not only to respect their norms and customs but also to fill in the gaps that may not be answered by pure ecological knowledge (Ruiz-Mallen & Corbera, 2013: Introduction, para. 2). An example of the latter is seen in a region in Indonesia where there were many large trees due to the local belief that cutting the trees down would incur the wrath of spirits, resulting in sickness and crop losses (Ruiz-Mallen & Corbera, 2013: Exploring the relationships between traditional ecological knowledge and community-based conservation, para. 2). CEbA aims to incorporate many sources of knowledge and multiple ways of knowing, resulting in a deeper understanding of the SES context in which the project is operating.

The CEbA rights-based participation approach is inclusive and engaging of communities, not just of communities but their traditional, indigenous and local governance structures. This provides both strength and benefits to the project. Firstly, the participation promotes stakeholder buy-in which among other things provides capacity for project activities and rapid emergency response at times of emergency (UNEP, 2016:99). Lastly, the structures in place already have set norms, rules and privileges, in other words, there is already a management structure in place to be followed. A community's access to ecosystem resources is established before CEbA projects begin. An understanding of who has what rights to the area's natural resources are crucial to the success of any ecosystem-based approach to increasing social resilience. Without correct social governance, EbA can result in the Tragedy of the Commons, and as such resilient customary laws, traditions or other robust governance structures of the community should be followed to avoid overexploitation of ecosystems (Girot *et al.*, 2012:8). By respecting and making use of these established structures, the stakeholders have a greater sense of project ownership, and the project requires fewer resources for management.

Both CbA and EbA can be cost-effective approaches and by deduction, the integrated CEbA approach also has the potential to be cost-effective (Roberts *et al.*, 2012:171; Reid, 2014:1). By basing strategy on local needs, local knowledge, and local natural resources, thus capitalizing on community assets, the bottom-up process can be affordable (UNEP, 2016:98). CEbA is low cost, especially in rural areas, compared to hard engineering solutions, but it is not no-cost (Roberts *et al.*, 2012:182). Thus, funding should be acquired from governments, non-government organisations (NGOs), stakeholders, businesses, or other potential sources (Girot *et al.*, 2012:14). Other funding streams can come from the multiple co-benefits of CEbA projects.

Co-benefits are benefits that communities gain from implementing a CEbA approach, other than adapting people and ecosystems to climate change. These potential benefits are listed below:

- Ecosystems provide habitats to a wide variety of biodiversity which, other than their intrinsic value, also support genetic diversity. Communities can adapt to climate change through more resilient and diversified fauna and flora (Lewis & Oosthuizen, 2014: 10).
- Ecosystem goods, such as wood, food, and water can support livelihoods and increase food security for locals (Lewis & Oosthuizen, 2014). This will be especially beneficial where local management of resources ensures equitable use.
- ES such as erosion control and buffering of storms reduce disaster risk and regulating natural systems provide fertile soils, clean air, and water (Lewis & Oosthuizen, 2014).

- Healthy ecosystems sequester carbon (Lewis & Oosthuizen, 2014) resulting in associated climate mitigation co-benefits and can bring in additional income to the community through the carbon credit system as seen in the Hiniduma Bio-link project in Sri Lanka (Senadheera, Wahala, Weragoda, 2019).
- Cultural benefits obtained from ecosystems include spiritual connections to nature, recreational and traditional activities, and aesthetic pleasure (Lewis & Oosthuizen, 2014). Cultural enrichment can also come through the co-learning and learning-by-doing processes.

The alternative to CEbA and other similar "soft" adaptation strategies are "hard engineering" solutions to the impacts of climate change like building dams in areas of decreased rainfall or erecting harbour walls in coastal areas experiencing sea-level rise, etc. In rural communities, these expensive hard engineering solutions are often not possible as the most vulnerable communities are often socially marginalized and left out of these top-down, large-scale solutions (Girot *et al.*, 2012:2,4). Another reason for the small communities being left out of hard engineering projects is that the areas are simply out of the government's reach or not prioritised for these solutions (Girot *et al.*, 2012:4). In these cases, CEbA can address many shortcomings through grassroots design and implementation that ensures a bottom-up strategy allowing for co-management between the local people, local institutions, and field experts (local or foreign, formal or informal). This does not mean to imply that CEbA has no shortcomings. The following paragraphs discuss CEbA limitations and challenges to achieving aims, as well as potential ways to minimize the negative effects of these inherent issues.

The spatial scale of community projects is small in comparison to the size of interconnected ecosystems. For example, a coastal community by an estuary is affected not only by the estuary but also by the surrounding landscape, as an estuary interacts and gets its water from the ocean and a river, which is fed from tributaries, sourced from the surrounding mountains in the greater drainage basin. This sets limits on how effective small-scale local community-led projects can be when set in the greater backdrop of larger interconnected ecosystems. However, community-led projects need not remain in the local area but instead could spread to surrounding areas, in other words, scale-up and diversify. It is thus important to both document successes and failures for replication, and to plan in terms of increasing a project's spatial scale.

The temporal scale of a project can also be seen as a challenge, as successful CEbA projects take years of continuous cycles of learning, planning, testing, monitoring and adapting. After the project completion, the nature-based and community-based implemented solutions still require effort and resources to be maintained in the long term (UNEP, 2016:97). This requires a clear plan and exit strategy for project leaders who wish for the long-term sustainability of the approaches (UNEP, 2016:100). The community must have

a sense of ownership of the project, with an understanding of the costs and benefits involved, as well as the technical capacity to continue with the adaptation responses without dependence on external support.

The limits and tipping points of ecosystems are complex, and it is unknown if, how, or when climate change impacts can push these ecosystems beyond their tipping points (Girot *et al.*, 2012:9). As such, creating adaptation strategies based on ecosystems can be a risky endeavour. This risk of ecosystem failure can be minimised if the ecosystem is healthy and not subject to intense non-climate stressors like overgrazing and destructive farming methods (Girot *et al.*, 2012:9). A major objective in Durban's Municipal Climate Protection Programme has been trying to reduce the impact of non-climate stressors, such as invasive alien encroachment in the city's ecosystems (Roberts *et al.*, 2012:178).

Another issue with using CEbA is the potential trade-off, regarding land availability (opportunity costs) and competition for natural resources. This can affect the community buy-in, which will affect the successful implementation of project activities. To address this risk assessments and scenario planning can be used to ensure sustainable maximisation of long-term benefits as well as fair conflict resolution between stakeholders, into perpetuity (Girot *et al.*, 2012:10). The assessments and planning will be context-specific to ensure that the best possible sustainable solutions are put into place, for present and future generations. Incentives and long-term benefits arising from the process can buffer the negative effects of trade-offs and encourage participation (Chevallier, 2017:2). The discussion of these incentives and benefits must be done carefully, without making promises one cannot keep so that expectations match reality without disillusionment with the process.

2.2.5 CEbA operationalised in previous studies

Many organisations have used CEbA approaches to adapt to climate change while having additional benefits to ecosystems and societies. For effective CEbA, approaches must be fine-tuned to address the SES vulnerabilities. SES vulnerabilities, such as subsistence-based livelihood dependence on coastal ecosystems, were the focus in the Climate-Resilience Communities and Protected Areas Project, where communities developed 6 adaptation action plans based on priority vulnerabilities and alternative livelihood activities (UNEP, 2016:102). This guided their adaptation strategy to enhancing their SES resilience to climate change. Lessons and best practices from previous similar projects can shape and influence projects, like in Pakistan where 13 natural resource and ecosystem restoration management projects were analysed to inform an adaptation project that made use of trees to increase SES resilience to the prolonged dry seasons (GIZ, 2018:49). To understand the concept of CEbA, it may be beneficial to take a deeper look into a CEbA

project that has succeeded in its goals of adapting to climate change and increasing SES resilience. The Tanzanian HASHI project (HASHI stands for *Hifadhi Ardhi Shinyanga* which is Swahili for "conservation initiative in Shinyanga" studied by Wainaina, Minang, Nzyoka, Duguma, Temu *et al*., (2021:2) can be considered a CEbA project even though it was implemented before the concept was born, as it conforms to the six main aspects of CEbA as laid out by Girot *et al.,* (2012:16,17). Through collaborative governance and external funding, the project made use of community-based conservation efforts that increased the SES resilience and the lessons learned were documented and shared. The HASHI project will be expanded upon below according to these aspects of CEbA, to provide a clear example of a successful CEbA project in a rural developing world context.

In 1986 the Tanzanian government initiated a conservation programme, called HASHI, in the Shinyanga region. The main aim of the Shinyanga project was to regreen the arid and semi-arid region of the time and not only stop but reverse the ongoing desertification (Wainaina *et al.*, 2021:2). This would be done through the reintroduction of Ngitilis, a traditional vegetation rehabilitation practice that involved the setting aside of areas for ecological restoration and conservation on agricultural land, which was abandoned in the 1920s under colonial rule (Duguma *et al*., 2013:An Illustrative Case Study: Applying the Non-Additive Synergy Model to the Ngitili System in Shinyanga, Tanzania, para. 2; Duguma *et al*., 2013:Fig. 5; Wainaina *et al.*, 2021:2). The practice serves as a synergistic approach to social development, environmental restoration, as well as mitigation and adaptation to climate change (Duguma *et al*., 2013). The restoration of ecosystems whose benefits and services gained would not only enhance environmental resilience but social and livelihood resilience too.

The Tanzanian Government understood that for the restoration project to be taken up by the local communities and to succeed, that the local institutions needed to be empowered and that local practices and knowledge needed to be adopted in the project. This resulted in the setting up of community environmental committees, which allowed for a democratic voice of the local people to partake in the programme's decision making and dialogue (Duguma *et al*., 2013:An Illustrative Case Study: Applying the Non-Additive Synergy Model to the Ngitili System in Shinyanga, Tanzania, para. 3). The Ngitili were owned communally, privately or by local institutions and as such the community members, in whatever grouping, managed them and ensured their protection (Wainaina *et al.*, 2021:2,3). The local people were supported by the Tanzanian Government, the World Agroforestry Centre, the National Forest Resources and Agroforestry Management Centre, the Norwegian Agency for Development Cooperation, who between them provided policy, technical and financial support (Duguma *et al*., 2013:An Illustrative Case Study: Applying the Non-Additive Synergy Model to the Ngitili System in Shinyanga, Tanzania, para. 4; Wainaina

et al., 2021:2). As such there was genuine engagement with local communities and collaborative governance between the local communities and national, as well as international institutions.

The co-benefits of the project, including carbon sequestration, increased water availability, increased food production, and the restoration of medicinal plants worked together to enhance the overall social and environmental resilience of the area. Conflicts were reduced between farmers and pastoralists regarding ecosystem goods and services (Duguma *et al*., 2013:An Illustrative Case Study: Applying the Non-Additive Synergy Model to the Ngitili System in Shinyanga, Tanzania, para. 7; Wainaina *et al.*, 2021:3). There were also positive social impacts for women and children, as it provided an area for livestock to be kept around and feed on, allowing children to attend school; and it provided easily accessible fuelwood, reducing the time women had to spend collecting wood every day (Duguma *et al*., 2013:An Illustrative Case Study: Applying the Non-Additive Synergy Model to the Ngitili System in Shinyanga, Tanzania, para. 7). As there was more wood for fuel, women no longer needed to burn cow dung for cooking, and so adverse health effects from burning cow dung were reduced, especially red-eye disease (Wainaina *et al.*, 2021:2). The increased quantity and diversity of food (including honey, milk, meat, mushrooms and fruits) produced in the Ngitili improved food security and health for all the local beneficiaries (Duguma *et al*., 2013:An Illustrative Case Study: Applying the Non-Additive Synergy Model to the Ngitili System in Shinyanga, Tanzania, para. 6,7; Wainaina *et al.*, 2021:3). The diversification of food for livestock is also beneficial as it increases the health and condition of the animals, which enhances the community's livelihood resilience. This livelihood and food security were felt by many in the region, because by the end of the project in 2004, 90% of the people in Shinyanga benefitted from their own Ngitili (Wainaina *et al.*, 2021:2). The hydrological ES gained from the Ngitili resulted in an increase in water availability which is beneficial to the local people, livestock, and ecosystem. This enhanced the adaptive capacity of the community people, who were then able to build small dams, which enhanced their resilience in dry seasons (Duguma *et al*., 2013:An Illustrative Case Study: Applying the Non-Additive Synergy Model to the Ngitili System in Shinyanga, Tanzania, para. 6). The reintroduction of the practice is culturally enriching for the people as the region reimplemented traditional customs abandoned 60 years earlier, allowing the locals to begin mending some of the disturbing impacts of colonial rule. The regreening of areas, by setting apart sections of land for minimal disturbance to allow for natural regeneration, reversed the desertification of the area (Wainaina *et al.*, 2021:2). The reduced livestock pressure on pasture and grazing lands, improved soil conditions as there was more ground cover to prevent topsoil erosion, the roots promoted better drainage and the dead biomass improved soil fertility (Wainaina *et al.*, 2021:2). The regreening and restoration of plant life then served as habitat for animal life, attracting 145 bird species and 13 mammal species (Duguma *et al*., 2013:An Illustrative Case Study: Applying the Non-Additive Synergy Model to the Ngitili System

in Shinyanga, Tanzania, para. 7). In 1986 the regeneration of these ecosystems sequestered an estimated 23.2 million tonnes of carbon over the following 25 years (Wainaina *et al.*, 2021:3). The Ngitili created positive environmental and social change in many ways, where setting aside grazing and farming areas reduced conflict, the reintroduction of a traditional practice that improved social cohesion, diversified crops and access to firewood improved health and allowed for less time to be spent on chores, and the ecosystem benefits and services from the healthy functioning ecosystems provided more livelihood opportunities.

The Shinyanga Ngitili restoration project of Tanzania has been thoroughly documented in academic literature and the UNDP made use of the Shinyanga project in their 2012 case study series (Duguma *et al*., 2013:References). These academic papers focus on various aspects of the project such as integrating mitigation and adaptation to climate change with development; determining the social, economic and environmental impacts of forest restoration; and how restoring woodlands can sequester carbon and benefit livelihoods (Duguma *et al*., 2013:References). These papers document the processes as well as share the lessons learned, which can then aid in the replication and diversification of similar projects. The documentation of the project, and integration or synthesis of themes (mitigation with adaptation, socio-economic development with environmental conservation, and carbon sequestration with livelihood benefits) garners financial support from diversified sources for such projects. Shinyanga was initially supported by the Royal Norwegian government in a financial capacity and later also benefited from the REDD+ payment mechanism due to the carbon sequestration of the Ngitili (Duguma *et al*., 2013:An Illustrative Case Study: Applying the Non-Additive Synergy Model to the Ngitili System in Shinyanga, Tanzania, para. 3; Wainaina *et al.*, 2021:6). The local people can also benefit financially by selling, or bartering, the produce of the Ngitili to neighbours and perhaps when access to consumer areas is improved, produce can get sold at markets (Duguma *et al*., 2013:An Illustrative Case Study: Applying the Non-Additive Synergy Model to the Ngitili System in Shinyanga, Tanzania, para. 8). The project, and others like it, thus have the potential to attract financial support and contribute to international academic literature.

This CEbA case study exhibits all the key points that Girot *et al.,* (2012:16,17) highlighted when defining how CEbA should ideally look. The arid region of Shinyanga experienced both risk and vulnerability to climate change, which was exacerbated by poor environmental management practices (Duguma *et al*., 2013:An Illustrative Case Study: Applying the Non-Additive Synergy Model to the Ngitili System in Shinyanga, Tanzania, para. 5). The use of Ngitili highlights the HASHI programme's focus on NBS and ecosystem health through community-based efforts. The programme was governed through a collaborative effort, with national governments, international institutions and local communities. The experiences, processes and lessons learned regarding the project were thoroughly documented and shared with

international academic circles. This project shows CEbA's ability to enhance social and environmental resilience in the face of climate change in the rural global south.

2.3 Resilience theory

2.3.1 Resilience

Resilience can be desirable or undesirable in specific contexts and it can be aimed at a specific component or the entirety of a SES. This begs the question, resilience of what and to what and for whom? In this study, general and desirable resilience of SES to climate change for communities and ecosystems is examined.

General resilience is the resilience of a SES to adapt or transform to change, whereas specific resilience is directed at a specified goal or component of a SES (Folke *et al.*, 2016:SES and Resilience, para. 3). Specified resilience has the potential to undermine general resilience, thus the management of a SES should take a more holistic outlook when aiming to enhance social and ecological resilience in general (Folke *et al.*, 2016:SES and Resilience, para. 3). Aiming to maintain a specific quantity and quality of a single resource, like pine trees within an ecosystem, is an example of specified resilience. By focusing on just one species or resource or aspect of a system, will result in an incomplete understanding of requirements to ensure the sustainability of the system. With the pine tree example, pine trees introduced into an area for logging may be resilient as it is unaffected by the area's natural indigenous population control, however, pines can reduce indigenous species' abundance and diversity, which occurred in the Cerrado woodland ecosystem (Cazetta & Zenni, 2020:Conclusion). This undermines the general resilience of the entire system which could result in a regime shift from native shrubs to grassland, affecting both the environment and society.

Resilience can be thought of as the ability of a system to withstand external shocks without shifting towards a new regime (Folke *et al.*, 2003b:354). From this understanding, resilience can be good or bad, in terms of a social or ecological, or economic outlook, in other words, a system can be resilient to shocks, while still being undesirable in a specific context (Folke *et al.*, 2003b:354). An example of this is occurring in Hawaii where introduced grasses are quick to re-establish and grow after a fire, at the expense of the indigenous vegetation, the grasses also promote fires thus making this system both resilient and undesirable socially and ecologically (Biggs *et al.,* 2012:430). Naturally, communities will wish to pursue the resilience of their SES which will benefit them. Desirable social-ecological resilience is seen as a state where the environment is healthy enough to sustain society and its development into posterity, in the face of shocks and uncertainty

(Folke *et al.*, 2003b:354). Thus, the resilience that is strived for in the context of this study is desirable socially, environmentally, and economically.

2.3.2 Persist, adapt and transform

Resilience in this study is the capacity of SES to either persist, adapt or transform in the face of change, while still being able to support human wellbeing and healthy ecosystems. Persistence is due to the absorptive capacity of the SES and it would occur because the disturbance was within the absorptive capacity of the SES (Haider, Schluter, Folke & Reyers, 2021:1305). Following a disturbance, the SES continues to function or persist without any changes as the disturbance was absorbed by the system. Adaptation can be thought of as incremental adjustments and adaptive changes and is due to the SES adaptive capacity (Haider *et al.*, 2021:1305). This adaptive capacity is the ability to modify SES characteristics to either benefit from changes or minimise negative impacts arising from the changes. This capacity is thus dependent on the ability of the SES to learn and have memory, which can be built upon to choose a pathway with the least damage or most benefit (Song & Baker, 2015:10; Preiser, Schluter, Biggs, Garcia, Haider *et al.*, 2021:37). Adaptability is a beneficial characteristic to strive for as it provides options for development actions on current pathways that nurture and improve development (Folke *et al.*, 2016:SES and Resilience, para. 1). Whereas transformation does not absorb changes or modify slightly due to changes as persistence and adaptation do, respectively. Transformation can be thought of as structural or systemic reconfigurations and it is due to the transformative capacity of the SES (Haider *et al.*, 2021:1305). Transformability is the ability of humans to shift development into new or even novel pathways (Folke *et al.*, 2016:SES and Resilience, para. 1). The resilience of systems thus looks different according to what capacity the system has.

Resilience is the ability to choose the desirable characteristics of a system and aim to maintain them through different practices that either modify, select, discard or retain SES traits (Haider *et al.*, 2021:1306). This shows the dynamic nature of SES resilience and frames it more as a process than an outcome, whereby the system is constantly evolving according to external changes and internal practice to retain desirable traits of the regime (Haider *et al.*, 2021:1306; del Mar Delgado-Serrano, Oteros-Rozas, Ruiz-Mallén, Calvo-Boyero, Ortiz-Guerrero *et al.*, 2017:581). By adopting a CAS perspective, resilience and development are coevolving, where development practices filter desirable SES traits which then shapes the state of resilience at that time (Haider *et al.*, 2021:1306, 1307) This has implications for sustainable development, as choosing desirable traits through developmental practice can shape change towards the twin goals of enhanced resilience and sustainability (Folke *et al.*, 2003a:4). Society thus has the power to make changes that reduce

vulnerability to climate change and increase the chance of having healthy, well-functioning SES now and into the future.

The understanding that humans and society have a hand in the trajectory of SES places responsibility on the management and governance of these systems. The stewardship outlook may be helpful in governing an SES towards resilience as it aims to reduce vulnerabilities towards probable change; maintain desirable SES traits throughout the change; and transform "bad" SES characteristics to more desirable and sustainable characteristics (Folke *et al.*, 2016:biosphere stewardship, para 6). Stewardship can steer SES systems onto more sustainable and desirable resilient pathways, by understanding and making practical use of the seven resilience principles set out by Biggs *et al.* (2012). The following section explores these principles.

2.3.3 Unpacking the seven principles of resilience

In the current age of unprecedented change there is a need for governance and management that brings about resilient SES. With this need in mind, the seven Principles for Enhancing the Resilience of Ecosystem Services were drawn up by Biggs *et al.* (2012). In answering the question "resilience of what, to what, for whom?", the principles focus on the resilience of ES, to disturbance and ongoing changes within SES, for ecological and social communities (Biggs *et al.*, 2012:423). As resilience has a holistic, rather than simplistic, outlook on building SES capacity to deal with change, any framework designed to understand what influences resilience should be holistic, too. This holism is captured in the framework developed by Biggs *et al.* (2012) which highlights the priority areas that should be focused on to enhance SES resilience. The seven priority areas are diversity and redundancy, connectivity, slow variables and feedbacks, complex adaptive systems thinking, learning, participation, and polycentric governance (Biggs *et al.,* 2012:424). These principles are interconnected and interdependent, thus producing a gestalt phenomenon. The seven focal points are purposefully not context-specific, so that they may be applied to any SES that aims to enhance its resilience. The following subsections provide a brief introduction to each of the seven Principles for Enhancing the Resilience of Ecosystem Services.

2.3.3.1 Maintain diversity and redundancy

In SES a diversity of distinct components that make up the SES (actors, species, knowledge types, landscapes, genes, livelihoods, etc.) allow for a variety of responses to change (Biggs *et al.*, 2012:425; Simonsen *et al.*, [n.d.]:4). Multiple components that can perform the same SES function, known as functional redundancy, ensure that SES functioning is not dependent on one component so that if that one

component experiences a shock, other components can work together and compensate for the loss without major change experienced by the SES (Simonsen *et al.*, [n.d.]:4). A balance should be struck between too little diversity and redundancy which can result in minimal choices available for responding to disturbances (making the system brittle), and too much diversity and redundancy which can result in reduced capacity for gradual changes (making the system stagnate) (Biggs *et al.*, 2012:427). Efficiency is therefore not necessarily a desired trait in SES, as it can decrease the resilience of a system by ensuring that only a few set pathways are available after a disturbance, however, inefficiency and the resulting inability to make changes, is also undesirable. Each context will require a deeper understanding of this interplay to set the right balance.

2.3.3.2 Manage connectivity

Biggs *et al.* describe connectivity as "the way and degree to which resources, species, or social actors disperse, migrate, or interact across ecological and social landscapes" (2012:427). Landscape components are called nodes and the connections between nodes are called 'links' (Biggs *et al.*, 2012:427). For example: two nodes, a wetland and a mountain, can be connected by a wildlife corridor, the link; or a government department and a community can be connected through key actors or institutional arrangements. Connectivity is influenced by whether there is a link between nodes and the quality of the links that are between the nodes (Biggs *et al.*, 2012:428). If the wildlife corridor in the above example has deteriorated and is of inferior quality; or there is no trust and minimal communication between the government department and community, then the connectivity between the nodes will be weak. This can result in minimal interaction between the nodes. If a disturbance occurs, it is preferable to have superior quality links, so that the connecting nodes are better able to facilitate and accelerate recovery or act as a refuge (Simonsen *et al.*, [n.d.]:6). Too many links, however, can also facilitate the spread of disturbances and thus undermine system resilience (Simonsen *et al.*, [n.d.]:7). So, just as a wetland connected to a mountain can increase the genetic diversity of a species and increase the species ability to adapt to disturbances, multiple connecting links can also spread diseases from the mountain species to the connected grassland, woodland, and wetland. A balance, again, with the understanding of context, must be struck between having too many connections, which can facilitate the spread of disturbance, and too few connections, which can result in a disturbance overwhelming a node.

2.3.3.3 Manage slow variables and feedbacks

As SES is so multifaceted and complex, there are many variables interacting, changing, and co-evolving, with some variables changing slowly while others change fast (Biggs *et al.*, 2012:429). Examples of slow SES variables are the concentration of phosphorus in the soil, or the accumulation and amount of dead organic matter in the soil, as these soil states are due to processes that take years in the making; other examples are traditions; social values; and legal systems (Simonsen *et al.*, [n.d.]:8). When a variable's output acts as an input into the same system, or the output "feeds back" into the system, it causes a loop in the system. This feedback loop can reinforce the change or the process, known as positive feedback, or it can weaken the change or process, known as negative feedback (Biggs *et al.*, 2012:430). An example of a positive feedback loop is observed in oceans when ocean acidity increases due to carbon uptake by the oceans, an increase in seawater acidity result in less carbon that can be sequestered by the ocean thus resulting in positive feedback for atmospheric concentrations of carbon dioxide (Williams, Katavouta & Goodwin, 2019:283). Monitoring of these slow variables and feedbacks are important to understand the underlying dynamics of a system and maintain resilience.

2.3.3.4 Foster complex adaptive systems thinking

A complex system, as opposed to a simple system, has several components interacting in non-linear and unpredictable ways, resulting in emergent and relational system properties (Folke et al., 2003a:5; Preiser *et al*., 2021:33). This principle adopts the belief that SES are complex adaptive systems, which will, in turn, have consequences with the way in which the SES are managed. This follows an understanding that CAS cannot be reduced to a sum of its parts and managed piecemeal, because then the emergent system behaviour, system feedbacks, the system's adaptive capacity, and its natural evolution and will not be considered and accounted for in management (Biggs *et al.*, 2012:432). Without this CAS mental framework, the intricate connections within and dynamic nature of SES are underestimated, resulting in management options that can undermine the resilience of the system (Simonsen *et al.*, [n.d.]:10; Biggs *et al.*, 2012:432). CAS thinking should thus go together with governance and management that expects uncertainty and disturbance, so that when unforeseen properties emerge, it can be managed in stride.

2.3.3.5 Encourage learning and experimentation

As SES are taken to be CAS, change and uncertainty are a given at any time, resulting in a constant stream of new information pertinent to gaining an understanding of the SES at that moment in time (Biggs *et al.*, 2012:434). This new information should be acquired and either modify or replace existing knowledge,

behaviour, skills, and values, and thus learning and experimentation should be encouraged (Biggs *et al.*, 2012:434). When acquiring new information, power dynamics need to be accounted for in order to be aware of any bias which could lead to certain knowledge or knowledge sources being taken up more than others (Simonsen *et al.*, [n.d.]:13). Learning can be achieved through monitoring (observation of SES processes and components) and experimentation (actively manipulating certain SES processes and components) as well as from gaining knowledge from past events (Biggs *et al.*, 2012:434). This learning could be at the individual level and spread through social interactions; facilitated processes; or even as an emergent outcome, to the social level, where it is known as social learning (Biggs *et al.*, 2012:434). Adaptive co-management, an iterative process of collaborative management between stakeholders, is the type of management that arises from this kind of co-learning and social learning (Borrini-Feyerabend *et al.*, 2004:69; Simonsen *et al.*, [n.d.]:12). The different perspectives, knowledge types and sources of information that is gained ensures a fuller picture of the natural and the social aspects of the SES as well as the interactions between them, and as such informs a management strategy that is more equipped to yield a resilient SES.

