The Integration of Disaster Risk Reduction and Climate Change Adaptation Strategies into Wetlands Management in the Eastern Free State, South Africa

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THE INTEGRATION OF DISASTER RISK REDUCTION AND CLIMATE CHANGE ADAPTATION STRATEGIES INTO WETLANDS MANAGEMENT IN THE EASTERN FREE STATE, SOUTH AFRICA

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DECLARATION

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

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Johanes Amate Belle   Date

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ABSTRACT

This research examined the integration of disaster risk reduction and climate change adaptation strategies into wetlands management in the eastern Free State in South Africa. The main identified problem was the continuous degradation of wetlands under changing environmental conditions characterised by increasing disaster risks, including risks associated with climate change. Well-managed wetlands mitigate disaster risks and climate change impacts. The main research question was: "Can integrating disaster risk reduction and climate change adaptation principles and practices into wetlands management promote wetlands resilience for sustainable ecological benefits in the eastern Free State?" The aim of the study was to develop a holistic wetlands management framework that promotes wetland resilience under changing environmental conditions. Resilient wetlands provide sustainable ecological services that support local communities.

The study used a systems thinking approach and is well-articulated in the emerging paradigm of ecosystem-based disaster risk reduction and climate change adaptation (Eco-DRR/CCA). A combination of four frameworks were necessary given the multidisciplinary nature of the research involving environmental management, disaster management and climate change science. The post-positivist and the interpretivist philosophies blended well in this study which combined social and natural sciences. A mixed research method approach was used. Stratified random sampling and convenient sampling was used to select 95 mostly valley-bottom wetlands in the study area. Valley-bottom wetlands are the dominant wetlands in the study area. Data were collected using questionnaires (176 wetland users), interviews (30 specialists), field observations (21 wetlands) and secondary data (from two weather stations). The data were analysed using Microsoft Excel, the Statistical Package for Social Sciences (SPSS) and thematic analysis using simple descriptive statistics. Triangulation, experts' inputs and pilot studies added credibility to the collected data.

The main conclusions were that wetlands, especially those in communal land, were very vulnerable to degradation. This vulnerability is because of poor comprehension of wetland functions and values, ignorance and problems associated with the legal and institutional arrangement for wetlands management in South Africa. There is no national wetland policy and the implementation of related legislations is not effective. There is poor coordination of wetland-stakeholders in the area. The activities of the various Expanded Public Work Programmes (EPWPs) sometimes overlap and are not properly coordinated. Wetlands were poorly managed, especially communal wetlands where poor land-use systems, overgrazed wetlands, and lack of management plans were identified. Communal wetlands are therefore not very effective in mitigating the common risks of droughts, veld fires and floods in the area. However, wetlands in protected areas and many in private commercial farms were in a good ecological state, but they also require constant monitoring as head cut erosion and the presence of alien and invasive species are still visible.

The main recommendations include that the government of South Africa, through the Department of Environmental Affairs, should formulate an effective and implementable national wetland policy that will speak directly and specifically to wetland issues. The government should also unify the control of the Extended Public Works Programmes (EPWPs) under one umbrella structure and improve the allocation of both human and financial resources to these EPWPs. There is a need for proper coordination of wetland stakeholders in the area and the provincial wetland advisory forum should be more effective. Education and creating awareness for wetland functions, values and management will be key to ensure the wise and sustainable management of wetlands. To build wetland resilience in the area, an Integrated Wetland Management Framework (IWMF) was proposed to manage wetlands from a holistic perspective, unlike the reactive approach that was dominant in the past. The IWMF integrates disaster risk reduction and climate change adaptation tools and strategies. Further research was recommended for the longitudinal testing of the framework that will be aided by the development of other quantifiable indicators. Finally, a study to quantify the soil organic matter (SOM) of wetlands in the study area should be conducted to investigate opportunities for carbon trading as a way of reducing greenhouse gas emissions and conserving wetlands.

KEY CONCEPTS

Ecosystems, environmental management, eastern Free State, climate change adaptation, disaster risk reduction, resilience, vulnerability and wetlands

OPSOMMING

Hierdie navorsing ondersoek die integrasie van ramprisikovermindering en klimaats-veranderingaanpassingstrategieë in vleilandbestuur in die Oos-Vrystaat in Suid-Afrika. Die belangrikste probleem wat geïdentifiseer is, was die voortdurende agteruitgang van vleilande te midde van veranderende omgewingstoestande wat gekenmerk word deur die verhoging van ramprisiko's, insluitende risiko's wat verband hou met klimaatsverandering. Goedbestuurde vleilande versag ramprisiko's en die impak van klimaatverandering. Die hoofnavorsingsvraag was: "Kan die integrasie van ramprisikovermindering en die beginsels en praktyke van klimaatsveranderingaanpassings in die bestuur van vleilande die veerkragtigheid van vleilande vir volhoubare ekologiese voordele in die Oos-Vrystaat bevorder?" Die doel van die studie was om 'n holistiese vleilandbestuursraamwerk te ontwikkel wat die herstel van vleilande bevorder te midde van veranderende omgewingstoestande. Herstelde vleilande bied volhoubare ekologiese moontlikhede wat plaaslike gemeenskappe kan ondersteun.

Die studie volg 'n sisteemdenkebenadering en is goed verwoord in die opkomende paradigma van ekosisteme gebaseer op ramprisikovermindering en klimaatsveranderingaanpassing (Eco-DRR/CCA). 'n Kombinasie van vier raamwerke was nodig, gegewe die multidissiplinêre aard van die navorsing met betrekking tot die omgewingsbestuur-, rampbestuur- en klimaatsveranderingwetenskappe. Die post-positivistiese en die interpretivistiese filosofieë is goed vermeng in hierdie studie wat sosiale en natuurwetenskappe gekombineer. 'n Gemengde navorsingsmetodebenadering is gebruik, saam met gestratifiseerde steekproefneming en 'n gerieflikheidsteekproef, om 95 meestal vallei-bodem vleilande in die studie-area te kies. Vallei-bodem vleilande is die dominante vleilande in die studie-area. Data is ingesamel met behulp van vraelyste (176 vleilandgebruikers), onderhoude (30 spesialiste), veldwaarnemings (21 vleilande) en sekondêre data (uit twee weerstasies). Die data is ontleed met behulp van Microsoft Excel, die “Statistical Package for Social Sciences” (SPSS) en tematiese analise met behulp van eenvoudige beskrywende statistiek. Triangulering, insetkundiges en loodsstudies het geloofwaardigheid verleen aan die data wat ingesamel is.

Die belangrikste gevolgtrekkings was dat vleilande, veral dié op kommunale grond, baie kwesbaar is vir agteruitgang as gevolg van 'n gebrek aan begrip van vleilandfunksies en -waardes. Hierdie kwesbaarheid is weens 'n gebrek aan begrip van vleilandfunksies en -waardes, asook onkunde en probleme wat verband hou met die wetlike en institusionele reëlings vir vleilande in Suid-Afrika. Daar is geen nasionale vleilandbeleid beskikbaar nie en die implementering van verwante wetgewing is nie doeltreffend nie. Die aktiwiteite van die

verskillende uitgebreide openbarewerkeprogramme oorvleuel soms en word nie behoorlik gekoördineer nie. Vleilande word swak bestuur, veral kommunale vleilande waar swak grondgebruikstelsels, oorbeweide vleilande, en 'n gebrek aan bestuursplanne geïdentifiseer is. Gemeenskaplike vleilande is dus nie baie effektief in die verligting van die algemene risiko's van droogtes, veldbrande en oorstromings in die gebied nie. Alhoewel vleilande in beskermde gebiede en op privaat kommersiële plase in 'n goeie ekologiese toestand was, benodig hulle ook konstante monitering omdat ‘head cut’-erosie en die teenwoordigheid van uitheemse en indringerspesies nog sigbaar is. Swak koördinering van belanghebbendes in die vleilandgebiede is ook as 'n probleem geïdentifiseer.

Die belangrikste aanbevelings sluit in dat die regering van Suid-Afrika, deur die Departement van Omgewingsake, 'n doeltreffende en implementeerbare nasionale vleilandbeleid moet formuleer wat vleilandkwessies direk en spesifiek sal aanspreek. Die regering moet ook die beheer van die openbarewerkeprogramme onder een sambreelstruktuur verenig en ook aandag gee aan die verbetering van die toekenning van beide menslike en finansiële hulpbronne aan hierdie openbarewerkeprogramme. Daar is 'n behoefte vir behoorlike koördinering van vleilandbelanghebbendes in die gebied en die provinsiale vleilandadviesforum behoort meer effektief te funksioneer. Onderrig en bewusmaking vir vleilandfunksies, -waardes en -bestuur sal die sleutel tot die wyse en volhoubare bestuur van vleilande verseker. Om vleilandherstel in die gebied op te bou, is 'n geïntegreerde vleilandbestuursraamwerk voorgestel om vleilande vanuit 'n holistiese perspektief te bestuur, in teenstelling met die reaktiewe benadering wat in die verlede oorheersend was. Die geïntegreerde vleilandbestuursraamwerk integreer hulpmiddele en strategieë vir ramprisikovermindering en klimaatsveranderingaanpassing. Verdere navorsing is aanbeveel vir die longitudinale toetsing van die raamwerk met behulp van die ontwikkeling van ander kwantifiseerbare aanwysers. Ten slotte is aanbeveel dat 'n studie onderneem word om die organiese inhoud van vleilande in die studie-area te kwantifiseer om geleenthede vir koolstofhandel te ondersoek as 'n manier om kweekhuisgasvrystellings te verminder ter wille van die bewaring van vleilande.

SLEUTELKONSEPTE

Ekosisteme, omgewingsbestuur, Oos-Vrystaat, klimaatsveranderingaanpassing, ramprisikovermindering, herstelvermoë, kwesbaarheid en vleilande

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

ACC	Africa Conservation Centre
ACCRA	Africa Climate Change Resilience Alliance
BBC	Birkmann, Bogardi and Cardona Model
CARA	Conservation of Agricultural Resources Act
CBD	Conventional on Biological Diversity
CCA	Climate Change Adaptation
CDC	Centre for Disease Control
CEM	Centre for Environmental Management
CHESM	Coupled Human−Environment System Model
CMS	Conservation of Migratory Species
CNRD	Centre for Natural Resources Development
CoGTA	Department of Cooperative Governance and Traditional Affairs
COP	Conference of Parties
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
DESTEA	Department of Economic, Small Business Development, Tourism and Environmental Affairs
DETEA-FS	Department of Economic Development, Tourism and Environmental Affairs, Free State Province
DFID	The UK Department for International Development
DiMTEC	Disaster Management Training and Education Centre for Africa
DoE	Department of Education
DRDLR	Department of Rural Development and Land Reform
DRR	Disaster Risk Reduction
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation
EbA	Ecosystem-based Adaptation
Eco-DRR/CCA	Ecosystem-based Disaster Risk Reduction and Climate Change Adaptation
EEA	European Environment Agency
EERI	Environmental Emergency Risk Index
eFS	Eastern Free State
EIA	Environmental Impact Assessment

EMP	Environmental Management Plan
EPA	United States Environmental Protection Agency
EPI	Environmental Performance Index
EPWP	Extended Public Works Programmes
ERA	Environmental risk assessment
EVI	Environmental Vulnerability Index
EWT	Endangered Wildlife Trust
GDP	Gross Domestic Product
GWP	Global Water Partnership
HFA	Hyogo Framework for Action 2005–2015
IAPs	Invasive Alien Plants
IDNDR	International Decade of Natural Disaster Reduction
IEM	Integrated Environmental Management
IEMP	Integrated Environmental Management Plan
IFRC	International Federation of Red Cross and Red Crescent Society
InfoRM	Index for Risk Management
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
IWMF	Integrated wetland management framework
JEU	Joint UNEP/OCHA Environment Unit
MA	Millennium Ecosystem Assessment
MDGs	Millennium Development Goals
MOVE	Methods for the improvement of vulnerability assessment in Europe
MWP	Mondi Wetland Project
NDMF	The South Africa National Disaster Management Framework
NEMA	National Environmental Management Act
NFEPA	National Freshwater Ecosystem Priority Areas
NGOs	Non-governmental organisations
NRMPs	National Resources Management Programmes
NSTC	National Science and Technology Council
NWA	National Water Act
PAR	Pressure and Release Model
PEDRR	Partners for Ecosystems and Disaster Risk Reduction
PfR	Partners for Resilience
RCPs	Representative Concentration Pathways
RCS	Ramsar Convention Secretariat
RDP	Rural Development Programme

RSS	The Royal Society of Science
RVA	Risk and vulnerability assessment
SADC	Southern African Development Community
SANBI	South Africa National Biodiversity Institute
SAWS	South African Weather Service
SDGs	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SFDRR	Sendai Framework for Disaster Risk Reduction 2015-2030
SPSS	Statistical Package for Social Sciences
StatsSA	Statistics South Africa
TEEB	The Economics of Ecosystems and Biodiversity
UCI	University of California, Irvine
UFS	University of the Free State
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNESCO	United Nations Education, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children Emergency Fund
UNISDR	United Nations International Strategy for Disaster Reduction
USEPA	United States Environmental Protection Agency
WCRAI	Wetland Classification and Risk Assessment Index
WESSA	Wildlife and Environment Society of South Africa
WftC	Working for the Coast
WfW	Working for Water
WfWetlands	Working for Wetlands
WI	Wetlands International
WMO	World Meteorological Organization
WoF	Working on Fire
WRA	Wetlands risk assessment
WRVA	Wetland risk and vulnerability assessment
WWF	World Wildlife Fund

LIST OF CHEMICAL SYMBOLS AND UNITS OF MEASURE

°C	degrees Celsius
CFCs	chlorofluorocarbons
CH_4	methane
CO_2	carbon dioxide
$GTCO_2$	gigatons carbon dioxide
HFCs	hydrofluorocarbons
km	kilometre
m	metre
N_2O	nitrous oxide
NF_3	nitrogen trifluoride
PPCs	perfluorocarbons
SF_6	sulphur hexafluoride

GLOSSARY OF TERMS AND CONCEPTS

Biodiversity

The richness in living organisms from terrestrial, marine and other forms of aquatic ecosystems that exist in ecological complexes and show diversity within species, between species and the whole ecosystems (UN, 1992). Biodiversity has two components which are the amount of genetic variability among individuals within the same species and the number of species within a community of organisms (Tietenberg and Lewis, 2012).

Biologically diversified ecosystems such as wetlands provide better ecosystem services that sustain the livelihoods of the rural poor. These rural poor may not be aware of the importance of conserving these ecosystems, hence massive education and awareness is important (Letšela, 2008). Conservation, wise and sustainable use, and fair distribution benefits, are the pinnacle in managing biodiversity (DEAT, 1998).

Wetlands contain a unique assemblage of plant species due to the presence of much water and soil nutrients. These plants provide food and shelter to many animals and birds, many of which are threatened, e.g. the White-wing Flufftail or Wattle Crane. It is important to conserve wetlands for their richness in biodiversity.

Capacity

Capacity or coping capacity is the sum of the strengths, skills and assets that are available within a community, society, organisation or a system that can be used to achieve set goals, which in this case will be to reduce vulnerability to disaster risks (UNISDR, 2009).

Capacity is the anti-thesis of vulnerability and the increase in one reduces the other. Coping capacity will include good physical infrastructure, well-functioning institutions, strong social networks, diversified economic activities, educated and skilled people as well as collective attributes like good leadership and management that are used to address shocks. Coping capacities assist households and communities to prepare for, prevent, mitigate, withstand, cope with and to quickly recover from a disaster. Available coping capacities reduce vulnerability and therefore the impacts of disaster risks (De Groeve *et al*., 2014).

Capacity is often used as a synonym to resilience (Coppola, 2011; IFRC, 2013; Wisner *et al.*, 2012). Despite their close relationship, resilience is a stronger and broader word than capacity (Twigg, 2009; UNISDR, 2005, 2009). The position in this study is that resilience is stronger and broader than capacity with the understanding that, while capacity may be addressing short term specific shocks, resilience prepares the community or system against long term and multi hazards. There is therefore coping capacity in resilience.

In wetlands management, the term 'adaptive capacity' is more relevant. Given time and appropriate conditions, wetlands have inherent qualities to adapt to stressors, except where the wetland is destroyed and overwhelmed by the stressor. Sometimes, wetlands rehabilitation facilitates these adaptive capacities.

Climate change

A change in the state of the climate that can be identified (for example, by using statistical tests involving changes in the mean and/or the variability of its properties), and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces, or due to persistent anthropogenic-related changes in the composition of the atmosphere or in land use (IPCC, 2007, 2012). This definition is aligned with the definition that has been adopted by the United Nations Framework Convention on Climate Change (UNFCCC) in that both the IPCC and the UNFCCC attribute climate change to both natural and anthropogenic factors, but UNFCCC ascribe current climate change more to anthropogenic factors.

While some scientists doubt any significant change in the current world climate and therefore prefer the term 'climate variability', the majority of scientists from around the world who make up the IPCC, are of the view that the current world climate is changing very fast due to anthropogenic factors. This rapid change in climate has resulted in the increase in the frequency and intensity of weather related extreme events like floods and droughts (see Chapter 7).

Climate change adaptation

CCA can be defined as the adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, and thus moderate harm or exploit beneficial opportunities as a result of the change (IPCC, 2012). Adaptation involves reducing risk and vulnerability; seeking opportunities; and building the capacity of nations, regions, cities, the private sector, communities, individuals, and natural systems to cope with climate impacts. CCA also involves mobilising local capacity so that they can effectively implement decisions and actions (Tompkins *et al*., 2010 in IPCC, 2014). Climate risks and vulnerability assessments help to identify adaptation needs and the types of needs provide a foundation for selecting adaptation options (IPCC, 2014). Adaptation needs include biophysical, social, institutional, engagement with private sector, information, capacity, and resource needs. While most structural adaptation measures may be very expensive for developing countries, natural and cheap adaptation strategies could be implemented through maintaining healthy ecosystems such as wetlands.

Climate change mitigation

Climate change mitigation are actions aimed to reduce greenhouse gas emissions and to enhance sinks aimed at reducing the extent of global warming (IPCC, 2007; Southern African Development Community [SADC], 2010). Climate change mitigation measures may include improving energy efficiency, enhanced use of alternative renewable sources of energy, adoption of cleaner production technologies, enhancing carbon sequestration and reducing emissions from deforestation, forest degradation and unsustainable land use practices (SADC, 2010). Wetlands, especially peat wetlands, perform an important function in carbon sequestration and can significantly influence climate change depending on how they are managed.

Disaster

A disaster is a serious disruption to the lives and livelihood systems of a society, community or system because of their vulnerability to the impact of a hazard, or a combination of hazards and results in loss of life, property, livelihoods and causing serious environmental damages on a scale which overwhelms the capacity of those affected to cope without outside assistance (UK DFID, 2014; UNISDR, 2009). A disaster is therefore different from any usual event in that the event must overwhelm the coping capacity of the affected community. All disasters are therefore usual or emergency events, but not all emergency events are disasters. Disasters affect a community, not an individual. This distinction is important for the declaration of a disaster.

The combination of hazards, vulnerability and the inability of a community to reduce and cope with real or potential negative consequences of a calamitous event, result in a disaster. Vulnerable communities lack resilience that will enable them to cope, resist, absorb and recover timeously from the negative effects of a calamitous event (Carter, 2008; Coppola, 2011; IFRC, 2013; Wisner *et al.*, 2012). A disaster is therefore a product of hazard and vulnerability on a community that lacks the needed coping capacities and by reducing vulnerability, disasters can be averted. The term ‘disaster’ only applies when people, their properties, their livelihood and their environment is affected. For example, an earthquake which happens in the middle of the ocean, cannot be considered as a disaster no matter its intensity and magnitude if it has no impact on humans or their livelihoods. EM-DAT (the main international data base on disasters) specifies that for a hazard event to be considered a disaster there should be at least:

- 10 or more people reported killed;
- 100 people reported affected;
- a declaration of a state of emergency;
- a call for outside or international assistance (EM-DAT, 2013; De Groeve *et al*., 2014).

The above requirements apply mainly to major disasters that are captured by EM-DAT, but the smaller events that affect fewer and very vulnerable groups and which may have high cumulative negative impacts are often missed by EM-DAT and other international-disaster capturing organisations. Small-scale and slow onset disasters which are often not captured in the international data bases and which are often not funded, have higher cumulative negative impacts and constitute higher percentage losses in developing countries than in the more developed countries (UNISDR, 2015). Different countries with good disaster policies have their laid down policy of declaring an event as a disaster and classifying disaster into various scales. For example, in South Africa, the National Disaster Management Act, Act 57 of 2002, uses the same definition quoted above, but has its own criteria of declaring an event as a disaster and divides disasters into local, provincial, national and even regional disasters (RSA, 2002).

Disasters are broadly divided into two groups: as natural and man-made or technological disasters based on the origin of the hazard (EM-DAT, 2013). **Natural hazards** are rapid or slow onset natural events that can be **geophysical** (examples include earthquakes, landslides, tsunamis and volcanic eruptions), **hydrological** (avalanches and floods), **climatological** (heatwaves, drought and wildfires), **meteorological** (cyclones and storms/wave surges) or **biological** (disease epidemics and insect/animal plagues)[1] (IFRC, 2013).

The fact that there is always a human contribution in natural hazards (like settlement in floodplains that may result in flood disasters or deforestation that may provoke drought disasters) makes many disaster management practitioners to argue that there is no pure natural disaster, but instead prefer to use the term **'socio-natural disasters'** to account for human contribution to naturally occurring events that end up in disasters. Also, a disaster is often the product of a hazard and vulnerability; the latter being the product of social, economic, cultural, institutional, political and even psychological constructs, all of which are not natural (UNISDR, 2004 in Dudley *et al.*, 2015). Besides, natural hazards have their pathways and it is by choice or lack of choice that people settle or find themselves in pathways of hazards, e.g. informal settlements in floodplains. It is the way then that humans manage natural hazards (through measures such as prevention, mitigation, preparedness, land use planning, natural resources management and response to hazards) that natural hazards may eventually

[1] Hyperlinks to the IFRC website are included for easy reference.

become disasters. It can therefore be argued that most often there can be naturally occurring hazards, but they are usually socio-natural disasters.

Technological or **man-made hazards** are events that are **caused by humans** and occur within or close to human settlements. Such events include, among others, complex emergencies/ conflicts, famine, displaced populations, industrial and transport accidents, environmental degradation. (IFRC, 2013). Another term commonly used recently to describe a natural disaster that cascades into a technological disaster is the **NaTech** disasters. NaTech disasters happen when natural hazards such as earthquakes affect industrial facilities that harbour hazardous materials (HAZMAT) such as nuclear power stations, chemical facilities, oil refineries and oil-depots and armouries, causing risks such as fire, explosions, toxic or radioactive release. A classic example of the NaTech disaster is the Great Japan earthquake of 11 March 2011 which resulted into a great tsunami that later led to the melt down of the Fukushima Daiichi Nuclear power plant.

Disaster management

The Disaster Management Act (RSA, 2002:7) defines disaster management as

> *… a continuous and integrated multi-sectoral, multi-disciplinary process of planning and implementing measures aimed at –*
>
> *(a) preventing or reducing the risk of disasters;*
> *(b) mitigating the severity or consequences of disasters;*
> *(c) emergency preparedness;*
> *(d) a rapid and effective response to disasters; and*
> *(e) post-disaster recovery and rehabilitation*.

On the other hand, the IFRC (2013) defines disaster management as “the organisation and management of resources and responsibilities for dealing with all humanitarian aspects of emergencies, in particular preparedness, response and recovery in order to lessen the impact of disasters.” (IFRC, 2013).

The two definitions above have much in common, but that of the South Africa Disaster Management Act is easy to understand as it is closely linked to the disaster management continuum or cycle. Wetlands are also affected by disasters that can be managed using the disaster management principles.

Disaster risk

Disaster risk is the potential loss in lives, livelihoods, assets, services or sustaining injuries, due to the impact of a hazard which could affect a particular community or society (United Nations Children Emergency Fund [UNICEF], 2011b). Disaster risk is a product of exposure, vulnerability, coping capacity and a hazard. According to Syed (2013), disaster risk is the likelihood of suffering harm or loss due to a hazardous event. The exposure of people and their assets globally has increased faster than the reduction in vulnerability and this has provoked new risks with higher disaster losses. These emerging trends have serious economic, social, cultural, environmental and health impacts in the short, medium and long term, especially in local communities (UNISDR, 2015).

Many real and potential losses from disaster risk may be difficult to quantify but knowledge from the prevailing hazards, patterns of population and socio-economic development are used to assess and mapped various risk scenarios for effective planning. The UNISDR (2015) lists the following as some of the important disaster risk drivers:

- Poverty and inequality.
- Rapid and unplanned urbanisation.
- Climate change and variability.
- Poor land use and management.
- Rapid demographic changes.
- Weak institutional arrangement.
- Poor governance.
- Non-risk informed policies and programmes.
- Lack of regulations and incentives for private DRR investments.
- Lack of integration of DRR into business management practices.
- Complex supply chain.
- Limited availability of technology.
- Unsustainable use of natural resources.
- Declining or degradation of ecosystems.
- Pandemics and epidemics.
- Lack of preparedness for effective response and Build Back Better during post-disaster recovery and reconstruction.
- Poor coordination and cooperation at local, national and international level.

Proper management of wetlands help to mitigate or avoid some of these disaster risks.

DISASTER RISK ASSESSMENT

A methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend (UNISDR, 2009). Syed (2013) adds that disaster risk assessment is a participatory process of the application of tools and methodologies to assess the hazards, vulnerabilities and capacities of a community. A participatory risk assessment process means involving the affected community in risk assessment because the local community better understand the hazards they live with, they have local or indigenous coping capacities that should be recognised and tapped into for solutions, they are the first respondents when a hazard strikes and their involvement boosts their psychological coping capacity (UK DFID, 2004; IFRC, 2013; Kaly *et al.*, 2004).

Risk assessments (and associated risk mapping) include a review of the technical characteristics of hazards (location, intensity, frequency and probability), the analysis of exposure and vulnerability (physical, social, health, economic and environmental dimensions) and the evaluation of the effectiveness of prevailing and alternative coping capacities in respect to likely risk scenarios. This series of activities is sometimes known as a risk analysis process (UNISDR, 2009).

It is important to conduct wetland risk assessment as the starting point for effective wetland management measures in the study area.

Disaster Risk Reduction

Disaster risk reduction is the concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment and improved preparedness for adverse events (UNISDR, 2009).

DRR is part of disaster management and it marked the first paradigm shift in the disaster management from an emphasis on disaster response to DRR measures. The tenets of DRR are encapsulated in the Hyogo Framework for Action 2005−2015 of the UNISDR, 2005−2015, which was succeeded by the Sendai Framework for Disaster Risk Reduction 2015−2030 (SFDRR) in March 2015. The ultimate aim of these global frameworks on DRR was and still is to substantially reduce disaster losses in human lives, human property, social, economic and environmental assets of communities and countries and build community resilience to disasters (Syed, 2013; UNISDR, 2005; UNISDR, 2015). See Chapter 8 for details on DRR, while the DRR framework is discussed later in Chapter 2.

Disaster risk reduction plan

A document prepared by an authority, sector, organisation or enterprise that sets out goals and specific objectives for reducing disaster risks, together with related actions to accomplish these objectives and it should be emphasised within a time bound (UNISDR, 2009). It is important to develop wetlands risk reduction plans as proactive measures in managing wetlands. The proposed integrated wetlands management framework in this study incorporates DRR and CCA planning.

Early warning systems

EWS is the set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organisations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss (UNISDR, 2009).

According to Syed (2013) there is no such thing as a sudden crisis, but rather a lack of information and analysis. The author goes on to propose that a single body should be designated with the overall responsibility for the functioning of early warning so that the unit should be accountable for failures or delays in early warnings. The question in South Africa is which unit should this be: The Disaster Management Centres or the South African Weather Bureau for weather related hazards? Early warnings are scarcely applied in environmental management, but it will be important to, for example, dictate early signs of wetland degradation so as to put in place early correctional measures. This study seeks to fill this gap.

Ecosystems

An ecosystem is a dynamic complex of plant, animal, and microorganism communities (the biotic environment) and their non-living physical and chemical communities (abiotic environment) interacting as a functional unit (MA, 2005; Pennington and Cech, 2010). A healthy or sustainable ecosystem means that the ecosystem is still intact and functioning well, and that the demand for the ecosystem services, does not exceed supply in relation to the present and future generations. Healthy ecosystems are made up of diverse plant and animal species, and together with their genetic diversity result in biodiversity (Sudmeier-Rieux and Ash, 2009).

Ecosystems can be of any size from a log, pond, field, lake, forest or even the biosphere (portion of earth with living organisms) (Pennington and Cech, 2010). Any definition of an ecosystem has three implications:

- All parts of the earth are ecosystems of varying sizes. The smaller the ecosystem, the more the interaction between the living and non-living components.
- All components of the ecosystem may not be native of the area, for example, birds fly across the sky, plant seeds are dispersed by air, water, people and animals may introduce instability in the system.

- Ecosystems generally do not have fixed geographical boundaries. These boundaries can be estimated depending on the purpose of the study.