2.3.3.6 Broaden participation

Participation can range from informing stakeholders to full involvement and collaboration with all stakeholders, either as individuals or through an elected representative that speaks on behalf of a group (Beder, 2006:119; Hara, 2003:24). Broadening participation can encourage more legitimate involvement, encompass more groups of people, and ensure that the management of SES is more public/community directed. This can increase the depth and diversity of knowledge, as a range of perspectives will be gained, some of which cannot be acquired through scientific means (Biggs *et al.*, 2012:434; Simonsen *et al.*, [n.d.]:14). Participation has the potential to build trust and understanding between groups which can aid in the comprehension of other types of knowledge and the actions that arise from it, as well as transparency of processes (Simonsen *et al.*, [n.d.]:14). All of this can increase the cooperation between actors and develop links between previously unconnected nodes (Simonsen *et al.*, [n.d.]:14). Participation is an enabler of ongoing social learning, and this helps raise awareness and public support for projects, (Biggs *et al.*, 2012:434; Simonsen *et al.*, [n.d.]:14). The collaboration between the right groups (or connections between nodes) with more direct information flows from source to management can result in faster reaction times to deal with disturbance and more effective decision making (Biggs *et al.*, 2012:434). Effective collaboration and participation require both understanding and trust between groups. In studies done in the Pacific region, the participants were reluctant to share LTK with the researchers as they were embarrassed to share their “old ways of thinking or superstitions" and “old backward thinking” with the “outsider”

researchers (Nalau *et al.*, 2018:860). This highlights the importance of building trust in these interactions between diverse groups to avoid a top-down feeling of participation and encourage a horizontal approach to communication, for honesty and transparency on both sides.

2.3.3.7 Promote polycentric governance systems

Governance is a complex process of interrelated problem solving and decision making which occurs at multiple scales and levels of authority, with collaboration between many decision-maker groups and stakeholders such as government departments, NGO's, indigenous groups, citizens, businesses, etc., (Borrini-Feyerabend *et al.*, 2013:15). A polycentric governance system is a system of governance that consists of many independent decision-making centres that are connected through vertical and horizontal links (Biggs *et al.*, 2012:437). These links may be due to a shared geographical area or shared areas of interest, matters of jurisdiction, or domain of authority, and can be achieved through informal or formal networks of communication (Biggs *et al.*, 2012:437). The independent decision-making centres are well equipped, and nested within the right context, to address issues as they arrive, and are connected to other centres when additional and different input or output is required, resulting in a collaborative process that is suited to the issue (Simonsen *et al.*, [n.d.]:16). The collaboration between many diverse groups is both the strength and the weakness of this form of governance. This system has the challenges associated with large groups of people collaborating, such as excessive costs of involvement, trade-offs among various stakeholders and continuity in decisions (Simonsen *et al.*, [n.d.]:16). Polycentric governance encourages diversity and redundancy, connectivity, participation and learning in its functioning and this results in reactions to disturbances that are competent and qualified to manage the situation in a timely manner. These characteristics are a benefit to the SES and act together to enhance SES resilience.

2.3.4 Resilience operationalised in previous research

Salomon *et al.* (2019) used the seven resilience principles to reveal opportunities for transforming environmental governance. Quantitively measuring SES resilience had been an elusive endeavour until Salomon *et al.* (2019) translated the theoretical set of resilience principles, developed by Biggs *et al.* (2012), into 22 social and ecological metrics that could then be measured. Traditional knowledge holders from the indigenous Heiltsuk Nation then answered an interviewer-administered questionnaire (Salomon *et al.*, 2019:Resilience metrics, para.1). The questionnaire was aimed at assessing the magnitude changes of all 22-resilience metrics during the three sequential dominant governance regimes of the Pacific herring fishery in northwestern Canada (Salomon *et al.*, 2019:Resilience metrics, para.1). The interviewees then ranked

the 22-resilience metrics on a Likert scale from 1 to 5 (low to high resilience rating) for each of the three governance eras (Salomon *et al.*, 2019:Resilience metrics, para.1). This was then analysed to quantify the effect of each governance regime on the 22-resilience metrics, the seven principles of resilience and the entire Pacific herring SES resilience (Salomon *et al.*, 2019: Statistical analyses, para.1). The results show changes in variables that confer SES resilience, which can then be analysed to indicate the preconditions for transforming environmental governance. This information can then be used to catalyse SES governance transformation towards a just, sustainable and resilient outcome. This study advanced the field of sustainability science by creating social and ecological metrics that allowed for the theoretical set of resilience principles to be measured. This method can be used to assess SES resilience in many different settings by simply redefining the metrics to be context specific.

2.4 Conclusion

The motivation for this thesis was to uncover whether CEbA is a viable solution to enhancing SES resilience in the face of climate change, particularly in the developing rural south. There is a need to address climate change vulnerabilities of rural communities with effective and sustainable solutions that enhance rather than undermine their resilience. The key concepts, CEbA and resilience, had to be explored to uncover whether CEbA is a viable solution to enhance SES resilience and to help poor, rural communities adapt to climate.

The chapter started out by defining EbA and CbA separately to have a holistic understanding of their integration to form CEbA. It was seen that EbA uses ES as a strategy for communities to adapt to climate change and contribute to SES resilience in the face of uncertainty and change (Chevallier, 2017:3; Midgley *et al.*, cited in South African National Biodiversity Institute, 2017:55; Prabhakar *et al.*, 2019:3). CbA utilises and builds upon community strengths to identify their vulnerability and enhance their own resilience to the impacts of climate change (Chevallier, 2017:3). This research then argues that by combining these approaches there is a better chance of addressing more components that build social-ecological resilience, especially for resource dependent, poor, developing communities. CEbA is a novel solution that can be adapted to fit unique circumstances as it is a range of interventions that include EbA strategies and CbA processes (Coll Besa, 2015). Through correct governance, CEbA empowers locals to build their own resilience to climate change and restore, manage and preserve ecosystems that provide adaptive goods and services as well as co-benefits (Girot *et al.*, 2012:4). By integrating EbA and CbA, CEbA can address weaknesses within the two parent strategies and build on their strengths. CEbA also has its own emergent strengths, resulting in an approach with many strengths and co-benefits which make it a desirable approach

for poor, developing communities. Theoretically CEbA thus appears to be a viable option and so this research then took a closer look at CEbA in practice.

CEbA was defined in practice as exhibiting NBS, community-based efforts, social and environmental resilience, collaborative governance, and the documenting, as well as sharing, of lessons learned (Girot *et al.*, 2012:16,17). To gain a deeper understanding of CEbA the research then looked at the Tanzanian HASHI project, a rural developing world CEbA project that succeeded in its goals of adapting to climate change and increasing SES resilience. This information provided a comprehensive overview of CEbA, however, to deduce whether CEbA truly has resilience enhancing potential, the research must ascertain whether CEbA corresponds with the seven Principles for Enhancing the Resilience of Ecosystem Services as developed by Biggs *et al.* (2012). This required an exploration of resilience theory.

The *Resilience Theory* section lays the groundwork for understanding resilience, why understanding resilience is important for managing SES and why measuring resilience can be beneficial for change agents. It was explained that this study focuses on general and desirable resilience of SES to climate change for communities and ecosystems, which thus guided this section. Resilience is the ability of a system to withstand external shocks without shifting towards a new regime (Folke *et al.*, 2003b:354). It is the capacity of SES to either persist, adapt or transform in the face of change, while still being able to support human wellbeing and healthy ecosystems. Managers can thus choose the desirable characteristics of a system and maintain them through different practices that either modify, select, discard or retain SES traits (Haider *et al.*, 2021:1306). This has implications for development, as society has the power to reduce vulnerability to climate change and increase the chance of having healthy, well-functioning and sustainable SES. With these implications in mind, the seven Principles for Enhancing the Resilience of Ecosystem Services were drawn up by Biggs *et al.* (2012). The seven resilience principles focus on the resilience of ES to disturbance and ongoing changes within SES for ecological and social communities. The framework highlights the priority areas that should be focused on to enhance SES resilience. The seven principles are (1) maintain diversity and redundancy, (2) manage connectivity, (3) manage slow variables and feedbacks, (4) foster complex adaptive systems thinking, (5) encourage learning and experimentation, (6) broaden participation and (7) promote polycentric governance systems. These principles are a preliminary guide to enhancing resilience of ES upon which human wellbeing is dependent. As such, if CEbA complements these principles, it should in theory promote the resilience of ecosystems as well as the resilience of the communities that are dependent on these ES. This knowledge can then be used by change agents to promote the implementation of CEbA in highly resource dependent and poor rural areas, however, until recently measuring resilience had been quantitively elusive. Salomon *et al.* (2019) thus advanced the sustainability science field by

translating the theoretical set of resilience principles into social and ecological metrics that could be measured. This method can be used to assess SES resilience in many different settings by simply redefining the metrics to be context specific.

This chapter set the foundation for the following chapters as it highlighted the potential of CEbA to assist resource dependent, poor rural communities in adapting to climate change while at the same time potentially possessing the ability to enhance resilience of SES. This chapter presented the seven resilience principles and highlighted why each principle is important to enhance resilience, which will be important to understand when discussing the case study according to the resilience principles. By stating how Salomon *et al.* (2019) operationalised the resilience principles, this chapter introduced the method to be used in this research in the following chapters.

CHAPTER 3: METHODOLOGY

3.1 Introduction

The following chapter presents the research design and methodology that went into answering the research questions. It discusses the types of data used, where the data was collected and how it was analysed. It provides reasons as to why the specific case was chosen to study and the limitations involved. Lastly, the chapter looks at the philosophical paradigm that guided the research and the ethics of this study.

3.2 Research questions and aims

The research aims to highlight the role CEbA can play in resilience building, especially in rural, resource dependent communities within developing countries. To answer the research questions, the two previously unconnected literature on CEbA and resilience had to be explored to build a foundation of understanding of the concepts. After this foundation has been built, it can be applied to the LCCAP case, with the intention of discovering whether CEbA has the potential to enhance resilience. The qualitative data of the LCCAP case is extensive which allows for a deep exploration of CEbA approaches implemented, how these approaches were taken up by the project communities and the outcomes of these approaches. An exploration of this qualitative data can identify the resilience building capacity of these approaches.

The research has three main research questions, each with their own sub-questions:

1. What characteristics did the LCCAP exhibit for it to be classified as CEbA?
    a. What characteristics define a project as CEbA?
    b. Does LCCAP conform to CEbA characteristics?
2. Do the methods employed in the LCCAP case have the potential to enhance livelihood and ecosystem resilience?
    a. What methods did the LCCAP use?
    b. Did these methods employed adhere to the seven resilience principles that enhance ES?
3. Does CEbA have the potential to enhance SES resilience in the face of climate change?
    a. What are the framework similarities between CEbA and the seven resilience principles?
    b. Do the characteristic, methods and principles used in CEbA complement or contend with the seven resilience principles?

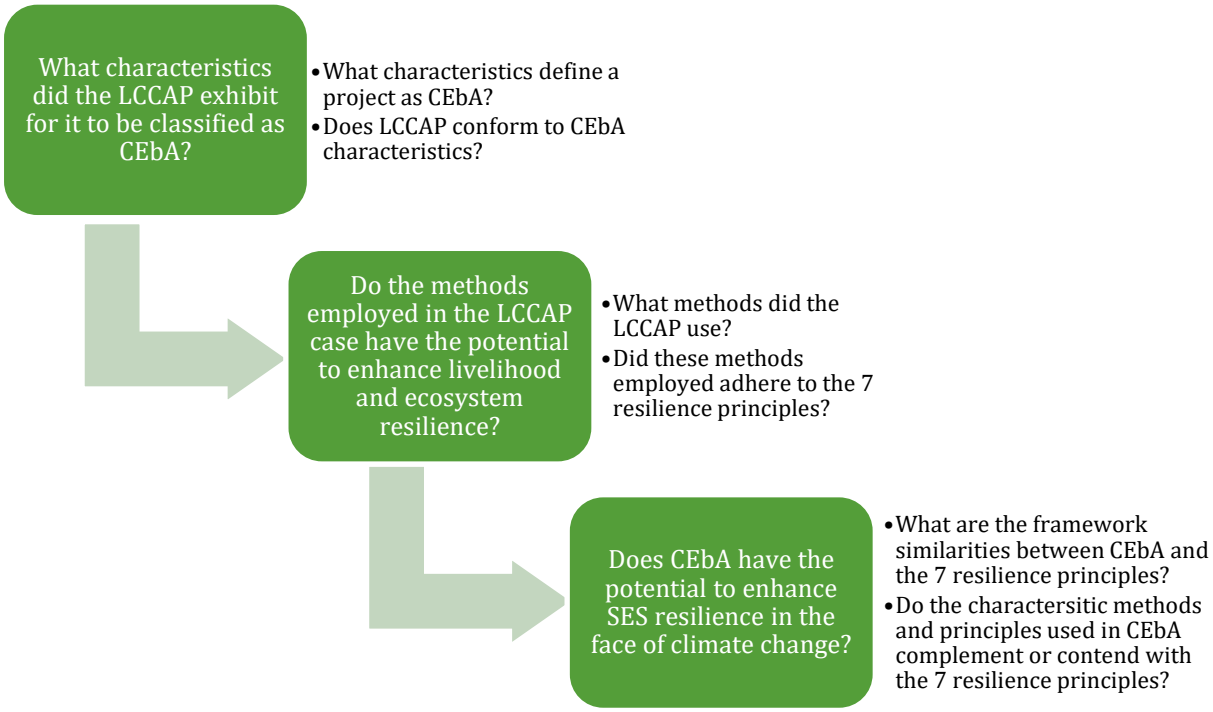

Figure 2 Stepwise research questions.

The research questions work in a stepwise manner, where the sub-questions guide the research to answer the main research questions and the first two research questions must be answered to answer the third research question. The aim of this research is to uncover whether CEbA has the potential to enhance resilience as it attempts to do. To achieve this, the research must first understand CEbA so that the case chosen is a clear example of CEbA; secondly the research must develop context specific metrics that can be used to measure the seven principles of resilience by proxy; thirdly the research will need to categorise the CEbA methods employed during the LCCAP according to these metrics, which then can allow for the methods to be described as resilience enhancing or undermining; and fourthly the potential of CEbA approaches to build SES resilience can be deduced with reference to the LCCAP case.

The research questions guide the research to achieving the research aim of connecting the previously unconnected fields of CEbA and resilience, and to uncover any potential synergies between them.

The research aims to explore CEbA and its potential to build SES resilience through the following objectives:

1. Unpacking CEbA to document its definition, characteristics and aims.
2. Unpacking resilience thinking and the 7 resilience principles.
3. Design metrics that can be used to determine whether CEbA enhances or undermines each of the 7 principles of resilience.

4. Illustrating the connections of resilience and CEbA theory through the Lesotho case application.
5. Discuss and conclude the potential of CEbA approaches to build SES resilience.

3.3 Research design and methodology

The research is qualitative, empirical, and it studies existing textual data. Qualitative research is deemed as the most appropriate research method for answering the research questions. This is because SES resilience is built up from a combination of interacting SES capacities and assets, with multiple components which are difficult to measure and assess, and thus are quantitatively elusive (Sturgess & Department for International Development, 2016:7; Salomon *et al.*, 2019:Methodological advances, limitations, and assumption, para.1). And so, qualitative methods with its use of interpretive and descriptive textual data were chosen as the best method within the scope of this study. Existing studies can be used for analysis to explore the processes and results in a new light. The study undertakes an exploration of the links and interconnections of CEbA and resilience, in the context of climate change.

The design makes use of mixed methods, including a literature review, theory synthesis, and a case study research design. The theory synthesis focuses on integrating the previously unconnected resilience literature, as set out by Biggs *et al.* (2012), with CEbA theory (Jaakkola, 2020:21). While the case study can provide a descriptive illustration of this integration in practice. This design is used with the goal of building coherence between CEbA and resilience, as well as enhancing the existing understanding of CEbA in terms of its resilience potential. Theory synthesis is used when conceptual integration of multiple theories is desired (Jaakkola, 2020:22). It provides structure to a burgeoning concept/theory, in this case, CEbA, by viewing it through a specific theoretical lens, in this case, a resilience lens (Jaakkola, 2020:22). The integration and synthesis required of a theory synthesis require the building blocks of each concept, resilience, and CEbA, to be unpicked and explained, for the commonality to be determined and built upon, to enhance the concepts and theory (Jaakkola, 2020:21). This synthesis is grounded by exploring a CEbA case through the lens of resilience.

The Climate Change Adaptation Project in the Lesotho Highlands was selected to illustrate integrated CEbA. The use of a case will enable more time for case exploration and thus allow for a deeper understanding of the specific case. This is illustrated in "Incentives for landscape restoration: Lessons from Shinyanga, Tanzania", (Wainaina *et al.*, 2021) where a case study was explored in depth through a theoretical lens and reported on. A case study will be useful as it allows the exploration of theories at the

micro-level and for the conceptual study to be grounded (Wainaina *et al.*, 2021:3). The CEbA case chosen should, through exploration and interpretation, be able to illustrate key points of resilience theory.

3.4 Methods

3.4.1 Method of data collection

Triangulation is a research study method that combines theories, methods and sources with the attempt to reduce uncertainty and bias, and increase credibility and validity (Noble & Heale, 2019:67). For this reasoning, triangulation of methods, data and sources was applied to this study. The data gathered for the non-empirical literature review and the empirical theory synthesis will be obtained from online journal databases like JSTOR and ResearchGate and will be based on published academic literature regarding Resilience, SES, CEbA, CbA, and EbA literature. The theoretical framework on resilience used in the theory synthesis will primarily be based on the paper "Toward Principles for Enhancing the Resilience of Ecosystem Services" by Biggs *et al.* (2012). And the literature for the real-world case, LCCAP in The Lesotho Highlands, is open access and can be found on the websites of two of the collaborating parties: USAID[1] and the Institute of Natural Resources[2]. The case data is in the form of discussion documents, infographics, fact sheets, video captured interviews, annual reports from 2010 to 2018, the project's closeout report as well as a study report on the integration of EbA and CbA for the Lesotho Highlands project. Unrestricted access information will be used for the case study as far as possible as the sharing of lessons learned for the benefit of society is an important principle of CEbA. And as such the information used for the case study should be readily available to anyone with access to the internet.

The Lesotho CEbA case was chosen as it exhibits the following characteristics:

1. Well-documented CEbA case with open access to information collected over its 8-year duration.
2. Exhibits adaptation to climate change based on both the ecosystems' and communities' capacity.
3. The communities are from a developing country, it is rural and resource dependent.
4. The case has climate change-associated risk as well as high vulnerability to said risk.
5. The community members are meaningfully involved in most of the adaptation and resilience-building stages.

[1] https://dec.usaid.gov/dec/search/FusionSearchResults.aspx?q=CLIMATE+CHANGE+ADAPTATION+IN+THE+LESOTHO+HIGHLANDS

[2] https://instituteofnaturalresources.wordpress.com/

3.4.2 Methods of measurement

Recent academic work in fisheries (Salomon *et al*., 2019) and mountain habitats (Son & Baker, 2015) have advanced sustainability science by attempting to measure and assess SES resilience (Salomon *et al*., 2019:Methodological advances, limitations, and assumptions, para. 1). By creating context specific metrics of the seven resilience principles, researchers can indirectly measure SES resilience (Salomon *et al*., 2019:Methodological advances, limitations, and assumptions, para. 1). The metrics can be measured through expert stakeholder questionnaires, interviews and focus groups, and/or from direct observation and measurement in the field (Son & Baker, 2015:3). If the metrics show that the principles are being adhered to, then the SES should theoretically be resilient to shocks and disturbances (Biggs *et al.*, 2012:424). A general resilience metric table can be seen below.

Table 1: Generalised resilience-building metric table, adapted from Salomon et al., 2019.

Resilience principle	**Resilience-building metrics**
Maintain Diversity and Redundancy	Species and habitat diversity Response diversity and redundancy Diversity of perspectives and cultures Diversity of livelihoods Diversity of institutions and organisational forms Diverse sources of knowledge and knowledge types Diversity of users and managers of an ecosystem Diversity of crops by small scale farmers Structural complexity in landscapes Buffers around sensitive ecological areas Controlling overabundant invasive species
Manage Connectivity	Degree of information sharing Wildlife corridors Cross scale and cross sectoral mechanisms and links for information sharing Sharing of information between groups
Manage Slow Variables and Feedbacks	Understanding of gradual changes Decisions updated with new information Ability of manages to respond to key changes Incentives and punishment
Foster Complex Adaptive Thinking	Acknowledging that social-ecological systems are based on a complex and unpredictable web of connections and interdependencies Willingness to embrace change Preparedness to cope with unexpected change Scenario building
Encourage Learning and Experimentation	Innovation and willingness to experiment Cross scale and cross sectoral mechanisms and links for information sharing Sharing of scientific and local, indigenous and traditional resources Learning from crisis Developing coping strategies
Broaden Participation	Amount and type of participating groups Methods of participation Sharing of information between groups Building trust Building capacity for participation

	Providing incentives for participation
Promote Polycentric Governance	Use of local and indigenous knowledge Distribution of governing power Accountability & transparency Conflict management and resolution mechanisms Building capacity for self-organization Policy that promotes devolution Bridging organisations

These metrics, as seen in the table above, were adapted and fine-tuned by the researcher after studying the LCCAP, to better fit the Lesotho SES context. The qualitative data from the LCCAP can then be sorted by grouping the approaches used according to the metric developed. This information can then be analysed according to the theoretically grounded framework set out in 'Towards Principles for Enhancing the Resilience of Ecosystem Services' (Biggs *et al.*, 2012). The research by Biggs *et al.*, (2012) outlines the way each principle can either enhance or undermine resilience, this will be used to analyse whether the approaches implemented in the Lesotho case enhanced the SES resilience as it aimed to do. This method indirectly measures SES resilience, by identifying the system characteristics that either act to enhance or undermine resilience. Salomon *et al.*, (2019) used this method to determine Pacific herring SES resilience. By simply defining context specific resilience metrics the method can be used to assess any type of SES resilience. Using this SES resilience metric method is a simple but effective way of connecting CEbA practice with resilience theory.

4.3.3 Method of analysis

For the case study, the activities implemented by the project team will be divided and discussed according to the metrics developed by the seven resilience principles. From this discussion and interpretation of activities undertaken by the project and their outcomes, a rating will be given, by the researcher, on a Likert scale from 1 (low) to 5 (high) for before and after the LCCAP implementation. From these ratings each metric will be classified as having either enhanced, had no effect, or undermined the SES resilience because of the LCCAP. The baseline is the state of the SES before the project began. Each metric rating that was given will be averaged to find the average effect that the project had on the resilience principle. The general effect of the project on the SES resilience can then be ascertained from the average rating of each resilience principle. This method of analysis and use of a rating system is adapted from the innovative resilience study by Salomon *et al.*, (2019). From this analysis lessons can be learnt about project activities and how these activities impact the SES resilience. The lessons can be used to benefit policy makers and future CEbA or similar projects that wish to enhance resilience.

3.5 Limitations and assumptions

The research assumes that disregarding the seven resilience principles would act to undermine SES resilience, while adhering to them would enhance SES resilience. The work is limited by the reliance on data that is already existing and available from the LCCAP case. This is often a methodological challenge experienced when studying resilience (Béné, cited in Sturgess & Department for International Development, 2016:8). The scope of the project, with its limitations in both available time and resources, made it impossible to have a more systematic approach with primary data collected from the field.

The method used is susceptible to uncertainty and bias. The LCCAP was undertaken by scientific organisations with professionals applying expert knowledge to the project, however, the data collected is not direct empirical resilience measurements and even expert observation is subject to a degree of uncertainty and bias (Hillborn & Mangel, cited in Salomon *et al.*, 2019). The data and observations collected is descriptive and relates to resilience but can never paint the full picture of SES resilience. Another issue is that the data assessed is from the project team and this study's author, where this research would have benefitted from direct contact with community members and government officials involved, to gain their input on the project's influence on SES resilience.

3.6 Conclusion

The methodology chapter provided the contextual framework for the research. The first research question explores and explains CEbA. The second research question requires a connection between two main pieces of academic literature, CEbA and resilience. As these fields have previously not been connected, a synthesis of ideas was required, which then required an explanation of each topic. This understanding and information could then be applied to a case study to better answer the three research questions. The third research question required a metric to be applied to the chosen case study to conclude on the ability of CEbA to enhance resilience. The research was presented as qualitative, empirical and making use of secondary data. The data was obtained from online journal databases, peer reviewed literature, and literature based on the case study. Mixed methods, involving a theory synthesis and case study, was motivated by the aim and research questions of this study. A limitation of this study is reliance on existing data collected from the LCCAP case study, which was not designed to answer these research questions, and the documentation of the case data is thus limited in that regard. The data was analysed through an interpretivist philosophical paradigm, with associated relativist ontology and subjectivist epistemology. This research study was granted exemption from ethics review and clearance by the Social, Behavioural and Education Research section of the Research Ethics Committee.

The research design and methodology are summarised in the table below:

Table 2: Research summary.

Context	CEbA and Resilience
Research purpose	Exploratory and explanatory
Philosophical paradigm	Interpretivism
Epistemology	Subjectivism
Ontology	Relativism
Data typology	Qualitative, secondary data
Data collection	Desktop collection
Empirical design	Theory synthesis, case study
Framework	Principles for Enhancing the Resilience of Ecosystem Services

CHAPTER 4: CASE STUDY

4.1 Introduction

This chapter serves to introduce the case study, the LCCAP used for this research. This chapter will provide a closer look into the locations, with a focus on the predominant climate for the area, the risk and vulnerability of the region, its socio-economic conditions, and the LCCAP's aims.

The LCCAP is an Institute of Natural Resources initiative funded through a USAID grant, that took place in the Lesotho Highlands between 2010 and 2018, implementing CEbA practices with the aim of enhancing resilience to the impacts of climate change (Institute of Natural Resources, 2018:4; USAID Southern Africa, 2014;3). The LCCAP chose four community areas to pilot their adaptation interventions (Institute of Natural Resources, 2011:10; Institute of Natural Resources, 2018:11; Lewis, McCosh, Pringle, Bredin, & Nxele, 2011:10). The table below provides information on the four pilot sites used in the LCCAP.

Table 3: Basic information pertaining to the four pilot sites of the LCCAP.

Pilot Sites	District	Catchment Area	Village Name	Household Population
Konstabole-Sepinare	Leribe	Katse	Ha Konstabole Ha Sepinare	286
'Muela	Botha Bothe	'Muela	Boinyatso 'Muela Moreneng	557
Setibi-Mamohau	Leribe	Katse	Ha Lejone Ha Poli	553
Tšiu – Koporale	Thaba Tseka	Mohale	Ha Koporale Ha Tšiu	308

4.2 The LCCAP location and ecosystem type.

The highland, mountainous region of the country is home to 24% of Lesotho's population (as of 2018) (Institute of Natural Resources, 2018: 9). Lesotho is situated in a grassland biome made up of three major grassland ecological zones consisting of a rich endemic biodiversity (Department of Environment, 2009:4-9). This indigenous biodiversity is important for the ecosystem goods and services they provide, and the livelihoods that are supported by them (Institute of Natural Resources, 2018:9). The four pilot sites are situated within the Lesotho Highlands, in a major Afromontane grassland habitat called the Lesotho Highland Basalt Grassland (Cape Farm Mapper, 2021: VegMap 2018). The sites were chosen due to their proximity to critical Lesotho Highlands Water Project dams (Katse, Mohale, and 'Muela) as these degrading wetland and rangeland ecosystems provide essential ES, not only to the communities, but also to the greater Lesotho and South African areas through the water project. The pilot sites fall within the mountain catchment area of the Orange-Senqu River (Dejene, Midgley, Marake, & Ramasamy, 2011:9,11).

The pilot sites exhibit the grassland and shrubland vegetation endemic to the area, as well as wetland and streambank vegetation (Lewis *et al.*, 2011;12). These ecosystems provide essential ES for the pilot site communities.

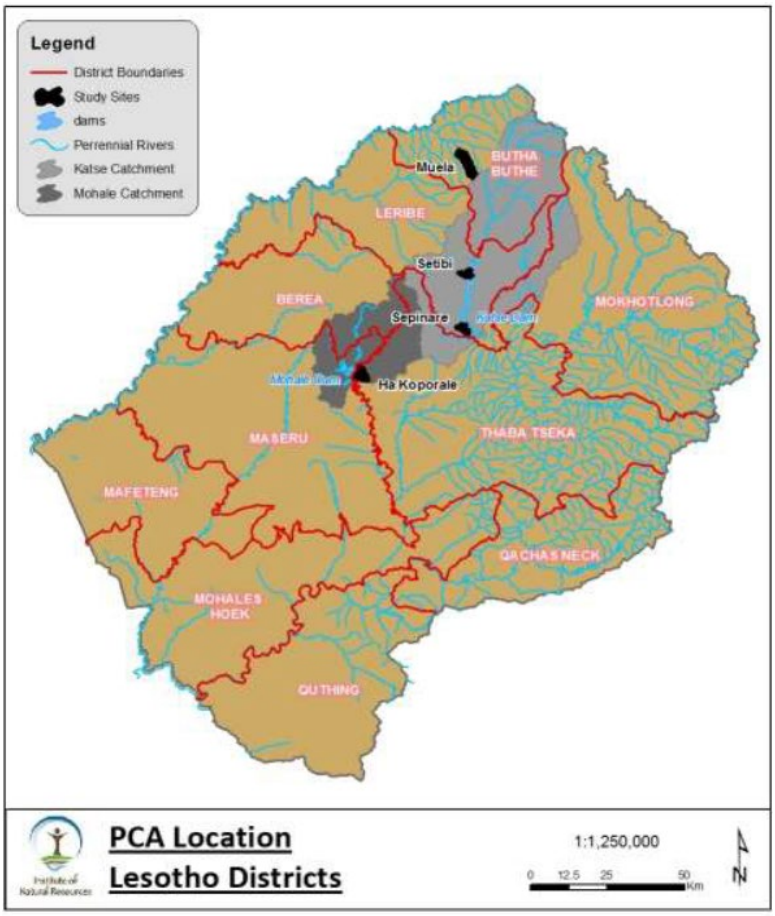

Figure 3: Map taken from Lewis et al. (2011:8) showing the location of the pilot sites.

4.3 Lesotho's climate and projected climate change

The Kingdom of Lesotho is a landlocked southern African country located on a plateau (ranging between 1400m to 3480m above sea level) and characterized by high mountains which make up 60% of the country (Lesotho Meteorological Services, 2021:Climate of Lesotho; Institute of Natural Resources, 2018: 9). It lies between 28 and 31 degrees south thus placing it in the subtropical high-pressure belt, but it experiences weather associated with both this zone and the westerly low-pressure belt (Cape Farm Mapper, 2021; Lutgens & Tarbuck, 2013:199). As Lesotho is on the cusp of two pressure systems, it experiences weather changes with the seasonal movement of the Inter-Tropical Convergence Zone: the winter months are characterized by high-pressure systems resulting in dry and cold conditions; and the summer months are

characterized by low-pressure systems resulting in wet and hot conditions (Lesotho Meteorological Services, 2021:Climate of Lesotho). The country's climate is also affected by the two ocean currents that converge on the tip of southern Africa: the warm Agulhas Current of the Indian Ocean and the cold Benguela Current of the Atlantic Ocean (Lesotho Meteorological Services, 2017:1). Winter precipitation is in the form of snow and summer months experience humidity, rain, cloudy conditions, thunder, and hailstorms with strong winds (Lesotho Meteorological Services, 2021:Climate of Lesotho). Lesotho has already experienced increased frequency in erratic precipitation patterns as well as extreme weather events that can overwhelm vulnerable communities, such as storms, flooding, and droughts (Lesotho Meteorological Services, 2017:2). Climate change projections for the area predict that these extreme events (droughts, flooding, etc.) will increase in frequency and duration (Institute of Natural Resources, 2018:9). Lesotho will experience increased temperatures with warmer climatic conditions, associated extreme heat spells, and dry winds (Institute of Natural Resources, 2018:9; Lesotho Meteorological Services, 2017:1,4). Other changes include increased rainfall variability with precipitation increases in winter and decreases in summer and spring (Institute of Natural Resources, 2018:9). The severity of the impacts felt by Lesotho from these changes depends on their social, economic, and environmental resilience and vulnerability to such impacts (Dejene *et al*., 2011:5). As such, to understand the risk climate change places on Lesotho communities' resilience, there must be an understanding of their vulnerabilities.

4.4 Lesotho's risk and vulnerability to climate change

Lesotho is ranked 122 out of 182 countries in their vulnerability to climate change and readiness to improve their resilience by the ND-GAIN Country Index, it thus has both high vulnerability and low readiness with regards to climate change (ND-GAIN Index, 2019:Lesotho). In the most recent results of 2019, Lesotho was ranked the 67th most vulnerable country and 46th least ready country to improve resilience to climate change (ND-GAIN Index, 2019:Lesotho). By looking closer at the vulnerabilities that the country has, the pathway to becoming more resilient will be clearer.

As of 2011, 68% of the population of Southern Africa is rural and dependent on agriculture, with the Lesotho rural population being dependent on rainfed and undiversified subsistence agriculture, however farming is declining at a steady rate (Lesotho Meteorological Services, 2017:2 Dejene *et al.*, 2011:III, V). Climate change projections for the area paint a bleak picture for Lesotho agriculture, with the staple crops of maize, wheat, and sorghum at risk, thus affecting the area's food security (Dejene *et al.*, 2011:III). This risk and decline in agriculture are due to many interrelated factors, such as degraded soils, degraded

vegetation, harsh weather conditions, and limited financial resources to implement better farming techniques.

In Lesotho, 80% of the population are dependent on soil for their livelihoods, however, the soil is becoming more fragile and degraded due to the high population pressure that is dependent on this resource (ORASECOM, 2014:3; Lesotho Meteorological Services, 2017:2). The condition of the soil is further deteriorated due to heavy torrential rainfall that results in severe soil erosion (Lesotho Meteorological Services, 2017:2). Erratic rainfall, floods, and droughts are predicted to increase due to climate change, which will have negative effects on the land, which is already under pressure (Institute of Natural Resources, 2018:9; Dejene *et al.*, 2011:1). There is competition for the limited arable land in the Lesotho highlands (Lesotho Meteorological Services, 2017:2; Dejene *et al.*, 2011:V; Institute of Natural Resources, 2018:9). This competition puts pressure on the limited natural resources and exacerbates environmental degradation, biodiversity loss, and habitat transformation.

Although local farmers have noticed the deterioration of the environment, the current farming methods (including tiling, overgrazing, burning of the grasslands) are not changing at the rate required for mitigation or adaptation (Institute of Natural Resources, 2018: 49; ORASECOM, 2014:21). The growing poverty in Lesotho is one of the factors making it difficult for rural farmers to implement adaptation solutions to build resilience to climate-induced vulnerabilities (Dejene *et al.*, 2011:V). Poverty and lack of financial capacity also inhibit the ability of the nation to build infrastructure that can withstand the severe weather conditions that are already experienced by the population and that are expected to increase in severity and frequency (Dejene *et al.*, 2011:V). When such shocks do occur, the people have little to buffer the effects. This increases the population's vulnerability to the risks that climate change introduces.

Another natural resource at risk due to climate change is freshwater sources (Dejene *et al.*, 2011:III). The Maloti Mountain range in Lesotho gives rise to the Orange Senqu River (Earle, Malzbender, Turton, & Manzungu, 2005:2). The highlands of Lesotho have regulatory and provisioning ES, upon which the Orange-Senqu River's health and functioning are dependent (ORASECOM, 2014:3). The Orange-Senqu River itself provides many ES to wildlife, such as aquatic, wetland habitats, and grassland habitats; and many ES to society, including natural irrigation, water filtration, and fertile land for agriculture. The river is further used for economic activities in Lesotho and South Africa including hydroelectric power generation, mining, and industry (Earle *et al.*, 2005:13). This is already in danger due to overgrazing which adds to the severe soil erosion already occurring and it degrades the highland's wetlands (Earle *et al.*, 2005:31). Soil erosion leads to decreased infiltration and increased surface runoff of water and thus more

frequent flooding (ORASECOM, 2014:17). Soil erosion also results in higher sediment loads in the river with associated siltation of dams (ORASECOM, 2014:17). The flow of the river and the quality of water is thus highly affected by soil erosion. The wetlands associated with the headwaters of the river provide vital services to the river, including the retention and regulated slow release of water into the river, which thus acts as a flood control as well as quality control of the water because the wetland filters out nutrients and sediments are deposited (ORASECOM, 2014:7). Thus, the degradation of wetlands has negative effects on the quality, quantity, and flow of the freshwater source, as well as the surrounding wildlife. Climate change puts this at further risk due to increased torrential rains which further exacerbates soil erosion, which then further exacerbates wetland degradation and results in compounded negative effects for the freshwater resource.

This highlights the necessity to plan for the impacts of climate change with enough time to adapt and build resilience to aspects that are currently at risk and vulnerable. This requires awareness and action, especially amongst government officials and policymakers. In 2017, the Lesotho Meteorological Services (2017:3) confirmed the awareness amongst government departments was present, however, the policy and instruments to address climate change were lacking, if even existent. To address this lack and the high risk and vulnerability Lesotho faces in climate change, the National Climate Change Policy was drawn up to begin the national pathway to climate change resilience that encompasses "a prosperous sustainable economy and environment in Lesotho" and increases "the well-being of Basotho" (Lesotho Meteorological Services, 2017:5).

4.5 Socio-economy

As Lesotho is a Least Developed Country, it is subject to high vulnerability to climate change, with regards to food insecurity, poverty and ecosystem function (Dejene *et al.*, 2011:2; Lewis *et al.*, 2011:9). The four pilot area communities all reside within the mountain zones of Lesotho and are characterised by environmental degradation and extreme climatic conditions which then exacerbate the high levels of poverty and food insecurity already experienced in the area (Institute of Natural Resources, 2018:9; Lewis *et al.*, 2011:8). The LCCAP team undertook vulnerability assessments at the four pilot sites through household questionnaire and focus group discussions, to solicit the community and household perceptions of local vulnerability (Lewis *et al.*, 2011:43). Unemployment is viewed by the pilot sites as a main driver of vulnerability as this results in community households being highly dependent on what they produce themselves with no financial safety network to shocks (Lewis *et al.*, 2011:7,44). The communities are dependent on agriculture and the lands for their livelihoods, including rangelands for livestock and

croplands for subsistence farming (Institute of Natural Resources, 2018:9). The LCCAP team concluded from simple calculations based on the land access of average households, the energy supplied by the staple crop and the average people per household that the energy requirements of many households are unable to be met (Lewis *et al.*, 2011:45). Limited access to land, another key driver of vulnerability for the pilot sites, is then exacerbated by the deteriorating cropland and rangeland conditions. Poor and declining crop yields have been reported at the project sites, thus contributing to food insecurity. Poor rangeland conditions decrease the quantity and quality of livestock that can be sustained on the land and decrease the resilience of the livestock to shocks such as frost or drought (Lewis *et al.*, 2011:45). The condition of the croplands and rangelands is dependent on the weather and climate of the area. Households from the pilot sites acknowledge that climate variability they are experiencing in the area increases their vulnerability by undermining their ability to meet their livelihood needs (Lewis *et al.*, 2011:45). From these vulnerabilities, intervention is required to build community resilience to shocks and stressors.

4.6 The SES

The Lesotho communities embedded in their natural environment are a clear example of a SES, where the Basotho people are dependent on and interacting with the bio/litho/hydro-sphere constantly. The topography, climate, and biome shape the economies, communities, and lifestyles of the people just as the values, practices and cultures shape habitats, landscapes, and biodiversity. As such the Lesotho society and environment are interdependent and coevolving, resulting in a single dynamic SES rather than two distinct systems that are merely interacting. An example of the coevolving nature of the natural and social systems is evident in the rangeland management, where the topography, including steep mountains, deep valleys, and rocky outcrops, brings about a rural agriculturally dependent society (Dejene *et al.*, 2011:2; ORASECOM, 2014:7). Livestock is especially important to Basotho, due not only to the spiritual and cultural value of cattle but also to the ability to keep cattle in areas where crops cannot be grown (ORASECOM, 2014:13). The reliance on livestock for livelihoods has led to overgrazing, and subsequent deterioration, of the rangelands (Earle *et al.*, 2005:32). Humans, who have the potential to shape this coevolution, can then persist, adapt or transform in reaction to changing environmental conditions. These actions then have the potential to shape the environment, and so the coevolution continues. Characteristics of the environment provide a set of options and pathways for society, which then shape the health and functioning of the environment, and so the cycle continues. The practices and management introduced by society can nudge this cycle in a direction that is mutually beneficial or mutually destructive. Thus, the dynamic, co-evolving nature of this SES requires management to accept change and uncertainty as

inevitable and so adopt an adaptive management style that has the foresight required and involves a wide range of stakeholders.

4.7 The LCCAP's aims

The LCCAP team stated that their aim was to enhance the resilience of livelihoods, sustain ES and increase the adaptive capacity of communities in the Lesotho highlands in response to environmental deterioration exacerbated by climate change (Institute of Natural Resources, 2018:4). One answer to the question "the resilience of what, to what, for whom?" is that the project aimed to enhance the resilience of ecosystems to shocks and disturbances for the pilot communities. The multidisciplinary project team aimed to develop an integrated adaptation strategy that addressed the complex intertwined issues of livelihoods, ecosystem services, and climate change (Lewis & Oosthuizen, 2014: 8). The approach used by the team integrated CbA and EbA to develop a strategy that best worked in the rural Lesotho highlands community context.

The LCCAP acknowledged the abundant ecosystem goods and services that the communities' benefitted from. The team identified and grouped these goods and services according to the four categories developed by Millennium Ecosystem Assessment, namely: Provisioning of ecosystem products; Regulating of ecosystem processes; Cultural benefits; and Supporting services necessary for production of other ES (Lewis *et al.*, 2011:23). The diagram below sorts some of the goods and services derived from the ecosystem. These goods and services, and processes that generate them, needed to be protected to ensure a constant supply of ES to communities as well as to enhance the resilience of livelihoods. The project team decided that an integrated CEbA approach had the potential to enhance the resilience of the ecosystems, maintain a constant supply of ES, and enhance the resilience of the communities.

Figure 4: Ecosystem goods and services, adapted from Lewis & Oosthuizen (2014:10).

The project was implemented in two phases, the first phase ran from 2010 to 2015 and the second phase ran from 2015 to 2018, giving an overall run time of 8 years (Institute of Natural Resources, 2018:4). The aim of phase one was to understand livelihoods and ecosystem functioning to identify context-specific adaptation strategies for building livelihood resilience while sustaining ES (Institute of Natural Resources, 2018:4; Lewis *et al.*, 2011:12). Phase two aimed at securing capital through the development of locally appropriate financial mechanisms that could support the interventions introduced in phase 1 (Institute of Natural Resources, 2018:4).

In phase one of the project, ecosystem and livelihood vulnerability assessments were undertaken to understand the risk and vulnerability experienced by the people at the pilot site (Lewis *et al.*, 2011:43). From the livelihood vulnerability assessment, it became clear that the primary determinants of vulnerability were land rights for crop production and their livestock holdings and that if these two determinants were lacking, then households were extremely vulnerable to shocks (Lewis *et al.*, 2011:47). Other determinants that affected household resilience and wellbeing were personal assets such as paraffin stoves, beds and blankets and broadcasting technology for valuable information (Lewis *et al.*, 2011:47). The information gained from the vulnerability assessments were vital to informing project approaches in phase one. Phase two made use of an adaptive approach based on the successes and limitation of phase one interventions and focused on creating enabling conditions for the upscaling of these interventions (Institute of Natural Resources, 2018:4).

4.8 Conclusion

This chapter introduced the LCCAP case study. It provided background information regarding the country's location, predominant ecosystems and its climatic conditions. It then discussed the risk and vulnerabilities of Lesotho to climate change and connected this to the socio-economic conditions of the area. The SES was then described before delving into the LCCAP's aims.

The Kingdom of Lesotho is a landlocked, mountainous country (Lesotho Meteorological Services, 2021:Climate of Lesotho; Institute of Natural Resources, 2018: 9). Its climate is the result of its altitude, latitude and position between a warm and a cold ocean current. In winter, the weather conditions are dry and cold, whereas in summer, the conditions are wet and hot (Lesotho Meteorological Services, 2021:Climate of Lesotho). Climate change projections for the area predict increased temperatures and an

increase in frequency and duration of extreme weather events, such as droughts and flooding (Institute of Natural Resources, 2018:9). Lesotho has already begun experiencing the effects of climate change.

The severity of the impacts felt by Lesotho from these changes depends on their social, economic, and environmental resilience and vulnerability to such impacts (Dejene *et al*., 2011:5). Lesotho is both highly vulnerable to the effects of, and unready to adapt to, climate change (ND-GAIN Index, 2019:Lesotho). To understand the risk climate change places on Lesotho communities' resilience, there must be an understanding of their vulnerabilities.

As of 2011, 68% of the population of Southern Africa is rural and dependent on agriculture, with the Lesotho rural population being dependent on rainfed and undiversified subsistence agriculture (Lesotho Meteorological Services, 2017:2). The environment is deteriorating with degraded soils and wetland conditions. These conditions are worsened by the harsh Lesotho climate and poor agricultural practices. The Basotho are aware of the deteriorating conditions, however their margin to experiment is too small, due to their dependence on a constant crop yield and their low number of resources to try new methods. High rates of unemployment are self-identified by the communities as the main driver of vulnerability and other vulnerability drivers are the limited access to crop and rangeland, poor crop yields and poor rangeland conditions (Lewis *et al*., 2011:7,44). The high dependence on agriculture coupled with deteriorating environmental conditions, results in a high vulnerability to climate change in Lesotho.

The LCCAP aim was to enhance the resilience of livelihoods, sustain ES and increase the adaptive capacity of the four pilot communities in the Lesotho highlands in response to environmental deterioration exacerbated by climate change (Institute of Natural Resources, 2018:4). The Lesotho communities embedded in their natural environment are a clear example of a SES. The dynamic, co-evolving nature of this Lesotho SES requires management to accept change and uncertainty as inevitable and so adopt an adaptive management style that has the foresight required and involves a wide range of stakeholders. The project team developed an integrated adaptation strategy that addressed the complex intertwined issues of livelihoods, ecosystem services, and climate change (Lewis & Oosthuizen, 2014: 8). The team used an integrated CEbA strategy that they believed would work best in the rural Lesotho highlands community context.

The project was implemented in two phases, the first phase was to understand livelihoods and ecosystem functioning to identify context-specific adaptation strategies for building livelihood resilience while sustaining ecosystem services (Institute of Natural Resources, 2018:4; Lewis *et al*., 2011:12). The second

phase aimed at securing capital through the development of locally appropriate financial mechanisms that could support the interventions introduced in phase 1 (Institute of Natural Resources, 2018:4). The project team worked closely with the communities to ensure the project was well received and adopted by the community members. The project team believed the CEbA strategy had great potential to enhance the resilience of the ecosystems, maintain a constant supply of ES, and enhance the resilience of the communities.

CHAPTER 5: DISCUSSION

5.1 Introduction

The following chapter unpacks the management approaches taken by the LCCAP team, who encouraged a stewardship role in the management of the Lesotho SES, and groups these approaches according to the seven principles that build and maintain resilience. The seven resilience principles have been subdivided into metrics of SES resilience that can be used to assess the change in resilience brought about by the implementation of the LCCAP's interventions. This is done to discern whether the CEbA approaches implemented either undermined or enhanced the resilience of the Lesotho SES.

The table below represents the metrics used for the LCCAP to determine the effect of interventions on SES resilience. This chapter will discuss each metric and assign it either an undermined or enhanced value. In this chapter's conclusion, each resilience principle will be assigned with either an undermined or enhanced value corresponding to overall effect that interventions had on the principle.

Table 4: Context-specific resilience-building metric table, adapted from Salomon et al., 2019. .

Resilience Principle	**Resilience-Building Metrics Specific to Lesotho SES**	**Effect on Resilience**
Maintain Diversity and Redundancy	Response Diversity and Redundancy Diversity of Livelihoods Diversity of Crops by Small Scale Farmers Diversity of Users and Managers of an Ecosystem	
Manage Connectivity	Cross Scale and Sectoral Mechanisms/Links for Information Sharing Connecting Groups Wildlife Corridors	
Manage Slow Variables and Feedbacks	Identifying Key SES Slow Variables and Feedbacks Understanding of Gradual Changes Decisions Updated with New Information Ability of Manages to Respond to Key Changes Incentives as Feedbacks that Promote Adaptation	
Foster Complex Adaptive Thinking	Acknowledging that SES are Based on a Complex and Unpredictable Web of Connections and Interdependencies Willingness to Embrace Change Preparedness to Cope with Unexpected Change Scenario Building	
Encourage Learning	Innovation and Willingness to Experiment Sharing of Scientific, Local and Traditional Resources Learning from the Past, Crisis and Mistakes Monitoring and Evaluation	
Broaden Participation	Amount and Type of Participating Groups Methods of Participation Building Trust Building Capacity for Participation Providing Incentives for Participation	
Promote Polycentric Governance	Distribution of Governing Power Transparency and Accountability Building Capacity for Self-Organization Bridging Organisations	

5.2 Maintain diversity and redundancy

Diversity and redundancy were a major resilience building principles used by the project team. In managing a SES, it is important to ensure diversity of components and redundancy of functions, to ensure a range of options for responding to changes that are not dependent on single system components or relationship (Biggs *et al.*, 2012:425; Simonsen *et al.*, [n.d.]:4). The project aimed for diversity of livelihoods and crops, while managing and rehabilitating wetland and rangeland ecosystems that could then maintain biodiverse species. The project team fostered relationships with diverse actors and stakeholders to ensure multiple streams of management were available and many types of knowledge were incorporated into the understanding of the SES as well as the planning and operation of the project tasks. The following section will be dedicated to unpacking the project activities that focused on diversity and redundancy.

5.2.1 Diversity and redundancy of responses

The team embraced a diversity of responses to address the issues of SES resilience and adaptation. To enhance ecosystem resilience and maintain the delivery of ES the project team designed and implemented improved livestock production systems as well as reclaiming, conserving and managing degraded wetland, rangeland and mountain ecosystems (Institute of Natural Resources, 2018:33). This diversity of responses to the ES problem was achieved through diversity and redundancy of approaches and methods including improving stocking rates and grazing patterns of livestock; harvesting and reseeding of indigenous seed; and controlling soil erosion (Institute of Natural Resources, 2018:33,22,32). Other methods of controlling land degradation, which also enhanced food security, was the implementation of climate smart agricultural techniques such as appropriate seed selection, soil management and improved crop production practices (Institute of Natural Resources, 2018:33). These practices required financial aid or incentives to increase the sustainability of these approaches, which the team investigated.

A diverse set of innovative financing mechanisms aimed at supporting adaptation interventions were explored to fit local contexts, the set consisted of micro-financing services, environmental conservation funds, environmental subsidies, payment for ES, insurance and agricultural microcredit schemes, and village saving schemes (Institute of Natural Resources, 2018:17). In the end, only three of these mechanisms were implemented: Technology Affordability Saving Scheme (TASS), Eco-innovation Entrepreneurship Scheme (EES), and Catchment Rehabilitation (CaRe) Fund (Institute of Natural Resources, 2018:18). These were implemented to transition from the USAID project funding in the duration

of the project, to multiple sources of funding after project completion that would be self-sustaining and enhance the sustainability of the adaptation intervention (Institute of Natural Resources, 2018:19).

The LCCAP team actively focused on diversifying the livelihood options of community members and having multiple potential streams of income and food generation that was less natural resource intensive, this included diversifying crops; implementing secondary economic activities through value adding of current primary products; and introducing fuel efficient and solar technologies (Institute of Natural Resources, 2018:33). The following section takes a closer look into the diversity of livelihood options.

5.2.2 Diversity of livelihoods

An aspect that makes people living in the communities especially vulnerable to climate change is their livelihood dependence on undiversified crops and livestock (Dejene *et al.*, 2011:III; ORASECOM, 2014;7). To address this vulnerability the project team produced alternate livelihood strategies (Institute of Natural Resources, 2018:5). These strategies were divided into two types, which shared the goal of increasing the diversity of livelihoods or methods of livelihoods. The first set of strategies focused on improving the current livelihood methods and the second set of strategies provided alternatives to current livelihoods.

Livelihood diversification was promoted through the demonstration of initiatives and training of locals in select livelihood supporting activities (Institute of Natural Resources, 2018:5). A sizable portion of income generation from these communities comes from selling raw wool and mohair sheared from their sheep and goats (ORASECOM, 2014:7; Institute of Natural Resources, 2014:3; Institute of Natural Resources, 2015:4). Value-adding to this income-generating activity, to maximise earnings on the raw materials, can be achieved through spinning and weaving. Twenty community members from two of the pilot communities (Ha Kosetabole and Ha Sepinare) undertook wool and mohair spinning training, alongside business and financial management training, and were given spinning wheels, brushes, and dye equipment (Institute of Natural Resources, 2014:3; Institute of Natural Resources, 2018:22). The yarn spun from the households' livestock increases livelihood resilience as it can be sold to the Lesotho and South African market to generate additional income for the households. As the yarn does not expire like fresh produce, is lightweight, and is not easily damaged in transport, it is a well-suited financial activity for remote villages that may have difficulty getting to markets (Institute of Natural Resources, 2014:3). These income enhancing activities focused on animal by-products, whereas other approaches to diversify livelihood options focused on value adding to crops.

A communal fruit orchard was planted, consisting of peach and apple trees donated by the Ministry of Forestry and Land Reclamation, which provided an opportunity for value adding services that could generate household income (Institute of Natural Resources, 2018:23). In addition to this, solar technology demonstrations were held to promote the use of renewable energy to meet the energy needs of community members. Demonstrations of the solar oven and solar cooker were coupled with food preservation training so that in times of surplus yield, excess produce can be dried (Institute of Natural Resources, 2014:4,5,6). Many types of fruit and vegetables can be dried or preserved in these solar technologies, including the peaches and apples from the community orchard (Institute of Natural Resources, 2018:23). This secondary economic activity provides resilience in multiple ways. It provides food security to the preservers during the off-season when community members do not receive enough vitamins and minerals from sparse crop yields (Institute of Natural Resources, 2014:6). The dried fruits and vegetables can also be sold to neighbours and neighbouring communities, and thus it can contribute to household income. Again, the extended shelf life of this product is a beneficial characteristic to rural villages that are far from markets, as the product lasts longer than fresh fruit and vegetables, so a delay in market delivery will not result in large losses. This income enhancing activity, as with the mohair spinning activity, is still dependent on the land and what the land can produce. The next livelihood opportunity moves away from land dependency, towards external market products.