Ecosystem-based adaptation

Ecosystem-based adaptation (EbA) uses biodiversity and ecosystem services as part of an adaptation strategy to assist people and communities to adapt to the negative effects of climate change (UNEP, 2010)

Ecosystem-based disaster risk reduction and climate change adaption

Ecosystem-based disaster risk reduction and climate change adaptation (Eco-DRR/CCA) is an ecosystem approach in DRR and CCA that involves effective strategies for maintaining and restoring well-functioning ecosystems in order to provide livelihoods, mitigate disaster risks, adapt to climate change and promote healthy environments (Renaud *et al*., 2013; UNEP, 2010). EbA and Eco-DRR/CCA have a lot in common and the two are integrated in this study.

Environmental management

Environmental management is the application of skills and techniques on the earth to achieve desired goals of a sustainable society (Fuggle and Rabie, 1992). Environmental management for disaster risk reduction and climate change adaptation does not exist as a formal field of practice, but is often seen as part of the goals set by organisations working on related issues such as ecosystems conservation, sustainable development, disaster risk reduction and climate change adaptation/mitigation (UNEP/UNISDR, n.d.). This study, which focuses on the sustainable management of wetlands for DRR and CCA, was undertaken to bridge the gap mentioned above.

Extreme weather or climate event

The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as ‘climate extremes’ (IPCC, 2012).

Extreme events affect some ecological functions in many wetlands. The ability of some wetlands to store floodwater and prevent drought may be affected, thereby increasing the risk of flood disaster (Wu *et al.,* 2000, in Wang *et al.,* 2008). The deterioration of wetland ecosystems influences adjacent regions and may lead to degeneration of vegetation communities, soil salinisation, soil erosion and drought. Wetland degradation increases their vulnerability to natural disasters, including the negative impacts of climate change (Wang *et al.,* 2008). A vicious cycle is thus created that can be broken through better management of wetlands.

Hazard

A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (UNISDR, 2009).

A hazard event should have the potential to cause injury or loss of life to people, destroy property and/or affect the environment. There are different types of hazards which may vary in their intensity, frequency of occurrence, magnitude or area affected. Some geographical areas are noted for particular hazards. For example, Bangladesh, India and Pakistan are noted for recurrence floods; the pacific islands are noted for earthquakes and sub-Sahara Africa for drought and epidemics. This general picture, however, hides localised and specific details that need to be taken care of in hazard identification and analysis. Wetlands can be affected by natural or human-induced hazards but, in turn, well-managed wetlands can also reduce the impact of many hazards. This cause and effect relationship is highlighted in this research.

Land use planning

The process undertaken by local government authorities to identify, evaluate and decide on different options for the use of land, including consideration of long-term economic, social and environmental objectives, as well as the implications for different communities and interest groups and the subsequent formulation and promulgation of plans that describe the permitted or acceptable uses (UNISDR, 2009). Good land use planning mitigates disasters and reduce risks by discouraging settlements and construction of key installations such as service routes for transport, power, water, sewage and other critical infrastructures in hazard-prone areas (Syed, 2013). In proper land use planning, natural and artificial wetlands can be used to mitigate many hazards and even adapt to climate change. In South Africa, land use planning is regulated by the Spatial Planning and Land Use Management Act (SPLUMA), Act 16 of 2013.

Resilience

Resilience refers to the ability of a system and its component parts, community or society exposed to hazards to anticipate, resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner, through the preservation and restoration of its essential basic structures and functions (UNISDR, 2009; IPCC, 2012). The Rockefeller Foundation (2009), supported by The Royal Society of Science (2014:18), define resilience as "*the capacity of individuals, communities and systems to survive, adapt, and grow in the face of stress and shocks, and even transform when conditions require it".*

Resilience can be seen as the results or consequences of many processes and strategies such as DRR, CCA, integrated environmental management. Major international dialogues such as the Sendai Conference of March 2015 and the Conference of Parties (COP21) in Paris (December 2015) all put more emphasis on building community and system resilience. The aim of this study is to propose a management framework for wetland resilience.

Risk

Risk denotes a combination of the probability of an event and its negative consequences (UNISDR, 2009). Any disaster risk has the element of a hazard or hazards, a certain degree of vulnerability and a degree of lack of coping capacity of a community, system (like a wetland) or organisation. Risk is often expressed in a risk equation as:

RISK = HAZARD × VULNERABILITY/CAPACITY

To better manage wetlands, it is important to assess which risk they face. This is done through a risk assessment.

Risk management

The systematic approach and practice of managing uncertainty to minimise potential harm and loss (UNISDR, 2009). Risk management involves assessing and analysing risk so as to implement strategies and actions to control, reduce, and transfer such risks. Risk management is mostly used by organisations to guide investment decisions and businesses to guide against business risk such as production failure, social unrests, environmental damages and natural hazards. A distinction should therefore be made between risk management and disaster management.

Risk transfer

The process of formally or informally shifting the financial and other socio-economic consequences of risks from one party to another, whereby a household, community, enterprise or state authority will obtain resources from the other party, after a disaster occurs, in exchange for ongoing or compensatory social or financial benefits provided to the other party (Syed, 2013).

Insurance is a well-known form of risk transfer, where coverage of a risk is obtained from an insurer in exchange for ongoing premiums paid to the insurer. Risk transfer can occur formally where governments, insurers, multilateral banks and other large risk-bearing entities establish mechanisms such as re-insurance contracts and catastrophe bonds to help cope with losses in major events (Syed, 2013). Risk transfer can also exist informally within family and community networks where there are reciprocal expectations of mutual aid using gifts or credits.

Risk transfer is important in disaster mitigation and preparedness. Though risk transfer is always strongly encouraged in DRR planning, the practice is seldom adhered to by the poor and most vulnerable group, either due to problems of affordability or that of ignorance. For example, subsistence and small emerging farmers in South Africa are not adequately protected against possible agricultural risks, including those associated with climate change (Jordaan, 2012). Effective education and awareness campaigns, and sometimes state subsidies, to cover items like insurance premiums could boost risk transfer activities. Well-managed wetlands on private farms can reduce the cost of insurance to the farmers as the risk is reduced.

SUSTAINABLE DEVELOPMENT

The United Nations Economic Commission for Europe (UNECE, n.d.: Online) mentions that the term ‘sustainable development’ was first presented by the Brundtland Commission’s report in 1987. This Commission defined sustainable development as "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs". Though this definition is widely used it, however, leaves many unanswered questions such as the interpretation of the concept of development as well as balancing the three pillars of sustainable development which include economic, social and environmental.

Disaster risk may be associated with unsustainable development, for example draining and degrading wetlands which could buffer against floods and droughts. On the other hand, disaster risk reduction could contribute to the achievement of sustainable development through reduced losses and improved development livelihoods (Syed, 2013). DRR is the pinnacle of sustainable development and should be integrated into development policies, programmes and processes. Increase in frequency and intensity of disaster risks which are exacerbated by climate change, will also impede sustainable development (UNISDR, 2015). According to Fuggle and Rabie (1992) there are nine principles on which to build a sustainable society and out of these nine principles, six relate directly to caring for the environment which include wetlands.

VULNERABILITY

The UNISDR (2009) defines vulnerability as *“[t]he characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard.”* The

IFRC (2013) explains vulnerability as the diminished capacity of an individual or group to anticipate, cope with, resist and recover from the impact of a natural or man-made hazard. From another perspective, Syed (2013) is of the view that vulnerability is a set of conditions, which adversely affect the community's ability to prevent, mitigate, prepare for, respond to and recover from hazards. From another perspective, Gitay *et al.* (2011) use the sensitivity and lack of adaptive capacity to explain the vulnerability of natural systems such as wetlands.

Vulnerability is an important and complex concept in both environmental and disaster management. There is no single agreed upon definition of vulnerability (Birkmann *et al*., 2013). Despite the different definitions of vulnerability, there is convergence in that all definitions cited above acknowledge the presence of an adverse event on one side and the lack of means and ways to counteract, resist and overcome the adverse event by a community, asset or system on the other side. This situation supports the Progression of Vulnerability (PAR) model of Wisner *et al*. (2004). The pursuing paragraphs look at vulnerability from the disaster management perspective.

Vulnerability is relative and dynamic and is often associated with poverty, rapid population growth, unplanned urbanisation, climate change, social group, gender, ethnic or other identity and age. Vulnerability may also arise when people are isolated, insecure and defenceless in the face of risk, shock or stress (IFRC, 2013). Vulnerability is influenced by physical, economic, social, environmental and political factors. Generally potential vulnerable groups in any society include the poor, displaced people, migrants, women and children, pregnant and nursing women, unaccompanied children, elderly, sick people and disabled people (IFRC, 2013; UNISDR, 2009; Wisner *et al.,* 2004; Wisner *et al.* 2013).

To determine community vulnerability, it is important to know who are vulnerable, to what threats or hazards and what makes the group or community vulnerable to such threats or hazards. A common tool that is used to determine vulnerability is the risk and vulnerability assessment (RVA) that often includes hazards, vulnerability and capacity assessment (Coppola, 2011; IFRC, 2013; RSA, 2002; UNISDR, 2009; Wisner *et al.*, 2013;)

Vulnerability to most hazards and disasters is gender bias whereby women are more vulnerable to disasters than men. For example, during the Indian Ocean tsunami in 2004, two thirds of the fatalities were women, and in the 2005 earthquake in Pakistan, more women died than men. The reasons for this gender differential disaster impacts are varied and many, but are often linked to the fact that women and men in different cultures and religions have different areas of responsibilities, tasks, freedom of movement, dress codes, and education (MSB, 2009). These dynamics of vulnerability are important to note when conducting a RVA.

The following generic measures can be used to counteract vulnerability:

- Where possible, avoid or reduce the impact of the hazard through prevention, mitigation, prediction and early warning; preparedness.
- Build community capacities to withstand and cope with hazards.
- Address and reduce the root causes of vulnerability, such as poverty, poor governance, discrimination, inequality and inadequate access to resources and livelihoods. These measures are well-elaborated upon in the Progression of Vulnerability and in the Progression of Safety (PAR) model (IFRC, 2013; Wisner *et al*., 2004;).

Risk and vulnerability assessment should be the starting point for any disaster risk management effort at any level.

Chapter 1
OVERVIEW OF THE STUDY

1.1 INTRODUCTION

Disaster risk reduction (DRR) and climate change adaptation (CCA) strategies could easily be integrated into the wise and sustainable management of wetlands to build wetlands resilience. Well-functioning wetlands provide better ecological services to the local community, including services that reduce disaster risks and adapt to climate change impacts. The Free State Province (FS) has about 54 000 wetlands (South African National Biodiversity Institute [SANBI], 2010). Poor wetlands management associated with poor land use, poor institutional and legal arrangements, the effects of climate change and other wetland stressors negatively affect the ecological status of many wetlands, thus compromising their ability to provide ecological services (Gitay *et al*., 2011; Kidd, 2011; Kotze *et al*., 2012; United Nations Environmental Programme [UNEP], 2009). In the same line, the inability of degraded wetlands to provide appropriate ecological services increases the socio-economic and environmental vulnerabilities of the local communities, which in turn negatively affect local livelihoods and community resilience (Costanza *et al*., 2014; Intergovernmental Panel on Climate Change [IPCC], 2014). A complex of dynamics is thus created requiring systems thinking. This study explored better wetlands management options by looking at the possible integration of DRR and CCA principles into a proactive and holistic management of selected wetlands in the eastern Free State (eFS). Such a holistic management approach can only be effective when it is well-understood by the local community and backed by effective institutional and legal frameworks. The legal framework for the management of wetlands in South Africa seems problematic as there is no national wetland policy and ineffective implementation of general environmental related legislations (Keevy, 2011; Kidd, 2011). The aim of the study, therefore, is to develop an integrated framework for wetlands management for the eFS that incorporates DRR and CCA strategies within a better legal and institutional arrangement. Such an integrated framework could henceforth serve as a management tool that will help to improve on wetlands ecological health, promote ecosystem-based disaster risk reduction and climate change adaptation (Eco-DRR/CCA), strengthen the sustainable use of wetlands, promote wetlands biodiversity and foster local livelihoods for development.

The study adopted a multi-disciplinary approach involving ideas from disaster management, environmental management and climate change. A combination of theoretical frameworks from these three disciplines was also used. A hybrid of quantitative and qualitative primary data was generated from selected valley-bottom wetlands (the dominant wetland type) in the eFS. Questionnaires and interviews were also administered to randomly selected stakeholders involved in the management and use of wetlands. These stakeholders included farmers in whose land most of the selected private wetlands were found, the local communities – especially those living around and within the communal wetlands – wetlands experts, disaster management experts and climate change experts in the province. Secondary data were obtained from the South African Weather Service (SAWS) and the data were used to explore the phenomenon of climate change in the area. Extensive literature was reviewed spanning from the global perspective down to the local realities on related themes.

The primary quantitative data collected were analysed using the Statistical Package for Social Sciences (SPSS) from where simple descriptive statistics were generated. At the same time, qualitative data were grouped into emerging themes and used to back up quantitative data analysis. The results are presented in tables, photos, graphs and diagrams. The conclusions and recommendations were based on an extensive literature study, secondary data analysis and findings from the primary investigation. The outcomes of the study are expected to benefit farmers, academics interested in the study of wetlands, environmentalists, disaster management practitioners, water and catchment management utilities, land use planners and of course the end users of wetland services, who are the local communities. The study will help to raise awareness on the value and the beneficial functions of wetlands and this will justify the need for their sustainable use and conservation. This study will also be used for advocacy on the new international emerging paradigm on Eco-DRR/CCA which has a lot of relevance, especially to the rural poor in Africa who are facing serious challenges with increasing disaster risks and the negative impacts of climate change. The study also advocates for systems thinking in managing wetlands. This opening chapter looks at the study area, the research problem, the research questions, research hypothesis, the research objectives and ethical issues in research.

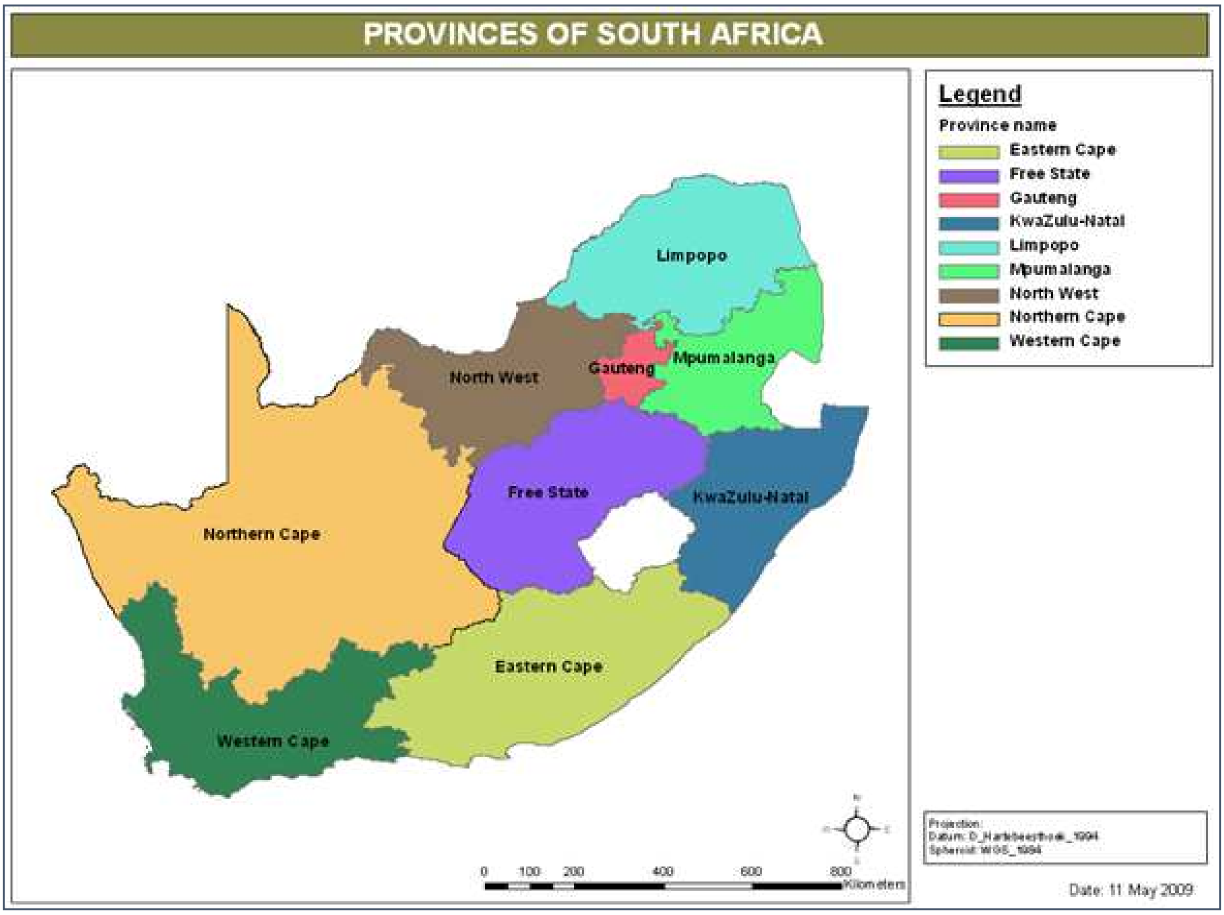
1.2 BACKGROUND OF THE STUDY AREA

The study area is described under various subheadings as discussed below:

1.2.1 Location

This study is located within the FS province which is one of nine provinces that make up the Republic of South Africa (in this study simply referred to as South Africa). Though the focus is on the eastern part of the FS, difficulties in clearly delimiting the eFS as a precise geographic or administrative unit prompted the description of the whole FS Province and then try to narrow down to an artificially delimited eFS.

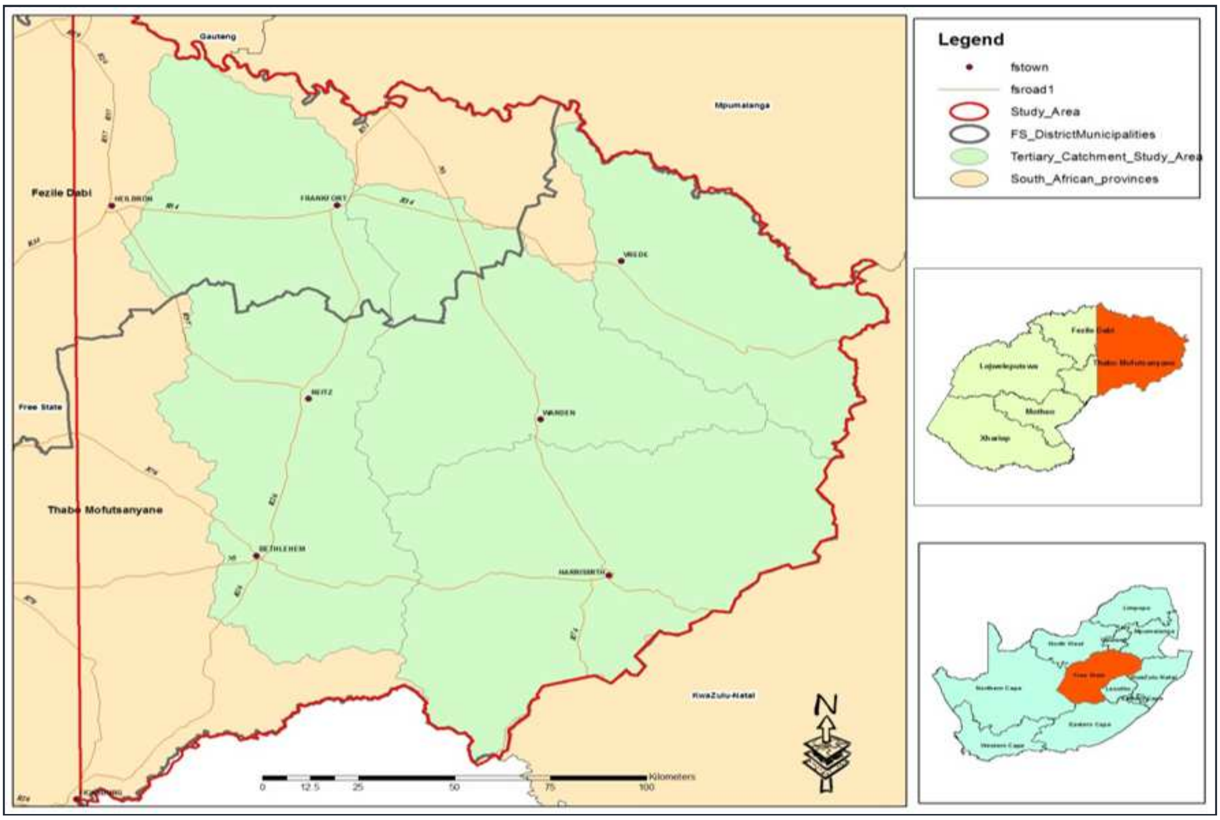
The bean-shaped FS province lies on the inland Africa escarpment with all land surface lying 1 000 m above sea level. The province is bordered in the north by the North West, Gauteng and Mpumalanga Provinces; in the east by the Kingdom of Lesotho and the KwaZulu-Natal Province; in the south by the Eastern Cape Province and in the west by the Northern Cape and part of North West Province (Figure 1.1). The FS is the third largest province by surface area (129 480 km^2 or 10,6% of South Africa's surface area), but the province is the eighth in terms of population in South Africa, only ahead of the Northern Cape Province in terms of number of inhabitants (Statistics South Africa [StatsSA], 2011). The main city in the province is Bloemfontein which is also the judicial capital of South Africa, while other important towns include Bethlehem, Kroonstad, Welkom, Ladybrand, Sasolburg, Wepener and Ficksburg.



Source: Collins (2011)

Figure 1.1 The location of the Free State Province in South Africa

The delimitation of the eFS was arbitrary, but the dividing line closely follows the 28ºE meridian and the 500–700 mm annual rainfall which permits rain-fed agricultural practices. The arbitrary demarcation of the study area also separates the dry grassland in the west from the moist grassland in the east. The dominant type of wetlands in this part of the province are valley-bottom wetlands and the focus was to sample mainly this wetland type. The study area was of sufficient size to include many natural valley-bottom wetlands from which to select a representative sample (Figure 1.2).



Source: Author’s own (2016)

Figure 1.2 The location of the study area in the eastern Free State Province

1.2.2 Local administration

The FS Province has five district municipalities and nineteen local municipalities. Mangaung was added to the list of eight South African metropolitan municipalities. Since this study concentrated on wetlands in the eFS, the most important district in the study area is the Thaba Mofutsanyane District Municipality (Figure 1.3).

Source: Free State Department of Agriculture (n.d.)

Figure 1.3 Free State district municipalities

1.2.3 Climate

A review of the FS climate is preceded by a discussion on the climate of South Africa.

1.2.3.1 South African climate

As a subtropical country (22ºS to 35ºS and 17ºE to 33ºE), South Africa has a predominantly subtropical climate which is under the influence of the high-pressure systems of the subtropical high pressure belt (Department of Science and Technology [RSA DST], 2010). These systems cause air to sink over South Africa which leads to the suppression of the formation of clouds and rainfall. The complex topography and the presence of two oceans also contribute in shaping the South African climate. South Africa, therefore, experiences an astounding variability in weather and climate and this variability poses a challenge for weather prediction, seasonal forecasting and projection of climate change over the country (RSA DST, 2010).

The South Africa rainfall pattern shows a remarkable intra-annual and inter-annual variability. Summer rainfalls are usually below normal during the El Niño years (El Niño events occur every three to seven years) and above normal during La Niña years. There is a general observable increase in aridity from the east to the west of South Africa. The following are also observable:

- The Western Cape mostly receives winter rainfall in the form of frontal rainfall.
- The eastern escarpment and the Highveld mostly receive summer rainfall due to the development of the Intertropical Convergence Zone.
- The western interior, especially the Northern Cape and Eastern Cape, receives autumn rainfall as a result of the northward shift in the Intertropical Convergence Zone and the formation of cloud bands that form west of the region of subsidence.
- Spring rainfall is experienced in the interior of South Africa, following the development of a heat low over the western part of southern Africa that causes thunderstorms to increase eastwards, starting with KwaZulu-Natal before spreading toward the interior. The spring rainfalls are caused by the westerly winds that create 'westerly waves'.
- The easterly winds transport warm air from over the Indian Ocean and the Agulhas current towards the eastern escarpment causing orographic rainfall in the east. A similar phenomenon occurs in the southern escarpment of the Western Cape (RSA DST, 2010).

Generally, most ecological regions of South Africa are dry or semi-arid (Table 1.1).

TABLE 1.1 ANNUAL RAINFALL DISTRIBUTION AND CLIMATE CLASSIFICATION IN SOUTH AFRICA

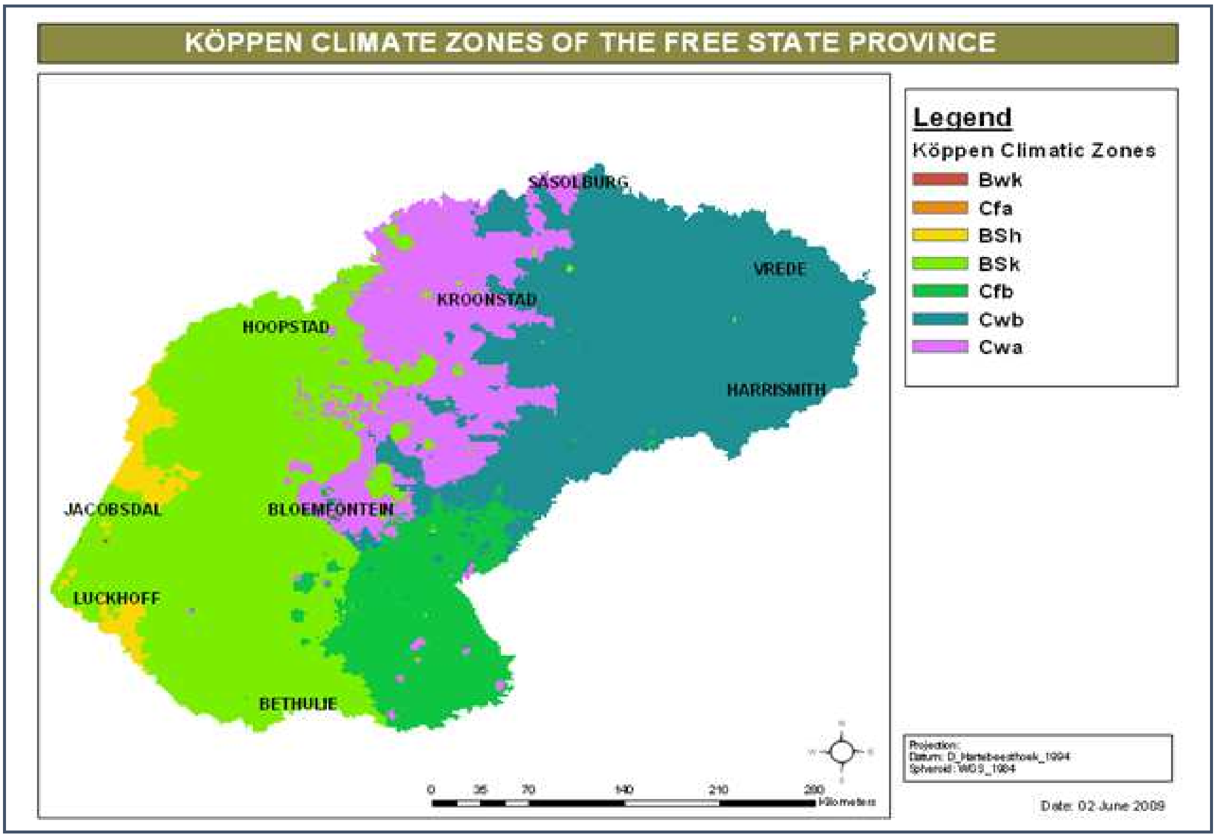
Rainfall	Classification	Percentage of land surface
<200	Desert	22.8
201–400	Arid	24.6
401–600	Semi-arid	24.6
601–800	Sub-humid	18.5
801–1 000	Humid	6.7

Source: Schulze (1997)

South Africa has a warm climate with average annual temperatures above 17 ºC. The southern and eastern escarpments have the lowest temperature due to the higher altitude. The warmest areas are coastal KZN, the Lowveld of KZN and Mpumalanga, the Limpopo valley and the interior of the Northern Cape. The presence of the two oceans helps to moderate the temperatures. The warm Agulhas current warms the eastern coast and makes the temperature higher than the western coast which is washed by the cold Benguela current. Meanwhile, upwelling (meeting of the cold and warm currents) also help to lower the temperature (RSA DST, 2010).

1.2.3.2 Free State climate

The FS has a continental climate with warm to hot summers and cool to cold winters (Collins, 2011; RSA DST, 2010). The eastern part and the high mountain range experiences snowfall, while the western part experiences extremely hot summers. Aridity increases towards the west where evapotranspiration is generally more than precipitation. All precipitation is in the summer (hot) months with occasional afternoon thunderstorms. The climatic situation brings out the problem of water scarcity, thus highlighting the eminent role of wetlands in the province, especially among the farmers in the eFS. Figure 1.4 below shows the general climate in the FS.