The Eco-Innovation Entrepreneurship Scheme (EES) is a financial aid scheme developed by the project team to help start-ups with capital, as well as showcase and demonstrate the uses of solar technologies such as solar water heaters, solar lanterns, solar chargers, and energy-efficient equipment such as parabolic cookers and fuel-efficient stoves for household use (Institute of Natural Resources, 2015:11,16). Local people who showed an interest in highlighting these technologies were trained to become Solar Ambassadors where they encourage rural households to purchase alternative technologies to be less natural resource-dependent and thus more resilient to climate change (Institute of Natural Resources, 2015:15,17). An EES pilot group, the “Thaba-Chitja Solar Power Solutions” was established and constitutes local entrepreneurs who demonstrate these technologies, secure orders, and payments from locals, place orders with the suppliers (SunFire Solutions), and arrange delivery (Institute of Natural Resources, 2018:40). These technologies can further be used by the customers to generate additional income through innovative ways, such as cooking meals for busy families off the cookers. One community member, who bought the solar charger, made money off it by letting neighbours charge their phones on it for a fee (Tukisi, cited in, Institute of Natural Resources, 2018:33). This is another way the project has brought in new income-generating activity for the EES salespeople and the buyers of these products, while also decreasing household vulnerability in terms of resource dependency.

The second set of strategies aimed at improving the current methods of livelihood-dependent agriculture includes the demonstration and development of conservation agriculture practices; rangeland and wetland rehabilitation activities; as well as rangeland and livestock management practices (Institute of Natural Resources, 2018:5).

Demonstrations were held in the pilot communities to inform community members on enhanced methods of agriculture that either reduce resource dependency or do not contribute to environmental deterioration. This included soil management and crop production practices, such as conservation agriculture, that were more sustainable to their specific context (Institute of Natural Resources, 2018:33). Climate-smart, or conservation, agriculture was promoted based on improved household food security in combination with reduced environmental deterioration (Institute of Natural Resources, 2014:8-9). Conservation agriculture was applied in fields at some of the pilot communities to demonstrate the efficacy of the methods and of different seed varieties (Institute of Natural Resources, 2014:9). Basic equipment, site visits, and in-field demonstrations and training of conservation agriculture were provided, alongside cross visits of conservation agriculture farming to encourage uptake of the practices through co-learning and encouragement (Institute of Natural Resources, 2018:44). Among the activities piloted were seed trials for local farmers to select, through experimentation, the most viable crop seeds; no-till farming practices; intercropping for crop diversity and soil health; mini-greenhouses and keyhole gardens; and the establishment, by local farmers, of a communal fruit orchard of peach and apple trees donated by the Ministry of Forestry and Land Reclamation (Institute of Natural Resources, 2018:23). These interventions introduced diversity and redundancy of food sources and farming techniques, thereby increasing the resilience of these farmers to shocks.

Sustainability incentives were provided for the uptake of community-based rangeland catchment management and rehabilitation, through the projects' Catchment Rehabilitation (CaRe) Fund. CaRe is a ratified partnership between the Khokoba community and SanLei, an aquaculture company on the Katse Dam (Institute of Natural Resources, 2018:41). Community members designed and implemented their ecosystem management plan which included rehabilitation of degraded areas and monitoring the progress, towards the objectives of increased basal cover and reduction of soil erosion (Institute of Natural Resources, 2018:41). Other than supporting the livelihoods of the active CaRe Fund members, the profits are reintroduced to the community through development projects such as investing in a community potato farm, where the potatoes are then sold locally (Institute of Natural Resources, 2018:41). Not only does this increase the resilience of member livelihoods, but it also improves the health and functioning of the area's

ecosystems which has multiple environmental and social benefits (Institute of Natural Resources, 2018:41). The environmental benefits such as improved soils and grazing land for cattle translates to social benefits reaped from improved land resources, such as food security.

These interventions were put into place to increase livelihood diversity so that households are more resilient to shocks. There were many success stories that came from these interventions as well as challenges that were experienced that undermined the efficacy of the livelihood resilience-building interventions. Additional income avenues, co-learning, social networking, and greater understanding of the environmental problems were some of the positive resilience-building effects gained by the communities. Scope of the project, extreme weather events, limited financial capital, and difficulty finding markets for products were the main challenges.

A severe hailstorm damaged crops at one of the sites, which highlighted that conservation agriculture, although beneficial for the rangelands and wetlands, still did not increase the resilience to extreme weather events, which are predicted to increase with climate change (Lesotho Meteorological Services, 2017:2; Institute of Natural Resources, 2014:10). The demonstrations and encouragement for the uptake of conservation agriculture were unsuccessful in its aim for widespread adoption for multiple reasons, including uncertainty of new methods, the labour-intensive nature of the methods, and the need to buy equipment (Institute of Natural Resources, 2018:47). Conservation agriculture was still adopted, however, by 64 new farmers, with wide overall recognition that there are many benefits to the practice (Institute of Natural Resources, 2018:5). Community members observed how farmers who implemented conservation agriculture were able to harvest crops during a drought due to the benefits the practice had on soil moisture (Khotso, cited in, Institute of Natural Resources, 2018:33). The information is now out there as an alternative which may result in more people adopting conservation agriculture, or some of its methods, if traditional methods fail. Thus although it was not adopted as widely as hoped, the conservation agriculture intervention was still valuable.

The CaRe Fund wetland project was successful in many ways due to the vast support received from SanLei and other entities such as the Katse Botanical gardens, Ministry of Forestry Range and Soil Conservation, who continue to support the initiative after the LCCAP closure (Institute of Natural Resources, 2018:41). A challenge at first was ensuring no trespassing of livestock on rested rangeland areas, but after some time and consultation, herders are more cooperative due to the understanding that they will be beneficiaries of the project (Mphale, cited in, Institute of Natural Resources, 2018:41). After only eight months of the intervention, herders already saw the improvements to the rangelands and wetlands which benefitted not

only the cattle but their households too, thereby pledging support to the CaRe community initiative (Lenka, cited in, Institute of Natural Resources, 2018:42). As much of the fund money comes from SanLei, it introduces outside money into the community and has the potential to raise living standards. This initiative has provided jobs for community members and the profits from the fund are inserted back into the community, with a large majority going towards additional money-making enterprises, such as the potato business (Institute of Natural Resources, 2018:41). Diversifying community enterprises not only brings in additional revenue but also enhances the resilience of the community to shocks that could eliminate one or more revenue streams.

The yarn made by local women in Ha Kosetabole and Ha Sepinare was taken up well by the community, however, there are challenges to sell the product as Lesotho's market is saturated (Institute of Natural Resources, 2015:5). This project team strove to address this challenge by facilitating a meeting between a South African weaving company and the Lesotho spinning enterprise, so that market linkages could be formed between them (Institute of Natural Resources, 2015:5). Challenges persist with selling to a South African market, as the spinning team would need to make enough yarn for partnerships to be feasible (Institute of Natural Resources, 2015:5). The project team then facilitated a meeting with the aim of supplying the spinning enterprise with the help of the local wool and mohair farmers association (Institute of Natural Resources, 2016:10). The challenge of selling the yarn can be overcome through the correct connection and create a new industry for the small, isolated community. The community spinning team could enhance their livelihood resilience if they can secure buyers for their yarn. The same constraint and opportunities exist for the fruit preservers.

The fruit preservers could make market connections and sell their wares to a larger market; however, this involves logistical problems and will require a passionate community change agent or leader to set this path in motion. Fortunately, there is always the opportunity to sell the dried and preserved fruit at a lower price to their neighbours, or even barter the produce. The dried and preserved fruit thus is successful in not only enhancing livelihood resilience but also in increasing the families' food security. This was only possible because of the technologies introduced at the sustainability commons, a demonstration centre set up at each pilot site by the community to showcase alternative technologies.

The success of the sustainability commons and the EES is seen in the Thaba-Chitja Solar Power Solutions enterprise. The entrepreneurs involved are self-sufficient in their business; they have developed and maintained a business partnership with the solar technology suppliers; and they secured continuous support from the Department of Cooperatives (Institute of Natural Resources, 2018:40). Not only has this initiative

enhanced the entrepreneurs' livelihood resilience, but also that of their clients who are able to build small businesses from the products.

The livelihood enhancing initiatives were restricted by the scope and funding of the LCCAP and they experienced successes as well as challenges, some of which they overcame. Even though some of the initiatives did not provide alternative revenue, they did provide training and enhanced skills, which can be used as experience to gain employment and as such the impacts of these initiatives on livelihoods will continue.

5.2.3 Diversity of crops by small scale farmers

The farmers learnt the necessity of crop diversification and the importance of planting more than just the staple crops, like maize. The community members understand now that the diversification of crops will build their resilience to effects of climate change such as late rain seasons and drought (Bobojane, cited in, Institute of Natural Resources, 2018:32). Different varieties of crop seeds are now used, some of which mature faster and thus accommodate for late rain seasons (Motsoahae, cited in, Institute of Natural Resources, 2018:34). Farmers planted a communal fruit orchard in Ha Lejone that consisted of 154 peach trees and 30 apple trees that were donated to the community by the Ministry of Forestry and Land Reclamation with the aim of improving community access to fruits, which could be preserved for non-harvest season (Institute of Natural Resources, 2018:23). They also implemented and made use of keyhole gardens and mini greenhouses (Institute of Natural Resources, 2018:33). Increasing the diversity of crops increases the resilience to shocks such as parasites, disease or extreme weather events that can decrease yields or even wipe out an entire species of crops. By having access to many different fruits and vegetables with different growing seasons and conditions to growth increases the community's food security and nutritional health.

5.2.4 Diversity and redundancy of managers of an ecosystem

Through the rangeland and wetland management activities, the users of the environment (herders, farmers and households) were empowered to also be the managers of the environment. In the case with CaRe, this action was incentivised by the collaboration with a trout farm and Lesotho Highlands Development Authority (LHDA), both of whom also make use of and manage the environment (Institute of Natural Resources, 2018:41). In another instance the wetland monitoring activities of a community acquired the commitment of the LHDA to assist the community in rehabilitation and was added to the list of protected

wetlands by the Department of Water Affairs, who also committed to assist the community in rehabilitation actions (Institute of Natural Resources, 2015:9). In these community-based land management actions, the users of the environment have been empowered to manage the environment. This ambitious feat has attracted the attention and support of government, parastatal and private parties, which has aided in the formation of partnerships between these groups. On-the-ground managers, teamed with government departments and/or private companies results in a cross-scale collaboration where information can be shared quickly, and the right group can tackle issues at the right level. From the many institutions involved in the management of the ecosystem there is an incorporation of diverse sources of knowledge, knowledge types, perspectives and cultures in the use and management of the ecosystems and natural resources. The many managers of the ecosystems thus also provide functional redundancy, with independent, but also overlapping roles, for managing the rangeland and wetland management.

5.2.5 The influence of diversity and redundancy on resilience

Before the implementation of the LCCAP, the Lesotho SES was brittle, with low diversity and low redundancy. ES-based activities were not diverse, with the main activity being agriculture: aquaculture in the dam, subsistence farming and grazing for animals. Local households and communities used the ecosystem for livelihood activities such as subsistence farming and grazing, and private companies used the aquatic ecosystem for aquaculture. The main form of land degradation, being vegetation degradation and the resultant soil erosion, puts all these activities at risk. Another way that resilience was undermined in these communities was through their undiversified crops and methods of farming. There was minimal intervention from the government and minimal collaboration between the community and private sector to remedy these issues. The lack of diversity and redundancy mentioned above interacted with one another to produce a SES that was highly vulnerable to climate change.

The LCCAP team understood the need for response diversity and functional redundancy in maintaining ES resilience in the face of disturbances and shocks. They paid special attention to diversifying livelihoods of the communities as there was a large dependence on cattle and subsistence farms (Institute of Natural Resources, 2018:10). By introducing value-adding to the agricultural products, households had the potential of more than one breadwinner. This enhanced the resilience of households to shocks that may render the sole breadwinner unable to provide. Household resilience was also enhanced through the implementation of mini greenhouses, an orchard, keyhole gardens and a variety of crops all of which gave variety and spatial heterogeneity to farming (Institute of Natural Resources, 2018:23). These diversity characteristics make the food systems more resilient as they limit the spread and impact of disturbances. The multiple

sources of food provided the households with functional redundancy regarding nutrient uptake and food security, thus allowing for substitution between food types in the instances of disturbance. By increasing the diversity and redundancy of managers in the SES, the project introduced a diverse range of responses and redundancy of function when managing the ecosystems. The variety of organisational groups have overlapping duties so if a disturbance occurs, making one of these groups unable to fulfill their role, the other groups are still able to function and even substitute some roles. Another way this boosted resilience was through response diversity of managers, which allows for a variety of perspectives and management options that fit different disturbances (Biggs *et al.*, 2012:425). The diversity and redundancy implemented by the LCCAP provided more options for communities to adapt to the changing and deteriorating condition of the environment, as seen in Figure 5 below showing the resilience metrics ranked on a Likert scale from 1 (low) to 5 (high) before and after the LCCAP. These increased options for adaptation enhanced the resilience of communities to disturbances and shocks associated with climate change, as seen in Table 5 below.

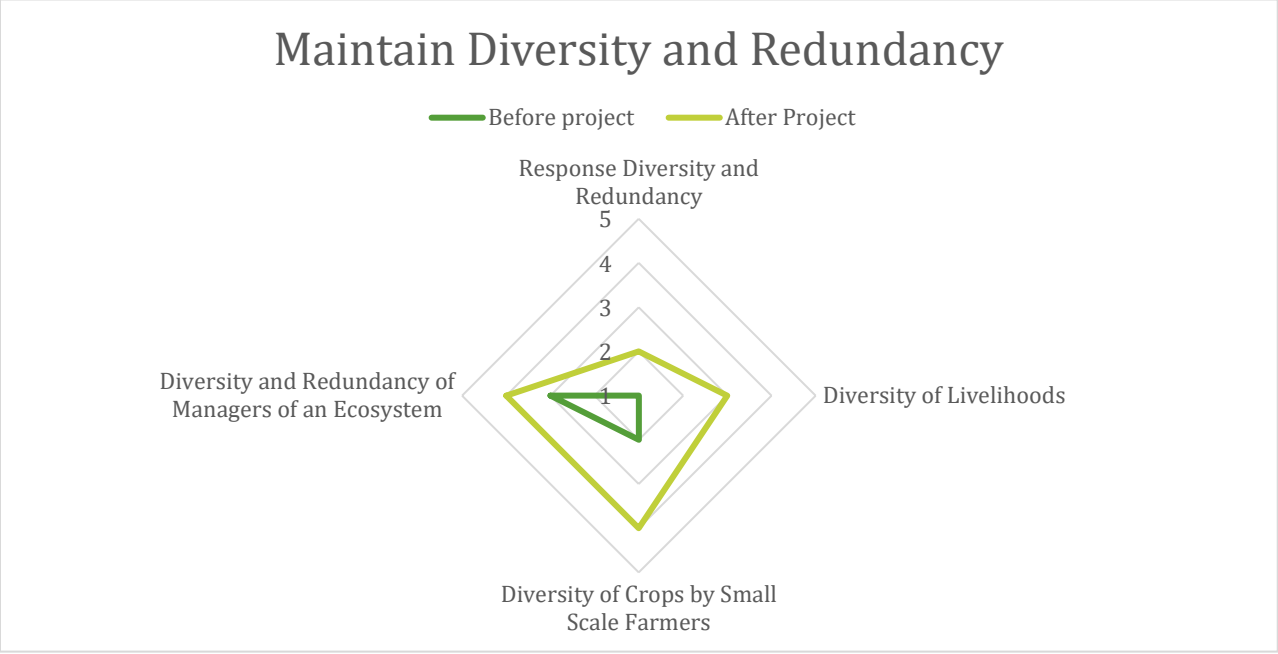

Figure 5: Diversity and Redundancy resilience metrics ranked on a Likert scale from 1 (low) to 5 (high) before and after the LCCAP. See appendix 1 for details on the Linkert Scale ratings.

Table 5: Project's influence on the Diversity & Redundancy metrics.

Resilience Principle	**Resilience-Building Metrics Specific to Lesotho SES**	**Effect on Resilience**
Maintain Diversity and Redundancy	Response Diversity and Redundancy	Enhanced
	Diversity of Livelihoods	Enhanced
	Diversity of Crops by Small Scale Farmers	Enhanced
	Diversity and Redundancy of Managers of an Ecosystem	Enhanced

5.3 Manage connectivity

The project managed connectivity by increasing links between groups at different scales and in different sectors, and by trying to decrease the links between natural areas. By making cross scale and sectoral connections between groups of people, the project team facilitated the sharing of information between different social nodes in the SES. This enhanced resilience by increasing response diversity and decreasing response time to shocks. By decreasing wildlife connectivity (see section 5.3.3), it increased the heterogeneity of the landscape and allowed for the restoration of sections of land. The following sections explore how the project managed connectivity in more detail.

5.3.1 Cross scale and cross sectoral mechanisms and links for information sharing

The project team acted as bridging facilitators between the community members and government departments or agencies at a local, district and national level. This connectivity allowed for information sharing and collective action between these levels. Workshops on various climate change adaptation topics gathered many interested and affected parties together, including multiple government departments, private sector enterprises and NGOs (Institute of Natural Resources, 2018:28,29). This allowed for these parties to meet and engage with one another, providing the opportunity for connections, links, or networks to be made between these cross-sectoral, but related, parties. These connections are particularly helpful when the country needs resilience building climate change policy and strategies. Show days worked well towards making connections, as seen by the wetland field day and demonstrations attended by community members as well as a range of authorities, which facilitated the formation of links between these groups (Institute of Natural Resources, 2015:9). These events formed the foundation of relationships between them. From these meetings and events, mentorships were organised, which allowed for continued cross scale connections between the community member groups and government officials (Institute of Natural Resources, 2018:29). These mentorships provided a link where information could continuously flow between the communities and government.

5.3.2 Connecting groups

As far as possible the project team made use of local products, knowledge and practices to gain buy-in from local actors and forge links between groups that would remain after project closure (Institute of Natural Resources, 2017:19). This was successfully implemented in phase two of the project for one of the financial mechanisms. The CaRe Fund was a successful formation of partnership between a community, Khokhoba, and a private company, SanLei (Institute of Natural Resources, 2017:19). The link connecting these two

nodes allowed for joint efforts in catchment management and restoration activities that were mutually beneficial (Institute of Natural Resources, 2017:19). The community drew up and implemented their management plan for the catchment area, which improves the quality of the dam and in return SanLei pays into the CaRe Fund (Institute of Natural Resources, 2018:41). This partnership is formally supported by a steering committee, made up of government departments and parastatals, that continued to provide support and assistance after project closure (Institute of Natural Resources, 2018:41). CaRe has thus forged close cross sectoral relations between this community and the local big business, SanLei; as well as with the parastatal, LHDA; and government departments like the Ministry of Water and the Ministry of Forest Range and Soil Conservation (Mphale, cited in, Institute of Natural Resources, 2018:41; Institute of Natural Resources, 2018:41). The community members feel empowered to approach these groups and request services needed by the community as well as technical support for the CaRe project (Mphale, cited in, Institute of Natural Resources, 2018:41). As such these connections not only increased the resilience of the catchment area and its management activities but also the resilience of the community who are now linked to groups that can provide them with support.

5.3.3 Wildlife connectivity

The natural areas (wildlife zones, rangelands and wetlands) are highly connected to each other, and to villages, as there are low artificial or natural barriers separating areas. This acts to undermine resilience as cows are free to roam and graze any areas, which spreads the overgrazing related soil erosion to sensitive natural areas like wetlands. Managing this roaming, as is done in the CaRe project, allows for the natural vegetation, like grasses and seedlings, to regenerate. As the CaRe project limits the connectivity between the wetlands and grazing land, and enforces rotational resting periods for sections of rangeland, it slows the spread of stressors and damage caused by grazing cows (Institute of Natural Resources, 2017:19). Decreasing the hyper-connectivity of different nodes thus enhanced the resilience of the SES. By establishing isolated patches in the ecosystem for rehabilitation, the ecosystem managers are encouraging the growth of pristine ecological refuge nodes. These refuge nodes are then able to aid in restoration of damaged surrounding areas after a disturbance like soil erosion due to grazing.

5.3.4 The influence of connectivity on resilience

The project took an active role in managing the interaction between SES variables. They noticed that there was minimal interaction socially as the social groups, or nodes, are isolated spatially, as well as by sector, with minimal links and infrequent interactions between them (Institute of Natural Resources, 2018:42). By

connecting previously unconnected social nodes the project team allowed for these nodes to interact, develop trust and form links necessary to facilitate collective action. New perspectives, experiences and knowledge types were introduced into these communities from the newly formed links. The heterogeneity between these previously unconnected social nodes (rural community, private companies and government departments) is good for the SES and increases resilience as severe disturbances to one node are very unlikely to spread to the other nodes. This heterogeneity between the groups also minimises the risk of knowledge and perception homogenisation between the groups (Biggs *et al.*, 2012:429). Forming the links between these nodes also allow for the community groups who are actively using certain ES to be engaged in a multi-levelled management of ecosystems which facilitates the sharing of experienced knowledge of the SES function. The heterogeneous social nodes were only moderately connected after project interventions, which is highly beneficial for SES resilience as it strikes a balance between isolation and homogenisation (Biggs *et al.*, 2012:429). The way connectivity was managed between the social SES variables in the project served to enhance the resilience of the SES.

In managing the ecological connectivity of the SES, the project team understood the danger of the overconnected ecosystems and grazing livestock nodes. By creating nodes of recovery, where grasses were left to reach seeding stages and wetlands were protected from soil erosion, not only was the spread of the disturbance inhibited but the recovery after a disturbance was facilitated. Nodes of pristine areas under protection may serve as refuges and gene banks. These pristine nodes, being spatially connected to the nodes that underwent grazing, allows for accelerated restoration through recolonisation and spreading of seeds after a disturbance. The project thus implemented connectivity interventions in the ecological domain that corresponded with enhancing resilience. Connectivity changes over time and is dependent on the nodes and the links between them (Biggs *et al.*, 2012:429). The project facilitated both the formation of connections between groups and the formation of isolated refuge patches in the ecosystems. These types of interventions have the potential to enhance the SES resilience if they are nurtured by the SES users and managers. The positive changes in resilience as a result of the project can be seen below in Figure 6 where the connectivity resilience metrics are ranked on a Likert scale from 1 (low) to 5 (high) before and after the LCCAP. These positive changes are seen to have enhanced the SES resilience in terms of connectivity as seen in Table 6.

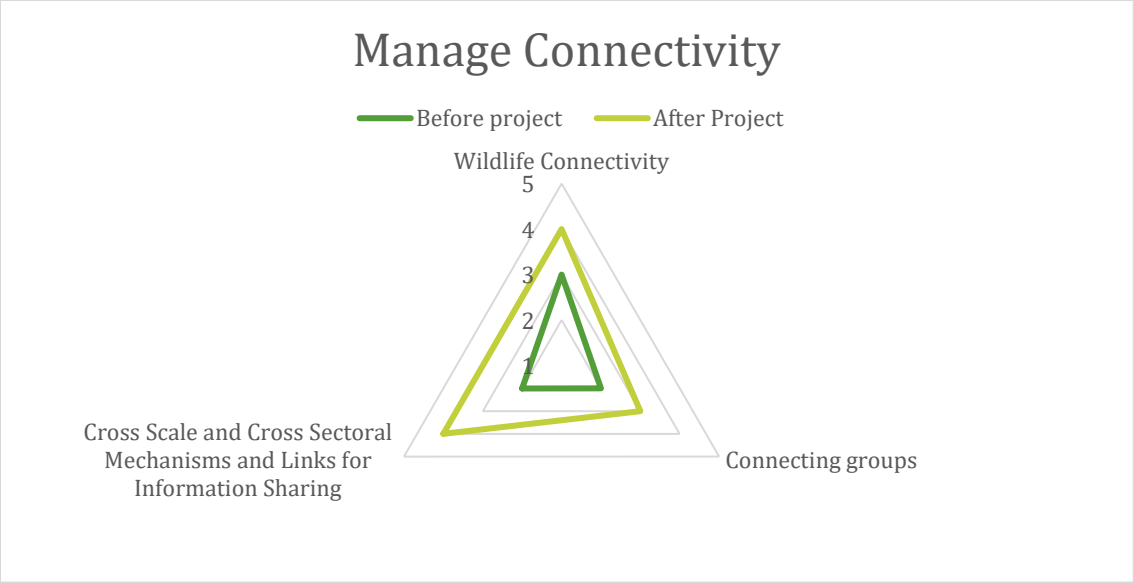

Figure 6: Connectivity resilience metrics ranked on a Likert scale from 1 (low) to 5 (high) before and after the LCCAP. See appendix 1 for details on the Linkert Scale ratings.

Table 6: The LCCAP's influence on the Connectivity metrics.

Resilience Principle	Resilience-Building Metrics Specific to Lesotho SES	Effect on Resilience
Manage Connectivity	Cross Scale and Cross Sectoral Mechanisms and Links for Information Sharing	Enhanced
	Connecting Groups	Enhanced
	Wildlife Connectivity	Enhanced

5.4 Manage slow variables and feedbacks

The LCCAP team ensured that they actively managed the SES slow variables and feedbacks, by first identifying them, then understanding the processes and from that forming adaptation and resilience enhancing interventions. Once the interaction between the interventions and the SES variables took place, the decisions of the project team were updated to adapt to changing circumstances. The project team made use of incentives as positive feedback to promote activities that enhanced SES resilience. The following sections explore some of the ways the project team and other stakeholder groups managed slow variables and feedbacks within the Lesotho SES.

5.4.1 Identifying the key SES slow variables and feedbacks

The project team identified and then mapped the SES slow variables with their associated feedback loops, to uncover where there are strategic points for interventions that will sever self-reinforcing negative feedback loops and instead introduce sustainable resilient pathways (Lewis & Oosthuizen, 2014:17). Overall, the project team observed that provisioning ES (grasses for grazing and thatching, fuel sources,

building materials, medicine and food production/gathering) were being exploited at the expense of regulating ES (stream-flow regulation, sediment retention, erosion control, soil moisture) (Lewis & Oosthuizen, 2014:11,13). The team identified strategic points in the feedback loops between slow variables, which included, to name a few: transformation of rangelands and degradation of ecosystems; erosion and overstocking driving degradation; decline in the condition of livestock; change in ecosystem's species composition; and decreasing benefits from natural resources (Lewis & Oosthuizen, 2014:17). Finding these strategic points for intervention led to the identification of CEbA solutions that would strengthen desirable feedbacks leading to a more resilient SES. Identifying these variables and feedbacks then guided monitoring and evaluation activities during the projects.

5.4.2 Understanding of gradual changes

The project team developed an adaptation framework due to the understanding that climate change will have impacts on the pilot communities' livelihoods and ecosystems (Institute of Natural Resources, 2018:20). When building the draft adaptation framework, and building scenarios for likely futures, a large emphasis was placed on identifying cause and effect linkages as well as feedback loops within the SES (Institute of Natural Resources, 2018:20). By understanding these processes, the project team were better able to implement solutions targeted at minimising negative and exploiting positive impacts.

Aiding the communities' understanding of slow variables and feedbacks was an important strategy in gaining the input and support from these communities. Interactive simulation games were played at district and village level workshops to raise awareness on gradual changes like degradation and climate change and the links between these phenomena (Institute of Natural Resources, 2018:24). Through catchment rehabilitation and management interventions, the community understands that improper farming practices, such as overgrazing by cattle, is a major driver in decreased vegetation cover, soil erosion and eventually land degradation (Institute of Natural Resources, 2018:47). Cattle slowly eat the soil cover and inhibit the maturation of seedlings, which then change the vegetation composition of the area. Decreased soil cover results in the loss of fertile topsoil, siltation of dams and formation of dongas. The resultant degraded landscape has a lower carrying capacity for crops and livestock and a reduced resilience to climate change stressors. This understanding of gradual changes and feedbacks has changed the mindset of local communities, affecting their decisions on land management.

5.4.3 Decisions updated with new information

Local farmers that underwent cross visits to farms in surrounding areas that had implemented rangeland management saw first-hand the feedback that sustainable grazing had on the land and the improved quality of animal products, such as mohair and wool (Institute of Natural Resources, 2018:31). After a rangeland management field study, communities altered their fire regimes, as too frequent fires or fires in the wrong season can be detrimental to the grassland with increased soil erosion and reduction of woody plants (Chief Qhobela, cited in, Institute of Natural Resources, 2018:34). They also saw how the other communities diversified their crops to be more resilient against the effects of climate change (Bobojane, cited in, Institute of Natural Resources, 2018:32). The farmers took this knowledge back home with them to share and start practicing within their communities (Khotso, cited in, Institute of Natural Resources, 2018:31).

Project methods, approaches and decisions were updated when new information came along. The LCCAP team made use of adaptive learning, and with new information and on-the-go learning from the project, the project's trajectory was shifted, and new activities were planned. A clear example of this is at the completion of Phase one, a lesson learnt by the project team was that the challenges to uptake and upscaling of the resilience building interventions implemented was affordability. By realizing that the major challenge was affordability, Phase two of the project aimed at providing incentives and financial assistance for the uptake of interventions (Institute of Natural Resources, 2018:35). This was also seen in the time-consuming process of building trust and connections with stakeholders, who were large in number and spread far apart geographically, in phase one of the project (Institute of Natural Resources, 2018:46). To use resources more efficiently and with greater effect, phase two of the project was adapted to the prior phases' lessons learnt by reducing the number of pilot sites and thus stakeholders (Institute of Natural Resources, 2018:46). This shows the ability of the project team to respond to new information and take steps to exploit feedbacks that enhance SES resilience.

5.4.4 Ability of managers to respond to key changes

The ability of the project team to respond to changes in phase two was heightened by the continued mentorship of the financial mechanisms committee members as new information gathered from the on-site meetings positively influenced the adaptive approach to solutions (Institute of Natural Resources, 2018:29). This link allowed for new information to be shared regarding challenges or logistics, which then led to changes and improvements to methods and approaches (Institute of Natural Resources, 2018:29). Not only does this show the value in maintaining connectivity to ensure adaptive management and the ability to

respond to changes, but also how adaptive decision making can lead to project improvements, as opposed to sticking to a rigid plan with top-to-bottom application.

Community-based rangeland and wetland monitoring, as incentivized through the CaRe project, monitors the impact and range of conservation and rehabilitation activities (Institute of Natural Resources, 2018:22). This information is then put into a report by the monitors and circulated to partners, who then have the information available to respond to changes occurring in the environment. Monitoring and evaluation plays a significant role in the ability of managers to respond to changes within the SES, however the way in which the partners respond to changes can then either enhance or undermine the SES resilience.

5.4.5 Incentives as feedbacks that promote adaptation

The LCCAP team understood the need for incentives, as well as financial aid, for the successful uptake of resilience building and adaptation interventions. The challenges and limitations experienced by the community members outweighed their willingness to embrace change without aid or incentive (Institute of Natural Resources, 2018:47). The communities are poverty stricken with little room to allow for experimentation, as error could be crippling. By providing alternative means for livelihoods and financial aid in the form of financial mechanisms, the project has helped the communities socio-economically and thus enhanced their resilience.

The three financial mechanisms developed and implemented each acted as an incentive to minimise negative impact on the natural environment. TASS members wish to buy energy efficient and solar technology to improve their household resilience and access to this fund made that a possibility (Ramakesana, cited in, Institute of Natural Resources, 2018:39). By making EES members beneficiaries of energy efficient and solar technology sales, the members were incentivised to promote, demonstrate and sell these technologies (Institute of Natural Resources, 2018:40). The use of these technologies has feedback on natural areas as households using fuel efficient cookers and solar water heaters are no longer as heavily dependent on foraged fuel sources like woody plants (Khesoa, cited in, Institute of Natural Resources, 2018:39). The decreased pressure on these plants and natural areas allows for natural rehabilitation to take place.

SanLei, paying into the CaRe Fund for services rendered, directly incentivises the Khokhoba community to restore, manage and monitor their natural areas (Institute of Natural Resources, 2018:41). The community members have noticed the positive effects of the environmental management activities, such as the return

of springbok to the area; medicinal plants growing before the rainy season begins; and the wetland remaining wet for more months in the year (Lenka, cited in, Institute of Natural Resources, 2018:42). As these positive environmental impacts benefit more community members, greater support will be garnered for the activities thus creating a positive feedback loop for environmental protection. Unambiguous evidence has been captured showing increasing basal cover and reduced soil erosion for the area. These activities thus manage and monitor slow variables such as soil erosion, siltation and land degradation.

5.4.6 The influence of slow variables and feedbacks on resilience

The LCCAP team understood that to maintain the desired regime with its set of ES, slow variables and feedbacks had to be identified, monitored and managed. It was found that provisioning ES were being exploited in the Lesotho SES at the expense of regulating ES (Lewis & Oosthuizen, 2014:13). Slow variables are linked to regulating ES, so by conserving the regulating ES, the slow variables can be kept below their critical thresholds (Biggs *et al.*, 2012:431). Maintaining these regulating ES is thus an effective way to manage slow variables and maintain desirable regimes and associated ES (Biggs *et al.*, 2012:431). The project implemented ecosystem restoration activities that would actively maintain regulating ES. The restoration and rehabilitation of critical habitats combined with the reduction of livelihood dependence on provisioning ES, works together to decrease soil erosion. As soil erosion undermines and diminishes regulating ES (such as slope stabilisation, stream-flow regulation and sediment retention) controlling soil erosion by proxy maintains regulating ES. This has positive feedback on slow variables, which are kept within healthy thresholds within the desirable SES regime. There is a need to identify and understand slow variables, like soil nutrient accumulation and soil moisture regimes, and not just fast variables, like crop yields, however, this understanding must be paired with action for resilience building (Biggs *et al.*, 2012:431). The LCCAP team found it necessary to disrupt feedbacks that resulted in undesired regimes, such as overgrazing that resulted in soil erosion and desertification, however, this required active participation from communities. Incentives were used, such as the financial mechanisms' pay outs, which acted as feedbacks that promoted positive behaviour and inhibit negative behaviour. The use of incentives had powerful positive feedback on community-based support and action. With the aim of ensuring the SES remains functional and produces desirable and necessary ES, the LCCAP paid special attention to identifying and managing slow variables and feedbacks. As seen in Figure 7, the project had a positive effect on all slow variables and feedback related metrics as compared to before project implementation. In Table 7 the effect of each metric on resilience is seen to be enhanced due to project interventions.

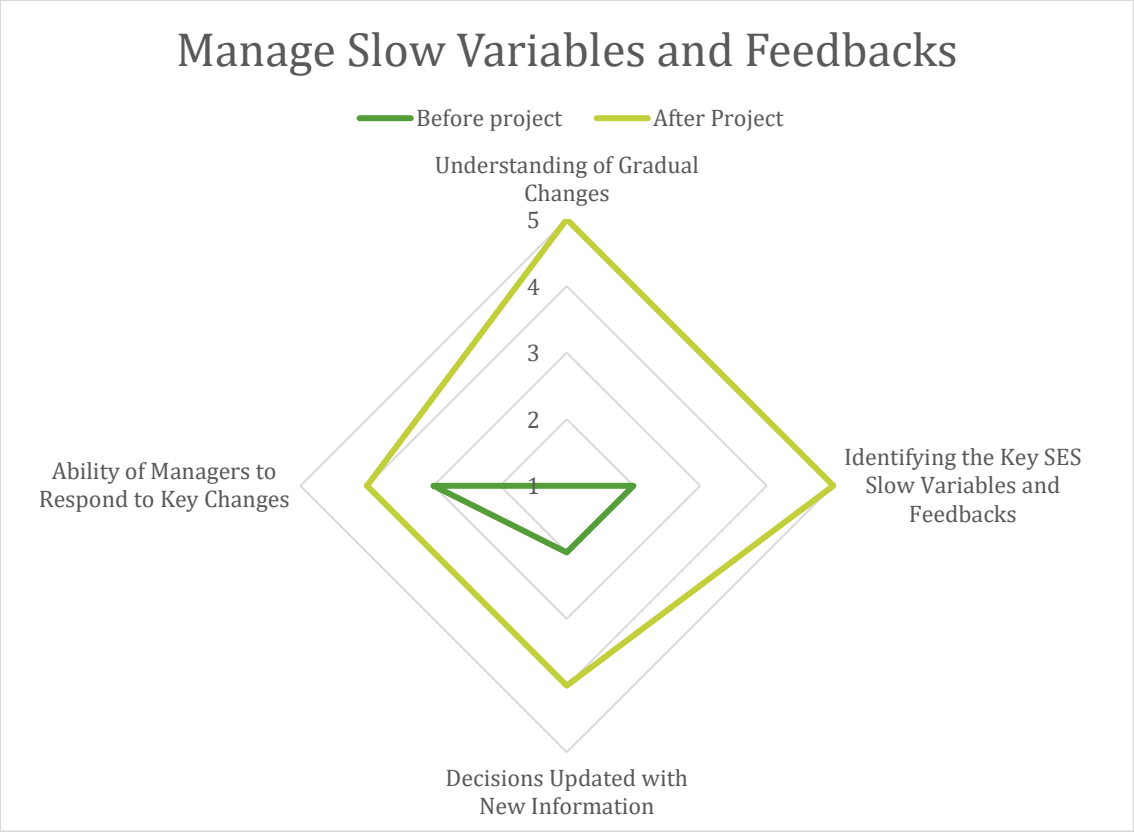

Figure 7: Slow Variables and Feedbacks resilience metrics ranked on a Likert scale from 1 (low) to 5 (high) before and after the LCCA project. See appendix 1 for details on the Linkert Scale ratings.

Table 7: LCCAP's influence on the Slow Variables & Feedbacks metrics.

Resilience Principle	Resilience-Building Metrics Specific to Lesotho SES	Effect on Resilience
Manage Slow Variables and Feedbacks	Identifying Key SES Slow Variables and Feedbacks	Enhanced
	Understanding of Gradual Changes	Enhanced
	Decisions Updated with New Information	Enhanced
	Ability of Managers to Respond to Key Changes	Enhanced
	Incentives as Feedbacks that Promote Adaptation	Enhanced

5.5 Foster complex adaptive systems thinking

The complex issues and wicked problems experienced in the Lesotho SES, such as the vulnerability and risk to climate change, land degradation and poverty, do not have clear solutions. The project team decided on an approach that acknowledged the complex and intricate web of interconnected SES variables, thereby moving away from a reductionist view of the problems. By understanding and accepting that change is inevitable and must be accounted for, the project team aimed to foster the communities' willingness to embrace change as well as be prepared for change. The following sections explore the ways that CAS thinking was fostered throughout the project.

5.5.1 Acknowledging that SES are based on a complex and unpredictable web of connections and interdependencies

The LCCAP's integrated approach to climate change adaptation stems from the understanding that SES are made up of a complex and often unpredictable connections and interdependencies. The team made use of social learning which allows for many sources of knowledge to contribute to the investigation of SES variables, connections and interdependencies for all involved to have a deeper understanding of the system dynamics (Institute of Natural Resources, 2018:45). By understanding these dynamics and the local context, holistic adaptation interventions and resilience enhancing approaches were collaboratively developed. At the end of phase one, there was a deeper understanding of the risks and vulnerabilities associated with the local livelihoods and ecosystems (Institute of Natural Resources, 2018:52). From this deeper understanding of the complex connections and interdependencies, the adaptation framework developed for the communities focused on CbA and livelihood diversification; EbA and catchment resilience; and climate-smart conservation agriculture (Institute of Natural Resources, 2018:21). The framework guided the management options but did not act as a static plan to be enforced.

The expectation of change and uncertainty, as opposed to stability, motivated an adaptive approach to planning. The adaptive management process enabled the team to observe the results of the interaction between adaptation interventions with SES dynamics before deciding on the next step in the process (Institute of Natural Resources, 2018:45). Flexibility enabled successes to be built upon and challenges to result in revisions or adaptations to plans (Institute of Natural Resources, 2018:48). These methods were applied due to the understanding of the complex nature of SES components and how minor changes to a system can often have large impacts that were not expected to either the system's components or the system. This understanding of complex connections and ripple effects was passed on to community members through the implementation of different project activities.

The CaRe Project has fostered CAS thinking amongst Khokhoba community members, with the awareness that SES are made up of complex connections and interdependencies. After a year of the CaRe Project, the community members witnessed the return of indigenous biodiversity and the positive changes in the wetland ecosystem (Lenka, cited in, Institute of Natural Resources, 2018:42). As herders started to see the results of managing overgrazing and soil erosion on the landscape, they became more supportive of the interventions (Mphale, cited in, Institute of Natural Resources, 2018:41). The complex connections between SES components became more visible through the intervention's actions and results, thus enhancing understanding of these connections, and strengthening the support for the ecosystem management actions.

5.5.2 Willingness to embrace change

The willingness of the project team to embrace change is seen in their adaptive management approach to the LCCA project. This is seen in many examples including updating the financial mechanisms due to information received from the government, private sector and from the challenges and issues experienced during implementation (Institute of Natural Resources, 2018:28,29). This acceptance of change and uncertainty by the project team was mirrored in the pilot communities.

Communities were willing to embrace changes once they understood the reason, and potential results, for the actions that would bring about change. The understanding that overgrazing impacted vegetation cover, biodiversity and ecosystem function, led to the community-based experimentation of livestock exclusion on plots of land to monitor and evaluate the results (Institute of Natural Resources, 2018:22). This represents the willingness of the communities to embrace change in a CAS. Other ways they were willing to embrace change was through the purchase and use of modern technology that reduced land resource usage. By the end of 2018, 334 community members purchased solar or other fuel-efficient technology, which moved away from traditional methods of collecting fuel for heat and light, as well as from more common technology that relied on electricity or batteries (Institute of Natural Resources, 2018:27). By connecting the over reliance on land to both land degradation and the undermining of SES resilience, community members were willing to make changes towards more sustainable trajectories.

5.5.3 Preparedness to cope with change

The project team has gained invaluable knowledge from this project, which can be passed on, used and built upon for similar adaptation and resilience enhancing activities and projects in the Lesotho SES (Institute of Natural Resources, 2018:53). This enhanced knowledge has broadened the understanding of the project team, and by extension the four collaborating organisations that make up the project team, regarding resilience issues, this broadened understanding will continue to benefit the Lesotho SES if they continue to work in the area.

Some of the ways the team enhanced the preparedness of the communities to cope with changes were through diversifying livelihoods and crops, as well as establishing the financial mechanisms. Diversifying livelihoods ensured that households were not dependent on one source of income which could be vulnerable to a shock. By providing multiple livelihood options, households were prepared to cope with changes by

providing them with more options to respond and adapt to changes. In the same way diversifying crops also increased community preparedness to cope with changes or shocks such as drought or late rains (Bobojane, cited in, Institute of Natural Resources, 2018:32). If one crop is wiped out by an unforeseen event, like a virus, the communities can still rely on other crops. The financial mechanisms, alongside the training provided to the mechanism's committee members, also increased the preparedness of the communities to cope with unexpected changes (Institute of Natural Resources, 2018:28). Access to funds in case of emergency, connections to other institutions and enhanced social cohesion are some of the ways that the financial mechanisms bolstered community preparedness to cope with changes. Encouraging communities to expect change and providing them with multiple options to respond to changes helps prepare them to handle the changes that may come.

5.5.4 Scenario building

In the first year of the project, after reviewing climate change models of the area, 17 scenario building workshops were held to understand the implications of climate change on local ecosystem function and livelihoods, and from there the project team-built scenarios that depict likely futures (Institute of Natural Resources, 2018:20). Scenario-building was used to determine the impacts that key driving forces, complex interactions of SES components and uncertainty will have on ecosystems, ES and human well-being (Lewis & Oosthuizen, 2014:13). By developing scenarios, resilience building adaptation strategies, that are relevant and sustainable in the long term, can be developed and assessed according to each scenario (Lewis & Oosthuizen, 2014:13). The project team made use of an 8-step scenario-building process which were (Lewis & Oosthuizen, 2014:13):

1. Identify focal issue
2. Identify driving forces in the local environment
3. Rank impact and predictability of driving forces
4. Select scenario logics
5. Develop scenario narratives
6. Determine leading indicators for monitoring
7. Determine impacts for different scenarios
8. Evaluate alternative strategies

From these steps, four scenarios were developed, namely: Tortoise, Rabbit, Vulture, and Jackal (as seen in figure 8 below) (Lewis & Oosthuizen, 2014:13). Focusing on ecosystems, ES and human well-being for each scenario painted a bleak picture of the future. Wellbeing improved only in the Rabbit scenario, whereas

ecosystem health and ES declined in every scenario (Lewis & Oosthuizen, 2014:13). A clear pattern was observable in all four scenarios, which was the trade-off made when harvesting provisioning ES to the detriment and decline of regulating ES (Lewis & Oosthuizen, 2014:13). This pattern shaped many of the adaptation interventions introduced into the LCCAP, where the project team aimed to reduce natural resource dependency and stressors while actively managing the ecosystem's regulating services.

The figure below taken from Lewis & Oosthuizen (2014:13) represents the four future scenarios developed by the LCCAP team, according to the Millennium Ecosystem Assessment's Ecosystems and Human Well-Being: Scenarios, Volume 2 publication.

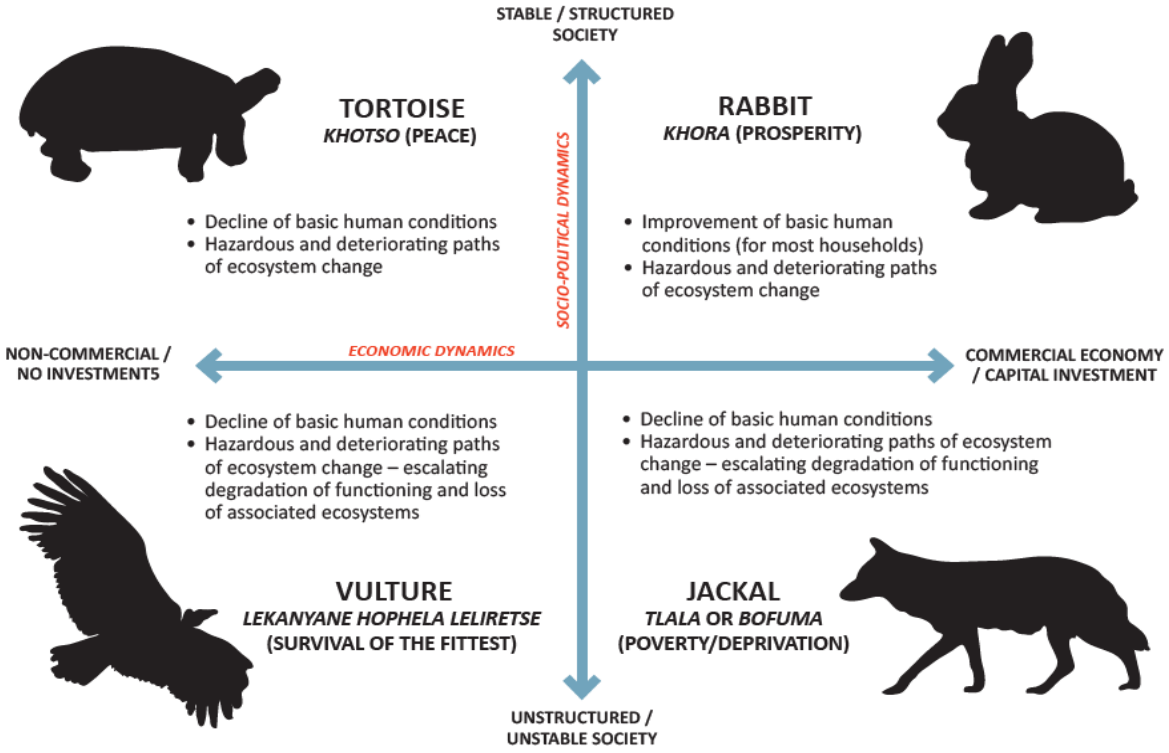

Figure 8: Future scenarios for Lesotho taken from Lewis & Oosthuizen (2014:13).

5.5.5 The influence of fostering CAS thinking on resilience

The project team helped stakeholders foster CAS thinking through the project approach and the interventions used in the project. Understanding that SES are CAS influences the choice of management interventions and approaches (Biggs *et al.*, 2012:432). This was achieved in the project by adopting an integrated CEbA approach that makes use of adaptive management and focuses on coping with change and uncertainty. The project team understood the need for a more holistic systems approach that relied on broad participation and adaptive learning, as opposed to rigid reductionist approaches to individual issues

experienced in the SES. Approach methodologies, like scenario planning, aid in understanding SES as a CAS (Biggs *et al.*, 2012:433). This methodology was applied by the project team to yield four likely futures. This showed the complexity of interacting SES variables without creating a sense of bewilderment amongst stakeholders. The project approach made use of activities which promoted a CAS understanding amongst project participants in communities, who then better understood the need for certain actions. The adaptive approaches and willingness to make changes, as shown by the project team and the stakeholders, especially from the pilot communities, represented the understanding amongst these participating groups about the need to adapt to the inevitable change and uncertainty. The interventions used in the project enhanced the preparedness of these stakeholders to cope with changes. SES are constantly evolving in response to interacting system components (Biggs *et al.*, 2012:432). The project instilled this awareness in stakeholders, who now understand the need to accept changes and uncertainties within the SES and are now better prepared to do so. In each metric the project interventions fostered CAS thinking and resilience was enhanced, as seen in Figure 9 and Table 8 below.

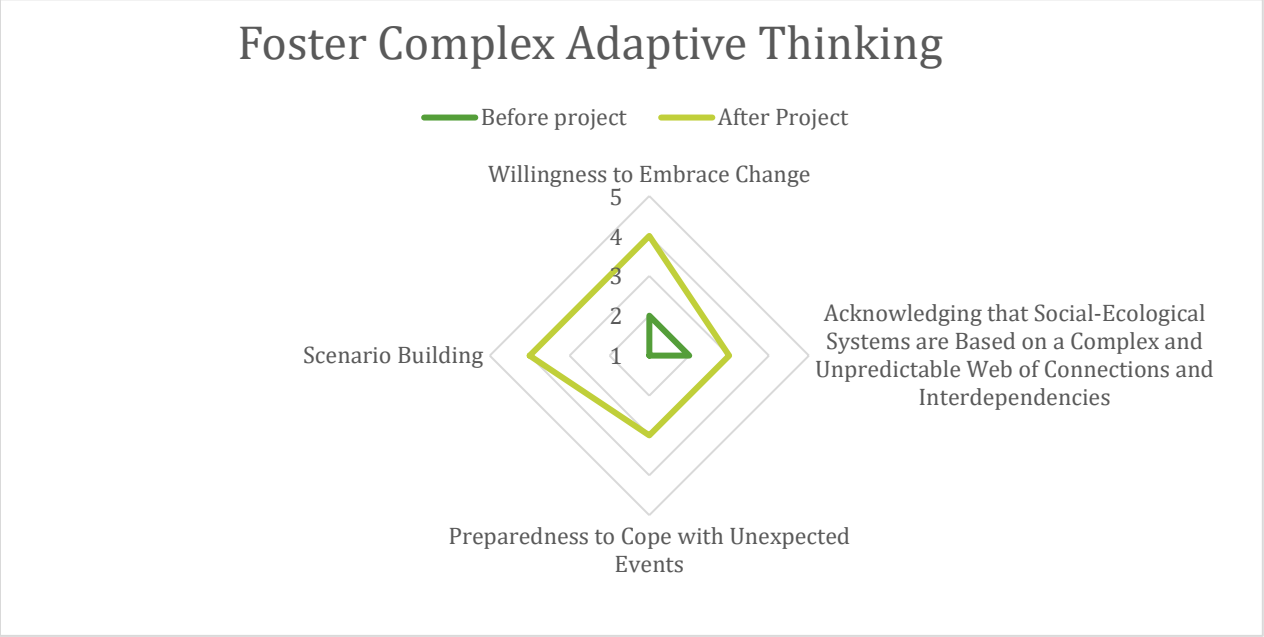

Figure 9: CAS thinking resilience metrics ratings before and after the LCCAP. See appendix 1 for details on the Linkert Scale ratings.

Table 8 LCCAP's influence on the CAS Thinking metrics.

Resilience Principle	**Resilience-Building Metrics Specific to Lesotho SES**	**Effect on Resilience**
Foster Complex Adaptive Systems Thinking	Acknowledging that SES are Based on a Complex and Unpredictable Web of Connections and Interdependencies	Enhanced
	Willingness to Embrace Change	Enhanced
	Preparedness to Cope with Change	Enhanced
	Scenario Building	Enhanced

5.6 Encourage learning and experimentation

The approaches applied in the LCCAP focused on learning and included social learning; co-learning and cross-learning; learn-by-doing, and experimental learning through trial and error (Institute of Natural Resources, 2018:18; Institute of Natural Resources, 2018:45). These approaches to learning shaped the activities and how they were implemented in the project. Through demonstrations, awareness raising and training, more than 2 800 people at all scales had enhanced adaptive capacity through learning from the project (Institute of Natural Resources, 2018:18). The following sections explore how learning was encouraged through the project.

5.6.1 Innovation and willingness to experiment

The project team embraced innovation and experimentation. At the time of the project inception CEbA approaches were unheard of and implementation was rare in Lesotho, the LCCAP was thus an innovative experiment (Institute of Natural Resources, 2018:31). To get a better understanding of the SES risks in phase 1 of the project, innovative tools and methodologies were employed by the team, which included: participatory livelihood vulnerability assessments that made use of downscaled climate change projections of the area; ecosystem mapping and rating of the associated ES for surrounding communities; and constructing feedback loops with SES variables (Institute of Natural Resources, 2018:31; Lewis & Oosthuizen, 2014:14). The project team also showed innovation and their willingness to experiment in their resilience-building interventions. The LCCA approach showed a willingness to experiment in phase 2 of the project by piloting three innovative financial mechanisms that were aimed at upscaling adaptation (Institute of Natural Resources, 2018:27). All project activities undertaken showed the willingness of the project team as well as stakeholders to experiment to bring about enhanced resilience.

The project encouraged learning through community experimentation with conservation agriculture, seed trials, and intercropping (Institute of Natural Resources, 2014:9). Through community-based experimentation the farmers were able to distinguish better performing seed varieties and saw first-hand how simple agronomic practices like weeding, correct spacing of seedlings and crop rotation had improvements on their yields (Institute of Natural Resources, 2013:23). By diversifying crops and seed varieties, households and communities have shown a willingness to experiment to be more resilient in case of drought, late rains, or pests, where some crops may be unaffected or perform better than other crops (Bobojane, cited in, Institute of Natural Resources, 2018:32). With the intention of raising awareness and

promoting innovation and experimentation, a farmer's day was held at the end of the growing season, which facilitated farmer-to-farmer learning and sharing (Institute of Natural Resources, 2014:10). This on-the-ground experimentation in combination with the sharing of lessons with other locals promotes the spread of successful adaptation interventions beyond the active participants of the project.

5.6.2 Sharing of scientific, local and traditional resources and information

The project made use of multiple sources of knowledge throughout the project. As far as possible the project team focused on gaining and using existing knowledge in the area, i.e., the pilot sites, surrounding businesses and government departments (Institute of Natural Resources, 2018:46). To complement and add to this knowledge experts, professionals and specialists from many diverse fields were consulted for the duration of the project, with the aim of receiving experienced scientific input (Institute of Natural Resources, 2018:14). The information was shared with community-level stakeholders by the project team, locals or external actors through interactive demonstrations, training and activities (Institute of Natural Resources, 2018:44). The information was also adapted into diverse types of media, which was distributed to specifically allocated groups to target the right groups with context specific information (Institute of Natural Resources, 2018:46). All the information generated from the project (booklet, flyers, infographics, studies and videos) was shared on the INR website, available to all with internet access (Institute of Natural Resources, 2018:46). In this way, information gained from the project spread to more than just the project stakeholders, as anyone around the world now has access to the information online.