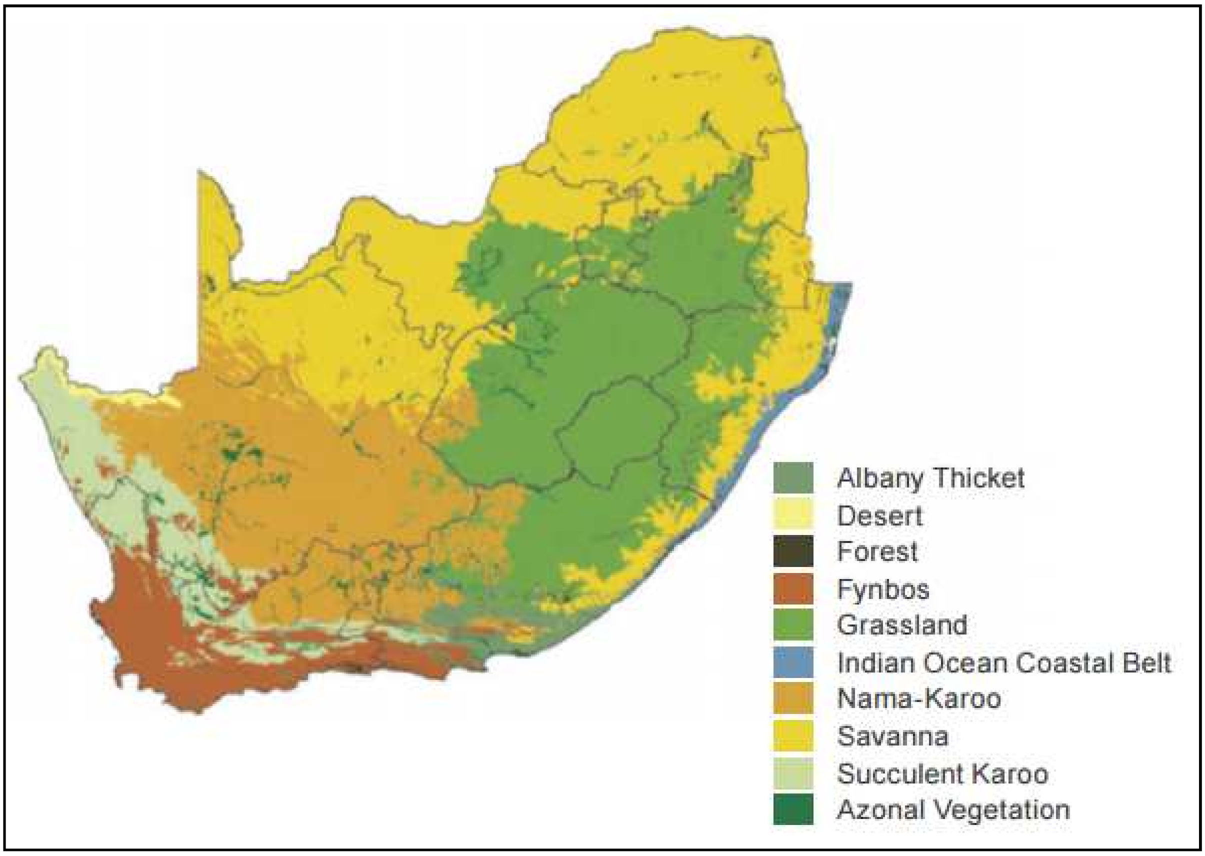


Source: Schulze *et al*. (2006) in Collins (2011)

Figure 1.4 Free State climate zones

1.2.4 Vegetation

Four of the nine vegetation biomes in South Africa (Figure 1.5) occur in the FS. The four vegetation biomes in the FS include the grasslands, savanna, nama-karoo and forests (Figure 1.6). Riparian vegetation is found in patches along sheltered ravines. The grassland biome mostly occurs in the summer rainfall areas with an annual rainfall gradient of 400 mm to more than 1 200 mm per annum and has a temperature gradient ranging from frost-free to snow-bound in winter (Midgley *et al*., 2008 in RSA DEA and SANBI, 2013).

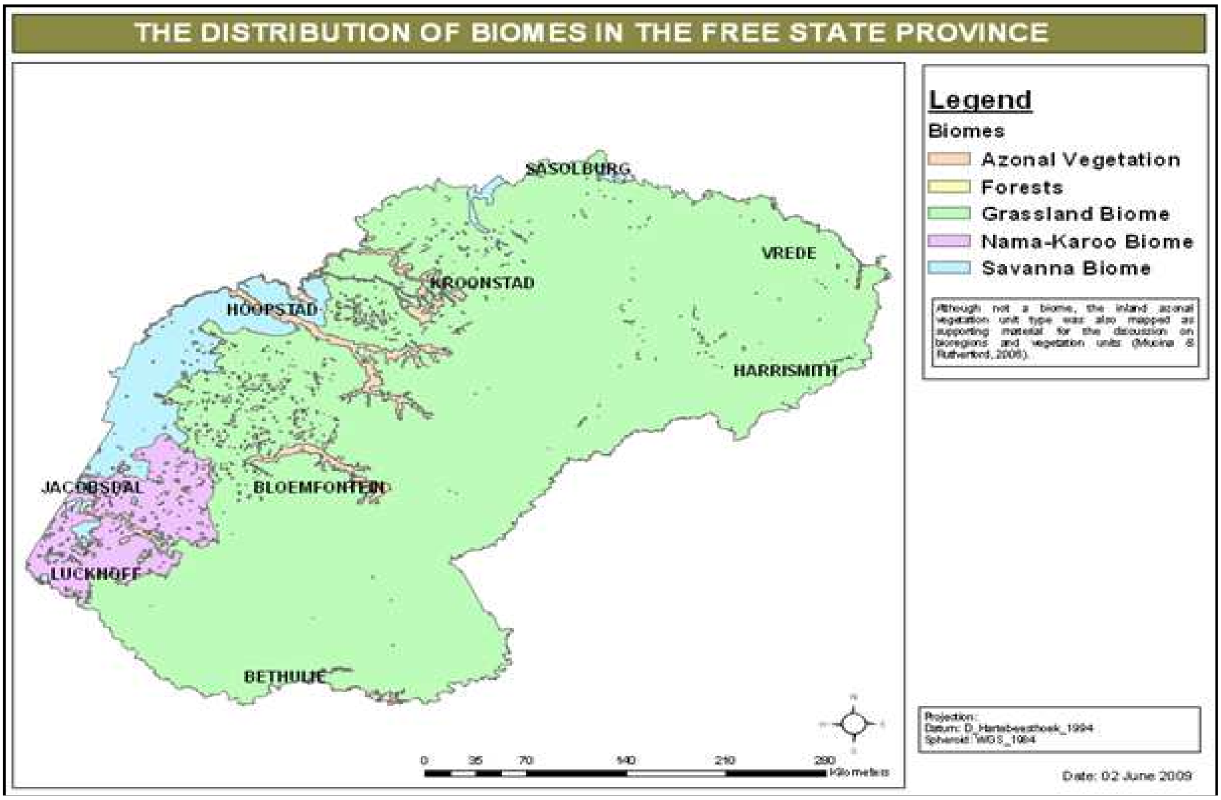


Source: After Cadman *et al*. (2010) in RSA DEA (2013)

Figure 1.5 The biomes of South Africa

The dominant grassland biome in the FS consists of the dry grassland in the west and the moist grassland in the east, separated by the 500–700 mm annual rainfall (Collins, 2011). The moist grassland is further divided into the mesic Highveld grassland, the Drakensburg grassland and the sub-escarpment grassland. The three subdivisions of the moist grassland are mostly influenced by topography.

Based on the threatened status and the protection level of the nine biomes of South Africa, the savannah biome is considered endangered with a low protection status and is the second (after the Indian Ocean Coastal Belt) most vulnerable to land use change (RSA DEA and SANBI, 2013). More serious is the fact that under all climate change scenario projections (low, median and high), the grassland biome is the most threatened, where large portions of it are feared to be replaced by either savannah or potential forest vegetation (RSA DEA and SANBI, 2013). Wetlands play a critical role in conserving this threatened grassland vegetation.



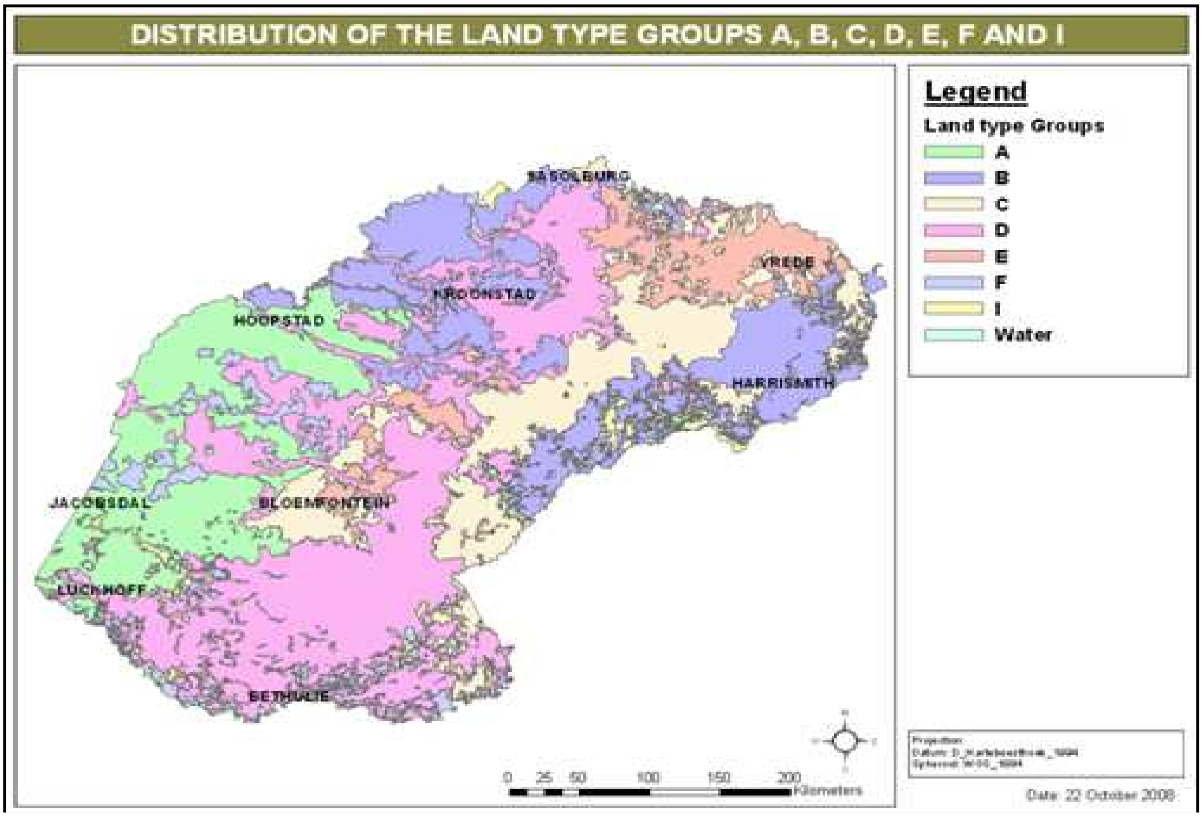
Source: Mucina and Rutherford, 2006 (in Collins, 2011)

Figure 1.6 The vegetation biomes in the Free State

1.2.5 Soil

Soil is normally the thin, uppermost and dynamic layer of the earth crust which supports life (vegetation, micro- and macro-organisms). Five main factors influence the formation of soil (climate, organic matter, relief, parent material and time). These soil-forming factors are sometimes remembered with the mnemonic CLORPT which stands for the first letter of each soil-forming factor (Arbogast, 2011; Reynolds *et al*., 2015; Strahler and Strahler, 2005).

The FS is divided into seven land type groups to which different soil types are described and all these are based on the terrain morphology and the prevailing macroclimate (Land Type Survey Staff, 2004, in Collins, 2011; Hensley *et al*., 2006 in Nel *et al.*, 2011). The land type groups and characteristic soil types are described in Figure 1.6 and Table 1.2 below.



Source: Land Type Survey Staff, 2004 (in Collins, 2011)

Figure 1.7 Land types in the Free State

Only 9% of the soil in the FS province is highly suitable for agriculture, where the Lejweleputswa and Fezile Dabi administrative districts (Figure 1.3) contribute 23.6% and 15.4%, respectively (Department of Economic Development, Tourism and Environmental Affairs, Free State Province [RSA DESTEA-FS], 2012).

TABLE 1.2: A BRIEF DESCRIPTION OF THE DOMINANT SOIL CHARACTERISTICS OF THE LAND TYPE GROUPS IN THE FREE STATE PROVINCE

Land type group	Brief description of associated soils	Area	
		km^2	%
A	Red-yellow, structureless, freely drained soils	21 569	16.7
B	Plinthic catena: upland duplex and margalitic soils – rare	22 786	17.6
C	Plinthic catena: upland duplex and margalitic soils – common	19 536	15.1
D	Duplex soils – dominant	43 954	34.0
E	Dark coloured margalitic clay soils with marked swell-shrink properties	9 992	7.74
F	Shallow soils on rock	7 045	5.4
I	Miscellaneous soils	4 089	3.1

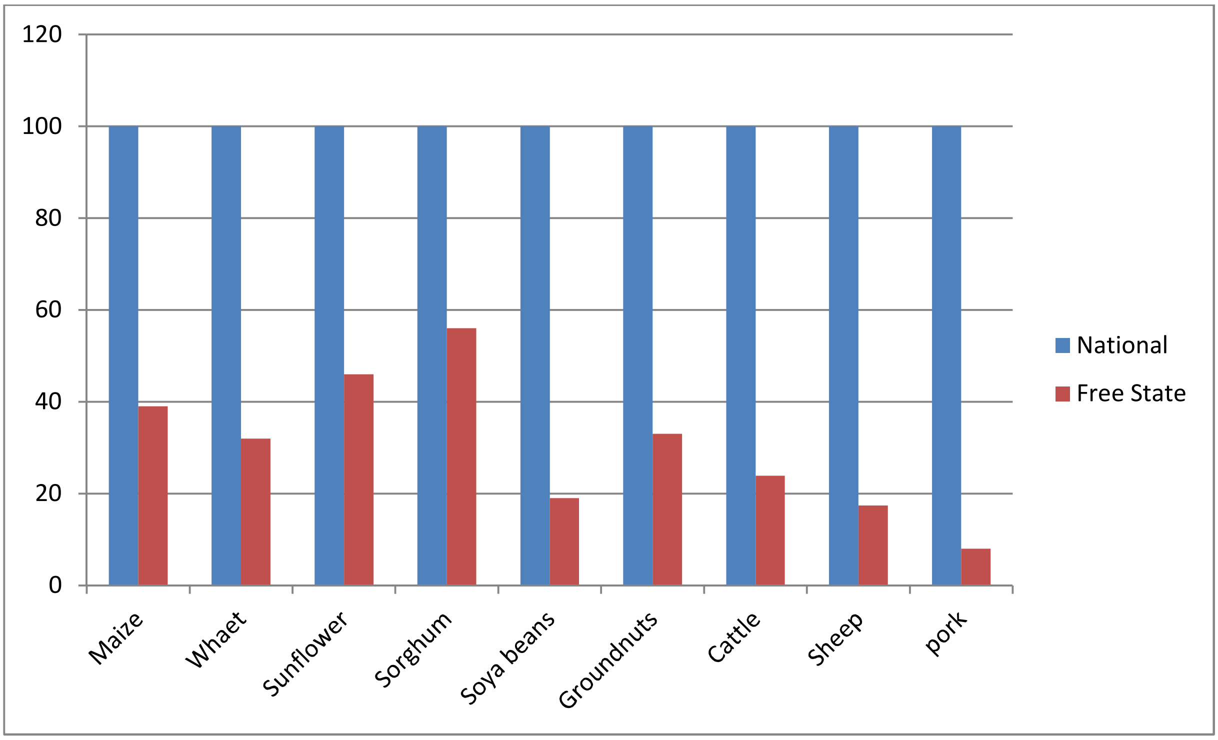
Source: Hensley *et al*., 2006 (in Collins, 2011)

From Figure 1.7 and Table 1.2 above, it can be observed that the eFS is dominated by four main land types and associated soils (B, C, E and I).

1.2.6 The economy

The dominant economic activity in the FS is agriculture. In fact, the FS is said to be the granary or the grain basket of South Africa (SouthAfrica.Info, 2015). About 30 000 farmers in the FS produce 70% of South Africa's grains. Crops cultivated include soya, sorghum, sunflower, wheat, maize, asparagus, potatoes. About 40% of South Africa potatoes come from the FS province, while about 1.2 million tons of cut flowers are exported every year. Ficksburg alone produces 90% of South Africa's cherry crop and has the two largest asparagus factories in South Africa (SouthAfrica.Info, 2015). Cattle and sheep rearing are the main pastural activities in the natural veld and grazing land that covers an area of about 8.7 million hectares (87 000 km^2). Grazing is the dominant land use within the wetlands that are found in the eFS.

About two million hectares of land in the FS are under agricultural production, with only 100 000 ha relying on irrigation (RSA GCIS, 2010/11). Therefore, most farmers in the FS rely on rain-fed agriculture and the wetlands serve as water reservoirs for both arable and pastoral farming. Despite the dominance of rain-fed agriculture, irrigation is the highest water consumer per sector in the province (StatsSA, 2011). Figure 1.8 shows the percentage of the contribution of the province compared to the national agricultural production.



Source: RSA DETEA-FS (2012)

Figure 1.8 Percentage contribution of Free State to selected national agricultural production

Though predominantly an agricultural province, mining (especially gold mining) is the largest contributor to the Gross Domestic Product (GDP) and the largest employer in the FS.

The Free State Consolidated Goldfields, with twelve goldmines, is the largest and produces 30% of South Africa's output in gold and is ranked fifth in the world. The Free State Consolidated Goldfields operates in the three towns of Odendaalsrus, Virginia and Welkom. Besides gold, the petrochemical industry at Sasolburg converts coal into petrochemical products and it is the world's leader in fuel, waxes, chemical and low-cost feedstock production. Silver and uranium are also produced in the FS, while other high technology industries are found in the Province (RSA DETEA-FS, 2012).

1.2.7 Socio-demographics information of the Free State

The total population of the FS is estimated at about 2 759 500 people (mid-year estimate 2011), representing 5.46% of the total population of South Africa (see Table 1.3). The population is dominated by Blacks, followed by Whites and then a few Indians and Chinese (Nicolau, 2006; RSA GCIS, 2010/11; StatsSA, 2001and2011).

TABLE 1.3 FREE STATE DEMOGRAPHICS

Demographics	1996	2001	2007	2011
Population per year				
South Africa	**40 583 573**	**44 818 778**	**48 502 059**	**51 770 560**
Free State	2 604 346	2 706 775	2 773 058	2 759 500
Major age groups				
0–14 years (Young)	820 276	830 228	799 232	798 915
15–64 years (Active)	1 665 427	1 742 128	1 821 832	1 795 919
More than 65 years (Aged)	118 643	134 419	151 994	150 756

Source: Adapted from StatsSA (2011)

As can be seen in Table 1.3, the total population of the FS declined between 2007 and 2011. This can be attributed to a number of factors such as a decline in birth rates, net out-migration and possibly the effect of HIV and Aids. In 2011, the FS topped the reversal of the national gender ratio by having 65.8% males and 34.2% females. This affected the number of married people or people living together which also fell by 2.6% compared to other provinces (StatsSA, 2011). The dominant male farm labourer could partly explain this gender ratio. The unemployment rate (29.8%) in the FS is higher than the national average, which in 2011 was 25.7% (StatsSA, 2011). The arbitrary demarcation of the eFS in this study makes it difficult to isolate socio-demographic information, but generally it is expected to follow the provincial pattern.

1.3 PROBLEM STATEMENT

Welman, Kruger and Mitchell (2005) state that a research problem involves narrowing down the scope of the research topic to a particular research problem for investigation, and in the process, research questions are generated. Though other researchers contend that research problems could also be stated in the form of research questions (Mouton, 2001), in this research, the two are separated to better focus the research on the problems identified about the management of wetlands in the eFS. Four fundamental problems guided this research:

- Many wetlands in the eFS have been degraded, which could be attributed to poor management such as not integrating DRR and CCA into wetland management approaches.
- The degraded wetlands cannot fully perform their ecological functions, which include DRR, CCA, water supply and provision of sustainable livelihoods to the local communities.
- The legal and institutional arrangement for wetlands management is problematic in South Africa and therefore in the study area.
- The human dimension of environmental management and the link between disaster and environmental management has not received enough attention in the study area.

These four fundamental problems directing this research are expanded in detail subsequent paragraphs.

The rate of loss of wetlands is increasing all over the world (Wetlands International [WI], 2015). A realistic estimate is that about 50% of the world's wetlands have been lost. The continuous food demand to feed an increasing world population, settlement, water abstraction together with the increasing cultivation of energy crops like palm plantations in Southeast Asia, put more wetlands in danger of being reclaimed or used unsustainably (Oellermann *et al*., 1994; Verhoeven and Setter, 2010; Wang *et al*., 2008). The increase in intensity and frequency of disaster risks and those associated to climate change also build more pressure on wetlands degradation (Centre for Natural Resources and Development – Partnership on Environment and Disaster Risk Reduction [CNRD/PEDRR], 2013; IPCC, 2014; United Nations Development Programme [UNDP], 2012; United Nations International Strategy for Disaster Reduction [UNISDR], 2013; WI, 2015). Though richer in biodiversity (plants and animal species) than any other ecosystem, wetlands are the most vulnerable to over-exploitation, drainage and conversion (WI, 2015). Wetlands are in fact the fastest declining ecosystems in the world (WI, 2016).

The seriousness of environmental degradation and climate change impacts has touched Christian thinking. The head of the Roman Catholic Church in the world, his holiness Pope Francis, declared 1 September 2015 as a day of prayer for the environment. This ecological conversion and repentance is very significant, not only for the carnal sins of all the Catholic Christians, but also as an acknowledgement of the harm that humanity has caused on the natural environment. It is a call upon Christians and even non-Christians to respect and live in harmony with the natural beauty of God's creations. Pope Francis took his message to the COP21 summit on climate change in Paris, France, in December 2015 (Catholic Link, December 2015). All these point to the fact that humans are abusing the natural environment (including wetlands) through unsustainable land use and this needs informed research as part of the solutions.

Difficulty in valuing wetlands ecological services in monetary terms has led to undervaluation, misunderstanding and misconception among many land users. Wetlands are often seen as unproductive wasteland that breeds and spreads diseases and serves as rubbish dumps (Barbier *et al*., 1997; Pennington and Cech, 2010; The Economics of Ecosystems and Biodiversity [TEEB], 2010; Turpie, 2010). Though this wrong perception is gradually changing, much still needs to be done through evidence-based research, education, training and awareness campaigns. Wetlands are public goods which provide widely dispersed benefits, but because these benefits are not well-understood by citizens and policymakers, protection and conservation of wetlands are increasingly becoming challenging (Spray and McGlothlin, 2004). The human–environment interaction needs some systems thinking. For example, global efforts to eradicate poverty are increasingly receiving a great blow with continuous degradation of ecosystems and this is likely to worsen in the next 50 years, making it unlikely for the international community to meet the Millennium Development Goal (MDG) of reducing poverty and maintaining healthy environments (House of Commons Environmental Audit Committee, 2007). It is now internationally recognised that the total economic value (both marketed and non-marketed) of unconverted wetlands is often greater than that of converted wetlands (Millennium Ecosystem Assessment [MA], 2005). Wetlands are also documented as the most productive ecosystem (Russi *et al*., 2013). The MA (2005) estimates showed that wetlands provide services that are worth US $15 trillion worldwide.

South Africans have historically regarded wetlands as wasteland that are good for nothing but to be reclaimed for other land use (Dini, 2004). Between 35% and 50% of wetlands in major South African catchment areas have been lost or seriously degraded (Kotze, 2008). Part of this problem lies in short-sighted development, poor land management and inappropriate land use (Dini, 2004; Kotze, 2008).

International and national policies do not adequately protect wetlands (Turner *et al.*, 2000). Wetlands were the first ecosystem to receive international attention for their conservation in the Ramsar Agreement of 1971. Despite this agreement, in 2011, the National Biodiversity Assessment revealed that 65% of South African wetland types were under threat (48% critically endangered, 12% endangered and 5% vulnerable). Only 11% of wetland ecosystem types were well-protected, with 71% not protected at all (RSA DEA, 2015). The MA (2005) contend that the degradation and loss of wetlands and its species are happening more rapidly than any other ecosystem. Degradation means that wetland ecosystem services are lost, thus affecting human well-being, especially the well-being of poor people living in low income and low technology countries (MA, 2005). The eFS is not exonerated from this problem stated in the MA of 2005 and highlighted by other researchers. It is therefore high time to take stock of all these issues and change our human–environment management approaches through informed research that adopts a holistic or systems thinking.

The role of healthy ecosystems like wetlands in providing cheap and reliable DRR solutions against natural hazards is internationally recognised (Dudley *et al*., 2015). However, integrating environmental concerns into DRR and CCA strategies at local and national levels has not received adequate attention and practical guidance (Sudmeier-Rieux and Ash, 2009). Priority 4 of the Hyogo Framework for Action (HFA) 2005−2015 – *"Reducing the Underlying Risk Factors"* – touches on environmental degradation as a risk factor, while the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015–2030 which replaced the HFA, maintains that healthy ecosystems and sustainable environmental management are considered key actions and cross-cutting issues in DRR (UNISDR, 2015). The underlying risk factors of disasters are increasing; more people are living in vulnerable areas, such as low-lying coastal areas, steep hillsides, floodplains, near and within communal wetlands in the eFS – most often out of necessity, but sometimes out of choice. The people affected by disasters are often the most dependent on natural resources for their livelihoods and the appropriate management of ecosystems can play a critical role in their ability to prevent, cope with, and recover from disasters (Sudmeier-Rieux and Ash, 2009). More than two billion people (mostly in rural areas) live on less than US $2 per day and many of them depend on natural resources for their well-being. Conserving natural resources such as wetlands can therefore have significant positive gains for these peoples' well-being (UNEP, 2010).

The important role of wetlands in water provision is compromised if they are not well managed. Wetlands are important for South Africa, especially as a dry country. By 2025, South Africa will be among 1 out of 14 African countries that will experience severe water scarcity. Conventional water supply will provide only 1000 cubic metres of water per person per year (Dini, 2004).

The way wetland management issues are handled could either help to exacerbate the water problems or it could be part of the solution to water problems in South Africa, including the eFS. Some forecasters believe the Third World War will be caused by fighting over natural resources, of which water will be central (Turton, 2012). Other authors claim that at the current world population of over seven billion people, the world has already exceeded the Hydraulic Density of Population (Turton, 2012) (where 2 000 people are expected to share a million cubic metres of water). It means that the current world population has exceeded its ecological footprint in relation to conventional natural water supply sources. Semi-arid and arid regions like South Africa and the eFS are quite vulnerable to water crisis where climate change and other factors are predicted to increase droughts and dry spells (IPCC, 2014). Useable and renewable freshwater resources are found in lakes, wetlands, rivers and aquifers and water availability and access affects all segments and economic sectors of the society. However, population growth, rapid urbanisation and industrialisation, the expansion of agriculture and tourism, and climate change, all put water under increasing stress (International Union for the Conservation of Nature [IUCN], 2012; Russi *et al*., 2013; United Nations Economic and Social Council, in Pennington and Cech, 2010). Given the growing pressure on wetlands as a water resource, it is critical that they be properly managed (Global Water Partnership / International Network of Basin Organizations [GWP/INBO], 2009; Russi *et al*., 2013).

In the words of Rocio Cordoba, the Water Unit Coordinator of the IUCN:

> *There is no 'one size fits all' solution to the water challenge. Many different approaches are needed but more democratic management of our natural ecosystems within river basins such as forests, lakes and wetlands can, and should, play a key role in building a fair and sustainable world* (IUCN, 2012: Online).

Therefore, better management of wetlands would help in addressing water, disasters and climate change impacts but it should be noted that wetlands are very sensitive and precarious to external stressors (Africa Conservation Centre [ACC], 2011; CNRD/PEDRR, 2013; MA, 2005). The potential effects of climate change on wetlands, as well as the role wetlands can play to reduce the impacts of extreme weather events, require thorough research and careful planning.

DRR and CCA have always been treated as separate entities both at local, national and international levels. Efforts to reduce disaster risk and adapt to climate change are planned in different sectors and these efforts do not add up to the sum of their parts (Partners for Resilience [PfR], 2012). Besides, there is often a lack of local engagement in the planning, knowing that disasters and climate change impacts hit hardest in local poor areas and that DRR and CCA are best applicable in the local context (PfR, 2012). There is therefore the need to investigate the degree of divergence, convergence and overlaps between DRR and CCA to avoid the creation of parallel structures and therefore duplicating activities for natural resources management such as wetlands. One pillar of this study is to clarify the need to marry DRR and CCA into environmental management so as to build resilience, using the case of wetlands management.

The National Wetlands Inventory has mapped out about 120 000 wetlands that make up about 7% of South Africa's surface area (SANBI, 2010). Almost half of these wetlands (54 000) are in the FS province alone where they help (among other ecological benefits) in the control and supply of water that is used not only for agricultural activities, but also to satisfy other water needs in the province. It is scientifically proven that the extraction of surface water affects the groundwater table because both are closely linked and wetlands help to balance the scale between surface water extraction and groundwater replenishment (Wilby, 1997). These wetlands or natural marshes (*vlei* as it is popularly referred to in Afrikaans in South Africa) have other very important economic, social, cultural, spiritual and environmental benefits that are discussed in detail later in this study. For example, an important environmental benefit of wetlands is that they are used as sinks for atmospheric carbon dioxide, to purify contaminated water, to control flood and soil erosion (Rampedi, 2003). Unfortunately, many wetlands were damaged before their ecological importance was realised (Wilby, 1997).