Scenario building workshops, demonstrations and talks at the pilot sites enabled the project team to share scientific information regarding climate change with the communities (Institute of Natural Resources, 2018:20). Many members of the community had never learnt about climate change prior to the LCCAP (Rapheko, cited in, Institute of Natural Resources, 2018:31). They had seen changes to the weather and environment and could not locate the cause of such changes (Rapheko, cited in, Institute of Natural Resources, 2018:31). The project set out to share scientific information regarding climate change and environmental degradation with these communities so that the communities could adapt to these changes accordingly to enhance their resilience. One innovative and engaging way of spreading information on climate change was through playing the Adapt-Able game. The Adapt-Able game encouraged discussion on climate change related issues and adaptation options, to raise awareness on climate change, the various methods of adaptation and the need for planning (Institute of Natural Resources, 2018:24). To reach as many groups as the scope allowed, 50 copies of the game were produced and given to stakeholders from the national to the local level, at locations like government departments, community groups and schools

(Institute of Natural Resources, 2018:44). The focus of sharing information and raising awareness on climate change was thus not directed at the local level alone, but at the national level too.

The project team aimed at enhancing the understanding of the risks of climate change and the need for adaptation and mitigation at a national level. The project organized educational talks for senior managers of selected national government ministries on climate change and adaptation topics given by recognised climate change experts (Institute of Natural Resources, 2018:25). This was done not only to share scientific knowledge on the matter but also to build capacity to facilitate participation in climate change adaptation strategies and form connections between the project and national government. The project team also hoped to learn from national stakeholders and government officials who had experience in implementing large projects. The project team set up a national level Learning Workshop on Lessons from Financing Mechanisms for Upscaling Climate Change Adaptation in Lesotho which had participants from government departments and potential donors (Institute of Natural Resources, 2018:28). This was done to share information regarding financing resilience-building interventions, as well as receive input and participation from these national stakeholders and so these workshops facilitated co-learning between these groups.

Co-learning was promoted between local level actors, especially for livelihood enhancing activities such as farming and spinning. Different farming techniques, experiences and ideas were shared between farmers of Lesotho through workshops and cross visits. The cross visits enabled cross-learning between farmers, which made the approach more relatable to the community members as they were learning from people in similar situations to themselves (Institute of Natural Resources, 2018:46). The Sustainable Land Management cross visit allowed for the pilot community farmers to observe successful soil, catchment and rangeland rehabilitation through improved grazing management approaches implemented by farmers from other districts (Institute of Natural Resources, 2014:11). The conservation agriculture cross visit allowed for the demonstration of conservation agriculture tools and for the pilot community farmers to learn about and observe the methods and benefits of conservation agriculture in practice (Institute of Natural Resources, 2013:26). Wool and mohair spinning training was provided to interested community members by experts from a co-operative based in Teyateyaneng, near Maseru (Institute of Natural Resources, 2018:22). This on-the-ground co-learning allowed for sharing of lessons and tips between Basotho from communities so like their own.

Community stakeholders also learnt from external actors and the project team. During the rangeland and wetland management trips the community stakeholders learnt from rangeland management specialists how to harvest and reseed indigenous seed to preserve beneficial grasses (Institute of Natural Resources,

2018:22). Reseeding indigenous seeds can assist in grassland rehabilitation, thereby halting soil erosion and providing grazing food for livestock. As the livestock are sources of wool and mohair, this would have positive socio-economic impacts too. During the mohair and wool spinning training, a member from the project team, who is an ILO Start and Improve Your Business certified trainer, provided business and financial management training to the spinners (Institute of Natural Resources, 2018:22). External actors and the project team engaged a variety of participants to share knowledge on many topics. These workshops, demonstrations and training days resulted in extensive engagement with participants and provided an appropriate setting for information sharing.

5.6.3 Learning from the past, crisis and mistakes

The project team made use of adaptive management, which allowed them to learn from the past and from mistakes. A few instances of such learning occurred in the transition from phase one to phase two. Engaging with the substantial number of pilot sites, coupled with the large distances between them, was resource intensive, and as such the project team narrowed their focus in phase two to fewer pilot sites (Institute of Natural Resources, 2018:46). This way resources (financial, human and time) could be focused on fewer communities with the aim of the interventions employed having a deeper impact. After phase 1 of the project, it became clear that one of the main barriers of the pilot communities to adopting adaptation proposals was their lack of finances to implement them, maintain them or even risk them (Institute of Natural Resources, 2018:6). As such, phase two of the project learned from phase one and developed strategies to overcome these issues. This led to the identification, review and selection of 11 financing mechanisms through investigating similar international and national initiatives, as well as consulting with experienced Lesotho experts and stakeholders (Institute of Natural Resources, 2018:27). By learning from the previous phase, the project team was able to redirect the course of interventions to fit the context better. Lessons learned from the development and implementation of the finance mechanisms were documented in a range of booklets and publications (Institute of Natural Resources, 2018:28). This allowed stakeholders to review the stages of the process and learn from hindsight about what worked and what challenges they faced. This has the potential to aid stakeholders when adapting the mechanisms as well as external change agents who may want to start new, but similar, mechanisms. The adaptive management approach allowed the team to learn from the past, as opposed to following a rigid plan, which resulted in more context specific, guided solutions to the problems of resilience.

The deterioration of the land from improper natural resource management has decreased the resilience of the SES. The 2016/2017 drought was one of the worst droughts experienced in 50 years, with the Katse

dam at an all-time low and farmers struggling to harvest crops (Institute of Natural Resources, 2018:48). This event, and the likelihood that such extreme events will happen more frequently and with greater intensity, helped community members understand the need for adaptation and resilience enhancing interventions. The local councils and community members have learnt from this and have implemented natural resource management techniques, especially with regards to overgrazing and soil erosion control (Ramphele, cited in, Institute of Natural Resources, 2018:28). The cross visits and demonstrations of conservation agriculture showed how these sustainability practices kept moisture in the soil enabling conservation farmers to harvest during the drought (Khotso, cited in, Institute of Natural Resources, 2018:33). Community members witnessed the benefits of conservation agriculture and rangeland management and the practice of it is slowly spreading as a result (Khotso, cited in, Institute of Natural Resources, 2018:33). Learning from crises and observing the benefits of sustainable practices can encourage communities to make changes that will make the SES more resilient to extreme events.

5.6.4 Monitoring and evaluation

The project aimed to encourage long term monitoring and evaluation of key ecosystems. The team encouraged collaborative learning by empowering the community to monitor and evaluate the ecosystems. After being provided with training and monitoring kits, communities undertook rangeland monitoring to uncover the trends and the extent of the landscape degradation and from there discover what interventions worked to stop the degradation process and facilitate recovery and restoration (Institute of Natural Resources, 2015:7). Monitoring of wetland conditions formed the foundation of wetland protection and restoration activities. From the monitoring and evaluation of set aside areas for grazing, in comparison to protected areas, the devastating effects of unchecked overgrazing became clear (Institute of Natural Resources, 2015:9). Continued mentorship allowed for more contact time between the project team and the monitors, which facilitated discussion where issues were raised and monitoring results could be reviewed (Institute of Natural Resources, 2015:8). The monitoring and evaluation of changes in the ecosystems encouraged shifts in the perceptions of community members regarding taking on a more active role in CBNRM for the benefit of the entire SES.

5.6.5 The influence of learning and experimentation on resilience

SES are constantly changing, and thus triggering the need for adaptation (Biggs *et al.*, 2012:434). Adaptation to changing conditions requires constant learning about the SES and the possible pathways to take to bring about resilience. The utilisation of many types and sources of knowledge (traditional and

indigenous knowledge from community members; policy and SES knowledge from government; and scientific and experimental knowledge from project team and specialists) benefitted the project as it gave a fuller picture into the SES. The project then integrated and incorporated each stakeholder group's knowledge into project planning and implementation. Many of the project's approaches were innovative and new to the SES, requiring experimentation from pilot communities.

Experimentation in the SES was risky as the community could not afford to make mistakes. Due to this risk, there was a need to buildup social capital (there was a need for trust, leaders, networks and resources) before experimentation could begin (Biggs *et al.*, 2012:435). The project slowly built-up trust between stakeholder groups and empowered local community members to take up leadership roles. The project team then facilitated the formation of networks between community leadership committees with other groups that could provide the right resources to the communities for experimentation, monitoring and evaluation. Experimentation and innovation allow stakeholders to observe outcomes and choose which pathways are worth pursuing, whereas monitoring and evaluation provides information on the SES and the ES produced (Biggs *et al.*, 2012:434). Both types of learning are necessary to make educated decisions on processes to pursue that will enhance SES resilience and maintain a healthy supply of ES.

The learning processes in this project were collaborative and facilitated social learning. Communities, government organisations, donors, and the project team's organisations all learnt valuable lessons during the LCCAP. Some of these lessons were planned, while others were the result of unexpected project outcomes. Learning about the SES and the ES it produces helped change the worldview of stakeholders regarding their dynamic relationship with their environments. A better understanding led to improved, collaborative governance of the SES, which serves to enhance the system's resilience, as seen in Table 9 and Figure 10 below.

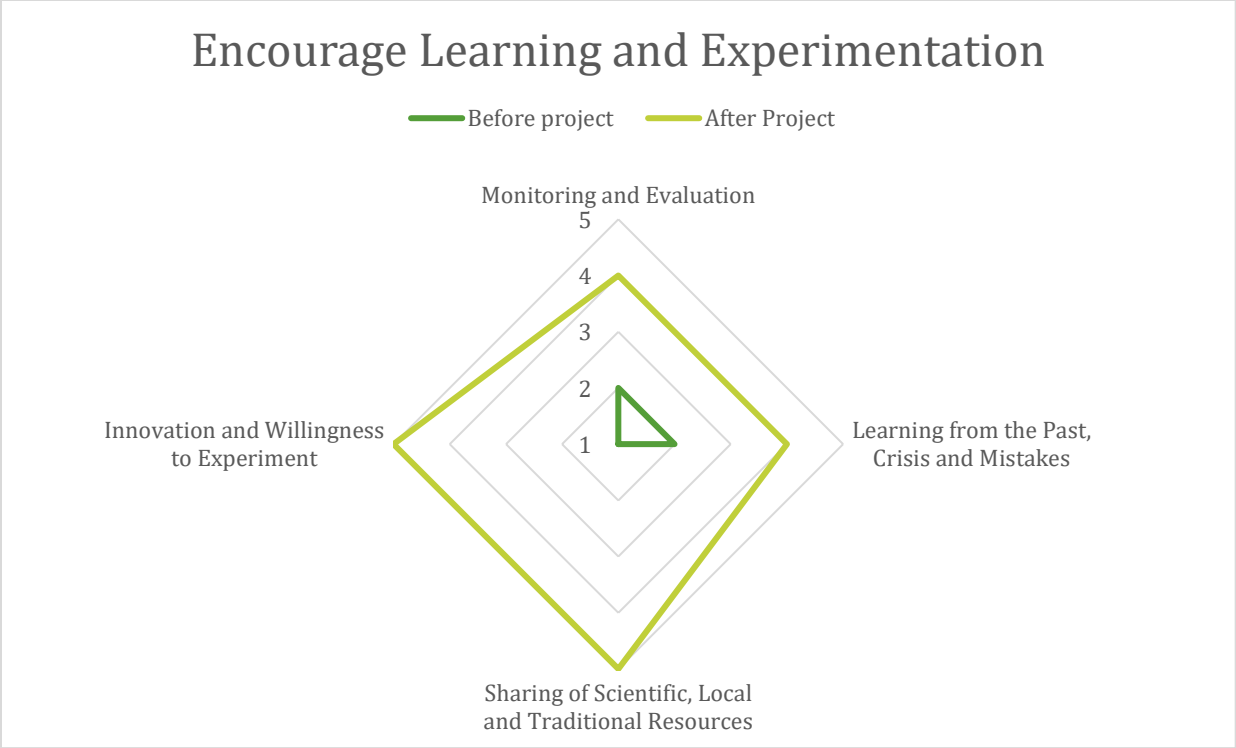

Figure 10: Learning and Experimentation resilience metrics ranked on a Likert scale from 1 (low) to 5 (high) before and after the LCCAP. See appendix 1 for details on the Linkert Scale ratings.

Table 9: LCCAP's influence on the Learning metrics.

Resilience Principle	Resilience-Building Metrics Specific to Lesotho SES	Effect on Resilience
Encourage Learning	Innovation and Willingness to Experiment	Enhanced
	Sharing of Scientific, Local and Traditional Resources and Information	Enhanced
	Learning from the Past, Crisis and Mistakes	Enhanced
	Monitoring and Evaluation	Enhanced

5.7 Broaden participation

Participation of many different stakeholder groups played a significant role in the LCCA project. The project team went through lengths to encourage stakeholders at local, district and national level to participate in the project. Broadening of participation required building trust between groups and providing incentives for stakeholders to participate. By building the capacity of these stakeholder groups to participate, the project team hoped to upgrade participation from informing stakeholders to collaborative adaptation efforts. The following sections look at the different participating groups, the methods of participation and the strategies employed by the project to encourage and broaden participation.

5.7.1 Amount and type of participating groups

Involving stakeholders from the project's onset was invaluable to the project. The project team embraced participation with the understanding that adaptation is the responsibility of governments, communities, donors and the private sector, and that it requires partnerships (Institute of Natural Resources, 2018:38). Stakeholders that were successfully engaged with and that supported the project included the 8 communities at the pilot sites; government ministries; district councils; the National Climate Change Committee and Lesotho Council of NGOs (Institute of Natural Resources, 2018:20). In phase one of the project 4 946 stakeholders were engaged, with 3 429 of these stakeholders having an increased capacity to adapt to climate change impacts (Institute of Natural Resources, 2018:20). In phase two of the project 1 573 stakeholders were engaged, with 674 of these stakeholders having an increased capacity to adapt to climate change impacts (Institute of Natural Resources, 2018:29). A total of 11 institutions (one private, three community and seven government institutions) benefited from improved capacity to address impacts of climate change from phase two of the project (Institute of Natural Resources, 2018:50). And, lastly, approximately 334 people are using climate or risk-reduction information to enhance climate change resilience (Institute of Natural Resources, 2018:51). The project engaged with a great diversity of participants with the aim of increasing their awareness and building their resilience to the impacts of climate change.

5.7.2 Methods of participation

Participation was promoted by the project approach which constituted social learning and soft systems thinking for the complex problems of SES resilience and adaptation to climate change. (Institute of Natural Resources, 2018:13). These approaches involve participatory information collection, deliberation and analysis, as well as collaboration with local stakeholders including community members, local private sector actors and government officials (Institute of Natural Resources, 2018:13).

The project team aimed to incorporate meaningful participation from national stakeholders in both phases of the project. In phase 1, workshops and meetings with national level government ministries and NGOs were aimed at gaining input for the adaptation framework (Institute of Natural Resources, 2018:25). These government ministries and NGO representatives were invited to two national exhibits that displayed the progress made, and shared the lessons learnt, of the LCCAP (Institute of Natural Resources, 2018:25). The exhibits aimed to engage with these stakeholders to form beneficial networks and gain support, as well as input, into the project. Drafting of the adaptation plan was done through a participatory soft systems

approach that involved stakeholders at the national, district and local level (Institute of Natural Resources, 2018:21). In this way the SES resilience issues could be identified through perspectives from many sales and sectors, and from there holistic solutions could be explored.

In phase two, government departments were involved in the identification and selection of feasible financial mechanisms that would suit the community context that they were designed for (Institute of Natural Resources, 2016:3). Government departments played an important participatory role as a source of information due to their extensive experience and unique perspectives. The project team aimed to gain as many active participating groups as possible in the project to garner many perspectives and input to form robust solutions to the resilience issues.

The identification, development, feasibility study and support of the financial mechanisms involved stakeholders from the government, private sector and from the communities (Institute of Natural Resources, 2018:27). The involvement of so many participating groups facilitated the required trust and relationship building between the groups for collective action. The financial mechanisms themselves were partnerships between the target communities, the public sector and the private sector (Institute of Natural Resources, 2018:28). Members of the community who were interested in joining the financial mechanism's committee underwent various training which was targeted at the specific mechanism so that the committee members could successfully run the mechanisms beyond project conclusion (Institute of Natural Resources, 2018:28). Power was distributed down to the community level to run these mechanisms, allowing communities and individuals to take on a more active role in the project.

Community members who chose to be active participants in the project were involved in various resilience building activities in phase one and two. Community members participated through experimentation, testing and selection of appropriate adaptation approaches, such as seed trials, conservation agriculture practices, and alternative technologies (Institute of Natural Resources, 2018:23). Local farming expertise was harnessed in the planting of gardens as well as an orchard when community farmers from four pilot communities got together to improve community food security (Institute of Natural Resources, 2018:23). Community members also had active roles in their own livelihood resilience building activities, such as preserving fruit, producing yarn, and demonstrating and selling fuel efficient and solar equipment that reduces household dependence on the land (Institute of Natural Resources, 2018:21,23,40). Multiple community groups participated in CBNRM such as wetland and rangeland monitoring and evaluation, and in the case of the CaRe project, conservation and restoration (Institute of Natural Resources, 2018:22,41). Field days and demonstrations were held by the communities and project team to exhibit the results of these

community-based experiments, activities and changes in practice (Institute of Natural Resources, 2015:9,6; Institute of Natural Resources, 2018:21). From this the project activities were undertaken and promoted through a collaborative effort between the project team and the communities, who were active participants throughout the project.

5.7.3 Building trust

The LCCAP team extensively engaged with stakeholders to build trust, make connections and gain valuable input for the project (Institute of Natural Resources, 2018:46). The focus on participation and inclusive development built trust between the LCCAP team, community members and other stakeholders as the interventions were identified through a collaborative process (Institute of Natural Resources, 2018:52). The communities and LCCAP team built trust through the many collaborative initiatives that were implemented over the project's duration. This inclusive trust building process ensured that specific interventions were fully understood and supported by local actors.

The LCCAP team went to great lengths to secure the trust, and manage the expectations, of the communities during the project's inception. The project team approached the local authorities from the pilot site's community councils, the communities themselves and the traditional leaders of the pilot sites to introduce the project and request the support of these stakeholders as well as their active participation in the project (Institute of Natural Resources, 2011:9). The LCCAP team also undertook household and focus group interviews with members of the pilot sites for the vulnerability assessments, as well as formal and informal meetings with households regarding their field and rangeland management practices (Institute of Natural Resources, 2011:13). The extended engagement consisting of one-on-one talks and community meetings made the project's goals and scope clear to understand, thus minimising the risk of unrealistic expectations. After consolidating the information from these meetings, scenario building workshops were held in community halls and primary schools across the pilot site communities (Institute of Natural Resources, 2011:5). Stakeholders raised issues at these meetings which the project team addressed and incorporated into the project (Institute of Natural Resources, 2011:9). Incorporating public-raised issues into the project eventually garnered the trust of the stakeholders and ensured sustained support. All these activities to garner support and participation also acted to build trust and relationships with the communities and the project team.

Successful partnerships require trust between the participating groups. The project team believes that adaptation interventions require community-public-private-partnerships (Institute of Natural Resources,

2018:38). To gain support and meaningful participation for phase two of the project, the team hosted a national workshop on 'Building Partnerships for Upscaling Climate Change Adaptation in Lesotho' and asked national government ministry and department representatives in attendance to identify stakeholders that could be potential partners in phase two of the project (Institute of Natural Resources, 2016:8). The project team engaged with these potential partners multiple times during year six and seven of the project via workshops, presentations, preliminary discussions, and one-on-one meetings, all with the intention of building trust and partnerships (Institute of Natural Resources, 2016:8; Institute of Natural Resources, 2017:29; Institute of Natural Resources, 2018:38). Many of these potential partners were interested, however, not all were able to commit resources to the financial mechanisms (Institute of Natural Resources, 2018:38). The groundwork in building trust and pursuing partners was not, however, in vain as the engagements produced knowledge that was instrumental to the successes achieved and each of the three pilot projects were a result of this input and the successful partnerships formed between communities, government departments, parastatals and private companies (Institute of Natural Resources, 2018:38). The LCCAP team thus succeeded in building the trust required to form successful partnerships.

5.7.4 Building capacity for participation

The LCCAP's principles are aimed at encouraging local stakeholders to actively participate in all levels of climate change adaptation and resilience building. These principles are Participation and Empowerment; Inclusive Development; and Institutional Development (Institute of Natural Resources, 2018:14). At the local level, the LCCAP aimed to build capacity to participate through environmental awareness raising such as workshops, playing and distributing copies of the Adapt-Able game and disseminating booklets on adaptation actions to sustain ES as well as posters on topics such as climate smart agriculture, livelihood diversification and community-based rangeland monitoring (Institute of Natural Resources, 2018:24). The game, booklet and posters were printed in both Sesotho and English to facilitate understanding and reach a wider audience (Institute of Natural Resources, 2018:24). The LCCAP also adopted a more hands-on approach by developing a community-based rangeland and wetland monitoring programme, which provided training, equipment, to local management champions to build their capacity to participate in environmental management and monitoring (Institute of Natural Resources, 2018:25, 28). The management champions were then able to identify and track changes to rangelands and wetlands conditions (Institute of Natural Resources, 2018:25). These activities built the capacity of local people actively participate in climate change adaptation interventions.

National stakeholders benefited from the project with an increased capacity to participate in climate change

resilience building. The LCCAP team held 15 capacity building workshops for the district authorities in the initial stages of phase one (Institute of Natural Resources, 2018:24). The LCCAP team also trained and thus built the capacity of three of these district councils and an additional 13 community councils on integrating climate change adaptation with development planning (Institute of Natural Resources, 2018:25). This enabled these councils to develop their own adaptation plans that incorporated climate change information pertinent to their areas. The LCCAP provided training tools and materials to community councils, district councils and national government departments on topics related to climate change impacts, vulnerability, adaptation, and policy in the form of technical reports, manuals, booklets, newsletters, posters and flyers, all in English and Sesotho (Institute of Natural Resources, 2018:25). This was aimed at increasing the capacity of national stakeholders to participate in climate change action, such as CEbA, which would allow for the upscaling and diversification of the project and similar initiatives.

In phase two of the project, the LCCAP team and local government departments provided the financial mechanism committee members with ongoing training so that the committee members could successfully run the financial mechanisms, especially beyond the conclusion of the project. Building committee member capacity for successful participation was achieved through training in business, financial management, entrepreneurial skills and marketing (Institute of Natural Resources, 2018:28). These skills would benefit them in the long term to keep the financial mechanisms active and even start, as well as run and maintain, new initiatives.

5.7.5 Providing incentives for participation

The financing schemes developed by the LCCAP were meant to both support the uptake of adaptation interventions and incentivize participation (Institute of Natural Resources, 2018:15). The TASS is one of the three financial mechanisms developed in phase two of the project (Institute of Natural Resources, 2018:38). TASS is based on a village saving scheme concept and is aimed at making fuel efficient and solar technology more affordable to the rural households involved as well as enhancing household resilience (Institute of Natural Resources, 2016:6). After being operational for a year, the 14 members saved just over 22 000 Maloti (R22 000 or $1 570 at the time) after which the members enjoyed the first annual share-out (Institute of Natural Resources, 2018:38). This savings scheme increases rural household resilience in many ways, due to access to a “rainy day fund” which acts as incentives to participate in the scheme. Members can save and have access to money when times are scarce or for big purchases such as building material for their house or stock for their home-based businesses (Ramakesana, cited in, Institute of Natural Resources, 2018:39). With the annual share-out members are given a lump sum, which can go towards their needs and

wants, including children's school fees so that their children are not withheld an education due to late fees (Khesoa, cited in, Institute of Natural Resources, 2018:40). The members all have goals to buy energy efficient technology like solar lanterns which can allow their kids to study at night safely and home-based business can keep operating at night; and cookers so that less time will have to be spent on searching for dwindling stocks of firewood (Institute of Natural Resources, 2018:39,40). An unforeseen benefit from this project is that members feel that being a part of the group has built social cohesion amongst the members (Bobojane, cited in, Institute of Natural Resources, 2018:39). The access to the fund, as well as the way the member's livelihood and resilience has improved, acts as a major incentive to potential new members who want to join and others who want to start-up similar initiatives in their villages.

5.7.6 The influence of participation on resilience

The LCCAP team sought participation from project inception and approached many of the stakeholder groups in the first year of the project. Stakeholders were involved from the start through a soft systems approach in identifying the problems experienced in the SES as well as the potential goals and objectives of the project. The participatory nature of the project facilitated collective action from early in the project. Trust building combined with capacity building throughout the project facilitated a collaborative effort between stakeholder groups. These different stakeholder groups that were involved in the project improved the system's capacity to detect, as well as interpret, shocks to the SES and facilitated collective sensemaking (Biggs *et al.*, 2012:436). This then increased comprehension of all stakeholders into the decisions and actions implemented to enhance SES resilience (Biggs *et al.*, 2012:436). This fostered improved relationships between stakeholder groups.

The project improved cooperation between groups by introducing collective goals. Shared goals, such as decreasing soil erosion to yield improved ecosystem conditions, decreased competition between stakeholders and resulted in collaborative efforts. Collaborative efforts to manage the ecosystems encouraged the devolution of authority to local committees. This authority of local groups to manage ecosystems was paired with responsibility to protect their natural resources. Strengthening the link between on-the-ground information gathering and ecosystem management, aids decision making that leads to more resilient outcomes (Biggs *et al.*, 2012:436). Improved outcomes may facilitate changes in government to incorporate broadened participation more widely. Thus, participatory action could lead to changes in governance as well as perception and attitude (Biggs *et al.*, 2012:436). All these participatory factors, as seen in Figure 11 below, work together as a whole to enhance SES resilience, as seen below in Table 10.

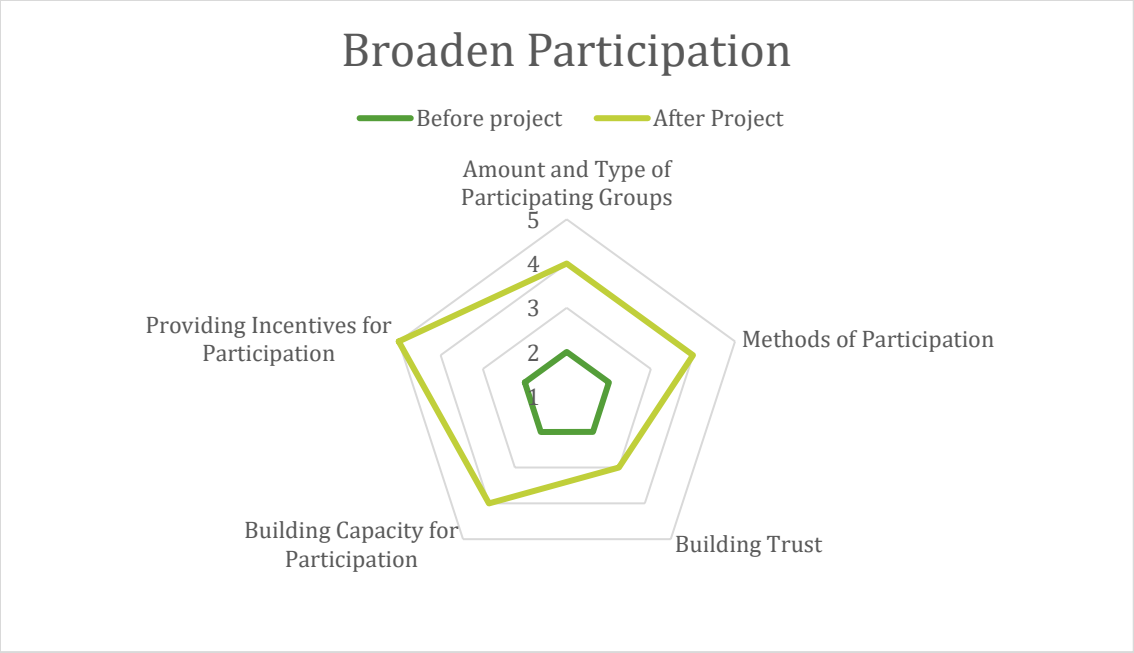

Figure 11: Participation resilience metrics ranked on a Likert scale from 1 (low) to 5 (high) before and after the LCCAP. See appendix 1 for details on the Linkert Scale ratings.