Field observation shows that many wetlands in the eFS have been degraded. Though some of the causes for the degradation are documented, others need to be investigated. The National Wetlands Inventory project which is now within the newly formed Ecological Infrastructure Programme, works in partnership and collaboration with the National Freshwater Ecosystem Priority Areas (NFEPA) to provide clarity on the extent, distribution and condition of South Africa's wetlands (RSA DEA, 2015). Such studies would ease the sustainable use and conservation of wetlands in South Africa, but that is still work in progress (RSA DEA, 2015). Restoring and rehabilitating degraded wetlands is a cost-effective strategy for DRR and CCA, with strong benefits for poverty reduction and biodiversity conservation (CNRD/PEDRR, 2013; TEEB, 2010; WI, 2011).

The eFS community, and especially the farming community rely a lot on wetlands, not only for water supply and agriculture, but for other wetlands ecological services including those that directly or indirectly address DRR and CCA. In January 2011, 28 municipalities in seven provinces of South Africa were declared flood disaster areas and three of the five district municipalities in the FS were among the flood-declared disaster areas (Jordaan, 2011). In 2011, most farmers expected a bumper harvest as a result of the La Niña bringing on good rains. Unfortunately, the rainfall was extreme and came a bit too early leading to serious damages to crops, especially maize that was not yet harvested. The problem and question here is whether the farmers were prepared to mitigate the effects of such unpredicted extreme weather events using healthy wetlands. Secondly, there are many wetlands (54 000) in the FS and most of them are located on private farms in the FS. The question that follows is whether these wetlands are in a good state to perform one of their vital ecological role of floods attenuation. These are some of the problems that this study is trying to investigate and propose solutions for.

One other problem observed in the FS is that there seems to be conflicting interests among wetland stakeholders that is polarised between conversion to other economic use and conservation of wetlands. Some of these wetlands have been converted to other uses, while others have been degraded. It should be noted that South Africa is part of the 1971 Convention on Wetlands (Ramsar Convention) which obliges countries to preserve wetlands, especially those of international importance (17 of these Ramsar sites are in South Africa) and the National Water, Act 36 of 1998, the National Environmental Management, Act 107 of 1998, and the Conservation of Agricultural Resources Act (CARA), Act 43 of 1983, all speak of the conservation of wetlands. Despite all these, a wetland was converted into a mall in Bethlehem, even after the case went into litigation.

There appears to be weak and unclear institutional and legal arrangements for wetlands management in South Africa and therefore in the eFS. For example, there is no national wetland policy in South Africa, and there are many public work programmes with direct or indirect responsibility on wetlands, the Free State/Northern Cape Wetland Advisory Forum is dysfunctional. Compliance issues and the proper enforcement of legislations related to wetlands management are not very effective in the province. For example, the Monontsha wetlands in QwaQwa, have been heavily degraded partly due to increasing population and illegal development within the wetland (Spark, 2012).

Last, but not least of the problems, is that the human dimension in environmental management has for long been neglected even though, globally, the livelihoods of millions of people depend directly on the natural environment (Fabinyi *et al*., 2014). This study does not only link disaster and environmental management, but also brings into the fore the human interface into the equation. In a way, the study is strongly linked to social ecology (Bookchin, 1993) and systems thinking to address wetland management problems.

The main problem driving this research can therefore be summed up in the continuous degradation of wetlands in a water scarce and poor rural area that is affected by increasing disaster risks exacerbated by unstable climatic conditions. It is with the background of the problems discussed above that research on integrating DRR and CCA into a holistic wetlands management with a strong legal and institutional arrangement is worthwhile for the eFS.

1.4 RATIONALE FOR THE STUDY

There is no previous research in which the integration of DRR and CCA into wetlands management is documented as a proactive tool for the wise and sustainable use of wetlands. There is also a gross lack of information and awareness about the full value of wetlands, the different wetland types and the ecological services that they provide to the local communities in the study area. Therefore, wetland research that combines social and natural sciences can help bridge this gap (Turner *et al*., 2000). Oellermann *et al.* (1994) examined management practices applied to wetlands in KZN and FS, but the sample was limited to seven study sites, no communal wetlands were studied and no aspects of DRR and CCA were investigated. All these gaps are bridged in this research. This study highlights the need to build synergy in cross-disciplinary research and management approaches to solve complex societal problems such as poverty reduction, building resilience and environmental sustainability by combining DRR, CCA and ecosystem management into a holistic management framework guided by systems thinking.

This research fits adequately into several international agenda with special milestones in 2015. First, the research echoes the Hyogo Framework for Action (HFA) 2005−2015, especially Priority 4 on reducing the underlying risk factors (UNISDR, 2005). The efficient management of wetlands in the eFS could well reduce the common disaster risks in the area such as fires, drought and floods. The research then holds a lot of relevance with the new SFDRR 2015−2030, especially Priority 3 on investing in DRR for resilience (UNISDR, 2015). This study focuses on integrating DRR and CCA into ecosystem management (wetlands) to build local resilience, improve on biodiversity and promote sustainable livelihoods through continuous flow of ecosystem services from resilient wetlands. Building resilience is the new paradigm shift in international discourses.

On the development realm, this study fits squarely into the MDGs, especially Goal 7 on ensuring environmental sustainability (UNDP, 2000). The wise and sustainable management of wetlands, as encapsulated in this study, contribute to building resilient wetlands and improving on wetland biodiversity, which is a pinnacle for environmental sustainability. The research equally fits into the new Sustainable Development Goals (SDGs) which replaced the MDGs in September 2015. The new SDGs, especially Goals 14 and 15, reiterate the need for conservation and sustainable use of natural resources as well as the avoidance of land degradation and loss of biodiversity (UNDP, 2015). These are all the objectives of this study, though at a micro-level, but it is 'little drops of water that make the mighty ocean'. In another vein, we all should 'think globally and act locally'.

This study tackles issues on climate change. The United Nations Framework Convention on Climate Change (UNFCCC) and the Conference of Parties (COP), especially COP21 with the Paris Agreement that bound 196 countries to reduce greenhouse gas emissions to 1.5 compared to the pre-industrial level and adopt peer-reviewed climate change mitigation and adaptation strategies, have a lot of relevance in this study. One of the pillars of this study is to manage wetlands for climate change mitigation (for example, to reduce carbon emissions from peat wetlands) as well as CCA through ecological services of better managed wetlands.

Another international dimension of this study is its relevance to Agenda 21 of the Earth Summit of 1992, as well as the follow-up United Nations Conference on Sustainable Development or Rio+20, all of which encourage sustainable development within sound environmental management (United Nations [UN], 2012).

This research also fits perfectly into the vision and mission of the Partners for Resilience (PfR). The key focus of the PfR is to make families and local communities resilient through the integration of CCA, ecosystem management and restoration into DRR (PfR, 2012). The PfR is an alliance of non-governmental organisations (NGOs) comprising of the Netherlands Red Cross, Care Netherlands, Cordaid, the Red Cross/Red Crescent Climate Centre and Wetlands International. The aim of PfR is to reduce impacts of natural hazards on vulnerable people worldwide through building resilience. It is realised that resilience is a central and the most effective way to deal with disasters and climate change through better management and restoration of ecosystems such as wetlands (PfR, 2012).

There is international consensus that natural disasters are increasing in intensity and magnitude and the UNISDR (2013) states that damages from disasters have grown out of calculable proportions. There is also growing international research interest on how to use the natural environment to mitigate disasters. Wetlands are often cited as possible buffers and first line of defence against natural disasters and the new term *Eco-DRR/CCA'* (ACC, 2011; CNRD/PEDRR, 2013) finds much relevance in this study. In Kenya, for example, wetlands are major grazing areas and the only source of water and pasture during frequent droughts that always hit the country (ACC, 2011). Wetlands can only act as good buffers against natural disasters like storms, floods and droughts if the wetlands are in a healthy ecological state through better management practices.

The evaluation of the impact or effectiveness of management activities on wetlands in South Africa is still in its infancy. There is porosity in data on the effectiveness of previous management activities that can be used to review management plans (WetEffective, 2005, in Kotze *et al*., 2009). This study will therefore help to fill this identified research gap.

Investing in preventive measures, that include maintaining healthy ecosystems, are seven-fold more cost-effective than the costs incurred in disaster response (World Bank, 2004, in Sudmeier-Rieux and Ash, 2009). Placing sustainable wetlands management for livelihoods at the centre of DRR and CCA strategies builds resilience at a low cost.

The inherent link between DRR and environmental management has been widely recognised, but there have been little research and policy work on this subject (Dudley *et al*., 2015). Using environmental tools like the Environmental Impact Assessment [EIA] have not yet been fully applied by many disaster and environmental practitioners in their operations (UNISDR, 2014; Dudley *et al*., 2015). It is therefore clear that the concept and practice of DRR and that of the wise use and conservation of natural ecosystems such as wetlands, is reciprocal and a win-win management approach that can solve many problems faced by our local societies. The essence of this research is to popularise these win-win linkages among the local communities in the eFS and among the community of practice of DRR, CCA and environmental management in South Africa as a whole. It is hoped that at the end of the study a better coordinated, proactive and integrated wetlands management framework will be developed for the eFS that could also be replicated in other parts of South Africa. Backed by an effective legal and institutional arrangement and popularised through effective education and awareness campaigns, such a holistic wetlands management framework could address several environmental risks and challenges in South Africa. First of its kind, this study therefore brings out the interlinkages between disaster management, climate change and ecosystem management into a single and management framework. The new framework demonstrates how wise and sustainably managed wetlands can reduce disaster risk, help local communities adapt to climate change and thus build local community resilience. It is a new systems thinking approach.

1.5 RESEARCH QUESTIONS

Research questions are used to pinpoint as precisely as possible what the study will attempt to find (Hofstee, 2006). The research question is usually associated with studies that are more problem-based, applied or practical, as opposed to hypothesis which most researchers associate to studies that are closely linked to theories. A hypothesis is then formulated and at the end the study will either support or disprove the stated hypothesis (Suter, 2006). This study makes use of research questions and, accordingly, the two main research questions directing this study are:

1. **Can integrating disaster risk reduction and climate change adaptation principles and practices into wetlands management promote wetlands resilience for sustainable ecological benefits in the eastern Free State?**
2. **Do the existing legal and institutional arrangements for the management of wetlands support wise and sustainable use of wetlands?**

As building blocks to answer the above-stated main research questions, the following sub-research questions were formulated:

1. What ecological services do wetlands provide to the local community of the eFS?
2. How do different land uses affect the value of wetlands?
3. What are the main wetland risks or stressors in the eFS?
4. What is the ecological status of selected wetlands in the FS?
5. How are wetlands managed in the eFS?
6. What are the common disaster risks in the eFS?
7. What are the general climatic trends and their potential effects on wetlands in the eFS?
8. Are there effective institutional and legal arrangements for the management of wetlands in the study area?

Answers to these questions guided the formulation of an integrated framework for the wise and sustainable management of wetlands in the eFS.

1.6 RESEARCH AIM AND OBJECTIVES

Generally, there is a very thin divide between the aims and objectives of a research. Many researchers and most literature use aims and objectives interchangeably (De Vos *et al.*, 2005; Leedy and Ormrod, 2001; Mouton, 2001; Suter, 2006). For the purpose of this study, the aims and objectives are separated and are explained below.

1.6.1 Aim of the study

The overall aim of this study is to formulate a resilient oriented wetlands management framework for the eFS province that integrate DRR and CCA strategies. The framework uses a holistic and integrated approach. The aim of this study fits into, or encapsulates the goals of the SFDRR 2015−2030 which include the prevention of new risks and reduction of existing disaster risks using integrated environmental measures that prevent and reduce hazard exposure and vulnerability to disasters (and in this research to climate change as well) and thus strengthen resilience (UNISDR, 2015). This stated Sendai goal is implied in the wise and sustainable management of wetlands for DRR, CCA and thus building local resilience.

To achieve this aim, the study had to determine the extent to which local communities are dependent on wetlands and to what extent these communities will be affected in the event of partial or total wetland loss due to identified wetlands risks, including poor management. The inclusion of DRR and CCA principles, especially wetlands risk and vulnerability assessment, together with an effective institutional arrangement, make the framework more robust.

1.6.2 Objectives of the study

The objectives are building blocks to achieve the overall aim of the study. Objectives normally have a shorter time frame. The objectives of any study should be specific, clear, achievable, measurable and time bound (De Vos *et al.*, 2005). Sometimes it is difficult to have a single objective at this level of research but several objectives. Considering the aim of this study as stated in subsection 1.6.1 and the research questions stated in subsection 1.5 above, the following objectives are pursued:

1. To identify and describe wetland functions and values which are important for the livelihoods of the various communities in the eFS.
2. To investigate the possible effects of different landownership and land use management on the health of wetlands in the study area.
3. To assess the possible risk and vulnerability factors that may affect the perceived wetland values in the future.
4. To examine the legal framework and institutional arrangement under which wetlands management operate in the area.
5. To assess the level of cooperation and coordination among role players involved in the management of wetlands in the study area.
6. To identify DRR and CCA measures that enhance wetland values and reduce local vulnerabilities in the eFS.
7. To examine some international best practices in wetlands management and conservation and make local adjustments.
8. To promote the concept and practice of Eco-DRR/CCA in wetlands management.
9. To combine objectives 1 to 8 and formulate an integrated and holistic wetlands management framework for the eFS province.

1.7 THEORETICAL FRAMEWORK

A theoretical framework sort of scaffolds the frame of the study in line with the researcher's disciplinary orientation (Merriam, 2001, in Rocco and Plakhotnik, 2009). Due to the multidisciplinary nature of this research, a single theoretical framework could not suffice; hence, many theoretical models covering disaster management, environmental management and climate change were used. Some of the theoretical frameworks that are discussed and applied include:

- The Wetlands Risk and Vulnerability Assessment models.
- Disaster Risk Assessment framework.
- Progression of vulnerability framework (The PAR Model).
- Disaster management cycle and spiral.
- Wetlands management framework.
- DRR and CCA frameworks.

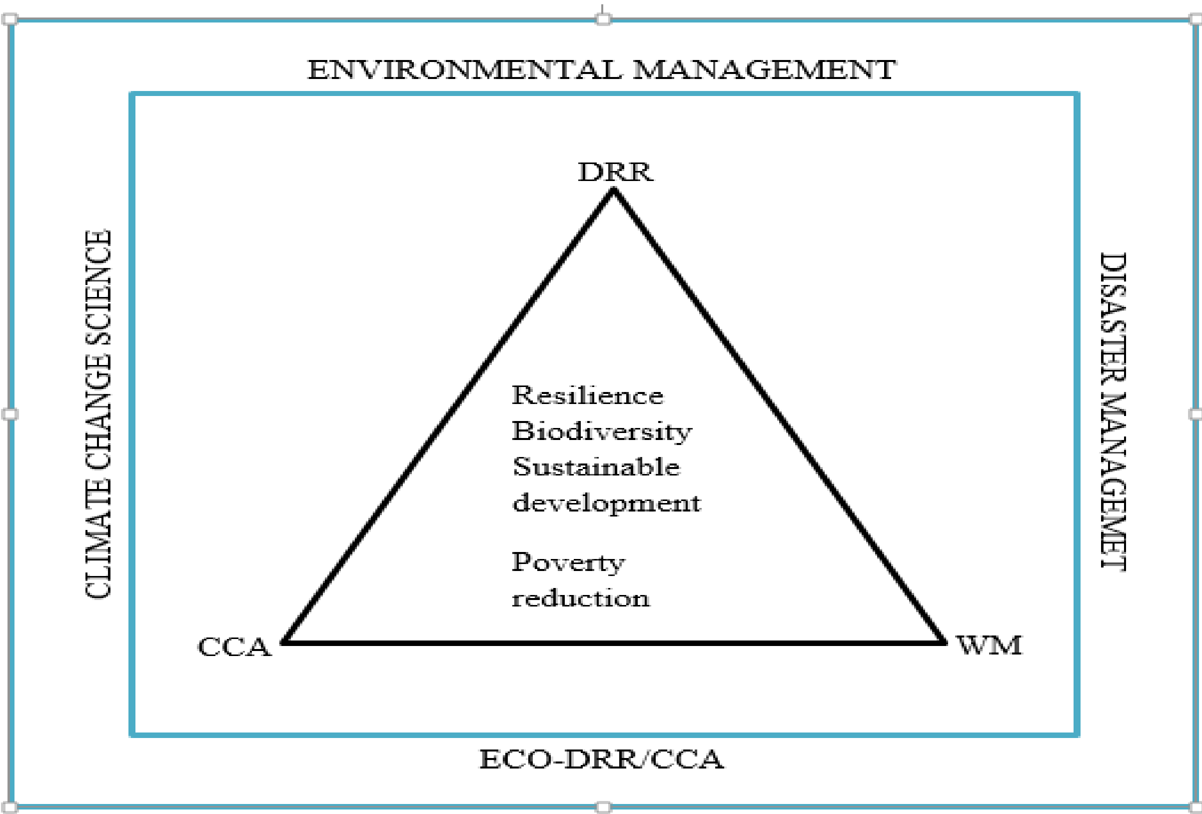
The IPCC models and reports formed the backbone for climate change analysis in this study. The wetlands management series of the Department of Water Affairs (DWA), now the Department of Water and Sanitation (DWS), was of paramount importance in this research. Of utmost importance was the WetEffective Management which looks at the effective management of wetlands in South Africa; WetHealth which sets the criteria for examining wetlands health in South Africa; the WetService which looks at the wetlands services in the country; and Wet-Legal which examines the legal framework for the management of wetlands in South Africa. The Millennium Ecosystem Assessment (MA) of 2005 and its wetlands management framework was carefully explored. Meanwhile, the HFA 2005−2015, the SFDRR 2015−2030 and the South African National Disaster Management Framework (2005) gave the policy and theoretical background on DRR. A couple of international agreements and local legislations formed the legislative background. All these theoretical frameworks were brought in, discussed and applied in the relevant chapters and sections in the study.

1.8 RESEARCH DESIGN AND METHODOLOGY

A detailed material and method used in this study are covered in chapter nine to avoid repetition.

1.8.1 Conceptual outline of the research

This is a multidisciplinary study involving three main disciplines that include environmental management with a focus on wetlands management (WM), disaster management with a focus on DRR, and climate change science with a focus on CCA. All these are encapsulated in the Eco-DRR/CCA) paradigm (Figure 1.9). The outcome will be to develop a framework that promotes wetland resilience with other spinoffs like promoting biodiversity, encouraging sustainable development, promoting sustainable livelihoods and reducing rural poverty.



Source: Author's own (2016).

Figure 1.9 Conceptual outline of the research

1.9 CHAPTER OUTLINE

The whole research project is divided into 11 chapters. A comprehensive literature review was carried out on six key thematic areas of the research (Chapter 3 to 8). These key thematic areas of the literature review constituted the main chapters of the thesis and laid the foundation on which the proposed integrated framework for wetlands management was built. The outline of each chapter is explained below:

Chapter 1 focuses on the general orientation of the study and discusses issues like the background of the study, the research problem and research questions, the objectives and rationale of the study and brief theoretical outline.

Chapter 2 explains relevant terms, concepts and theories that are linked to the research from either a disaster, environment or climate change perspective.

Chapter 3 explores the legal and institutional arrangement for wetlands management using some selected best practices from around the world and zooming down to South Africa and pinpointing it to the study area.

Chapter 4 explores the linkages between disaster and environmental management to bring out areas of possible cooperation, integration and to build synergy.

Meanwhile, **Chapter 5** shades light on the basic understanding and functioning of wetlands for non-wetlands specialists**.**

Chapter 6 looks into the risk and vulnerability assessment and links it to wetlands management as the foundation for DRR and CCA strategies.

Chapter 7 focuses on wetlands and climate change to explore the potential effects of climate change on wetlands and the role that well-managed wetlands could play in CCA.

Chapter 8 is almost the twin chapter to Chapter 7, but focuses on DRR as a management tool and to highlight the role of wetlands conservation for DRR. This chapter also explores the similarities and differences between DRR and CCA to exploit possible areas of cooperation and integration as pillars in building wetland resilience.

Chapter 9 explains in detail the material and method that was followed in the research, while **Chapter 10** deals with results from the primary and secondary data that were collected.

Chapter 11 works through the research project and brings out salient areas for discussion before stating the conclusions, and recommendations that includes the proposed Integrated Framework for Wetland Management.

There are many chapters in this research project due to the multidisciplinary and cross-cutting nature of the research problem and research objectives. The advantage here is that many of these chapters are intended to be converted into publishable and conference articles or even consolidated as chapters of a book on building wetlands resilience.

1.10 CHAPTER SUMMARY

Chapter 1 is an introductory chapter for the whole research and provided the general orientation of the study. Subsections covered in this chapter included the background and rationale for the study, the research problem and research questions, the objectives and rationale of the study, and lastly the theoretical frame of the study. The next chapter looks at related concepts, terms and theories in order to establish a common understanding of meaning of terms and concepts used. The theoretical framework helps guide the orientation of the study.

Chapter 2
THEORETICAL FRAMEWORKS

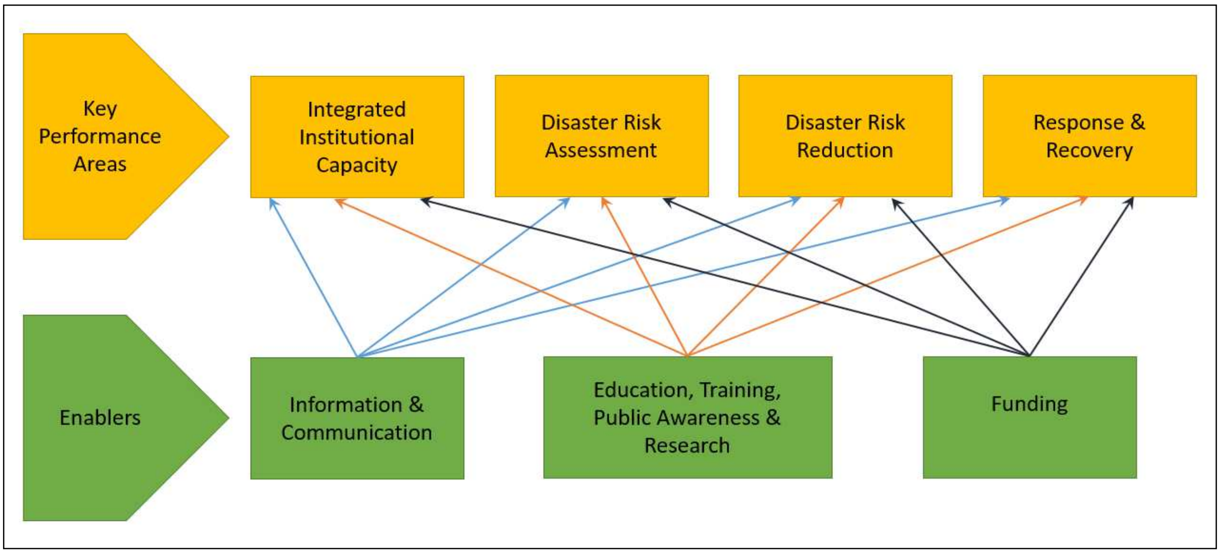
2.1 INTRODUCTION

The multidisciplinary nature of the study made it such that no one existing model could completely encapsulate the scope of the study. Theoretical frameworks were therefore chosen to cover the theoretical background of the three disciplines involved in this study (Figure 1.9). The theories discussed are related to disaster management with a focus on DRR; climate change science with emphasis on CCA; and environmental management with specific reference to wetlands and ecosystem management. Other relevant frameworks such as those on risk and vulnerability assessment are cross-cutting and are discussed under the appropriate sections in different chapters. How each of these frameworks relate to this study is discussed in the relevant sections. All these frameworks are used as sets of guides and building blocks toward the realisation of the aim of this study which was to formulate a holistic and integrated framework for wetlands management to build resilience (see 11.4.3).

2.2 DISASTER-RELATED FRAMEWORKS

2.2.1 The South Africa National Disaster Management Framework

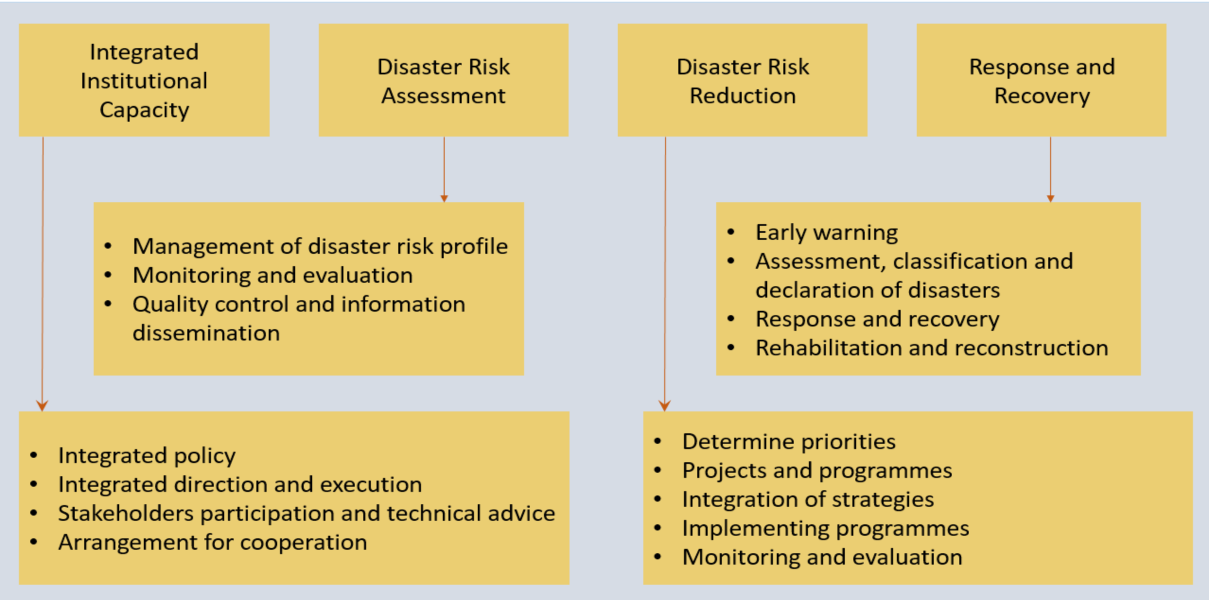
The South Africa National Disaster Management Framework (NDMF) of 2005 is the practical guide for the application and operationalisation of the South African National Disaster Management Act, Act 57 of 2002. This framework is important to this study as it sets the legal and institutional foundation for integrating DRR into wetlands management in the eFS. The four key performance areas which are supported by three enablers of the NDMF (Figure 2.1), are used to develop disaster management plans in South Africa for risks such as drought, fires and floods which are common in the eFS and also affect, and are affected, by wetlands.



Source: Adapted from RSA NDMC (2008:7)

Figure 2.1 The South African National Disaster Management Framework

The NDMF has operational activities (indicators) under each key performance area which are used to guide the planning tools for the operationalisation of disaster management in South Africa, as indicated in Figure 2.2 below. The first three key performance areas and all the enablers are key in the wise and sustainable management of wetlands in the eFS and are elaborated upon in appropriate subsequent chapters, while the last key performance area relates more to wetland rehabilitation and restoration (not covered substantially in this study) and are the key responsibility of the Working for Wetlands Programme (WfWetlands) (RSA DEA, 2014b).



Source: Jordaan (2011)

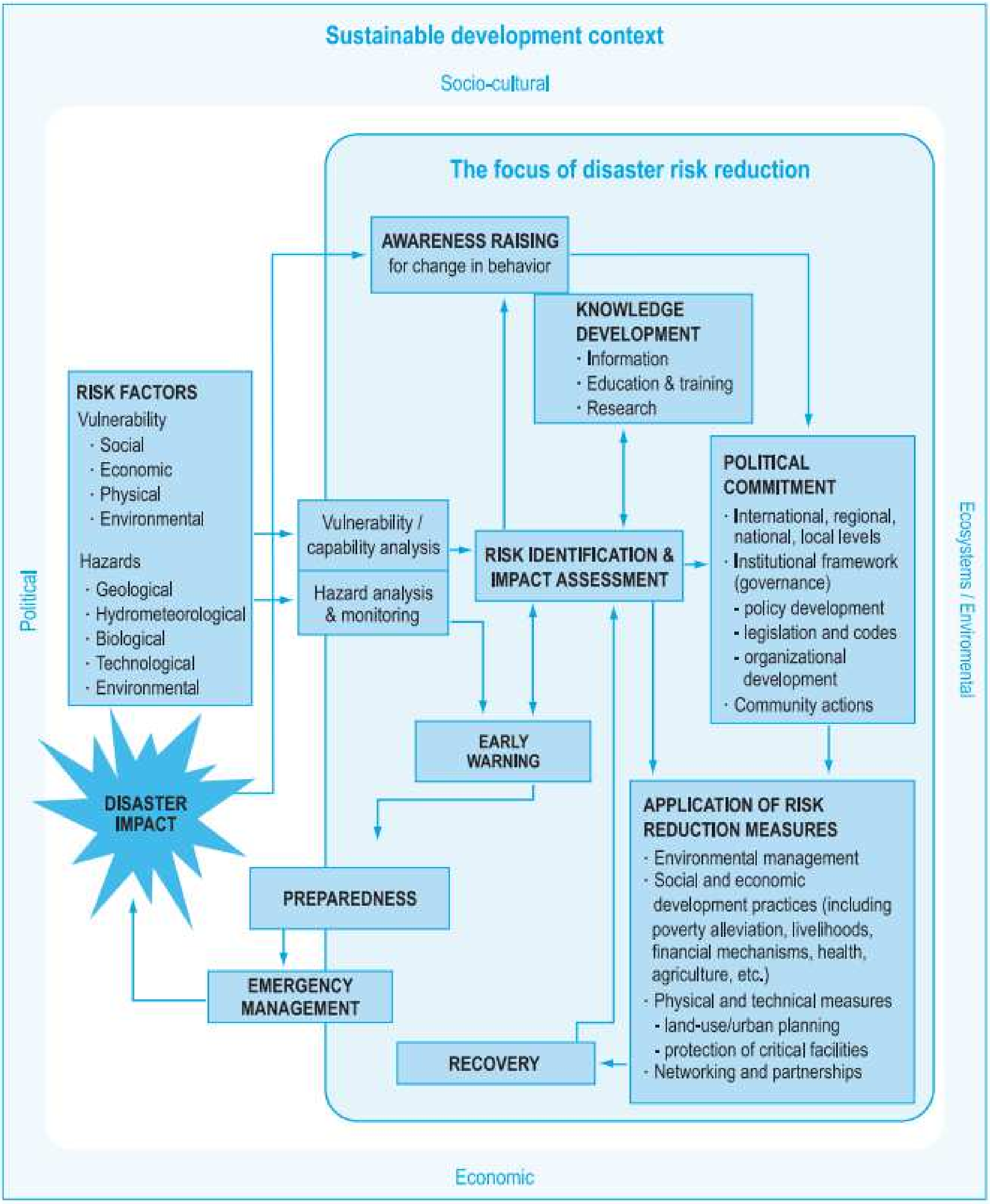
Figure 2.2 Key performance area indicators of the South African National Disaster Management Framework

2.2.2 Disaster risk reduction framework

Activities and processes to reduce disaster risk are summarised in the DRR Framework as indicated in Figure 2.3 below. This framework is an international benchmark on DRR, and it is important because DRR is one of the three pillars of this study. As illustrated in the framework, DRR normally begins with evidence-based risk and vulnerability assessment (RVA), but RVA can only be effective if there are good and strong political commitment with effective legislative and institutional frameworks (Figure 2.3). Information from RVA is then used to design various DRR strategies and plans. These DRR strategies are then incorporated into development planning to ensure sustainable development. Even during response and recovery to disasters, it is often advised to introduce DRR strategies, for example the Build Back Better concept, which is well-articulated in the new Sendai Framework for Disaster Risk Reduction (SFDRR) (UNISDR, 2015).

The DRR Framework can be divided into five thematic areas: First is knowledge management which normally includes public awareness and participation. The second key area is a strong political buy-in, with strong legal and institutional arrangements for DRR. This is backed by good and efficient governance and governments. Thirdly, any good DRR strategy should be informed by scientific and evidence-based risk identification and assessment. This will include hazard, vulnerability and capacity assessments. The fourth area is the risk management applications and instruments which is closely linked to the fifth thematic area that involves disaster preparedness, contingency planning and emergency management (UNISDR, 2005). All these DRR activities take place within the broad frame of sustainable development which has economic, political, social and environmental dimensions (Figure 2.3).

DRR should be more people-centred, multi-hazard and multi-sectoral; should be well-coordinated, inclusive and accessible to all stakeholders, which include the government (national, provincial, local), the private sector, civil society, research and academic institutions, community of practitioners, special groups like women, children, the elderly, people with disabilities, migrants, the poor and marginalised, indigenous people and volunteers, All these stakeholders should participate in the design and implementation of policies, plans and standards in DRR. International, regional, subregional and transboundary cooperation is vital to support states, businesses and local communities in their efforts in DRR (UNISDR, 2015).



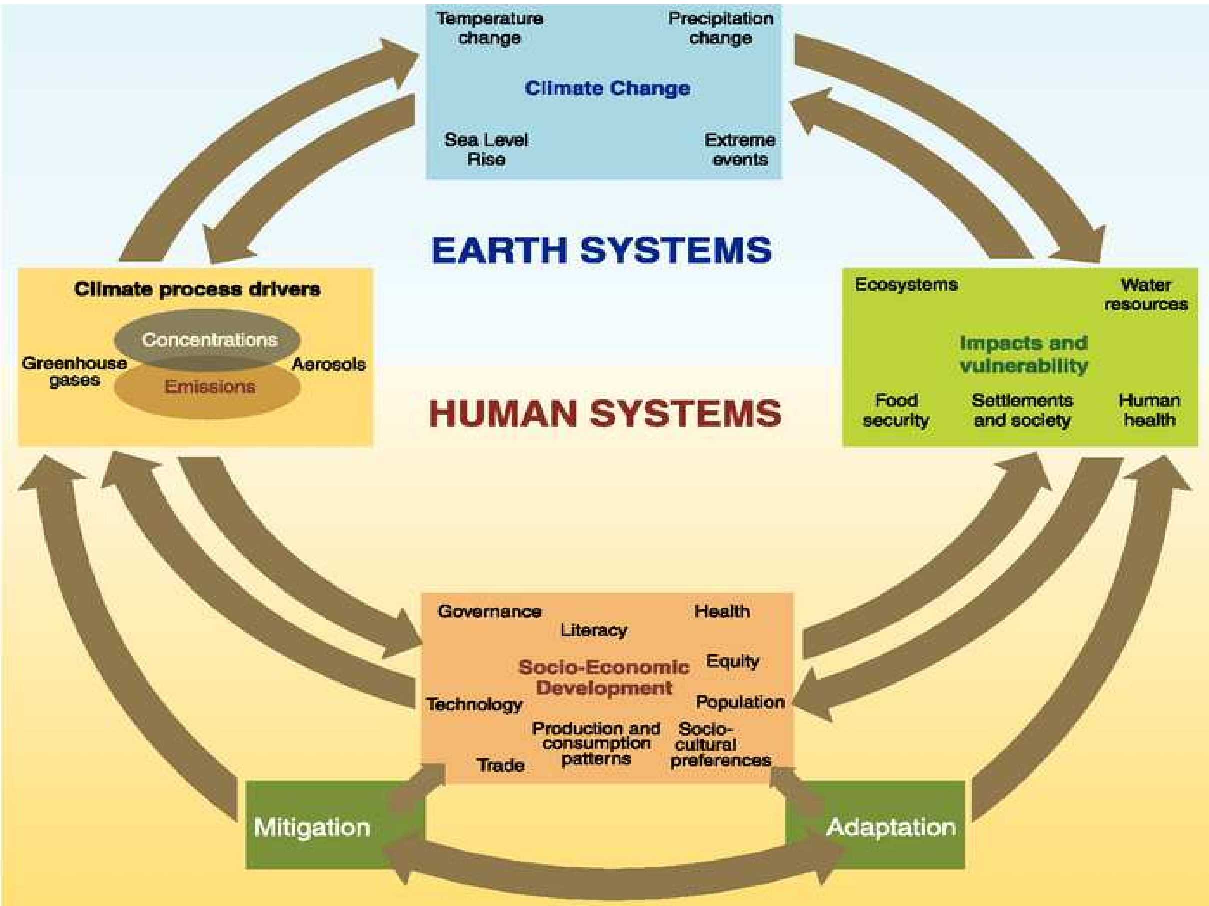
Source: UNISDR (2004:15)

Figure 2.3 Disaster risk reduction framework

These DRR strategies need to be incorporated into wetlands management practices to reduce both natural and man-made shocks that affect wetlands. This will help to improve the ecological status of the wetlands and make them resilient. On the other side, resilient wetlands which are in a good ecological state help to reduce disaster risks by acting as buffers. Promoting this cyclical relation is one of the main aims of this research and is strongly supported in the Eco-DRR/CCA approach.

2.3 CLIMATE CHANGE FRAMEWORK

The climate change framework illustrates the causes and effects of climate change and the need to manage both the causes and the effects in order to build climate resilient wetlands. Climate change is the result of the natural and human subsystem drivers, but more importantly, the human subsystem; hence the term 'anthropogenic climate change' (IPCC, 2001, 2007, 2014). The human socio-economic development has resulted in the emission of greenhouse gas emissions, especially carbon dioxide that has caused global warming. The latter has resulted in temperature rise, increase in extreme weather events, melting of polar ice and corresponding sea level rise, and changes in climatic bands with associated socio-economic and health effects. Climate change has diverse effects on ecosystems, such as food security, human health and water resources (IPCC, 2014). The main solutions to climate change are climate change mitigation and CCA (Figure 2.4).



Source: IPCC (2007)

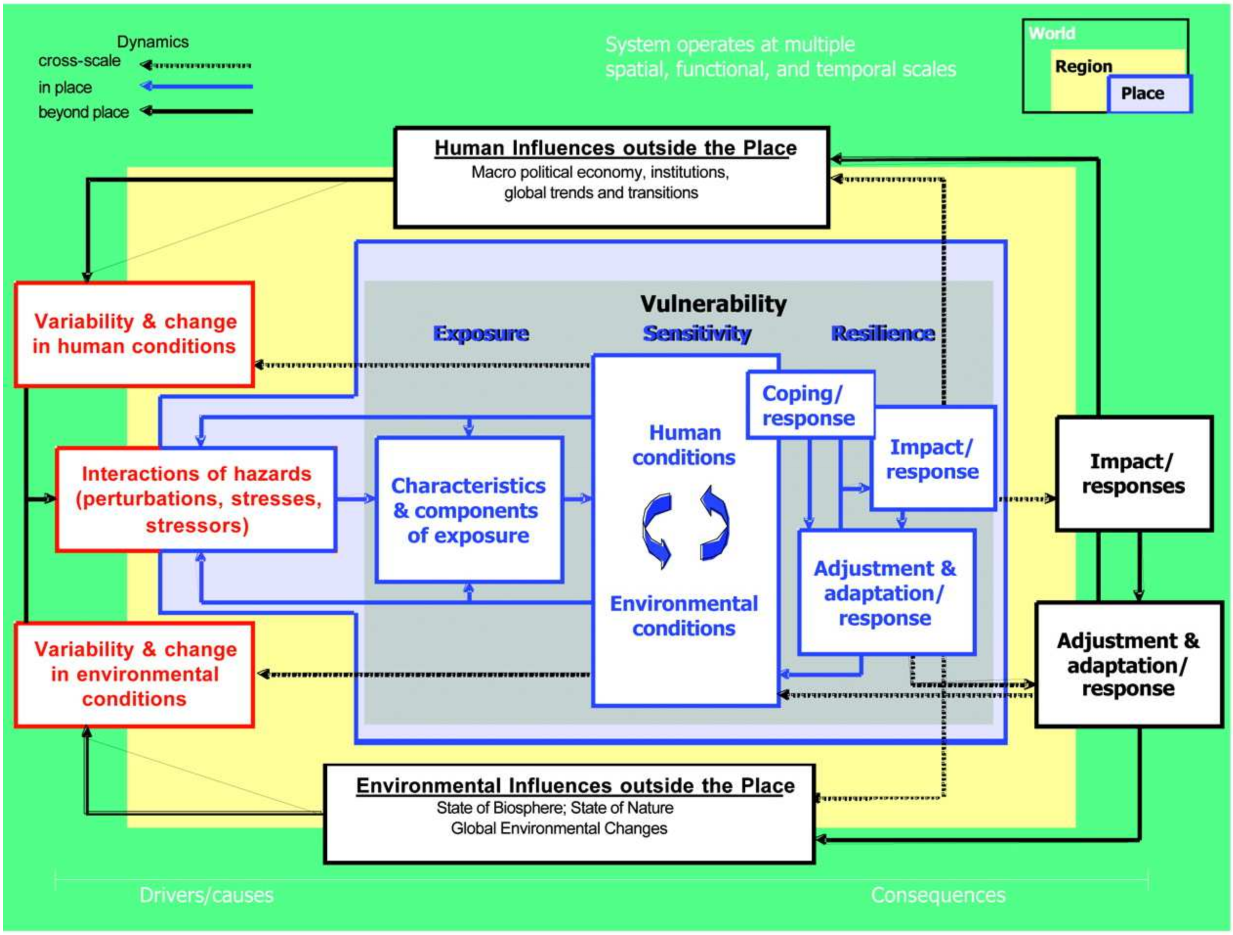
Figure 2.4 Schematic framework of anthropogenic climate change drivers, impacts and responses

The potential impacts of climate change on wetlands and how wetlands can provoke climate change, as well as the role of wetlands in CCA to support local resilience, are explored in this research.

2.4 ENVIRONMENT-RELATED FRAMEWORKS

2.4.1 The Coupled Human–Environment System Model

The Coupled Human–Environment System Model **(**CHESM**)** is a good approach that emphasises the social-ecology perspective of risk and was published by Turner *et al.* (2003). The CHESM predicates a synergy between the human and biosphere subsystems with processes that operate at different spatiotemporal and functional scales (Figure 2.5). This is one of the models that touches the ambient of sustainability science by expanding on vulnerability analysis (Turner *et al*., 2003).



Source: Turner *et al.* (2003:8076)

Figure 2.5 The coupled human−environment system

This model recognises that different systems or communities have different sensitivities to stresses or hazards that are linked to entitlement (legal and customary rights to exercise command over resources, including basic items like food). Systems and subsystems also have differential coping capacities (Lei *et al*., 2014), which enable them to resist or respond to harm as well as avert future hazards. Coping capacities are linked to entitlements, endowments and social institutions such as society social nets. The environment and political structures should be examined in an expanded vulnerability analysis. The model further acknowledges that the affected system or community is not passive in the wake of hazards such that learning from experiences to hazards builds degrees of coping capacities that should not be neglected in a vulnerability analysis (Birkmann *et al*., 2013). However, changes in the external environment, such as climate change, may erode or undermine such coping capacities by influencing changes in the nature, intensity and frequency of new and old hazards (IPCC, 2014; UNISDR, 2013). Such changes may therefore require the system or community to adjust and adapt while building new coping capacities.

The concept of resilience was used in the expanded vulnerability analysis originally from an ecological point of reference from where resilience denoted an ecological system's ability to bounce back to a reference state and maintain certain structures and functions after being subjected to a stressor or hazard (Birkmann *et al*., 2013; Turner *et al*., 2003). Today, resilience is used in inter-disciplinary research and is considered to be synonymous with concepts like coping and adaptive capacities, flexibility of ecosystems, sustainability, and learning in response to disturbance (Turner *et al*., 2003). With reference to ecosystems that are dynamic units, resilience denotes the ability of the ecosystem (such as wetlands) to still remain within a natural or desirable state, rather than a single reference state when subjected to a hazard (Turner *et al*., 2003). The concept of resilience is more comprehensively explained in the GLOSSARY OF TERMS AND CONCEPTS.

Issues of sustainability and resilience which are fundamental in the Coupled Human–Environment System Model expands the focus of vulnerability analysis and radiate around the precept that humans, while using the natural environment for development, should not '*kill the goose that lays the golden egg'.*

Vulnerability is examined within the context of the coupled human−environment system. This approach shows how the society transforms the natural environment and how such transformation in turn impacts on the social and economic systems. Vulnerability is the outcome of exposure, sensitivity and lack of resilience. The complex interdependencies created in the models poses challenges in its practical application.

The CHESM is relevant in this study to highlight the interdependent relationship between the local community (eFS) and the surrounding wetlands. Ecosystem services flow from these wetlands to the local communities. Meanwhile, the local communities have the duty to protect, preserve and sustainably use these wetlands so that they continue to support the local community. This interdependent relationship between humans and their natural environment applies to all ecosystems and at all levels of the society. This approach also resonates with systems thinking.

2.4.2 The Social–Ecological Model: A framework for prevention

Current environmental management approaches demand innovative research that cuts across traditional disciplinary boundaries, and environmental practitioners, scholars, and policy-makers alike are increasingly calling for the "*integration of natural and social sciences to develop new approaches that address the range of [complex] ecological and societal impacts of modern environmental issues"* (Virapongse *et al*., 2016). The theoretical development and practical application of the social−ecological system approach was an identified attempt to bridge the long existing gaps where disciplines approached complex environmental issues such as wetlands management in silos. Effective solutions to environmental problems require the integration of social and natural sciences and the SES framework recognises and addresses this expectation (Virapongse *et al*., 2016). A multidisciplinary approach and building ecological resilience are two fundamental concepts in the SES approach.

Social ecology is the study of the interaction between people and their environment. It is an analysis of the interactions within the social, institutional, and cultural contexts of people–environment relations that make up well-being. It uses a systemic approach in focusing on the interdependencies of social systems (University of California, Irvine (UCI, 2015). It is based on the premise that the foundations of ecological crises can lie in social structures, or that civil war can originate from environmental scarcity, or the multiple cause-and-effect relationships linking social−ecological system status and health; thus, it deals with system complexity. It is concerned with how the different objects of the study relate to, interact and change each other such that the social phenomenon cannot be attributed to any of its objects. It calls for thinking relationally, comprehensively and understanding the complexity of integrated systems, that require a multidisciplinary approach (UCI, 2015). This holistic approach in dealing with complex problems and issues is at the very essence of systems thinking.

Social ecology is underpinned by the fact that nearly all our present ecological problems, such as wetland degradation, come from deep-rooted social problems. Present ecological problems can therefore not be clearly understood or resolved without carefully dealing with problems within society (Bookchin, 1993). Many environmentalists pick up ecological problems with the preservation of wildlife, wilderness, or more broadly the planet, but environmental emergencies like the oil spill by an Exxon tanker at Prince William Sound in Alaska or the massive deforestation of redwood trees in California by the Maxxam Corporation all point to the fact that the real the ecological future planet will be decided on social grounds (Bookchin, 1993).

The social−ecological system approach represents a significant attempt to cross-discipline and build a holistic perspective on human–environment relations (Fabinyi *et al*., 2014). The social−ecological system model is therefore very close to the CHESM (2.4.1).

The Centre for Disease Control (CDC) uses a four-level social–ecological model to better understand violence and its potential prevention strategies. This model considers the complex interplay between individual, relationship, community, and societal factors. It allows for the understanding of a range of factors that put people at risk of violence or protect them from experiencing or perpetrating violence. Though the model was based on violence prevention, it was replicated in this study for the prevention of wetland degradation in the eFS by simultaneously acting across the multiple levels of the model, namely:

Individual level

This first level of the model identifies biological and personal history factors that increase the likelihood of becoming a perpetrator of wetland degradation. Some of the catalyst factors may include age, education, income and history. Prevention strategies to wetland degradation at this level could be designed to promote attitudes, beliefs, and behaviours that ultimately prevent wetland degradation. Specific approaches may include education, awareness and life skills training (CDC, 2015).

Relationship level

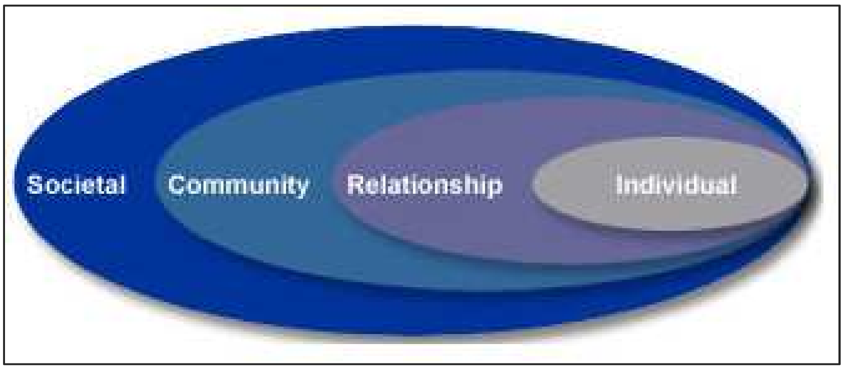
The second level of the model deals with close relationships that may increase the risk of perpetrating; in this case, wetland degradation. A person's closest social circle – peers, partners and family members– influences their behaviour and contributes to their range of experience. Prevention strategies at this level may include parenting or family-focused prevention programmes, and mentoring and peer programmes designed to reduce negation toward the environment, fostering problem-solving skills, and promoting healthy relationships among the people and the environment, such as wetlands (CDC, 2015).

Community level

The third level explores the settings, such as schools, workplaces, and neighbourhoods, in which social−environment relationships occur and seeks to identify the characteristics of these settings that are associated with perpetrating wetland degradation. Prevention strategies at this level are typically designed to impact the social and physical environment, for example, by reducing social isolation, improving economic and housing opportunities in neighbourhoods, CCA strategies, as well as good policies within schools, community and workplace settings (CDC, 2015).

SOCIETAL LEVEL

The fourth level looks at the broad societal factors that need to be addressed and which create a climate in which wetland degradation is encouraged or inhibits wetlands conservation. These may include social and cultural norms that support wetland drainage and pollution as an acceptable lifestyle. Other higher-order societal factors may include health, economic, educational and social policies that help to maintain economic or social inequalities between groups in the society (CDC, 2015). The last point supports the location of many informal settlements on communal wetlands in the eFS. Urban expansion and morphology is not haphazard, but is strongly controlled by forces operating within the society, such as land values, zoning ordinances, landscape features, circulation corridors, and historical contingencies such as apartheid in South Africa.



Source: CDC (2015: Online)

Figure 2.6 The social–ecological model: A framework for prevention

Well-managed human–environment interdependence contributes to building social–ecological resilience, and through the resilience approach strengthens sustainable development through goods and services that flow from the resilient system (Takeuchi *et al*., 2014). Social−ecological systems, which is based on the interdependent relationship between humans and the environment, has three important attributes (resilience, adaptability, and transformability) that are important for future sustainability (Walker *et al*., 2004 in Takeuchi *et al*., 2014). Like the CHESM, the social−ecological system model is important in this study to guide the development of a harmonious relationship between humans (the local community) and their environment (the wetlands).

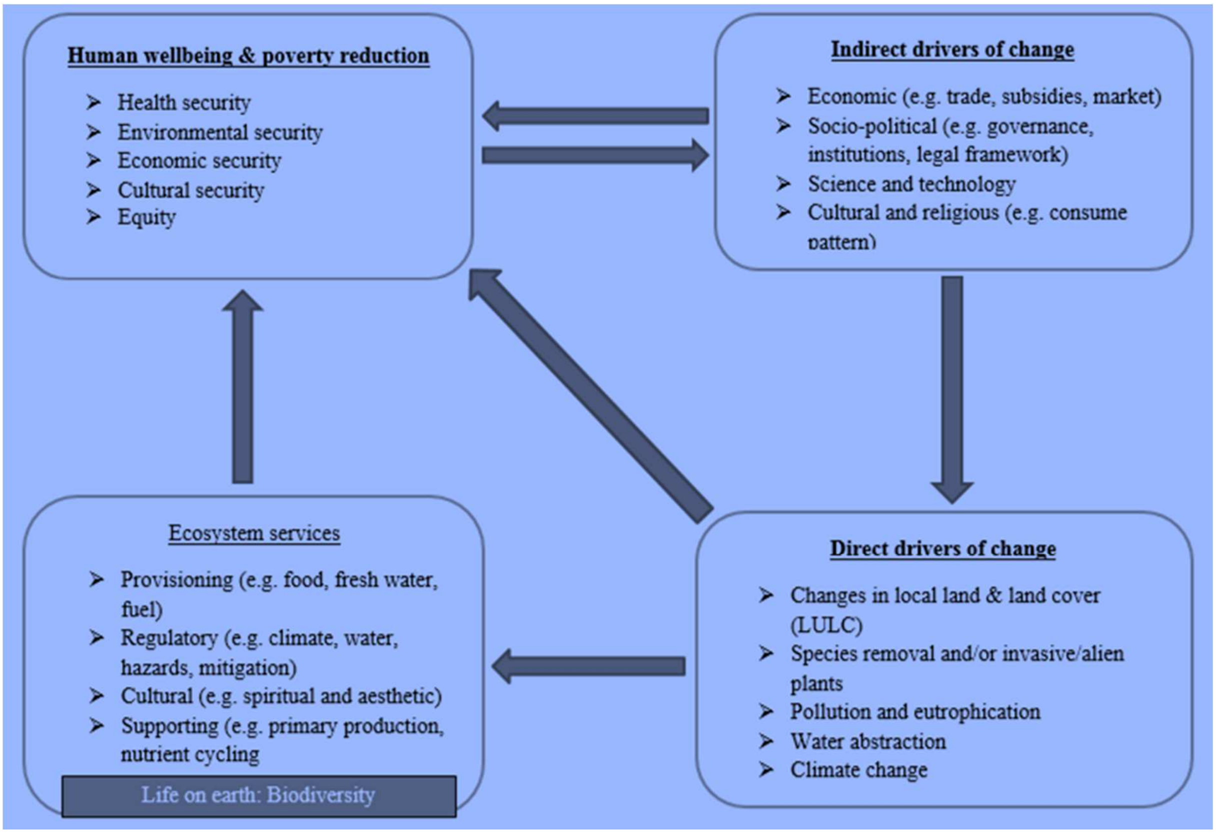
2.4.3 The framework for the *'wise use'* of wetlands

The *'wise use'* of wetlands is defined as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development" (Ramsar Convention Secretariat [RCS], 2010a). The essence of the concept, therefore, is the conservation and sustainable use of wetlands and their resources for the benefit of humankind (RCS, 2010a). Under the Ramsar Convention wise use and the maintenance of the ecological character of wetlands, or the sustainable usage and conservation of wetlands, are the guiding principles for wetlands management planning (Russi *et al*., 2013).

The *'wise use'* concept adopted is the longest (since 1987) established example of intergovernmental processes on ecosystem-based conservation and sustainable development of natural resources, including wetlands (Finlayson *et al*., 2012 in Russi *et al*., 2013).

The *'wise use'* concept and the maintenance of the ecological character of wetlands were adopted at COP3 (1987) and COP7 (1999), respectively, through the work of the Ramsar Convention's Scientific and Technical Review (RCS, 2010a). The *'wise use'* concept simply advises that wetlands management must take note and address both direct and indirect drivers of wetland change, since such changes impact on wetland services. These wetland services have direct or indirect impacts on human well-being and poverty reduction strategies. All these interactions are shown in Figure 2.7.

The MA emphasises using the ecological benefits of wetlands to achieve a number of MDGs, among which is poverty alleviation and environmental conservation. This will hardly be achieved if smaller wetlands, which directly touch the livelihoods of the rural poor, are left to the demise of those who do not have the expertise and means to conserve and use them sustainably. This same argument on local wetlands applies to smaller disasters whereby small localised disasters are often not taken into international account despite their huge cumulative impacts on the local and very often poor communities. It is therefore the essence of this study to bring the concept of wetlands '*wise use'* to the individual or communal level of the society where those who rely on wetlands most, are located.



Source: Adapted from RCS (2010a)

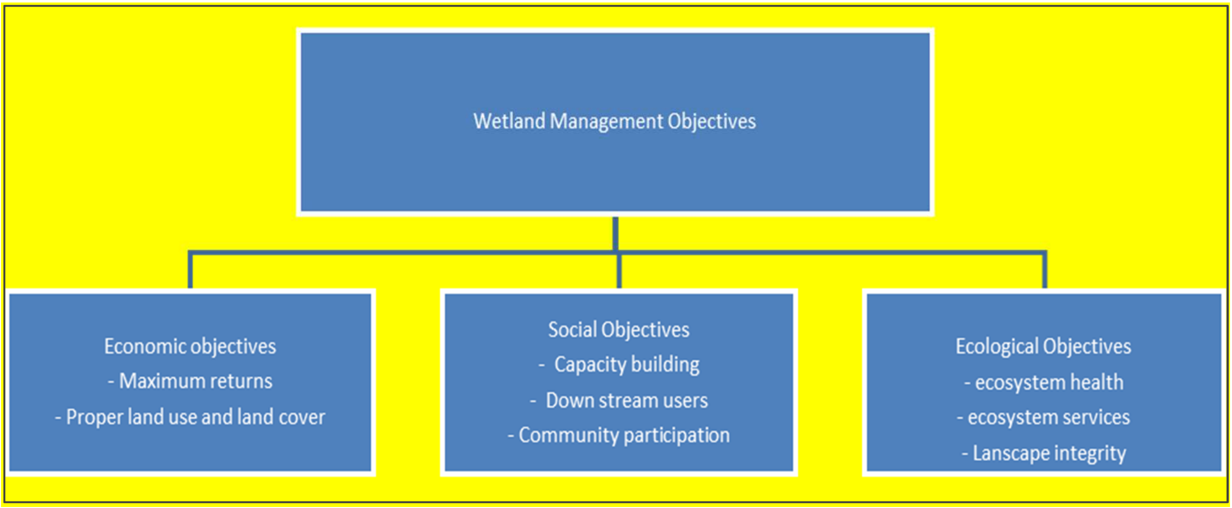
Figure 2.7 Framework for the wise use of wetlands

2.4.4 Strategic adaptive co-management of wetlands

According to Kotze *et al.* (2009), the effective management of ecosystems should be strategic, adaptive and inclusive. This is often referred to as *strategic adaptive co-management*. Strategic management has a vision that is built on a hierarchy of objectives. The objectives are then translated into a set of specific management actions (Rogers and Bestbier, 1997 in Kotze *et al*., 2009). Adaptive management is a structured process of ongoing *learning by doing* or *management by experiment*. In this approach, management actions are treated as potential learning opportunities. It involves monitoring the outcomes and then adjusting future actions accordingly (a reflexive approach). The successive cycles of action, monitoring and reflection thus leads to improvement in the management competency. Adaptive management allows for flexibility in response to the dynamics of ecosystems, uncertainties and changes in the interest of stakeholders, the political climate and in the resources available to management (The Ramsar Convention on Wetlands, 2004 in Kotze *et al*., 2009). Adaptive management is similar to the *Action Learning* of the Open Process Framework which promotes a learning process that is responsive, flexible and participatory (UNEP, 2004 in Kotze *et al*., 2009). The participatory or inclusiveness of wetlands management, especially the planning process, is emphasised by the Ramsar Convention on wetlands management where legitimate stakeholders, especially the local communities and indigenous people take an active role in planning and in the joint management of the wetlands.