Table 10: Project's influence on the Participation metrics.

Resilience Principle	Resilience-Building Metrics Specific to Lesotho SES	Effect on Resilience
Broaden Participation	Amount and Type of Participating Groups	Enhanced
	Methods of Participation	Enhanced
	Building Trust	Enhanced
	Building Capacity for Participation	Enhanced
	Providing Incentives for Participation	Enhanced

5.8 Promote polycentric governance systems

Polycentric governance systems allow for many groups at many scales to manage the SES collectively. The approach to the LCCAP was to increase resilience and incorporate adaptation into all sectors, including the private sector, national government departments, district councils, community councils and individual households (Institute of Natural Resources, 2018:16). This process of involving multiple stakeholder groups at many scales began with locating appropriate stakeholders, initiating partnerships between the groups and ended with the strengthening of the partnerships and the communication networks between them (Institute of Natural Resources, 2018:19). By fostering partnerships and promoting polycentric governance systems, the decentralisation of power and responsibility allows for a diversity and redundancy of knowledge types, responses and scales to address the problem.

5.8.1 Distribution of governing power

The LCCAP team, a firm believer in partnerships and the distribution of responsibility and governing power, was itself a collaboration between multiple organisations. The project team was a partnership of four organisations, namely the Institute of Natural Resources, Serumula Development Association, GROW, and Native Seed Consulting. The project team acted as facilitators, with the aim of empowering the community and governments to be self-organizing and self-sustaining after the project's completion.

In phase one, the wetland monitoring activities promoted polycentric governance systems in many ways. By building the local community's capacity to self organise and undertake wetland monitoring, captured the attention of The Department of Water Affairs and the LHDA, who made use of the local monitoring information (Institute of Natural Resources, 2015:9). From this information the wetland made the government's protected wetlands list, and a collaborative partnership was formed between the community and the Lesotho Highlands Development Authority, all towards the goal of wetland protection and restoration (Institute of Natural Resources, 2015:9). The wetland is now managed by three groups at three scales working in partnership, enabling the right group at the right scale to address issues at the right time.

In phase 2, the three financial mechanisms were started up by the project team, in collaboration with local government and the communities, however the project team then ensured that the mechanisms were run by local community members (Institute of Natural Resources, 2018:28). Each financial mechanism was run by a committee made up of around 13 local, community elected, committee members (Institute of Natural Resources, 2018:28). These committees formed partnerships with other groups thereby fostering collaboration, connectivity and distribution of power and responsibility over many Lesotho SES groups. CaRe is a successful community-public-private-partnership between Khokhoba community and SanLei with the support of the Ministry of Forestry, Range and Soil Conservation and the Lesotho Highlands Development Authority (Institute of Natural Resources, 2018:38). EES is another successful community-public-private-partnership between 'Muela community (Thaba-Chitja Solar Power Solutions community start-up company) and SunFire Solutions with the support of the Ministry of Industry, Trade and Cooperatives (Institute of Natural Resources, 2018:38). Whereas TASS is a successful community initiative of the 'Muela community, with the support of the Ministry of Industry, Trade and Cooperatives (Institute of Natural Resources, 2018:38). This distribution of governing power from the project team to the community members and community groups increased the sense of community ownership over adaptation solutions.

5.8.2 Building capacity for self-organisation

The project focused on building confidence and capacity for self-organization at the local level. In association with the Lesotho Meteorological Services and the United Nations Development Programme (UNDP), the project team collaborated with district and community councils to identify and integrate climate change adaptation into local development plans for the project site areas (Institute of Natural Resources, 2018:26). Included in this awareness raising and capacity building support was a climate change vulnerability mapping exercise and a policy review regarding climate change adaptation and resilience issues (Institute of Natural Resources, 2018:26). This aids in building the capacity of the community and district councils involved to develop their own adaptation plans, which facilitates the self-organisation of these stakeholders.

At a lower level of organisation, the project team set up innovation committees in phase 1 and financial mechanism committees in phase 2 and trained the selected community members to manage the adaptation mechanisms and interventions (Institute of Natural Resources, 2018:28). The aim of these community-based committees was to promote sustainability of interventions as well as strengthen the community's institutional capacity (Institute of Natural Resources, 2018:44). The committees managed the three financial mechanism projects, which also enhanced the local capacity for self organisation in many ways.

The CaRe Project empowered the Khokhoba community and built their capacity for self-organization. CaRe Committee members feel empowered to organize and lead a community; care for the natural environment; and manage partnerships between their community and private companies (Molefi, cited in, Institute of Natural Resources, 2015:8). The community manages, rehabilitates and monitors their catchment areas in partnership with the local big business, SanLei, a trout farm. The community project has drawn the interest of other parties which have grown into meaningful partnerships and relationships which the community can rely on for support (Institute of Natural Resources, 2018:42). CaRe, as well as the community-based rangeland monitoring, built the capacity of the communities to champion their land degradation issues and forge their own pathway to resilience (Institute of Natural Resources, 2015:8). EES and TASS also built the capacity of their members to self-organize and have shown that these initiatives can be successful in these areas. This has a ripple effect for change agents and entrepreneurs in the area who want to start up similar schemes. EES has given its members the knowledge and experience as the middleman between non-governmental business and consumer; demonstrating products; buying and selling; and as adaptation champions (Institute of Natural Resources, 2018:47). Whereas TASS has equipped its beneficiaries with the knowledge of how community saving schemes work and the benefits that they reap for members

(Institute of Natural Resources, 2018:47). The empowerment and skills gained from these initiatives enhance the capacity of these communities to enhance their own resilience to shocks.

5.8.3 Bridging organisations

Although there were no actual bridging organisations, the LCCAP team played a facilitative role, or a bridging role, to connect the different stakeholders, i.e., the pilot communities, government actors and the private sector (Institute of Natural Resources, 2018:19). This involved initial establishment of connections between stakeholders, strengthening of connections between stakeholders through improving relations and communication networks between them. The intention was that by the end of the project there would be no need for the project team to act as a bridging organisation as the communication networks would be established and strong. As the project was funded by an external donor (USAID), the team had more freedom to bridge partnerships with not only state actors but private actors, too (Institute of Natural Resources, 2018:53). This spread the decision making, governing and management power over multiple actors in multiple sectors and at many scales, as opposed to being a one company or a one government department initiative.

5.8.4 Transparency and accountability

The LCCAP was donor funded by USAID who required reports on the project's process and as such the project team had to make use of indicators and other methods of reporting. This enhanced the project's transparency and accountability. The project team made use of TraiNet, an e-tool for USAID data gathering and reporting, to capture the results of stakeholder engagement (Institute of Natural Resources, 2018:51). Each event had a start and end date with the event details, a register for the number of males and females attending for the first time, as well as a repeat attendance register (Institute of Natural Resources, 2018:51). Another tool used to track performance was the AIDTracker+ management system, which allowed for data capture and storage of project indicators, targets, results and the quarterly and annual project reports (Institute of Natural Resources, 2018:51). After AIDTracker+ was discontinued in 2018, the project team still captured and sent all this data via email. Other ways of reporting project details were in the form of technical reports; booklets from studies done in the area; posters to spread information and lessons learnt from the project; presentations to report project impacts; flyers and videos to spread success stories; and lastly, a close out report on the entire project (Institute of Natural Resources, 2018:55,56,57). All these reports, studies and booklets are freely accessible online and can be found on the USAID website or the

Institute of Natural Resources website. The transparency of project indicators, targets, results and lessons learnt enabled accountability for the project by USAID and other interested or affected groups.

5.8.5 The influence of polycentric governance systems on resilience

The LCCAP team implemented strategies that promoted polycentric governance systems in the Lesotho SES. The process of promoting polycentric governance systems began by building capacity of stakeholder groups, distributing power to these groups and making connections between different stakeholder groups. These connections resulted in formal arrangements forming between these groups. The project team achieved this by implementing multiple governing authorities within the project that could collaborate with other governing systems at different scales. These governance authorities (like CaRe) had independence within a specific area (the rangeland and wetland ecosystem management and monitoring) and could link to other groups horizontally (SanLei and the LHDA) while being nested within a broader network (Ministry of Forestry, Range and Soil Conservation which is linked to broader government). This connection provides governance groups with the opportunity to match SES governance levels to the scale of disturbances. It also provides functional redundancy and modularity of governance groups (Biggs *et al.*, 2012:438). Functional redundancy provides an extra layer of security to governance while modularity lowers the risk of disturbance spreading between groups (Biggs *et al.*, 2012:438). This type of SES management will benefit from scale-specific knowledge, resources and response time.

This type of governance has the potential to enhance resilience as it facilitates the other principles of resilience: redundancy, connectivity, learning and experimentation, participation (Biggs *et al.*, 2012:439). For these systems to enhance resilience of ES in cases there should be open communication and trust between groups as well as accountability for actions (Biggs *et al.*, 2012:439). The LCCAP actively worked at forming connections as well as building up trust, leadership and social capital. This provided the opportunity for stakeholder groups to formulate strategies for coordination and conflict resolution between centres of authority. The project thus enhanced the resilience of the SES, as seen below in Table 11, by implementing strategies and actions that promoted polycentric governance systems, as seen below in Figure 12.

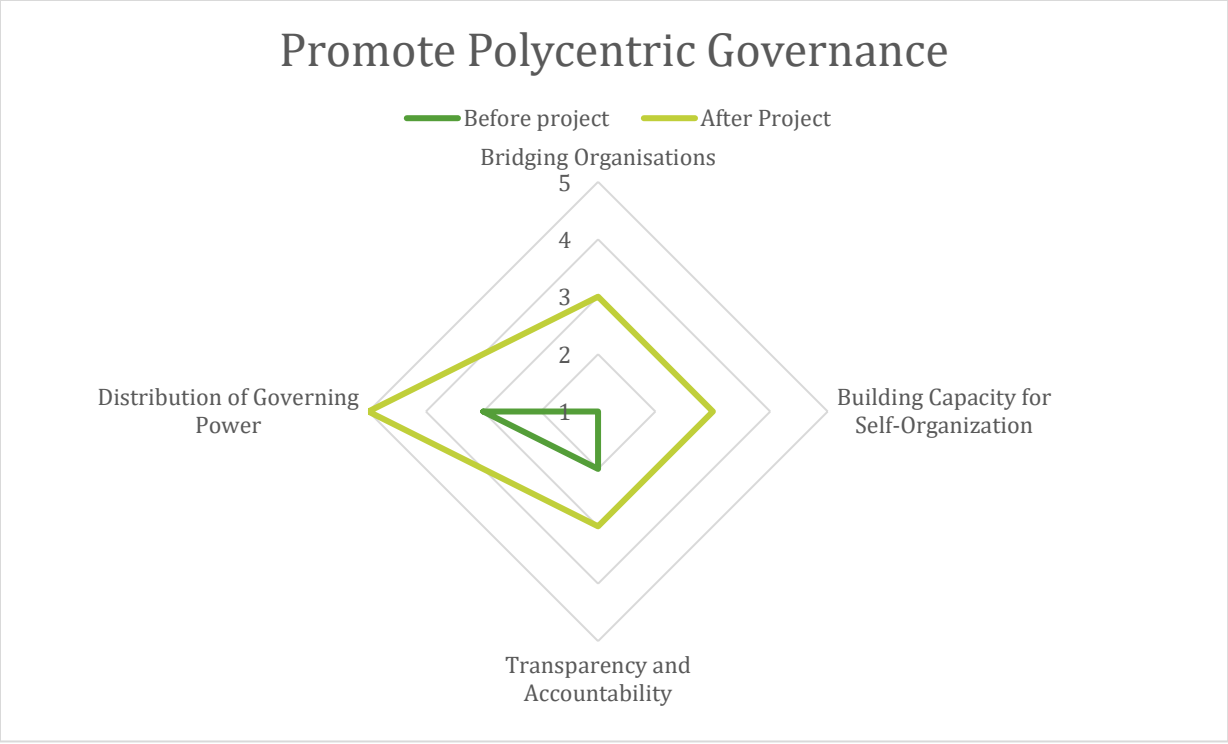

Figure 12: Polycentric Governance resilience metrics ranked on a Likert scale from 1 (low) to 5 (high) before and after the LCCAP. See appendix 1 for details on the Linkert Scale ratings.

Table 11: Project's influence on the Polycentricity metrics.

Resilience Principle	**Resilience-Building Metrics Specific to Lesotho SES**	**Effect on Resilience**
Promote Polycentric Governance Systems	Distribution of Governing Power	Enhanced
	Building Capacity for Self-Organisation	Enhanced
	Bridging Organisations	Enhanced
	Transparency and Accountability	Enhanced

5.9 Conclusion

This chapter unpacked the management approaches, used in the LCCAP, according to the seven principles that build and maintain resilience. These seven resilience principles were subdivided into metrics of SES resilience to assess the change in resilience from the LCCAP's interventions. This chapter discussed each metric and determined whether each metric was either undermined or enhanced the resilience of the SES. The following paragraphs conclude on whether each resilience principle was enhanced or undermined because of the LCCAP's interventions.

Before the implementation of the LCCAP, the Lesotho SES was brittle, with low diversity and low redundancy. The LCCAP enhanced the resilience of the SES through every diversity and redundancy metric by providing more options for the SES to adapt to the changing and deteriorating condition of the

environment. The project took an active role in managing the interaction between SES variables by facilitating both the formation of connections between groups and the formation of isolated refuge patches in the ecosystems. The way connectivity of the social and ecological SES variables was managed in the project served to enhance the resilience of the SES according to each of the connectivity metrics. With the aim of ensuring the SES remains functional and continues to produce the desired regime with its set of ES, the project team identified, monitored and managed slow variables and feedbacks. The activities that were undertaken all enhanced the SES resilience according to each of the slow variables and feedbacks metrics. The project team decided on an approach that acknowledged the complex and intricate web of interconnected SES variables and thus helped stakeholders foster CAS thinking as well. Stakeholders are now aware that they need to accept change and uncertainty as SES are constantly evolving in response to interacting system components. Each metric for fostering CAS thinking shows that the project's interventions enhanced resilience of the SES. The LCCAP approaches focused on encouraging stakeholders to embrace different methods of learning and experimentation. Adaptation to changing conditions requires constant learning about the SES and experimentation regarding the possible pathways to take to bring about resilience. Participation of many different stakeholder groups played a significant role in the LCCAP. The project team went to great lengths to encourage stakeholders at local, district and national level to participate in the project. Each metric focused on encouraging learning and experimentation showed that resilience was enhanced by the projects focus on this principle. The project team implemented strategies that promoted polycentric governance systems in the Lesotho SES, which allowed for many groups at many scales to manage the SES collectively. The promotion of this type of governance bolstered the success of some of the other resilience principles, including redundancy, connectivity, learning and experimentation, participation. The project successfully promoted polycentric governance systems according to the metrics set out which in turn enhanced the resilience of the SES.

The figure and table below represent the metrics used for the LCCAP as well as the status as to whether each metric enhanced or undermined the SES resilience. It is clear to see from Figure 13 and Table 12, shown below, that the project’s methods served to enhance the resilience of the SES through each of the resilience-building metrics.

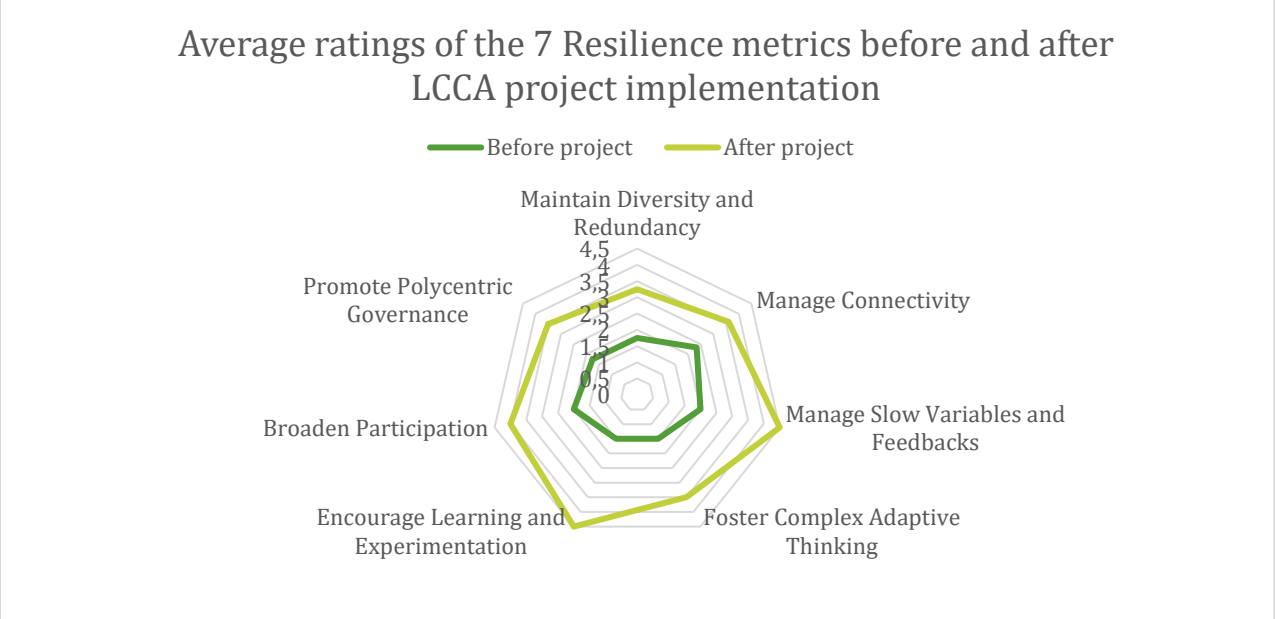

Figure 13: Radar Graph: Pilot communities' SES resilience metrics ranked on a Likert scale from 1 (low) to 5 (high) before and after the LCCA project. See appendix 1 for details on the Linkert Scale ratings.

Table 12: Project's influence on the resilience metrics.

Resilience Principle	**Resilience-Building Metrics Specific to Lesotho SES**	**Effect on Resilience**
Maintain Diversity and Redundancy	Response Diversity and Redundancy	Enhanced
	Diversity of Livelihoods	Enhanced
	Diversity of Crops by Small Scale Farmers	Enhanced
	Diversity and Redundancy of Managers of an Ecosystem	Enhanced
Manage Connectivity	Cross Scale and Cross Sectoral Mechanisms and Links for Information Sharing	Enhanced
	Connecting Groups	Enhanced
	Wildlife Corridors	Enhanced
Manage Slow Variables and Feedbacks	Identifying Key SES Slow Variables and Feedbacks Understanding of Gradual Changes	Enhanced
	Decisions Updated with New Information	Enhanced
	Ability of Managers to Respond to Key Changes	Enhanced
	Incentives as Feedbacks that Promote Adaptation	Enhanced
Foster Complex Adaptive Thinking	Acknowledging that Social-Ecological Systems are Based on a Complex and Unpredictable Web of Connections and Interdependencies	Enhanced
	Willingness to Embrace Change	Enhanced
	Preparedness to Cope with Unexpected Change	Enhanced
	Scenario Building	Enhanced
Encourage Learning	Innovation and Willingness to Experiment	Enhanced
	Sharing of Scientific, Local and Traditional Resources	Enhanced
	Learning from the Past, Crisis and Mistakes	Enhanced
	Monitoring and Evaluation	Enhanced
Broaden Participation	Amount and Type of Participating Groups	Enhanced
	Methods of Participation	Enhanced
	Building Trust	Enhanced
	Building Capacity for Participation	Enhanced
	Providing Incentives for Participation	Enhanced
Promote Polycentric Governance	Distribution of Governing Power	Enhanced
	Transparency and Accountability	Enhanced
	Building Capacity for Self-Organization	Enhanced
	Bridging Organisations	Enhanced

CHAPTER 6: CONCLUSION

6.1 Introduction

This concluding chapter summarises and concludes the findings of the research questions. This chapter starts by answering the three research questions, and their sub-questions. The research questions work together to provide a clear understanding of the role CEbA can play in resilience building, especially in rural, resource dependent communities within developing countries. The research questions connect the two previously unconnected literature on CEbA and resilience and applies it to the LCCAP case. The chapter will then provide recommendations based on the findings of this research and suggest areas for future study. The research promotes the use of CEbA for global south communities and recommends that CEbA make explicit use of the seven resilience principles for optimum results. The chapter ends with a summary of the contributions made in this thesis.

6.2 Research results

The results of this research are summarised below in the following subsections by presenting the answers to the three research questions. To answer each main research question, its' sub-questions are answered first.

6.2.1 Research question 1

6.2.1.1 What characteristics define a project as CEbA?

CEbA is an integration of EbA and CbA, and thus takes on characteristics from both these adaptation approaches whilst creating its own, unique characteristics, too. EbA makes use of ecosystems and their services to aid societies in climate change adaptation, whereas CbA makes use of societies and their potential to build up their own resilience (Chevallier, 2017:3). CEbA integrates these two approaches to build resilience for both the ecological and social spheres of the SES that is vulnerable to climate change. There is thus a range of measures, techniques and characteristics available to CEbA, on the continuum between CbA and EbA (Coll Besa, 2015). Each adaptation context making use of CEbA will require a unique set of traits on the CbA to EbA continuum. There is a set of characteristics that CEbA practice can follow, as set out by Girot *et al*. (2012) that was developed through a synthesis of lessons learned from CEbA practice in the field. This research refined and adapted these characteristics, that serve as a CEbA definition, to six main points. These points are listed and described below.

A practical, characteristics-based, definition of CEbA:

1. CbA for social resilience:

   There must be an active effort to enhance the resilience of the local people through the promotion of community-based adaptation, with an emphasis on encouraging and building upon community innovation. The vulnerabilities of the community should be uncovered addressed through a proactive rights-based approach that provides social security in the long term (Girot *et al*., 2012:16,17). These actions should be community-led and community-based, thus ensuring community direction and ownership of the interventions.

2. Collaborative governance:

   CEbA should be governed through collaborative management between stakeholders, including institutions and communities (Girot *et al*., 2012:17; Roberts *et al*., 2012:182,186). Effort should be placed into broad participation as well as developing and improving cross-sectoral partnerships (Girot *et al*., 2012:17). Communities should be placed at the centre of planning and remain central during the implementation and monitoring of solutions, (Girot *et al*., 2012:17; Reid, 2014:2; Chevallier, 2017:4;).

3. EbA & NBS:

   Healthy ecosystems should be used to help societies mitigate and adapt to the effects of climate change. These EbA and NBS should be context appropriate and forward-looking, that either complement or replace hard infrastructure adaptation or mitigation (Girot *et al*., 2012:16).

4. Promote ecosystem resilience:

   Ecosystems and wildlife should be conserved, specifically through community-based efforts, to enhance the adaptive capacity and resilience of ecosystems. CEbA should also ensure that interventions are environmentally sound and that external stressors to ecosystems are reduced.

5. Sharing lessons learnt:

   Learning and the sharing of information and lessons learnt, between project actors and the external community, should form a major component of CEbA. Integration of knowledge types, intentional learning, experimentation and co-learning can facilitate in the accumulation of compelling arguments necessary for the progress of CEbA.

6. Funding:

   CEbA has the potential to be low cost, especially in rural areas, however, funding will need to be acquired for change agents to implement interventions that are not free, to upscale interventions or to secure participation from locals who require incentives.

Figure 1: CEbA (adapted from Girot et al., 2012:16,17).

6.2.1.2 Does the LCCAP conform to CEbA characteristics?

This research has developed a six-component definition for CEbA through an adaptation of Girot *et al*.'s work *Integrating Community and Ecosystem-Based Approaches in Climate Change Adaptation Responses*. This definition was applied to the LCCAP to ensure that the project adhered to the developed CEbA definition. The LCCAP made use of CbA approaches to build the community's resilience to climate change related shocks by creating opportunities for livelihood diversification and establishing financial mechanisms that made funds readily available to members. The project team encouraged a collaborative governance structure whereby project activities were developed, implemented and monitored by the project team, government bodies and the communities. EbA & NBS such as catchment management and conservation agriculture were applied to problems such as soil erosion, the formation of dongas and water insecurity. The project promoted ecosystem resilience by reducing stressors to the natural environment, such as overgrazing, and establishing community-based ecosystem rehabilitation and conservation. All lessons learnt, challenges, successes and details of the project were recorded, from multiple sources, and shared, both within the project sphere and to the outside world, using posters, pamphlets, quarterly reports, technical reports and a close out report. Funding for the eight-year project was provided by USAID and further funding for the financial mechanisms was acquired by project stakeholders like local businesses and

the community members themselves. According to the definition developed in this research, the LCCAP is a clear example of CEbA, as it exhibits the required six components of CEbA.

6.2.1.3 What characteristics did the LCCAP exhibit for it to be classified as CEbA?

The approaches employed in the LCCAP conformed to the CEbA characteristics drawn up by Girot *et al.,* (2012:16,17). The project implemented community-based adaptation that aspired to achieve community resilience, address adaptation needs and provide social security (Girot *et al.*, 2012:17). This was done through assessing community vulnerability and developing resilience building approaches in a participatory manner (Institute of Natural Resources, 2018:31). The project team and community members understood that any separation of people and environment was artificial and as such understood that community resilience should be built alongside ecosystem resilience. The project promoted ecosystem health and resilience by reducing environmental stressors and rehabilitating ecosystems (Institute of Natural Resources, 2018:33). Ecosystems were key to project interventions, with adaptive capacity being linked to healthy and functioning ecosystems. Community-based conservation efforts were aimed at ecosystem management and improved agriculture to ensure a sustained flow of ES to support ecosystem-based adaptation (Institute of Natural Resources, 2018:33). The communities worked together closely with the CEbA project team.

The project was developed and implemented through collaborative management between the LCCAP team; government and private institutions; and the pilot communities (Institute of Natural Resources, 2018:33). Communities were placed at the centre of planning and remained central during the implementation and monitoring of solutions, as will be seen in the discussion chapter. The planning, implementation, and monitoring stages were well documented by the project team, who reported on a series of quantitative indicators quarterly, authored annual reports and published a series of technical reports (Institute of Natural Resources, 2018:50,51). As the gathering of evidence is important for demonstrating the effectiveness of the CEbA approach, it was required for the project donor USAID. The accumulation of compelling arguments can aid in securing further funding for the project's activities after the projects closure to aid in the sustainability of interventions. The reports developed contain compelling arguments and lessons learnt throughout the project which can aid other projects and provide evidence for academic studies such as this one. The project thus focused on ecosystem health, NBS, social and environmental resilience, community-based efforts, collaborative governance, and the documenting as well as sharing of lessons learned. The diagram below summarises the LCCAP activities according to the CEbA categories developed by Girot *et al.* (2012:16,17).

Figure 14: LCCAP activities divided into CEbA categories developed by Girot et al. (2012:16,17).