The three fundamental elements of the *strategic adaptive co-management* are important in the management of wetlands in the eFS so that these wetlands remain healthy and resilient to natural stressors.

Any wetland should be managed with three main objectives and subobjectives in mind. These include economic, social and ecological objectives and they should be clear with measurable indicators to show if these objectives have been met or not (Mulale *et al.*, 2013). While the economic objectives are always prioritised in private and communal wetlands, the social and ecological objectives dominate protected wetlands. However, these three objectives are interrelated and should be treated with equal importance.



Source: Adapted from Mulale *et al*. (2013)

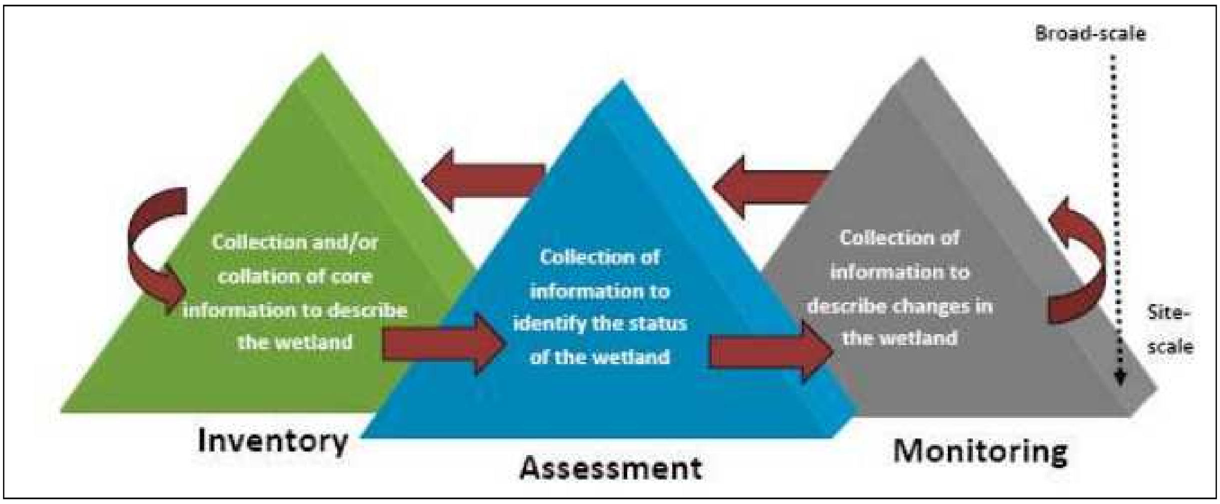
Figure 2.8 Wetland management objectives

2.4.5 Wetland inventory, assessment and monitoring framework

The Ramsar Convention strongly prescribes wetland inventorying, assessment and monitoring for the wise use and sustainable management of wetlands (Figure 2.9). These concepts are interrelated and constitute a good wetlands management framework that was adapted and integrated in the final framework proposed for wetlands management in the eFS. The key components of the framework and its application in this study are explained as follows:

- Wetland inventory involves collecting and collating important information for wetlands management to help in wetland assessment and monitoring activities.
- Wetland assessment identify the status, threats, functions and values of wetlands in order to facilitate the collection of more specific information through monitoring activities.

- Wetland monitoring involves the collection of specific information for management purposes in response to hypotheses made during the assessment and to use the monitoring results for implementation by management. The collection of time-series information that is not based on hypothesis from the wetland assessment is referred to as wetlands 'surveillance' rather than monitoring (Finlayson and Pollard, 2009).



Source: Finlayson and Pollard (2009)

Figure 2.9 The relationships between wetland inventory, assessment and monitoring

This framework shows an overlap between inventory and assessment and between assessment and monitoring. It also shows an interrelationship, as well as the circular nature of these interrelations among the three wetlands management components.

In this study, the hydrogeormorphic classification of wetlands was used (see Chapter 5) and the focus was on valley-bottom wetlands in the eFS. Valley-bottom wetlands are the dominant wetlands in the eFS. Information on the status and changes in the wetlands was captured in the wetland risk and vulnerability assessment (see Chapter 6) that provided the foundation for DRR and CCA measures to build resilient wetlands in the study area.

2.4.6 The sustainable livelihood framework

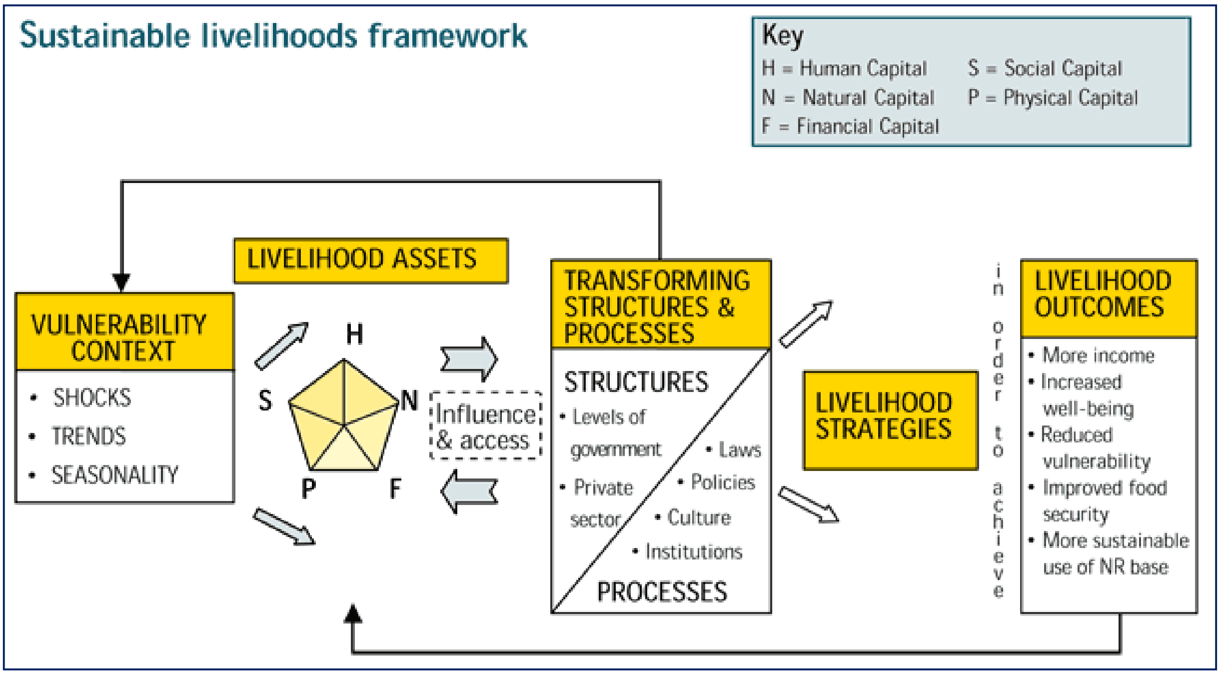
Though strictly speaking not a direct wetlands management framework, the Sustainable Livelihood Model is very relevant in this study because the aim is to develop a framework for wetland resilience that support sustainable livelihoods through the steady supply of wetland ecosystem services to the local communities in the eFS.

The Sustainable Livelihoods Model (UK Department for International Development [UK DFID], 2006) describes how people's pentagon of assets or capital (social, human, natural, physical and financial) can be vulnerable to hazards and other factors (Figure 2.10). Such vulnerabilities influence, and are being influenced by, the existing transformation structures and processes.

Depending on the type of livelihood strategies that are adopted, this can either increase or decrease livelihood outcomes (UK DFID, 2006).

The Sustainable Livelihoods Model integrates poverty reduction strategies, sustainable development, participation and empowerment processes into a framework for policy analysis and programming (Twigg, 2001).

This is a simple model that is commonly used by NGOs when providing humanitarian assistance to disaster affected communities. Of prime importance to this study (from the Sustainable Livelihoods Model) is how to conserve and build on the natural capital, which include all the goods and services provided by the natural ecosystems (wetlands) through proper wetland management processes to obtain desirable outcomes (resilient wetlands, biodiversity, and sustainable development).



Source: UK DFID (2006)

Figure 2.10 Sustainable livelihoods model

All the models discussed above constitute the theoretical building blocks that was fed into the proposed integrated wetlands management framework (IWMF at the end of this study (see Figure 11.5).

2.5 CHAPTER SUMMARY

This is a multidisciplinary research drawing from three main disciplines that include disaster management, environmental management and climate change. In this chapter, therefore, many frameworks were discussed to give a solid theoretical foundation of the research. To sum up on the aspects of the various theoretical frameworks that were used, the NDMF was explored to address the legal and institutional aspects involved in this research (see Chapter 3) and the risk and vulnerability assessment (RVA) which is discussed in detail in Chapter 6. The DRR framework, while touching on many aspects, was mainly focused on the DRR aspect of the research. The climate change framework addressed climate change issues implicated in the research. The social−ecological system model, the coupled human−environment system management, the strategic adaptive model and the wetland inventory, assessment and monitory framework were used to address wetlands management issues. Lastly, the Sustainable Livelihoods Model was included to consider issues of wetland resilience and its influence on local livelihoods. All these models were explored as theoretical building blocks to formulate and propose a wetlands management framework for resilience.

Chapter 3

LEGAL AND INSTITUTIONAL ARRANGEMENTS FOR WETLAND MANAGEMENT

3.1 INTRODUCTION

This chapter examines the various legislations, policies and institutional arrangements related to the management of wetlands in South Africa. The chapter also compares the legal and institutional management of wetlands in South Africa with those of other regional and international best practices to suggest what lessons could be learned from other countries.

This chapter is divided into three sections. The first section looks at some international agreements and agendas related to wetlands management. The second section examines the legal and institutional arrangements of wetlands management outside of South Africa as cases of international best practice. The third section investigates the legal and institutional arrangement for wetland management in South Africa and to explore how this arrangement affects wetland management in the eFS. Based on the three broad sections and information from primary data collected from the field, recommendations are made for an effective legal and institutional framework for wetland management in the eFS.

3.2 GLOBAL PERSPECTIVE ON LEGAL AND INSTITUTIONAL ARRANGEMENTS RELATED TO WETLAND MANAGEMENT

This section focuses on the legal and institutional arrangement regarding wetlands management outside of South Africa, starting with some related conventions. Uganda and Ghana have been cited as being some of the best cases in wetlands management in Africa (Kotze, 2009), while the USA has strong institutions and a long history in wetlands management. The aim of this section is to look at what worked or is working well in these countries and try to compare with the arrangements in South Africa in general and the FS, in particular, to come up with conclusions and recommendations. The arrangements in all these countries are strongly influenced by international agreements that have a direct or indirect relation with wetlands.

3.2.1 International agreements or multilateral environmental agreements

3.2.1.1 The Ramsar Convention of 1971

The Ramsar Convention was the first comprehensive international agreement on wetlands (RCS, 2010a; Turner *et al*., 2000). It was established in 1971 in Iran for the protection and 'wise use' of wetlands. The Ramsar Convention of 1971 is the hallmark convention on the conservation, rehabilitation and restoration of wetlands. The convention places emphasis on signatory countries to undertake ecological, economic and social feasibility studies of wetlands in order to establish wetland rehabilitation and restoration programmes, as well as to promote the 'wise use' concept of wetlands within their territories (Armstrong, 2009; Glazewski, 2013).

In 2013, there were 168 signatory countries to the Ramsar Convention as contracting parties. There were about 2 168 Ramsar sites in the world covering a total surface of 206 632 105 ha. There were 21 such Ramsar sites in South Africa in 2013 (RCS, 2013). The distribution of the top five countries in the world in terms of Ramsar sites is represented in Table 3.1:

TABLE 3.1: TOP FIVE WORLD COUNTRIES PER RAMSAR SITES

Country	Number of Ramsar Sites	Total Area Covered (ha)
1. UK	169	1.2 million
2. Mexico	139	8.8 million
3. Spain	74	303 090
4. Sweden	66	651 683
5. Norway	63	886 906

Source: RCS (2013)

No African country features among the top five Ramsar site countries which may suggest that either African countries do not conserve and protect their wetlands, or that most African wetlands do not meet Ramsar requirements as wetlands of international importance, or that Africa is generally dry relative to other European countries and therefore do not have as much opportunity as European countries do to have such wetlands listed. Table 3.2 shows the top five countries in Africa with the highest number of Ramsar wetlands, where South Africa ranks second after Algeria. One of the South African Ramsar sites (Seekoeivlei) was examined in this study.

TABLE 3.2: TOP FIVE AFRICAN COUNTRIES WITH RAMSAR SITES

Country	Number of Ramsar sites	Total surface area (ha)
1. Algeria	50	2.9 million
2. Republic of South Africa	21	554 136
3. Niger	12	4.3 million
4. Uganda	12	454 305
5. Nigeria	11	1 million

Source: Adapted from RCS (2013)

Contracting Parties to the Ramsar Convention are bound by three main categories of obligations regarding wetlands:

- **Non-site-specific obligations**: To promote the "*wise use"* of wetlands in their territory (Article 3.1).
- **Site-specific**: To designate at least one or more suitable wetlands of international importance for inclusion in the list (Article 2), promote the conservation of listed wetlands (Article 3.1) and to establish nature reserves on these wetlands with plans of wardening them (Article 4.1). A classic example, as mentioned earlier, is the Seekoeivlei wetland at Memel in the north-eastern Free State.
- **International cooperation**: To consult with other parties about implementing obligations arising from Ramsar in respect of transboundary wetlands, shared watercourses and coordinated conservation of wetland flora and fauna (Article 5). All these obligations apply to both inland and coastal wetlands and are linked to the *'wise use'* concept of wetlands (RCS, 2010a).

3.2.1.2 Wetland conservation and 'wise use' recommendations

The focus of this study is to promote the *'wise use'* and sustainable management of wetlands in the study area. The first Ramsar Convention of 1971 did not define the wetlands *'wise use*' concept, nor did they set out measures for its implementation. The first convention was also held before the concept of sustainable development was popularised, with which the term *'wise use'* is normally associated (RCS, 2010a). It was in later publications from the Ramsar Secretariat, following works of the Conference of Parties (COP) of the Ramsar Convention, that the 'wise use' concept was adopted.

In 1987, the COP approved the following definition of 'wise use': "the sustainable utilization of wetlands for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem", while sustainable utilisation was defined as "human use of a wetland so that it may yield the greatest continuous benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations" (RCS, 2010a). The Ramsar Strategic Plan (1997–2002) mandates each contracting party to develop national wetland policies that promote '*wise use'* and to handle all problems and activities related to wetlands in a national context (RCS, 2010a). As discussed later in this chapter, South Africa does not have a national wetland policy.

About 84% of the listed Ramsar sites are under threat (Dugan and Jones, 1992 in RCS, 2010b). Therefore, appropriate legal and institution frameworks are of paramount importance to prevent or mitigate the degradation and loss of wetlands, while promoting conservation, '*wise use'* and building the resilience of wetlands.

3.2.1.3 Sources of wetland laws

There are diverse sources of wetland laws that can be broadly divided into wetland-related legal measures, on the one hand, and sectoral legal measures which directly or indirectly affect wetlands, on the other hand. These various laws are the legal basis for regulatory powers, planning rules, public expenditures, taxation and economic measures for projects or activities which may positively or negatively affect wetlands (RCS, 2010b). Some laws may be specific on wetlands, while others are just general environmental or water laws with implications on wetlands as is the case in South Africa.

TABLE 3.3: SOURCES OF WETLAND LAWS AND INSTITUTIONAL MEASURES THAT MAY AFFECT WETLANDS

Wetland-related legal and institutional measures	Sectoral legal and institutional measures which directly or indirectly affect wetlands
Non-site-specific or generally applicable measures (e.g. integrated planning, environmental permit systems, impact assessment and audit procedures, habitat and species conservation, incentives) Site-specific measures (e.g. protected areas, site planning, participatory management) Institutional coordination between different levels of government and between sectors Transboundary and international cooperation mechanisms	Natural resource management Energy generation Industry and mining Territorial development Management of water quality and quantity Public health Tourism Trade controls on wetland products Communications and transport, including coastal and inland navigation Foreign and domestic investment Foreign affairs and national defence

Source: RCS (2010b)

South Africa signed the Ramsar Convention and ratified it in 1975, but there is no direct law on wetlands in South Africa (Kidd, 2011). Although there may be no specific law on wetlands in South Africa, it can, however, be argued that the establishment of the Working for Wetlands Programme is a clear evidence of compliance to the Ramsar Convention. Besides, there are 17 Ramsar designated wetlands in South Africa (Glazewski, 2013) though the RCS (2013) puts the figures at 21.

3.2.1.4 The Convention on Biological Diversity

The Convention on Biological Diversity (CBD) was signed in 1992 at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in Brazil. The CBD was ratified and came into effect in South Africa on 2 November 1995 (Department of Environmental Affairs and Tourism [RSA DEAT], 1998). The CBD is the first international agreement to establish the sovereign rights of nations over their genetic resources (RSA DEAT, 1998). As the name implies, the CBD is focused on the conservation of biodiversity. Through the use of plans and management strategies, signatory countries are required to rehabilitate and restore degraded ecosystems and promote the recovery of threatened species (Armstrong, 2009). According to the Ramsar Convention Bureau, as cited in Kidd (2011), wetlands are the most productive ecosystems on which countless of plants and animal species rely to survive, making wetlands the '*cradles of biological diversity'.* The South African National Environmental Management: Biodiversity Act, Act 10 of 2004 (hereinafter called 'Biodiversity Act'), is a direct response of the South African government to implement the objectives of the CBD (Kidd, 2011). Wetlands play a central role in the conservation and promotion of South Africa's biodiversity and it is important to preserve and conserve wetlands as part of promoting biodiversity.

3.2.1.5 Convention on the Conservation of Migratory Species of Wild Animals, 1979

The Convention on the Conservation of Migratory Species of Wild Animals (CMS), also known as the Bonn Convention, was adopted in 1979 and came into force in 1983. South Africa acceded to the CMS in 1991. The main objective of CMS is to protect migratory species which move in large populations across national boundaries, especially African species of wild animals which migrate annually to the northern hemisphere and within the continent (Glazewski, 2013). The CMS strictly protects endangered species, many of which are found within wetlands. The CMS compliments the Ramsar Convention because the CMS protects the migrant routes of these species, while the Ramsar Convention protects their wetland habitats. The CMS also encourages the establishment of Transfrontier or Peace Parks, such as the Kruger National Park and the Drakensberg Transfrontier Park in South Africa

(Glazewski, 2013). The Convention on Migratory Species promotes collaboration amongst nations to protect major routes for migratory species, including wetland-dependent species that needs to be properly managed (Russi *et al*., 2013).

3.2.1.6 UN Convention to Combat Desertification

The UN Convention to Combat Desertification (UNCCD) is one of the three outcomes of the Rio Convention in 1992. Desertification, climate change and the loss of biodiversity were identified as the greatest challenges to sustainable development during the 1992 Rio Earth Summit in Brazil (RSA DEA, 2015). UNCCD is the only legally binding international agreement that links the environment and development to sustainable land management. Ecological restoration, such as wetland restoration, is widely used to reverse the environmental degradation caused by human activities (RSA DEA, 2015). UNCCD addresses the arid, semi-arid and dry sub-humid areas, known as the dry-lands, where some of the most vulnerable ecosystems such as wetlands and poor people exist (RSA DEA, 2015). South Africa is a semi-arid country and ratified the UNCCD in September 1997 with the DEA as the focal point of the UNCCD in South Africa. This UNCCD is relevant to wetlands management in that it urges countries to rehabilitate, conserve and sustainably manage land and water courses, which include wetlands.

3.2.1.7 The Convention Concerning the Protection of the World Cultural and Natural Heritage, 1972

Known as the World Heritage Convention, this Convention was adopted under the auspices of the United Nations Education and Cultural Organization (UNESCO) and came into force in 1975. South Africa acceded to this convention in 1999 and in the same year the South African World Heritage Convention Act, Act 49 of 1999, was enacted (Glazewski, 2013). Four world heritage sites exist in South Africa, which includes variety of wetlands within the iSimangliso Wetland Park. The other three are the Sterkfontein caves, Robben Island and the uKhahlamba-Drakensberg Park (Glazewski, 2013). The fact that wetlands could be places of cultural and natural heritage such as the St Lucia wetlands, makes this convention relevant in wetlands management.

3.2.1.8 World Summit on Sustainable Development

The World Summit on Sustainable Development held in Johannesburg in 2002 was not a convention as such. However, the World Summit plan for implementation that was agreed upon by representatives of various countries emphasises the mitigation of the impact of drought and flood hazards through the promotion, protection and restoration of wetlands and watersheds (Armstrong, 2009; Syed, 2013). Wetlands therefore help to reduce disaster risks and promote sustainable development (Syed, 2013).

3.2.1.9 The UN Framework Convention on Climate Change

UN Framework Convention on Climate Change (UNFCCC) explains that wetlands need to be preserved and conserved since they act as natural water infrastructures for nature-based adaptation to climate change and mitigation of the impacts of greenhouse gas emissions. Wetlands, especially peat wetlands, play a key role in soil and the atmospheric carbon balance as they sequestrate atmospheric carbon into the soil (IPCC, 2007; 2014; Russi *et al.*, 2013).

3.2.1.10 Agenda 21 Principles

Agenda 21 of the United Nations Conference on Environment and Development held in Rio de Janeiro (1992), holds that the environment and development should be put at the centre of economic and political decisions and that development should be environmentally sound (Kotze, 2000). The DEA which promotes the Local Agenda 21 tries to make sure that developments do not degrade or destroy wetlands without a proper EIA and a cost-benefits analysis as supported by the case of the converted wetlands in Bethlehem (to be discussed later in this study).

3.2.2 Legal and institutional framework for wetlands management in the USA

A variety of laws exist in the USA with the goal of protecting the general environment. Some of these laws are generic for the entire environment, while some address wetlands specifically.

3.2.2.1 Legal arrangements for wetlands management in the USA

These may be grouped into federal, common and state laws and the most important ones that relate to wetlands are discussed below:

THE NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

NEPA was passed in 1970 and led to the creation of the Environmental Protection Agency (US EPA). The main objective was to protect the environment and ecosystems from both private and public harm. NEPA is the basic national charter for the protection of the environment. It establishes policies, sets goals and provides means for carrying out the policies (EPA, 2014). These policies also cover wetlands as part of the natural environment.

Endangered Species Act

The goal is first to prevent extinction of endangered plants and animals, and secondly, to recover these populations by preventing threats to their survival. The threatened species of many wetlands are covered by this Act.

Resource Conservation and Recovery Act

As a ‘cradle-to-grave’ system of preventing pollution, this Act ensures that waste is properly disposed of, and thus not dumped into the environment such as wetlands. Though wetlands may filter waste, when they are overdosed with polluted substances the capacity of the wetland might be compromised.

Comprehensive Environmental Response Compensation and Liability Act

Known as the ‘superfund’, this Act aims at cleaning up already polluted areas, including wetlands. This statute assigns liability to almost anyone associated with the improper disposal of hazardous waste, and is designed to provide funding for clean-up.

Clean Water Act of 1977

The Clean Water Act protects water by preventing discharge of pollutants into navigable waters in the USA from any point-source pollution. It is always difficult to control diffused pollution such as nitrates originating from agricultural practices. This law has the most direct effect on wetlands in the USA. For example, no permit will be granted if a practicable alternative exists that is less damaging to the aquatic environment or that could significantly degrade the US water ways (Gray *et al*., 2013). The applicant must make sure that steps have been taken to avoid wetland impacts, have minimised potential impacts on wetlands and have provided compensation for any remaining unavoidable impacts. This process is handled by the US Army Corps of Engineers (EPA, 2014; Gray *et al*., 2013) and is normally encapsulated in the environmental impact assessment (EIA) and the environmental management plan.

Federal Agriculture Improvement and Reform Act of 1996

Commonly referred to as the Farm Bill, this Act deals with programmes related to the conservation of wetlands on agricultural land. This type of law will be very appropriate in the eFS where more than 90% of the sampled wetlands are on private agricultural land.

North America Wetlands Conservation Act of 1968 and amended in 1989

This Act provides funding and administrative direction for implementation of the North American Waterfowl Management Plan and the Tripartite Agreement on wetlands between Canada, the USA and Mexico. This type of transboundary agreement will be very beneficial in

South Africa, and more specifically in the eFS between Lesotho and South Africa to exploit the benefits of, and minimise the impact of the Lesotho Highland Water transfer to South Africa. Many areas in the eFS, including the town of Bethlehem, witness floods during heavy rains and when the Lesotho Highland Water transfer canals overflow their banks. Here, healthy wetlands could play vital regulatory functions.

WETLANDS LOAN ACT OF 1961

This Act authorises and advances funds through the sale of 'duck stamps' to recover and acquire habitats of migratory water fowls.

3.2.2.2 Institutional arrangement for wetlands management in the USA

Four main, well-coordinated institutions have a direct responsibility on wetland issues in the USA; they include the U.S. Environmental Protection Agency (USEPA), the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service (EPA, 2014). In relation to wetlands, the USEPA is the main institution.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA)

USEPA is a Federal State regulatory agency with several laws for protecting the environment and public health. With regard to wetlands, the main federal law linking USEPA and wetlands is the Clean Water Act. USEPA has 10 regional offices and works with other federal agencies such as the U.S. Army Corps of Engineers (USEPA, 2014). USEPA monitors and analyses the environment, conducts research, and works closely with state and local governments to develop pollution control policies.

Regarding wetlands management, the U.S. Army Corps of Engineers determines whether an area is a wetland and issues permits for use of such an area. The permit applications are reviewed by the U.S. Environmental Protection Agency under Section 404 of the Clean Water Act (USEPA, 2014).

In addition to providing regulatory protection for wetlands, USEPA works in partnership with states, tribes, and local governments, the private sector, and citizen organisations to monitor, protect, and restore these valuable habitats. USEPA is also responsible for developing national guidance on wetland restoration, as well as constructed wetlands used to treat storm water and sewage.

Nationally, USEPA's Five-Star Restoration Program provides grants and facilitates information exchange using community-based education and restoration projects on wetlands.

USEPA works with many other federal agencies such as the U.S. Fish and Wildlife Service, the U.S. Department of Agriculture, and the National Marine Fisheries Service to protect and restore wetlands. The USEPA also partners with private interests and public organisations such as the Association of State Wetland Managers, the National Association of Counties, local watershed associations, schools, and universities to advance conservation and restoration programmes on wetlands (USEPA, 2014).

THE U.S. ARMY CORPS OF ENGINEERS

The U.S. Army Corps of Engineers works in collaboration with USEPA and its main focus is to administer the day-to-day programme, including individual and general permit decisions that may relate to wetlands; conducts or verifies jurisdictional determinations; develop policy and guidance; and enforces Section 404 provisions of the Clean Water Act (USEPA, 2014).

THE U.S. FISH AND WILDLIFE SERVICE AND NATIONAL MARINE FISHERIES SERVICE

It evaluates the impacts on fish and wildlife of all new federal projects and federally permitted projects, including projects subject to the requirements of Section 404 of the Clean Water Act.

WETLANDS ON AGRICULTURAL LANDS IN THE USA

Farmers who own or manage wetlands are directly affected by two important federal programmes which include Section 404 of the US Clean Water Act (1972) and the Swampbuster provision of the US Food Security Act (1985). The Swampbuster provision withholds certain federal farm programme benefits from farmers who convert or modify wetlands (Gray *et al*., 2013; USEPA, 2014). Since most wetlands in the eFS are in private farm lands, a similar measure like the Swampbuster provision of the Food Security Act in the USA is relevant for the conservation of wetlands on private farms.

3.2.3 Wetland management in Uganda

Wetlands occupy 13% (30 105 km^2) of the total surface of Uganda and they are regarded as one of the most valuable ecosystems in Uganda (National Environment Management Authority, 2000, in Moses, 2008). The government of Uganda made significant progress in establishing a comprehensive wetland policy, as well as legal and institutional frameworks for wetlands management (Moses, 2008). Wetlands in Uganda fall into two categories, namely: those associated with lakes (lacustrine) and those associated with rivers (riverine) (The Republic of Uganda, 1995a). Lakes and rivers are part of the fresh water system, but are not included in the definition of wetlands in South Africa (Ollis *et al*., 2013; RSA NWA, 1998b).

3.2.3.1 *Benefits of wetlands in Uganda*

THE ECONOMIC VALUE OF WETLANDS IN UGANDA

Kakuru *et al*. (2013) estimated the economic value of wetland resources and their contribution to food security in the three agro-ecological zones of Uganda (Table 3.4). By analysing a few goods and services provided by wetlands, the authors justified investment in the conservation of wetlands so that these wetlands continue to provide vital ecological services to the local communities.

TABLE 3.4: THE ECONOMIC VALUE OF WETLAND RESOURCES IN UGANDA

Number	Wetlands service	Estimated value in USD per year (US$)
1	Livestock pastures	4 240 000
2	Water for livestock consumption	34 000 000
3	Domestic water supply	13 900 000
4	Gross annual value added to milk production	1 220 000
5	Papyrus raw materials	4 630 000
6	Value added to papyrus to produce mat	11 500 000
7	Grass for mulching	8 650 000
8	Non-use value (water recharge and regulation)	7 100 000
9	Flood control	1 700 000 000
10	Fish breeding/spawning and availability	1 091 444
11	Crop farming	417 536 to 25 090 000
12	Wetland management costs for 2011/2012 financial year	48 668
13	Opportunity costs for limiting access to wetlands or stopping local communities from using wetlands	1 400 000 to 6 610 000
14	Average benefit for maintaining biodiversity in wetlands	48.24 per hectare
15	Average net contribution to food security (benefits-cost)	10.491 per hectare

Source: Adapted from Kakuru *et al*. (2013)

Table 3.4 demonstrates that the livelihoods of the local communities are highly dependent on wetlands, that the benefits of an effective and efficient management of wetlands for improved ecological services outweigh the cost of doing so. That wetlands contribute significantly to food security, and lastly, but most importantly, the study justifies the ‘wise use’ (for example for spawning and papyrus harvesting) and conservation of wetlands in Uganda. These wetland benefits are also expressed in the Millennium Ecosystem Assessment (MA, 2005). Similar studies in South Africa, in general, and the eFS, in particular, could make perfect sense.

3.2.3.2 *Institutional and legal framework on wetlands management in Uganda*

The legal and institutional framework for wetlands management in Uganda are cited as one of the best in Africa and are comparable to those in developed countries such as Iceland (Kotze, 2008; Moses, 2008). However, private ownership of most wetlands and the lack of adequate protection of wetlands in communal land or local municipalities are some of the problems facing wetlands management in Uganda (Moses, 2008).

The Uganda National Environmental Management Policy (1995)

The overall aim of the Uganda National Environmental Management Policy (1995) is to promote sustainable socio-economic development that enhances environmental quality and resource productivity on a long-term basis (Moses, 2008). The policy provides for the integration of environmental concerns in the national socio-economic development planning process, creates the opportunity for inter-sectoral cooperation and for a comprehensive and coordinated environmental management, as well as the formulation of a comprehensive environmental legal framework under the 1995 Constitution and the National Environment Act (Moses, 2008).

The ideas expressed in the Uganda National Environmental Management Policy (1995) are almost similar to those of the South African NEMA (RSA, 1998), but the latter lacks a clear and sustainable environmental policy with inter-sectoral cooperation that is comprehensive and coordinated.

The Uganda National Environmental Act 1995

It is the umbrella act on environmental issues. The Act provided for the creation of the Uganda National Environmental Management Authority which is mandated to coordinate, monitor and supervise all activities related to the environment, including issues related to wetlands (The Republic of Uganda, 1995a).

The Uganda National Policy for the Conservation and Management of Wetland Resources, 1995

The old practices and attitude of reclaiming and degrading wetlands changed in 1986 with the coming into power of the National Resistance Movement Government, which in September 1986 issued administrative guidelines that formed the basis of sound and rational management of wetland resources in Uganda (The Republic of Uganda, 1995b). In 1986, the government banned further large-scale drainage of wetlands and instituted the National Wetlands Conservation and Management Programme within the Department of Environment Protection. The programme was charged to analyse existing activities and assess the full range of functions and values provided by wetlands.

The lead Ministry of Natural Resources, in consultation with all stakeholders, developed the National Policy for the Conservation and Management of Wetland Resources and strengthened its practical application by incorporating the policy into the National

Environmental Statute in 1995. The overall aim of the policy is to promote the conservation of Uganda's wetlands in order to sustain their ecological and socio-economic functions for the present and future well-being of the people (The Republic of Uganda, 1995b). The national policy on wetlands has five focus areas, five goals and three main principles, with 36 policy statements tailored to achieve these goals (The Republic of Uganda, 1995b). These are referred to as the 5:5:3 success story of wetlands management in Uganda.

The **five focus areas** of the National Wetland Policy of Uganda:

- No drainage of wetlands unless more important environmental management requirements supersede.
- Sustainable use to ensure that benefits of wetlands are maintained for the foreseeable future.
- Environmentally sound management of wetlands to ensure that other aspects of the environment are not adversely affected.
- Equitable distribution of wetland benefits.
- The application of EIA procedures on all activities to be carried out in a wetland to ensure that wetland development is well-planned and managed (The Republic of Uganda, 1995b).

The **five main goals** of the national wetlands policy of Uganda:

- To establish the principles by which wetland resources can be optimally used now and in the future.
- To end practices that reduce wetland productivity.
- To maintain the biological diversity of natural or semi-natural wetlands.
- To maintain wetland functions and values.
- To integrate wetland concerns into the planning and decision-making of other sectors.

The **three main principles** to achieve the wetlands policy goals of Uganda:

- Wetland resources form an integral part of the environment and their management must be pursued in the context of an interaction between conservation and the national development strategies and activities.
- Wetland conservation can only be achieved through a coordinated and cooperative approach involving all the concerned people and organisations in the country, including the local communities.
- It is of vital importance for wetland conservation and management that the present attitudes and perceptions of Ugandans regarding wetlands be changed probably

through informed research, education and awareness campaigns (The Republic of Uganda, 1995b).

Other important legislations related to wetlands management in Uganda include:

The Uganda Local Government Act

The Local Government Act reserves some environmental management responsibilities to local governments. The Act outlines environmental management areas for which district councils are responsible and this includes wetlands management (Local Government Act, 1997, in Moses, 2008). This type of policy enables wetlands management to be designed and managed at grassroots level with the full participation and involvement of the local people.

The Uganda Land Act of 1998

The Uganda Land Act provides for the tenure, ownership and management of land. Section 44(1), (4) and (5) of the Land Act enshrines the public trust doctrine and provides that the government or the relevant local government holds in trust and shall protect for the common good of all citizens of Uganda certain environmentally sensitive areas such as wetlands, natural lakes and rivers, groundwater, natural ponds and streams, forest reserves, national parks and any other land reserved for ecological and touristic purposes. The government or the relevant local government has no powers to lease or otherwise alienate any natural resource referred to in this section (Land Act, 1998, in Moses, 2008).

The idea of cooperative management of wetlands, the public trust doctrine entrusted to the national and local governments and the fact that the government cannot lease out or alienate wetlands, is very paramount in the management and conservation of wetlands in Uganda.

As a signatory and contracting party to the Ramsar Convention, the government of Uganda recognises its international responsibility to conserve wetlands and sustainably utilise them, hence the application of the '*wise use'* concept of wetlands (Moses, 2008).

Concluding this subsection, it is clear that Uganda recognises that wetlands have been marginalised and regarded as 'wastelands' for long and therefore needed a strong institutional arrangement and a national legislation to reverse the high rate of degradation and ensure sustainable management. The government of Uganda also acknowledged that wetlands are a multi-sectoral resource and therefore there was a need to create and establish an appropriate institutional arrangement for their management. Although there were sectoral laws that referred to some aspects of wetlands such as water, or land or prevention of pollution (as is the case in South Africa), there were no comprehensive law for management of wetlands as an ecological entity.

Following this background, the Uganda government therefore adopted the following strategies:

- Enacted a national law for regulating the management of wetland resources.
- Encouraged district authorities to make by-laws for the proper management of wetlands.
- Disseminated the broad guidelines to district and urban authorities, as well as wetland users, researchers and academic institutions.
- Established an inter-ministerial policy implementation institution (The Republic of Uganda, 1995b).

3.2.4 Wetlands management in Ghana

The protection and conservation of wetlands resources in Ghana involve government and non-governmental institutions with a number of activities which are executed through a number of projects and programmes (Republic of Ghana, 1999). Activities for wetlands protection and conservation include data collection, monitoring, standard setting and execution of projects and programmes.

Government and non-governmental institutions concerned with wetlands in Ghana include the Wildlife Department, the Ministry of Environment, Science and Technology, the Environmental Protection Agency (EPA), the District and Metropolitan Assemblies, the Ministry of Food and Agriculture, the Survey and Meteorological Services Department, the Ministry of Lands and Forestry, the Forestry Department, Universities, the Council for Scientific and Industrial Research, as well as NGOs (Republic of Ghana, 1999).

Sub-regional Initiatives

Several West African sub-regional initiatives exist which relate to wetlands, for example, the large marine ecosystem of the Gulf of Guinea Programme, funded by the Global Environment Facility and administered through the United Nations Industrial Development Organization, assists several West African states to manage their coastal resources sustainably. The West and Central African Regional Seas Programme of UNEP has also helped in establishing sub-regional collaboration.

The proposed establishment of the Centre for African Wetlands Management to be located in Ghana will coordinate wetlands research for the West African sub-region.

Ghana's Wetlands Conservation Strategy, 1999

The establishment of Ghana's National Wetlands Conservation Strategy of 1999 was based on a couple of principles that promote the sustainable use and conservation of wetlands

(Republic of Ghana, 1999). These principles are similar to the environmental principles in South Africa (see 3.3.2).

TRADITIONAL MANAGEMENT PRACTICES TO CONSERVE WETLANDS IN GHANA

Traditional management practices through indigenous management systems such as traditional beliefs, customary law and taboos, are used to protect and conserve wetlands in Ghana. Traditionally, every river, lagoon or special water body such as a wetland are believed to have a god or goddess with its sets of unique regulations and are generally observed by local populations (Republic of Ghana, 1999). The fear of violating these rules and being punished by these super deities help to conserve wetlands

Generally, not much research has been done in South Africa on the cultural, religious and spiritual values of wetlands that can be used to advocate for the conservation and sustainable use of wetlands (WI, 2014). South Africa could be a good case study given its 'rainbow' nature with many tribes and races. Important lessons to learn from the case study of Ghana are the regional or cross-border initiatives for the management of wetlands and the use of traditional values for the conservation of wetlands.

3.3 THE LEGAL AND INSTITUTIONAL ARRANGEMENT FOR WETLAND MANAGEMENT IN SOUTH AFRICA

3.3.1 Introduction

Wetlands are dual ecosystems that link aquatic and terrestrial ecosystems. By this nature, a couple of government departments, NGOs and other institutions need to come together for a strong institutional arrangement to manage wetlands. In South Africa, the leading government departments with legal mandates on wetland issues include the Department of Water and Sanitation (DWS) (formerly known as the Department of Water Affairs [DWA]), the Department of Environmental Affairs (DEA), and the Department of Agriculture, Forestry and Fisheries (DAFF). Formerly, each of these leading government departments had National Resources Management Programmes (NRMPs) which included the Working for Water (WfW) programme of DWA, the Working for Wetlands (WfWetland) for DEA and LandCare South Africa for DAFF. However, recently these NRMPs have all been placed under the DEA (formally DEAT) under the Extended Public Works Programmes (EPWPs). Working on Fire (WoF) and Working for the Coast (WftC) have also been added to the list of the EPWPs and all five are popularly referred to as the 'Working for' programmes (RSA DEA, 2015). Besides these national departments and EPWPs, there are a couple of NGOs whose activities relate to wetlands, like the Mondi Wetland Project (MWP) and the Endangered Wildlife Trust (EWT).

A myriad of acts in South Africa either directly or indirectly address wetlands issues. Actually, there is no wetland protection act as such and many legislations that address wetlands management are haphazard and uncoordinated (Glazewski, 2013). The main legislations that address wetlands issues in South Africa include the following:

- The National Water Act, Act 36 of 1998 (RSA NWA, 1998).
- The National Environmental Management Act, Act 107 of 1998 (RSA NEMA, 1998).
- The Conservation of Agricultural Resources Act, Act 43 of 1983 (RSA CARA, 1998).
- The National Environmental Management: Biodiversity Act, Act 10 of 2004 (RSA, 2004).
- The National Environmental Management Act: Protected Areas Act, Act 57 of 2003 (RSA, 2003) (hereinafter called the Protected Areas Act).
- The National Forests Act, Act 84 of 1998 (RSA, 1998).
- The National Heritage Resources Act 25 of 1999 (RSA, 1999).

International conventions such as the Ramsar Convention of 1971, the Convention on the Protection of Migratory Species, the Convention on Biological Diversity and the UN Convention to Combat Desertification, discussed earlier, had strong influences on these acts.

This section examines these institutional and legal arrangement to bring out what is working and what is not to finally propose an institutional and legal framework that can be used for the effective management of wetlands in the FS, in particular, and other parts of South Africa, as a whole.

3.3.2 Legal arrangement for wetlands management in South Africa

Wetland management legislation can take the form of a legislative act, regulations, a policy, a planning document, programmes or even an informal understanding among the wetlands stakeholders (Glazewski, 2013). However, such a legislative framework or document must have a clear set of objectives, guidelines and institutional arrangements for effective implementation. More than three decades after signing the International Convention on Wetlands (Ramsar, 1971), South Africa still does not have a specific act or national policy on wetlands management (Glazewski, 2013; Keevy, 2011; Kidds, 2011; Kotze, 2008). While it is noted that carefully designed policies ensure better management of ecosystems such as wetlands (TEEB, 2010), in South Africa wetland issues are only mentioned here and there in many legislations. The implementation of such legislations seems not to be effective and will be discussed later in chapter 10. Some of the wetland-related legislations are discussed below:

3.3.2.1 The Constitution of the Republic of South Africa, Act 108 of 1996

The most important section of the Constitution that relates to the environment, and therefore wetlands, is section 24 of the Bill of Rights. This section is often referred to as '*environmental right'* or '*green right'* (Keevy, 2011) and it states that:

> *Everyone has the right –*
>
> *(a) to an environment that is not harmful to their health or well-being; and*
>
> *(b) to have the environment protected, for the benefit of the present and future generations, through reasonable legislative and other measures that –*
>
> *(i) prevent pollution and ecological degradation;*
>
> *(ii) promote conservation; and*
>
> *(iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development* (RSA, 1996:8).

There are two sides to this environmental right enshrined in the Bill of Rights. First, is the right of humans to a safe and healthy environment, and secondly, the right of the environment itself to be conserved and protected (Kidd, 2011). Wetlands are an integral part of the environment and should therefore be conserved and protected under the Constitution of the Republic of South Africa. Many other legislations that have relevance on the environment and therefore on wetlands such as the NEMA, NEMA: Biodiversity Act, NEMA: Conservation Act, NEMA Protected Areas Act, and NEMA: Pollution Act are drawn from the above bill of rights (Kidd, 2011; Van der Linde and Feris, 2010). Some of these legislations are discussed in the following sections:

3.3.2.2 The National Environmental Management Act, Act 107 of 1998

The NEMA is the main national framework legislation when it comes to environmental issues in South Africa. However, NEMA does not specifically address wetland issues, except for the listing of activities within a certain distance (32 m) of the wetland. NEMA is therefore dedicated to the protection of the general environment and not specifically dedicated to the protection of wetlands. This can be seen as a weakness when it comes to wetlands management. Some clauses in the NEMA, or national environmental management principles (Kidd, 2011) which directly or indirectly address wetlands management, include:

- Sustainable development and use of natural resources.
- Prevention and mitigation of disturbances of natural ecosystems and loss of biodiversity.
- Application of integrated environmental management principles.

- Environmental justice to avoid unfair distribution of negative environmental impacts, especially on the most vulnerable and disadvantaged persons.
- The *'Polluter pays'* principle where the polluter is defined as:
    - a person who is or was, responsible for, or who directly or indirectly contributes to environmental pollution or degradation of land;
    - the owner of the land or the owner who is the successor in title; and
    - the person in control of the land who has the right to use the land or who has negligently failed to prevent the pollution or degradation from occurring (Armstrong, 2009).
- Guaranteed protection of *'whistle blowers'*
- Equitable access to environmental resources that will also include wetlands and their ecological services.
- Promoting the participation of all stakeholders in environmental governance. For example, the effective management of wetlands must involve multiple stakeholders.
- Promoting community well-being and empowerment. This is seen in the EPWPs or the *'Working for'* programmes (RSA DEA, 2015).
- The environment is held in public trust, for the people and the environment should be protected as the people's common heritage. This clause is closely related to section 24 of the South Africa Constitution.
- Sensitive, vulnerable, highly dynamic or stressed ecosystems, such as wetlands, require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure (Kidd, 2011).

It should be noted that this last point calls for a strategic approach towards wetlands management. This requires knowledge of where wetlands are, what the pressures and threats are as well as their conservation status, all of which are, in the absence of a proper wetland inventory, mostly unknown. (This information is important in order to identify the sensitive, vulnerable, highly dynamic or stressed wetlands.) The FS is the only province which, at present, is attempting to address this deficiency by first trying to map wetland occurrences (through modelling), and secondly, to prioritise wetlands based on a wetland condition and functional analysis.

It might also be worthwhile pointing out that the FS is, thus far, one of only two provinces which has a wetland ecologist permanently employed within the provincial conservation department. The lack of such appointments in other provinces does hamper implementation of this point. It should also be noted that in an attempt to better address wetlands issues, the FS Province has a wetland policy, although not officially endorsed.

Some of the above generic and other environmental principles covered under NEMA (RSA NEMA, 1998) can be applied to wetlands management in the study area as follows:

- *Sustainable development* – applies equally to wetlands whereby wetlands, for example, should be managed and developed in such a way that their ecological services benefit the present generation without compromising the needs of the future generation (UN, 1987), or the management of wetlands must foster the integration of social, economic and environmental factors into planning, implementation and decision-making to ensure that wetlands serve present and future generations (Keevy, 2011; RSA NEMA, 1998).
- *Environmental justice* – wetlands management should ensure that the adverse impact is equitably shared and also that there is equitable access to wetland resources, benefits and services. This principle will make sure that the previously disadvantaged population in South Africa under the apartheid regime has equal access with the rest of the population to the ecological services provided by wetlands.
- *Public trust doctrine* – like any public good, *'res universitas'* (Keevy, 2011). This principle recognises wetlands as water courses and water resources in South Africa (RSA NWA, 1998) and are held in public trust by the South African government for the interest of South African citizens. Wetlands should therefore be protected as part of the common heritage.
- *Intergenerational equity* – which is closely linked to the principle of sustainable development, prescribes that one generation should not be favoured to the detriment of other generations in enjoying the benefits provided by wetlands in South Africa.
- *Precautionary principle* – which is closely linked to that of duty of care (RSA NEMA, 1998), calls on South African citizens and wetland managers to exercise all possible precautions or use a cautious approach in situations of uncertainty to not degrade, but instead to conserve wetlands in South Africa.
- *Preventative principle* – this principle calls on wetland managers and users to prevent the pollution and degradation of wetlands in South Africa and invariably those in the FS. Where prevention is impossible, all possible mitigation measures should be applied (Keevy, 2011).

- *Polluter pays principle* – implies that any identified polluter of a wetland must bear the cost of the wetlands rehabilitation and restoration. This is in line with the Rio Declaration Principle 16 (Keevy, 2011).
- *Human right to a decent environment* is a constitutionally guaranteed inalienable environmental right to every South African citizen. People must enjoy a clean environment (including wetlands). In addition, each citizen must protect and conserve the natural environment (RSA NEMA, 1998).

The NEMA prescribes the EIA as a risk assessment tool. Regulations have been promulgated in terms of NEMA that identify activities which require either basic or full EIA and that may not commence without environmental authorisation from the competent authority. Such activities include developments within or close to a wetland, the draining of wetlands and diversion of water from or into a wetland. However, implementation of the EIA process in South Africa faces challenges as discussed later in Chapter 10.

3.3.2.3 The National Water Act, Act 36 of 1998

The National Water Act (NWA) contains many clauses which refer directly to wetlands. The intention of the Act is to protect South Africa's water resources and their associated ecosystems, as well as to protect the biological diversity of these ecosystems. A water resource includes a watercourse and a water course includes a wetland, lake or dam into which, or from which, water flows (Armstrong, 2009; RSA, NWA, 1998). The NWA also provides a definition of what constitutes a wetland, which is the definition that is adopted in this study (Section 5.2).

The NWA emphasises prevention, and where prevention is not possible, on the mitigation of pollution and degradation of water resources (which includes wetlands). To achieve this aim, the national government is the public trustee of the nation's water and is therefore tasked with the protection of South Africa's water resources. In line with this objective and to uphold the principle of being the national trustee of South Africa's water resources, there is no provincial department of water affairs in the FS, but a regional Department of Water and Sanitation since they work on catchment areas, rather than political boundaries. The 'duty of care' principle is enshrined in the NWA and must be taken to prevent pollution of water resources from occurring, continuing or recurring (Armstrong, 2009). Still on the issue of pollution, similar to the NEMA, the NWA applies the 'polluter pays' principle. The NWA also gives the Minister the power to expropriate land for rehabilitation and remedial work, as well as to establish national monitoring systems for water resources.

The latter two clauses could be used to regulate, conserve and rehabilitate wetlands in the eFS which are located in government protected areas, in communal and in private land. It can be said that the conservation and protection of wetlands in the eFS, as elsewhere in South Africa, find more expression in the NWA than in any other national legislation.

The NWA stipulates that water use must be licensed and no one is allowed to impede or divert the flow of water within a water course, carry out activities that reduce stream flow, alter the bed, bank, course or characteristics of the water course if within a distance of 500 m upstream or downstream from the boundary of a wetland (Armstrong, 2009). All these are very good clauses that could help in the conservation and protection of wetlands, but in most cases, they are just rubber stamps; lacking effective implementation.

3.3.2.4 The Conservation of Agricultural Resources Act, Act 43 of 1983

The CARA became the first substantial legal instrument for protecting wetlands in South Africa (RSA DEA, 2015). The aim of CARA is to control the over-utilisation of South Africa's natural agricultural resources and to promote the conservation of soil, water resources and natural vegetation (Armstrong, 2009). Wetlands serve as natural agricultural resources, are part of the water resources of South Africa and are therefore to be conserved and sustainably used as prescribed by the CARA.

The CARA also gives the Minister of Agriculture the power to prescribe control measures that may include *"the utilisation and protection of vleis, marshes, water sponges, water courses and water sources"* (Clause 6(2)). Where the minister is of opinion that the restoration and reclamation of natural agricultural resources is necessary, the land may be expropriated for this purpose. This clause may favour the protection and conservation of wetlands in the eFS, but it may also create tension and confusion between the ministry of Water Affairs, Environmental Affairs and that of Agriculture who share the same land expropriation powers. The ministry of Environmental Affairs may use NEMA to conserve a particular wetland; the ministry of Water Affairs may use the NWA to protect the wetland, but the ministry of Agriculture may use the supporting clauses in the CARA to drain the wetland for agricultural purposes. This makes the sustainable management of wetlands a complex issue that needs a holistic and cooperative governance approach.

The CARA stipulates that authorisation is required to drain or cultivate any vlei, marsh or water sponge, cultivate any land within the flood area of a water course or within 10 m outside the flood area of a water course. No one should also divert run-off from a water course or burn veld, including wetland vegetation (Armstrong, 2009, Kotze, 2000). Wetlands are covered under these laws directly or indirectly as part of a watercourse, but again there is lack of proper implementation of these laws, and some of the reasons for this are discussed in chapter 10.

3.3.2.5 The Environment Conservation Act, Act 73 of 1989

In terms of this Act, certain activities, such as the reclaiming of wetlands (for example through drainage or infilling), dam building, river diversion and changes in land-use require environmental investigation to determine their impacts. This Act therefore supports application of the Integrated Environmental Management (IEM) principles (Kotze, 2000).

3.3.2.6 The National Environment Management: Biodiversity Act, Act 10 of 2004

The NEMA: Biodiversity Act aims at protecting species and ecosystems, while promoting the sustainable use of indigenous biological resources (Armstrong, 2009; RSA, 2004). The Biodiversity Act states that the state is the trustee of biological diversity. The Act also makes provision for establishing the South Africa National Biodiversity Institute (SANBI).

The NEMA: Biodiversity Act also relates to wetlands management in that it makes provision for the Minister or MEC to issue a list of threatened species that may need protection, and these species may include wetland species. The national bird of South Africa (the Blue Crane or *Anthropoides paradiseus*) breeds in wetlands that need protection. The Act also makes the 'duty of care' relating to alien and invasive species mandatory (Armstrong, 2009; Kidd, 2011). Alien and invasive species are some of the stressors of wetlands in the eFS that need careful management.

Under the NEMA: Biodiversity Act, authorisation is required for any activity that may disturb or threaten protected ecosystems, activities that disturb the environmental processes within an ecosystem, harm endangered species or may promote alien and invasive species (Armstrong, 2009). The planned diversion of the N3 in the Harrismith region in the eFS that will pass through wetland areas, will be a true test in the application of this and other wetland-related acts.

3.3.2.7 Water Services Act, Act 108 of 1997

The aim of the Water Services Act is to provide South Africans with access to basic water supplies, basic sanitation, and to set national standards, norms and tariffs. The Act also provides water services development plans, a regulatory framework for water services institutions and water services intermediaries, and also provides for the establishment and disestablishment of water boards and water services committees. The Act further provides for the monitoring of water services and intervention by the Minister or by the relevant Province;

provides financial assistance to water services institutions; defines certain general powers of the Minister; gathers and maintains a national information system and may repeal certain laws. The Water Services Act also covers wetlands as part of the water supply system (RSA, 1997).

3.3.2.8 The National Forests Act, Act 84 of 1998

The National Forests Act protects and promotes the sustainable use of the South African forests, and the relevant Minister may declare an area protected if not already protected under any other legislation. The Act prohibits tree planting or reforestation in areas reserved for the protection of natural water sources, which include wetlands (Kotze, 2000). Forest plantations are one of the land use threats to wetlands in certain parts of South Africa (Kotze *et al.*, 2009), and may soon become a threat to wetlands in the eFS without proper management.

3.3.2.9 Mountain Catchment Areas Act, Act 63 of 1970

This Act provides for the conservation, use, management and control of land situated in declared 'mountain catchment areas'. The Act calls for the control of fires so as to prevent soil erosion and protect natural vegetation. Wetlands within mountain catchment areas such as those in the Lesotho Highland from where water is supplied to South Africa via eFS, as well as wetlands around the Drakensberg Mountains which serves as the watershed for some rivers in the eFS, are covered or should be covered under the provisions of this Act.

3.3.2.10 The National Environmental Management: Protected Areas Act, Act 57 of 2003

The aim of the NEMA: Protected Areas Act is to conserve and protect ecologically viable areas and their natural landscape (Armstrong, 2009; RSA, 2003). The Act further states that protected areas should be managed by management authorities and should have a management plan. The Seekoeivlei wetland is located within a protected area and is therefore protected according to this Act. Other wetlands such as those in private and communal lands also need some degree of protection and management plans if they are to be conserved and sustainably used. This research highlights this need.

3.3.2.11 The Natural Heritage Resources Act, Act 25 of 1999

The aim of this Act is to protect South Africa's natural and cultural heritage. Some wetlands, such as the St Lucia wetlands, have very high social and cultural values and are heritage sites protected, or supposedly so, under the Natural Heritage Resources Act.

3.3.2.12 *Integrated Environmental Management guidelines and principles*

An IEM principle in South Africa ensures that the environmental consequences of development proposals are understood and adequately considered in the planning and implementation of the development project. The IEM is factored in land-use zoning plans and schemes, new activities, and existing activities. IEM is a useful and nationally accepted framework for planning development, and wetland-uses are fitted easily within this framework (Kotze, 2000). This holistic approach is also echoed in the Integrated Catchment Management Policy.

3.3.2.13 *Integrated Catchment Management Policy*

The term 'Integrated Catchment Management' represents a systems approach to the management of natural resources, in particular water resources, within the bounds of a geographical unit which is based on the catchment area of a single river system. Catchments are further divided into sub-catchments (Kotze, 2000). This policy recognises the need to integrate all environmental, economic and social issues within a river basin into an overall management philosophy, process and plan (Kotze, 2000). The main aim of integrated catchment management is the sustainable use of natural resources for the benefit of the local community. The implementation of integrated catchment management is usually assessed through the establishment of a catchment management forum, the composition and nature of which will depend on the particular situation (Kotze, 2000). These forums discuss wetlands issues as part of catchment management.

From the above discussion, it can be confirmed that a myriad of legislation relates directly or indirectly to wetland issues, but with no specific national policy on wetlands as those observed in Uganda.

3.3.3 Institutional arrangement for wetlands management in South Africa

This subsection examines government departments, NRMPs, the NGOs, wetlands management forums and other stakeholders directly involved in wetland issues in South Africa and in the eFS.

3.3.3.1 *Government departments*

Three national government departments have direct jurisdiction over wetlands in South Africa. These national departments include the DWS, the DEA, and DAFF (Glazewski, 2013). These national departments keep changing names at national, provincial and even down to the local spheres of government in South Africa. Some departments do not exist at provincial level. For example, the National DWS assumes a regional status in the provinces, like in the FS

Environmental Affairs changes from national to provinces where, for example, in the Free State it is called the Department of Economic, Small Business Development, Tourism and Environmental Affairs (DESTEA). The forestry directorate keeps changing between the national Departments of Water and Sanitation and that of Agriculture. This constant mutation in the institutional arrangement could create confusion and negatively affects the management of wetlands, especially around issues of responsibility, accountability and coordination. All these departments were discussed under the various legislations that guide their operations with regards to wetlands (see 3.3.2).