6.2.2 Research question 2

6.2.2.1 What methods did the LCCAP use?

The LCCAP was aimed at identifying strategies for communities in Lesotho to adapt to climate change and enhance their resilience of livelihoods and ES. Over the eight years of project implementation, the project team made use of various methods to bring about this aim (Institute of Natural Resources, 2018:10). The methods were divided into two main phases. Phase one focused on identifying, developing and implementing appropriate, and context specific, strategies that would improve the resilience of livelihoods and ES in the Lesotho Highlands (Institute of Natural Resources, 2018:10). Phase two focused on identifying, developing and piloting locally appropriate financial mechanisms targeted at supporting and

up-scaling priority adaptation and resilience enhancing interventions (Institute of Natural Resources, 2018:10). The project made use of a soft systems methodology to reach a consensus between stakeholders as to what the complex problems facing the Lesotho Highlands were and what the desired and appropriate interventions should be (Institute of Natural Resources, 2018:4). This formed the basis of the CbA component of the project as the soft systems approach empowered the communities to identify their own vulnerabilities as well as the methods that would potentially build their resilience. These methods were then piloted in the communities through collaborative partnerships involving not only the project team but also the community members, local authorities and some private sector actors (Institute of Natural Resources, 2018:5). Alternative livelihood options were introduced into the communities that were more resilient to a changing climate, such as wool and mohair spinning, as well as preserving fruits and vegetables (Institute of Natural Resources, 2018:5). Wetland and rangeland management practices were introduced to promote ecosystem resilience (Institute of Natural Resources, 2018:5). Soil management and farming practices were altered to improve the subsistence crop production and reduce environmental stressors (Institute of Natural Resources, 2018:5). The establishment of the sustainability commons, with its alternative technologies, offered community members alternatives to the natural resource intensive means of securing the necessities for survival (Institute of Natural Resources, 2018:21). The project team tried to spread the influence of the project by distributing informative publications, training members of government and preparing the way for up-scaling of adaptation interventions (Institute of Natural Resources, 2018:5). The main method employed to up-scale project interventions was through the establishment of financial mechanisms (Institute of Natural Resources, 2018:5). Three locally appropriate financial mechanisms were successfully implemented due to community-public-private partnerships that contributed by securing the funds, providing technical support and human resources (Institute of Natural Resources, 2018:6). The methods employed by the LCCAP thus included building partnerships, ensuring community collaboration, diversifying livelihoods, preserving ecosystems, sustainable farming, fuel efficient and solar technologies, sharing of information, and lastly establishing financial mechanisms that allowed for the social and environmental interventions to be more sustainable in the long term. These methods were put in place with the aim of increasing social and ecological resilience in the Lesotho Highland pilot communities. The next paragraph explores whether these methods adhered to the seven resilience principles.

6.2.2.2 Did these methods employed adhere to the seven resilience principles that enhance ES?

According to this research, the methods used to increase SES resilience in the Lesotho Highland pilot communities did adhere to the seven resilience principles. The first principle, to maintain diversity and redundancy, was encouraged in many ways with a focus on response diversity and functional redundancy.

The project provided the community members with a diverse set of options to respond to disturbances and shocks, such as a diversity of livelihood options and crop types. Encouraging multiple environmental managers at different scales and from different sectors provided functional redundancy in maintaining ES resilience. The second principle, to manage connectivity, was met both in both the social and ecological spheres. In the social domain, the team connected previously unconnected groups, who were then able to support each other, form cross scale and cross sectoral links for information sharing. Healthy ecological connectivity was maintained by managing natural corridors and establishing isolated, pristine ecological refuge nodes. The third principle, managing slow variables and feedbacks, was accomplished in the project by firstly identifying and mapping slow variables and feedbacks to better understand gradual changes and the effects that are brought on by these changes. This formed the basis of many of the project's activities. The project then showed the ability of the managers to respond to key changes by actively updating project decisions due to new information. Lastly, incentives were used by the project team as feedbacks that promote adaptation and positive behaviours, and disincentivise harmful behaviours. The fourth principle, fostering CAS thinking, was encouraged by the project through its adaptive management approach and project activities such as scenario building and experimentation. The project team acknowledged, and promoted the knowledge, that SES are based on a complex and unpredictable web of connections and interdependencies. This understanding was represented in the stakeholders' willingness to embrace change which enhanced their preparedness to cope with unexpected change. The fifth principle, to encourage learning and experimentation, was embraced throughout the project with the sharing of scientific, local and traditional information as well as lessons learnt throughout the project. Stakeholders, most evidently the pilot community members, embraced innovation and exhibited a willingness to experiment. Project experiments were monitored and evaluated, so that the stakeholders could learn from the approaches. The project team understood the need for the sixth principle, broad and meaningful participation, so they aimed to secure many diverse types of participating groups. Methods of participation varied amongst groups, with the most hands-on participation coming from the pilot communities. For successful participation amongst these groups the project team had to build trust between groups, build capacity for meaningful participation and provide incentives for sustained participation. For greater sustainability of the project the team promoted the seventh principle, polycentric governance systems, early in the project. This began by building the capacity of stakeholder groups for self-organisation. The project team acted as a bridging organisation between these stakeholder groups to build trust and establish communication between them. Once capacity for self-organization and communication channels were established the project team promoted the distribution of governing power between groups. Thus, according to this research, all seven of the resilience principles were adhered to by the project when implementing the project activities in the Lesotho Highlands.

6.2.2.3 Do the methods employed in the LCCA case have the potential to enhance livelihood and ecosystem resilience?

The LCCAPs' methods were aimed at improving the resilience of livelihoods and ES in the Lesotho Highlands (Institute of Natural Resources, 2018:10). The methods employed by the LCCAP adhered to the seven resilience principles, which are considered crucial for enhancing SES resilience. Each metric used to measure the effect of the projects' methods on each resilience principle, showed that the project enhanced resilience. This research thus puts forward that the methods employed in the LCCAP case do have the potential to enhance livelihood and ecosystem resilience.

The illustrations below show a summarised version of the ratings and research findings of the LCCAP's effect on each resilience principle. From the graph, it is clear that resilience was improved in each principal category due to project implementation. The table clearly states that each resilience principle was enhanced because of the project.

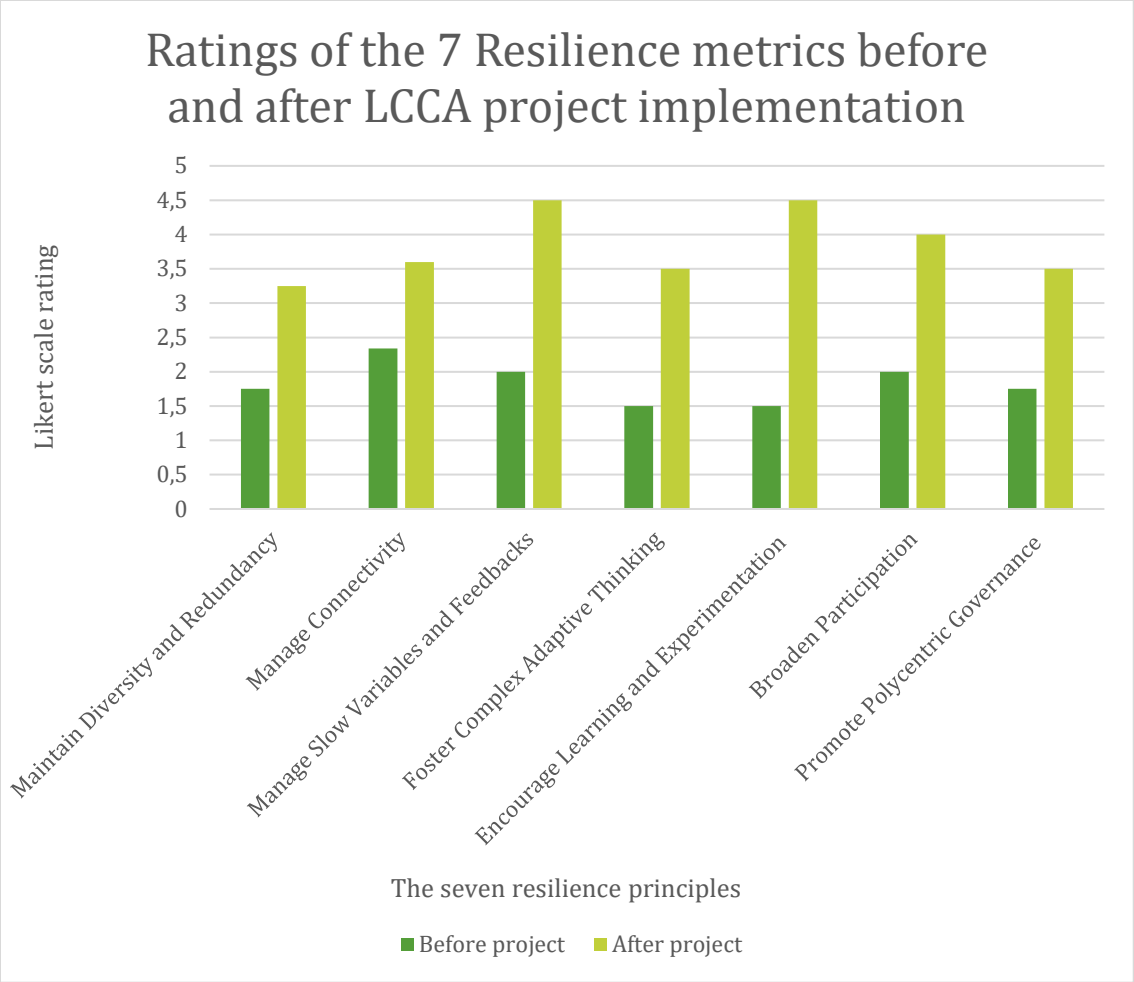

Figure: 15 Bar Graph: Pilot communities' SES resilience metrics ranked on a Likert scale from 1 (low) to 5 (high) before and after the LCCAP.

Table 13: LCCA projects' effect on the Lesotho SES resilience.

Resilience Principle	**Projects' effect on resilience principle**
Maintain Diversity and Redundancy	Enhanced
Manage Connectivity	Enhanced
Manage Slow Variables and Feedbacks	Enhanced
Foster CAS Thinking	Enhanced
Encourage Learning and Experimentation	Enhanced
Broaden Participation	Enhanced
Promote Polycentric Governance Systems	Enhanced

6.2.3 Research question 3

6.2.3.1 Do the characteristic methods and principles used in CEbA complement or contend with the seven resilience principles?

CEbA integrates EbA and CbA as it subscribes to the belief that humans and ecosystems are interdependent and together make up SES (Chevallier, 2017:2). It has a long-term and holistic outlook towards adaptation to climate change and realizes the need for healthy functioning of ecosystems as well as the empowerment of local communities to forge their own resilient adaptive pathways. This belief fosters a CAS, as opposed to reductionist, mindset to management. CEbA theory exhibits an understanding of the web of connections in a SES that produces emergent system properties. As systems are complex and adaptive, management must be adaptive and flexible to suit the problems, as there is no single solution to the plethora of resilience issues. CEbA can be considered a range of adaptation measures that include EbA strategies and CbA processes (Coll Besa, 2015). This allows for adaptive response diversity to any disturbances or changes and promotes experimentation of solutions which results in learning. In the planning and implementing of interventions human rights principles and ecosystem principles are adhered to, as CEbA is not just focused on human beings but on their surrounding ecosystems, too (Girot *et al.*, 2012:7). This has the potential to have a positive influence on the SES resilience, as a desired set of ES upon which human survival depends require functioning ecosystems. By adhering to human rights and ecosystem principles, the interventions indirectly manage feedbacks. Reducing environmental degradation can minimise indirect negative socio-economic impacts of climate change and *vice versa* (Chevallier, 2017:6).

There is also an understanding in CEbA that the social (cultural and socio-economic) and power relations' (institutional and governance) contexts cannot be ignored when addressing climate vulnerability (Girot *et al.*, 2012:6; Lewis & Oosthuizen, 2014:15; Reid, 2014:4;). Understanding that the SES consists of interconnected components and variables conforms to CAS thinking. By looking into the socio-economic patterns, CEbA is also gaining information on slow variables and feedbacks, as high rates of unemployment may correspond with greater natural resource dependence and environmental degradation. Acknowledging the social and power relation contexts complements encouraging and fostering broadened participation. If only powerful, or non-vulnerable, groups participate it may exacerbate issues for the vulnerable groups, as only one set of perspectives are acquired. By understanding these contexts, barriers can be overcome, and vulnerable groups can be empowered to participate meaningfully. This will, in turn, provide a richer picture of vulnerabilities as well as interventions that may enhance the SES resilience.

CEbA makes use of CbA and encourages collaboration between multiple sectors and groups. This directly aims to broaden participation and promote polycentric governance of SES management. In this way CEbA aims to manage the connectivity between diverse groups of people to enhance community resilience on multiple fronts. The active promotion of ecosystem resilience in CEbA maintains ecological diversity and strengthens the reliability of the flow of essential ES for human needs. This also manages connectivity, as these resilient ecosystems can act as refuge patches to vulnerable surrounding environments. Healthy, resilient ecosystems are required for the success of EbA and NBS. This aspect of CEbA promotes experimentation with its diversity of responses, as it encourages the search for novel solutions to unique problems, which then facilitates learning.

CEbA actively shares information gained and lessons learnt with stakeholders and the public. Not only does this encourage learning and experimentation, but it also fosters broadened participation. Sharing success stories and methods of adaptation can draw in many differing groups of people who are searching for solutions to their resilience issues. Meticulous documentation of success and lessons learnt can also attract funding opportunities for CEbA projects. Funding needs to be handled correctly in CEbA projects for many reasons. Communities should not become dependent on external revenue streams to ensure their resilience as this will inevitably result in vulnerability once the funding is removed. The funding should have no alternative agenda that results in an uneven weighting of certain participating groups or exacerbate power imbalances. Instead, funding should have an exit strategy that supports SES independent autonomy and funding should enforce project transparency and accountability of actions. If managed in this way, funding can open the door to a diversity of responses, connect groups that can share project responsibility, nurture experimentation and learning, and support the participation of groups who would have been unable to participate otherwise.

Although CEbA does not actively aim to operationalise or apply the principles of resilience, the characteristic methods and principles used in CEbA do complement, rather than contestwith, the seven resilience principles. CEbA consists of a loose group of methods, based on human rights and ecosystem-based principles and the seven resilience principles theory has a set of social and ecological factors that need to be met, based on governance and ES management. The two fields have the same goal of ensuring a sustainable supply of ES to meet human needs in the face of change and uncertainty. The two fields can work in unison towards the shared goal. CEbA methods can be implemented by following the resilience principles to bring about enhanced SES resilience.

6.2.3.2 What are the framework similarities between CEbA and the seven resilience principles?

The seven resilience principles and CEbA both treat social systems and ecological systems as interdependent and coevolving. They thus both conform to the SES mental model which takes the view that people are not separate from, and merely interacting with, the biosphere but instead that people are inhabitants of the biosphere, and are dependent on the biosphere (Biggs *et al*., 2012:423; Girot *et al.*, 2012:14,15; Folke *et al*., 2016: introduction, para. 2). People, communities, economies, cultures, values, and knowledge are all embedded within the biosphere, constantly shaping and being shaped by it (Folke *et al*., 2016: intro, para. 2). These interdependent systems co-evolve in response to changes in the economy, society, and the environment (Folke *et al*., 2003b: 356). As both the resilience principles and CEbA understand that changes in the SES are inevitable, resulting in dynamic systems that are constantly in flux, and they both advocate for SES management that allows for change and uncertainty (Folke *et al*., 2003b: 356; Biggs *et al*., 2012:433; Girot *et al.*, 2012:10; Preiser *et al*., 2021:35;). The seven resilience principles explicitly state that SES are CAS, which have many interacting components that behave in unpredictable ways (Biggs *et al*., 2012:425; Folke *et al.*, 2016: SES and Resilience, para. 2). Whereas CEbA implicitly accepts SES as CAS with the understanding that there are complex interdependencies and dynamic feedbacks between society and the environment (Girot *et al.*, 2012:15; Chevallier, 2017:2;). The multi-scale organisational patterns, as well as the interacting, emergent, and feedback characteristics of the system, ensures that SES is constantly in flux (Folke *et al.*, 2016: SES and Resilience, para. 2; Preiser *et al*., 2021:33). This complexity requires systems thinking, rather than the reductionist method of studying parts of a system, as SES has system properties that are because of, but different from, the singular components of the system (Folke *et al.*, 2003:5; Preiser *et al*., 2021:33). CEbA and the seven resilience principles theory thus share a cognitive framework through which they interpret issues and select appropriate solutions. These mental models have implications for how SES should be managed.

6.2.3.3 Does CEbA have the potential to enhance SES resilience in the face of climate change?

The characteristic methods and principles used in CEbA complement and adhere to the seven resilience principles. The seven resilience principles and CEbA fields share a common goal, which is to ensure the sustainable supply of ES for human needs in the face of change and uncertainty. The two fields complement one another and can work in unison towards the shared goal. Holistic solutions that aim to enhance resilience and address social, economic, and environmental issues are best addressed through a CAS perspective (Preiser, Biggs, Vos & Folke, 2018:introduction, para. 1). This perspective is adopted by CEbA

as seen by its aims to build adaptive capacity to climate change by integrating developmental and human rights needs with environmental protection and management. CEbA and the seven resilience principles theory thus share a cognitive framework through which they interpret issues and select appropriate solutions. This mental model has implications for how SES should be managed, with the understanding that the result of integrated solutions is much more than just the sum of the singular contributions.

There are thus no fundamental tensions between the fields of CEbA and the seven resilience principles. Instead, the similarities include their shared cognitive framework and goal. Both fields understand the need to manage and protect ES, as ES are the foundation of human survival. Both fields also understand that society can, and does, change the biosphere. The two fields can help each other to achieve their shared goal. As there are no fundamental differences between the fields, CEbA can make active use of the seven resilience principles to bring about enhanced SES resilience in the face of climate change. This research has thus shown that CEbA approaches do have the potential to bring about enhanced resilience pathways for SES in the rural global south.

6.3 Recommendations and future research

This section is aimed at making recommendations based on the findings of this research project. The recommendations offer future areas of research that may enhance the understanding and operationalisation of CEbA and the seven resilience principles. The impacts of climate change can be devastating for resource dependent, global south communities. Interventions are required to help these communities adapt to climate change and enhance the resilience of the entire SES to changes and disturbances. These recommendations aim to contribute to the search of appropriate interventions as well as further the study of potential interventions.

a) *CEbA to climate change should be implemented in the rural global south*

This research recommends that CEbA be used in rural developing context communities as an adaptation strategy to climate change as it is a viable option for enhancing livelihood and ecosystem resilience in the context of resource dependence and climate change.

b) *CEbA interventions should be explicitly guided by the seven resilience principles*

CEbA aims to empower communities to manage their ecosystems in ways that help the entire SES adapt to climate change (Chevallier, 2017:2). The seven principles of resilience aim to ensure a reliable flow of essential ES to meet human needs in the face of uncertainty,

change and disturbances (Biggs *et al*., 2012:423). These aims overlap and upon closer inspection there is more overlap and similarities between the CEbA and seven principles of resilience fields. This research has found no fundamental disconnects or differences between the two fields. The two fields are found to be complementary and could work together to produce synergistic results. This research thus recommends that CEbA interventions should be explicitly guided by the seven resilience principles. CEbA impacts could benefit from a more explicit focus on enhancing SES resilience. Metrics like the ones used in this research can be used to assess whether CEbA is enhancing the SES resilience for optimum results. These metrics can also be used as indicators to ensure accountability of CEbA projects. In this way, resilience can be brought about in rural developing communities vulnerable to climate change through CEbA interventions and methods.

c) *Development of an open-source database to document and share the lessons learnt from CEbA projects*

The database can store the information like the setup of this project, with background information to the SES, the division of project details according to the six CEbA characteristics and a discussion of how project interventions either enhanced or undermined resilience according to the seven resilience principles. The sharing of this information can make the methods, benefits and challenges of resilience enhancing CEbA projects more well known. It can also document all the different contexts in which the various CEbA strategies work. This central location for information can aid further study into these fields, which may help progress both the CEbA and the resilience principles' work, as the context specific cases can provide case study data for further study. This information can provide insight into the theoretical resilience principles being put into action. Operationalising resilience theory is still in its inception and can benefit from a database that documents resilience work in action. The evidence base for CEbA's effectivity needs to be built up, including information on its cost-effectiveness, how it addresses its governance and policy context, and its impacts at scale. The database can thus also provide the much-needed documentation of CEbA in practice to further the theory behind CEbA. This may help further study and spread the uptake of resilience enhancing CEbA projects.

d) *Pursuing the role of stewardship in resilience enhancing CEbA*

To adapt in the face of change, while pursuing resilient SES, requires a world view that understands the interdependent relationship between humans and the environment. This outlook is captured within an ecosystem or ecological stewardship. Ecosystem stewardship is the management of ES by humans who act as stewards through a sense of duty to protect, conserve and preserve the natural environment (Chapin *et al*., 2010:242). The aim of stewardship is to govern the environment in such a way that social-ecological sustainability is fostered in the face of change and uncertainty (Chapin *et al*., 2010:242; Folke *et al*., 2016:biosphere stewardship, para. 6). Development and human wellbeing are the desired outcomes; however, this is to be nested within the biosphere's capacity (Folke *et al*., 2016:biosphere stewardship, para. 11). It hopes to foster synergistic outcomes between ecosystems and communities, achieved through collaboration across multiple scales and levels, with a shared goal that unifies diverse groups (Folke *et al*., 2016:biosphere stewardship, para. 10). LTK is a key component of being an ecosystem steward, as stewards understand that the constant learning and knowledge generation that is required under stewardship should come from a variety of knowledge systems (Folke *et al*., 2016:biosphere stewardship, para. 8). It is thus clear to see the connections between ecosystem stewardship, climate change adaptation, and resilience.

Resilience is the ability to adapt to changes while maintaining desirable SES traits so that humans can develop sustainably in the pursuit of human wellbeing and ecosystem health. Stewardship is the relationship between humans and the environment where it is understood that humans can affect, and thus shape and direct ecosystems. As such humans have the responsibility to ensure the relationship is mutualistic and sustainable. Stewardship understands the adaptive nature of SES and thus uses this trait to direct the co-evolutionary pathway of SES towards a future where ecosystems are healthy and provide a stable supply of ES to foster SES resilience and human wellbeing (Chapin *et al*., 2010:242; Folke *et al*., 2016:biosphere stewardship, para. 6). Non-instrumental benefits to stewards are a bonus, where stewards feel that they are working towards a greater good and that their actions are altruistic, which gives them good reputations amongst their community, and they themselves feel a sense of purpose and worth (Folke *et al*., 2016:biosphere stewardship, para. 3). Therefore, stewardship is a beneficial way to view the relationship between humans and the environment when bringing about the twin goals of climate change adaptation and enhanced SES resilience in the face of climate change. The role of stewardship in resilience enhancing CEbA holds potential for future research.

6.4 Summary of contributions

While investigating the role of CEbA in enhancing SES resilience of developing rural communities in the face of climate change, this research offered the following contributions:

a) *The six characteristics that make up CEbA*

By narrowing down six characteristics that defined CEbA, this research provided a method to define a project as CEbA. This was then put into practice by assessing whether the LCCAP could be described as CEbA.

b) *Metrics to deduce the resilience enhancing potential of CEbA projects*

The metrics were used to assess the LCCAP methods as either resilience enhancing or undermining were based off of a context-specific quantitative resilience questionnaire. Questions were answered based on a Likert scale from 1 (low) to 5 (high) for both before and after the LCCAP implementation in order to measure the change in resilience that the project brought about. This questionnaire and method were both based on the Salomon *et al.* (2019) study and associated questionnaire. This method can be repeated for other contexts by tweaking the metrics to be context-specific. The metrics could also be used as indicators, which could provide a way for CEbA projects to be held accountable.

c) *Connecting the previously unconnected CEbA and resilience literature*

Showing that CEbA has the potential to enhance SES resilience in the face of climate change and is a viable strategy to help communities adapt to climate change as well as foster development that is sustainable.

By combining these various contributions, this thesis has demonstrated how CEbA, in conjunction with the seven resilience principles, can enhance SES resilience while at the same time empower communities and use healthy ecosystems to adapt to climate change.

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APPENDIX 1

Table 14 Quantitative resilience questionnaire of the Lesotho SES resilience. Questions were answered based on a Likert scale from 1 (low) to 5 (high) for both before and after the LCCAP implementation. Based on the Salomon et al. questionnaire (2019).

Resilience Principle	**Metric**	**Question**	**Rating Before Project**	**Rating After Project**
Maintain Diversity and Redundancy	Response Diversity and Redundancy	How would you rank the variety of ways in which the Lesotho SES stakeholders respond to abrupt ecological, social, or economic disturbances?	1	2
	Diversity of Livelihoods	How would you rank the variety of occupations in which the community members participate?	1	3
	Diversity of Crops by Small Scale Farmers	How would you rank the relative diversity of crops farmed by the Lesotho SES small scale farmers?	2	4
	Diversity and Redundancy of Managers of an Ecosystem	How would you rank the variety of managers (government, indigenous structures, community members, para-statals and NGOs) and overlap of duties that inform decision making in the Lesotho SES?	3	4
Manage Connectivity	Cross Scale and Cross Sectoral Mechanisms and Links for Information Sharing	How would you rank the quality of links between the diverse stakeholder groups of the Lesotho pilot community SES in terms of information sharing?	2	4
	Connecting Groups	How connected are ALL the groups involved in the pilot Lesotho communities?	2	3
	Wildlife Connectivity	How would you rank the quality of wildlife nodes and the links between them?	3	4
Manage Slow Variables and Feedbacks	Identifying the Key SES Slow Variables and Feedbacks	How would you rank the extent to which key Lesotho SES slow variables and feedbacks have been identified and mapped?	2	5
	Understanding of Gradual Changes	How would you rank decision-makers' understanding of gradual, long-term changes along the pilot communities (e.g. Slow changes in vegetation cover, people's values etc…)?	1	5
	Decisions Updated with New Information	How would you rank the level to which new information about the system is used in decision-making?	2	4
	Ability of Managers to Respond to Key Changes	How would you rank the ability of managers to respond to important changes (ecological, economic, & social)?	3	4
Foster Complex Adaptive Thinking	Acknowledging that SES are Based on a Complex and Unpredictable Web of Connections and Interdependencies	How would you rank the pilot community's decisions and methods in terms of incorporating the understanding of the complex and unpredictable nature of interdependent SES components?	2	3

	Willingness to Embrace Change	How would you rank the willingness to embrace change in the Lesotho SES pilot communities?	2	4
	Preparedness to Cope with Unexpected Events	How would you rank the preparedness of the pilot communities to cope with unexpected events?	1	3
	Scenario Building	How would you rank the scenario building in the management of the Lesotho SES?	1	4
Encourage Learning	Innovation and Willingness to Experiment	How would you rank innovation (Experimentation) in the management of the Lesotho SES?	1	5
	Sharing of Scientific, Local and Traditional Resources	How would you rank communication and the sharing of resources (data, research reports and modeling tools) across authority groups of the Lesotho SES pilot communities?	1	5
	Learning from the Past, Crisis and Mistakes	How would you rank the ability of authority groups and community members to learn from previous mistakes and crises?	2	4
	Monitoring and Evaluation	How would you rank the monitoring and evaluation of key SES variables?	2	4
Broaden Participation	Amount and Type of Participating Groups	How would you rank the level of participation of all users in decision-making?	2	4
	Methods of Participation	How would you rank the number of meaningful ways that different groups participated in decision-making and incorporating decisions?	2	4
	Building Trust	How would you rank the level of trust among ALL groups of the Lesotho SES?	2	3
	Building Capacity for Participation	How would you rank the capacity of all groups to participate in meaningful ways?	2	4
	Providing Incentives for Participation	How would you rank the efficacy of incentives put in place to encourage participation of ALL groups?	2	5
Promote Polycentric Governance	Distribution of Governing Power	How would you rank the level of power distribution among ALL Lesotho SES groups?	3	5
	Transparency and Accountability	How would you rank the transparency and accountability of decisions made in the Lesotho SES?	2	3
	Building Capacity for Self-Organization	How would you rank the potential of community members to self-organise?	1	3
	Bridging Organisations	How would you rank the quality of bridges connecting ALL the Lesotho SES groups?	1	3