3.3.3.2 National resources management programmes

These programmes are also referred to as the Expanded Public Work Programmes (EPWPs) and they include the following:

Working for Water (WfW)

The WfW programme was created in 1995 with the main objective of fighting invasive alien plants (IAPs) while creating local employment. Formerly, WfW was under the DWS but now it operates under DEA. The IAPs are considered as the single biggest threat to South Africa's biological diversity (Kotze, 2008; RSA DEA, 2015). Of the 9 000 plants introduced to South Africa, 198 are today classified as IAPs (RSA DEA, 2015). Since 1995, WfW has cleared more than one million hectares of invasive alien plants, provided jobs and training to approximately 20 000 mostly marginalised people, 52% of whom are women (RSA DEA, 2015). IAPs in wetlands are discussed in more detail under wetland risk and vulnerability in Chapter 6.

Working for Wetlands (WfWetlands)

The WfWetlands is a pan-governmental public work programme created in 2002 as part of the EPWP to conserve wetlands while creating employment for the 'poorest of the poor' in South Africa (RSA DEA, 2015; SANBI, 2010). It targets women, youth, the disabled, single-parent households, military veterans, former inmates and other disadvantaged groups in need of poverty relief (Dini, 2004).

WfWetlands is a joint initiative of three government departments, these being the DEA, the DWS, previously known as DWA, and DAFF. WfWetlands is an example of a programme that promotes cooperative governance and partnerships. Its projects focus on the rehabilitation, 'wise use' and protection of wetlands in a manner that maximises employment creation, supports small businesses, alleviates poverty and transfers relevant and marketable skills to the beneficiaries (RSA DEA, 2015). About 14 years since its inception, WfWetlands has invested more than R725 million in the rehabilitation of 1 011 wetlands, covering more than

80 000 ha of wetlands area. In the process the programme has provided 18,463 employment opportunities. WfWetlands has also provided almost three million person-days' work to date and has provided 193 780 days of training in both vocational and life skills (RSA DEA, 2015).

Most projects initiated by WfWetlands focus on rehabilitation, thus the idea of restoring and recovering damaged wetlands do not feature strongly in the projects of the programme. The dual purpose of rehabilitating degraded wetlands and creating employment at the same time, may slow down or reduce the ability of WfWetlands programmes to maximise the rehabilitation of many degraded wetlands in South Africa, as in the study area. Other challenges that WfWetlands face include the standards for selecting wetlands for rehabilitation, putting in place sustainable monitoring of rehabilitated wetlands, and ways that those temporary employed in the programme can have sustainable livelihoods after employment (Dini, 2004). Though some of these challenges are being addressed, more still needs to be done, especially at the current period of general economic melt-down with rising unemployment, corruption and several social unrests in South Africa.

LandCare South Africa

The LandCare South Africa programme was established in 1997 for the sustainable management of natural agricultural resources, and to mitigate and prevent the degradation of natural agricultural resources to reduce rural poverty, create jobs and improve food security. LandCare is a community-based programme with support from intergovernmental departments in partnership with NGOs, community-based organisations and the private sector. Its four thematic areas include soil care, water care, veld care and junior care. LandCare is indirectly involved in the management of wetlands as part of natural agricultural resources through its water care projects (source).

Working for Land (WfL)

The objective of WfL is to ensure that degraded ecosystems (such as wetlands) are restored to their formal or original state so that these ecosystems are able to maintain or support the natural species of that system. WfL is all about encouraging and supporting sustainable land use practices, raising awareness and promoting resource conservation ethics. It creates jobs and encourages community partnership and cooperation (RSA DEA, 2015). This programme seeks to address degradation of land due to desertification, overgrazing, soil erosion, poor storm water management, fight bush encroachment and unsustainable farming practices. WfL partners with the LandCare programme and other conservation groups/institutions in any catchment area. These include municipalities, farmers and/or farmer's forums, universities and schools, to tap into and share resources and expertise.

WORKING ON FIRE (WOF)

WoF was launched in 2003 to fight veld and forest fires, create jobs, alleviate poverty and sustain the environment. WoF employs more than 5 000 young people of both genders in about 200 teams in South Africa (RSA DEA, 2015). WoF works through integrated fire management practices, which includes supporting the development of the Fire Protection Association structure under the National Veld and Forest Fire Act, Act 101 of 1998. Effective and integrated fire management is key in maintaining the ecological integrity of wetlands. Fire is one of the main hazards in the study area and if not well managed leads to the degradation of many wetlands.

WORKING FOR THE COAST PROGRAMME (WFTC)

The WftC is part of the EPWP and is guided by the National Environmental Management: Integrated Coastal Management Act, Act 24 of 2008. The focus is to create jobs, alleviate poverty, while addressing coastal problems such as continuous sedimentation of coasts, coastal pollution (especially oil spills), direct destruction of coastal habitats, fighting IAPs, as well as urbanisation and influx of tourists to coastal zones. The vision of WftC is to ensure a healthy and sustainable coastal environment that is equitably maintained and preserved for current and future generations (RSA DEA, 2015). Through its activities, WftC should be able to address the degradation of coastal wetlands, including coastal mangroves. Though there are no coastal areas in the eFS, the WftC is part of the national institutional arrangement that has an influence on wetlands.

3.3.3.3 Non-governmental organisations

THE MONDI WETLAND PROJECT (MWP)

The MWP was established in 1991 as a joint venture between the World Wildlife Fund (WWF)–South Africa and the Wildlife and Environmental Society of South Africa (WESSA). The main aim of MWP is to bring about social changes that promote the sustainable and 'wise use' of wetlands (MWP, 2014). The MWP operates from Centurion in Gauteng and Horwick in KZN. The MWP strategic management aligns wetlands with the NWA, as well as demonstrates the link between wetlands and people. The MWP conserves wetlands outside nature reserves. The programme focuses mostly on palustrine wetlands such as meadows, marshes and floodplain wetlands (MWP, 2014). The MWP operates both at grassroots level and at a political decision-making level, and works with wetland stakeholders such as farmers, government, agricultural and conservation agents and historically disadvantaged communities. The MWP does not only focus on rehabilitating degraded wetlands, but addresses the root causes of wetland degradation through awareness, education, knowledge and capacity-building, and political support by lobbying. Through cooperative governance principles, the MWP could play a critical role in the conservation, protection, wise and sustainable use of wetlands. Unfortunately, the MWP is not prominent in the eFS.

The Endangered Wildlife Trust

The EWT was founded in 1973 with a focus on research, field-work and direct engagement with stakeholders. The EWT's work supports the conservation of threatened species and ecosystems. Priority interventions focus on identifying the key factors threatening biodiversity and developing mitigating measures to reduce risk and reverse the drivers of species extinction and ecosystem degradation (EWT, 2014).

The EWT has about 13 programmes with six imperative strategies (EWT, 2014), and if properly implemented, the EWT can support the conservation of threatened species and ecosystems that will include endangered wetlands species, as well as the conservation of wetlands as habitats for these species.

Other wetlands stakeholders

Other wetlands stakeholders in South Africa include private and communal land owners/users, the local communities, water management agencies, biodiversity conservation agencies, development agencies (including urban planners), as well as research and academic organisations. Coordination and building synergy amongst these various stakeholders (who sometimes have different and conflicting interests) is a challenge to wetland managers in the eFS.

3.4 THE ENFORCEMENT OF WETLAND-RELATED LEGISLATIONS IN SOUTH AFRICA AND THE EASTERN FREE STATE

Stakeholders who implement environmental laws, which also regulate wetlands management, include the state as the national trustee of the environment; controlling bodies like SANBI and its affiliated programmes like WfWetlands; environmental management inspectors or the 'green scorpions'; and officials of the conservation agencies like SANParks (Keevy, 2011; Kidd, 2011). The state may use criminal sanctions, administrative measures, civil measures or a combination of these measures to enforce environmental law (Keevy, 2011).

3.4.1 Difficulties in enforcing wetland management legislation

Wetlands do not have a specific legislation and management policy in South Africa, though a non-endorsed provincial policy exist in the FS. Wetlands are covered by multiple legislations that affect the general environment of which wetlands form part of. These laws have both inherent and contingent weaknesses in their enforcement (Armstrong, 2009; Keevy, 2011).

3.4.1.1 Inherent weaknesses

There is the high burden of time and cost that prevails between the commission of an environmental offence and the trial and persecution of the culprit. This arises from the need to gather enough expert evidence and for the offender to receive the constitutional right to a fair trial. It is also problematic to get witnesses to testify and sometimes the environmental complainants are reluctant to sue for cases with small fines and inadequate penalties, notwithstanding the cumulative impacts of such offences on the environment. The preparation of cases drains resources and even the 'green scorpions' may be reluctant to stand for long hours in court and thus sacrifice other tasks (Keevy, 2010; Kidd, 2011).

The reactive nature of criminal law is not favourable for environmental and wetland issues. The crime is consumed and the damage already done on the environment before action is taken. Criminal law is not preventive (Keevy, 2011) and wetlands management should be more preventive and proactive.

It is sometimes difficult to identify the main offender of the environmental crime (Kotze, 2000; Keevy, 2011). Typical examples are instances of disperse (or diffuse) as opposed to the point source pollution of wetlands. To establish the *'mensrea'* becomes a problem for law enforcement.

3.4.1.2 Contingent weaknesses

The contingent weaknesses of environmental law as cited by Keevy (2011), include the following:

- Lack of expert knowledge and training from the environmental management officials which may impact on the process of investigation.
- There are few environmental law experts in South Africa to handle environmental cases, resulting in inexperienced prosecutors, magistrates and lawyers handling environmental cases.
- There is also the problem of inadequate policing of the environment, which is compounded by the problem of a lack of environmental awareness in South Africa. It may therefore be necessary to train more environmental inspectors, as well as promote environmental education and awareness campaigns in schools and local communities (Keevy, 2011).

3.5 CHAPTER SUMMARY

This chapter examined the legal and institutional arrangement for wetlands management at global and national level. It started by looking at the international agreements that relate to wetlands and which South Africa signed and ratified. The chapter then examined the legal and institutional arrangement for wetlands management in the USA, Uganda and Ghana, since these countries were cited as having some of the best practices for wetlands management. It was realised that good coordination was practised by EPA in the USA, a national wetland policy exists in Uganda with good bottom-up arrangements for wetlands management, while in Ghana regional cooperation and traditional beliefs help in the conservation of wetlands. The arrangement in South Africa was then examined and while a number of similarities were noticed compared to the three other countries, there were, however, legal and institutional weaknesses in the management of wetlands, not only at national level, but also at local level. First, there were many legislations with direct or indirect relevance to wetland issues, but no specific legislation or policy on wetland unlike a whole legislation on the forest. Three government departments have direct responsibility over wetland issues, while many EPWPs are also linked directly or indirectly to wetlands management. The implementation of generic environmental laws which also cover wetlands, suffer from both inherent and contingent weaknesses and this affects their effective implementation.

Chapter 4

LINKING DISASTER MANAGEMENT AND ENVIRONMENTAL MANAGEMENT

4.1 INTRODUCTION

This chapter explores the interface between disaster management and environmental management as the main disciplines within which this study is grounded. However, CCA has also been included to make the final proposed framework more robust and holistic. This chapter looks at the basic principles and practices of both disaster management and environmental management to demonstrate the need to build synergy between the two disciplines. The chapter further zooms into environmental management to explore the role of ecosystems, particularly wetlands, in reducing disaster risks, adapting to climate change and enhancing community well-being.

4.2 DISASTER MANAGEMENT

The International Federation of Red Cross and Red Crescent Society (IFRC, 2013: Online) defines disaster management as follows:

> *[T]he organization and management of resources and responsibilities for dealing with all humanitarian aspects of emergencies, in particular* preparedness*,* response *and* recovery *in order to lessen the impact of disasters.*

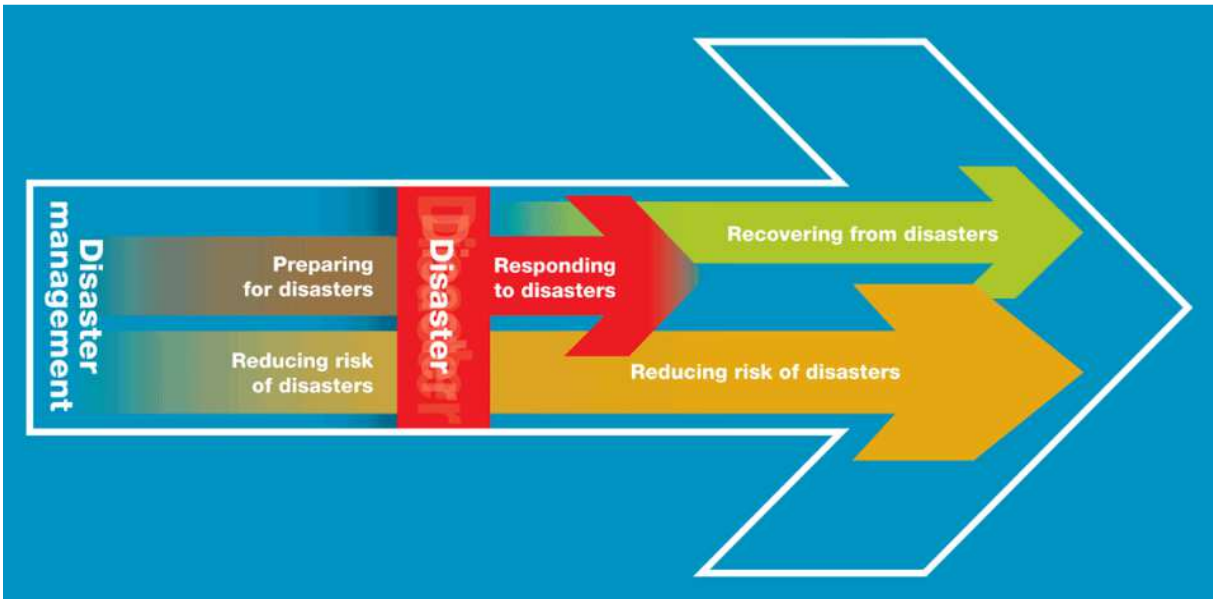
Though the IFRC has started incorporating pre-disaster measures, especially after 2003 during its 28th International Conference when it acknowledged the importance of DRR and to undertake DRR measures in its operations, the definition adopted clearly shows the orientation of IFRC toward a humanitarian response to disasters (Figure 4.1).

The definition of IFRC is a bit limiting than the one adopted by the South African National Disaster Management Act (RSA NDMA, 2002:7) which defines disaster management as follows:

> *[A] continuous and integrated multi-sectoral, multi-disciplinary process of planning and implementing measures aimed at –*
>
> *(a) preventing or reducing the risk of disasters;*
>
> *(b) mitigating the severity or consequences of disasters;*
>
> *(c) emergency preparedness;*

(d)   a rapid and effective response to disasters; and

(e)   post-disaster recovery and rehabilitation.



Source: IFRC (2013)

Figure 4.1   Disaster management process

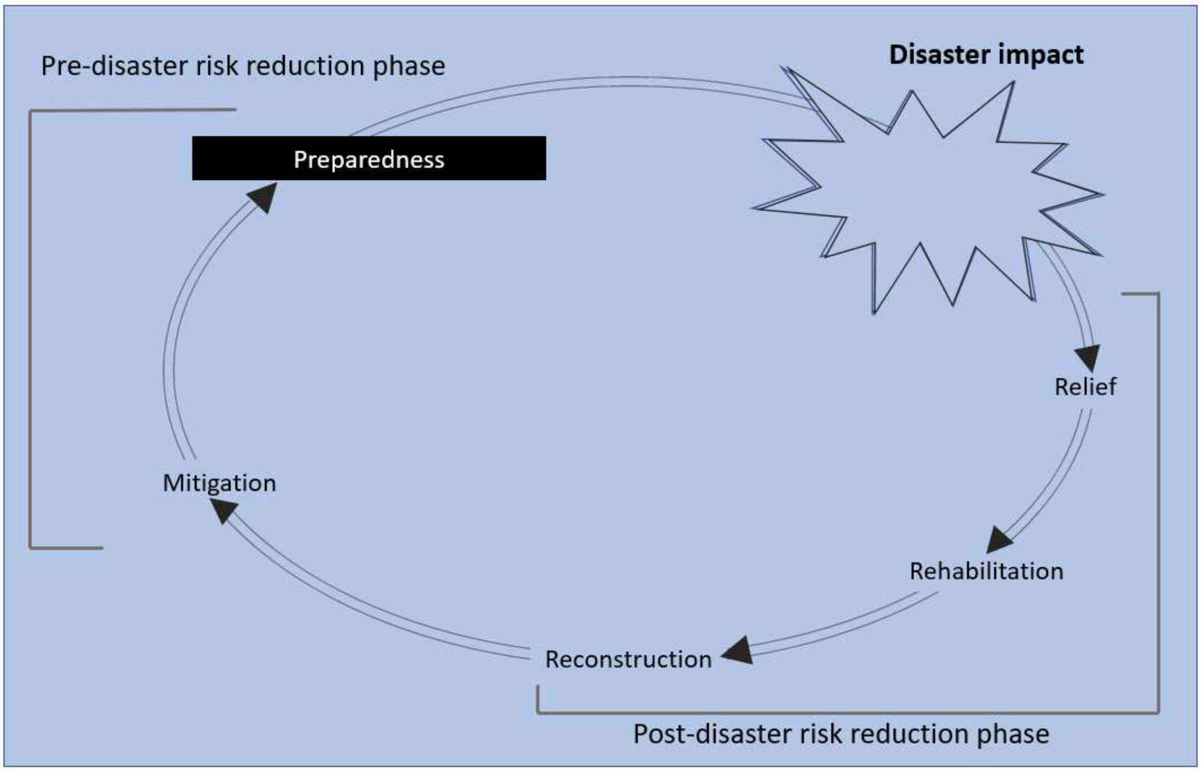
Though these two definitions have much in common, the South Africa definition closely follows the UNDP (1992) disaster management cycle (Figure 4.2). There also seems to be some repetition in the South Africa definition, for example reducing the risk of disaster is the same as mitigating the severity or consequences of disasters. This repetition is obvious since it is difficult to differentiate between preventive and mitigation measures (UNISDR, 2009). Also, the concept of recovery already covers rehabilitation which, together with restoration and reconstruction, forms part of the recovery process.

On the other hand, the IPCC (2012) looks at disaster management as the processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster DRR and risk transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, resilience, and sustainable development (IPCC, 2012). The IPCC's (2012) definition is quite comprehensive and shows improvement in the understanding of the new field of disaster management. From all these definitions, there is a clear indication in the convergence of understanding about a series of continuous and somehow cyclical measures involved in disaster management.

4.2.1 Disaster management cycle

It is always difficult to determine the timeline for the various disaster management interventions; for example, when the process of disaster relief or response ends and when rehabilitation should start, or to clearly demarcate when the process of rehabilitation should end and that of reconstruction should start. Some authorities hold that response should cover the first 2–3 weeks after a disaster and then after the process of rehabilitation should kick in, while to others the process of recovery could last between 5–10 years or even more (Carter, 2008).

It is interesting to note that the UNISDR (2009) is silent on the term 'disaster management', but instead prefers to use a closer term of 'disaster risk management'. The UNDP's (1992) disaster management cycle gave the base for later disaster management conceptual development. The old or traditional disaster management cycle is depicted below:



Source: Adapted from UNDP (1992)

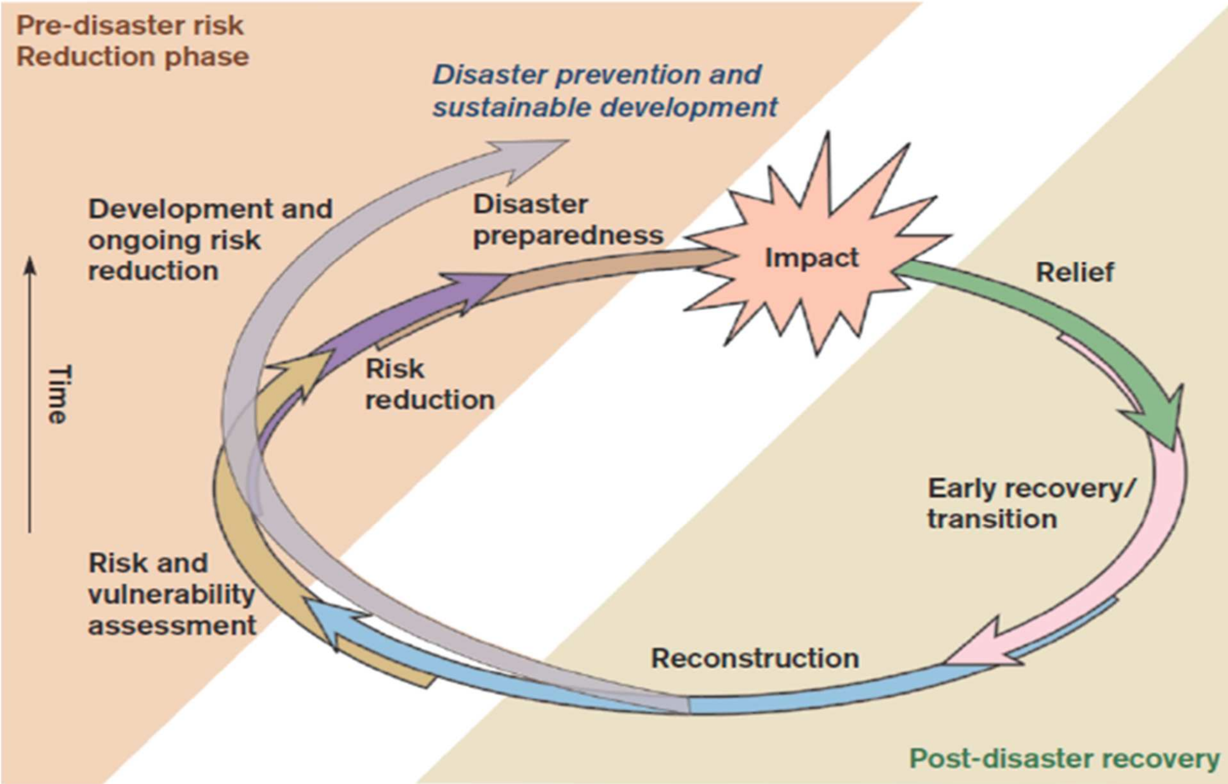
Figure 4.2 The traditional (old) disaster management cycle

The UNDP model is simple and easy to follow, especially to non-disaster specialist.

4.2.2 The more refined disaster management spiral

The disaster management spiral and recent versions of the disaster management cycle tried to correct the central criticism that was labelled on the traditional disaster management cycle.

The traditional cycle seemed to depict that disaster management as a cycle has a beginning and an end, with pre- and post-disaster activities, but later versions proved that DRR activities could be incorporated even in the post-disaster activities, for example the 'build back better' concept (UNISDR, 2013; 2015). The disaster management spiral was developed to improve on the traditional disaster management cycle so that more emphasis and importance be shifted to disaster prevention, mitigation and sustainable development. In order words, a paradigm shift from reactive to more proactive disaster management from the early 1990s, which marked the debut of the International Decade for Disaster Risk Reduction and culminated into the HFA 2005−2015 (RICS, 2009 in CNRD/PEDRR, 2013).



Source: RICS (2009), in CNRD/PEDRR (2013)

Figure 4.3 Disaster management spiral

Another very important concept that has been introduced in the disaster management spiral is the risk and vulnerability assessment, which is the backbone for all disaster management plans and activities (see Chapter 6).

4.2.3 Components or phases of disaster management

For simplicity sake, disaster management involves pre-disaster and post-disaster activities, as well as cross-cutting issues that must be addressed (Figure 4.4).

4.2.3.1 *Pre-disaster activities*

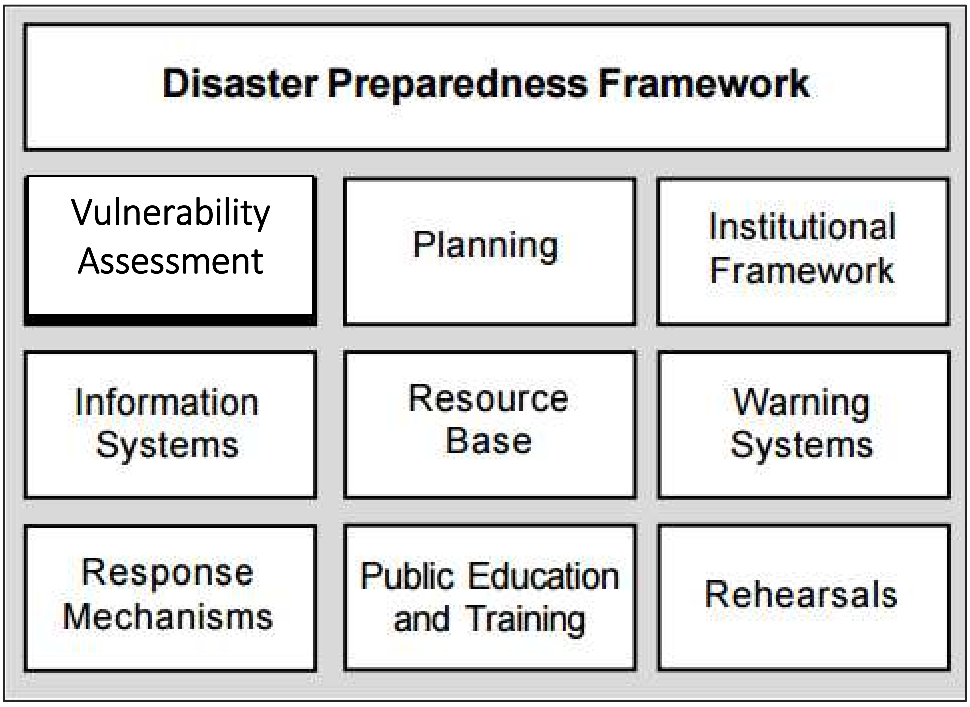
PREPAREDNESS

These are activities taken prior to a disaster. Preparedness refers to activities and measures taken in advance to ensure effective response to the impact of disasters, including the issuance of timely and effective early warnings and the temporary removal of people and property from a hazard pathway (UNISDR, 2009). Preparedness measures enable governments, organisations, communities, and individuals to respond rapidly and effectively to disasters, and such measures may include the following:

- Formulating and maintaining valid and updated counter-disaster or preparedness plans which can be brought into effect whenever required.
- Special provisions for emergency exercises, such as evacuating populations or moving them temporarily to safe havens.
- Providing effective early warning systems.
- Good and effective emergency communications.
- Effective public education and awareness.
- Well-designed training programmes, including exercises and tests or drills (Carter, 2008).

In the science of disaster management, the term ‘preparedness’ is basically the planning phase of drafting and testing early warnings, planning for evacuation and other response activities, as well as planning for effective recovery following a disaster. Therefore, a response and recovery strategy is only as good as it was planned for in the preparedness phase.

The UNDP/DHA Disaster Management Training Programme (Kent, 1994) developed a disaster preparedness framework with nine components (Figure 4.4), which is popularly used by disaster management practitioners (Twigg, 2004).



Source: Kent (1994:16)

Figure 4.4 Disaster preparedness framework

Disaster preparedness and response are linked, although they turn to appear on the opposite side of the disaster management cycle. The same can be said of the disaster preparedness framework and a disaster contingency plan. Any effective response depends on proper preparedness and some practitioners fuse the two plans into a single disaster response plan which is then separated from the disaster recovery plan (Carter, 2008). A good preparedness plan enables the community or organisation to predict, respond to and cope with the negative impacts of a disaster. *"To fail to prepare for an eminent disaster is to prepare to fail in responding to that disaster."* This is the price that no benevolent government, organisation or community can afford to pay for their people, property or the environment when hit by a disaster.

MITIGATION

These are actions taken to reduce the effects of hazards or disasters. Carter (2008) gives a list of mitigation measures which include:

- Dykes, levees and dam construction.
- Maintaining healthy ecosystems such as wetlands, coral reefs and forests.
- Enforcement of building codes.
- Land-use regulations and zoning.
- Safety regulations relating to high-rise building and control of hazardous substances.

- Safety codes governing land, sea, and air transport systems.
- Agricultural programmes aimed at reducing the effects of hazards on crops.
- Systems to protect key installations such as power supplies and vital communications.
- Developments in infrastructure, such as the routing of new highways away from disaster-prone areas.

Most hazards may not be completely avoided, but their severity and negative impacts can be reduced through good and effective mitigation measures. Mitigation measures could be grouped into the following categories:

- Structural measures which include activities like engineering techniques such as the building of dykes and levees, resistant construction of infrastructures like buildings, roads, bridges (also known recently as hard or grey engineering), as well as maintaining healthy ecosystems such as wetlands, forests, mangroves (known recently as green or soft engineering).
- Non-structural mitigation measures include actions like the enactment and enforcement of sound building codes, urban planning, land-use zoning and maintaining healthy ecosystems such as wetlands.
- Mitigation measures could also be grouped into **Active Measures** which involves physical interventions, like the measures cited under structural measures, and **Passive Measures** which could include law enforcement and the use of fines. Active measures will encourage individuals to apply mitigation measures, while passive measures will apply punitive actions for non-compliance to stated mitigation measures.
- Mitigation measures can also be short-term or long-term measures when a time factor is built into the applied mitigation measure (Kesten, 2008; PEDRR, 2013).

In climate change terminology, mitigation is conceived differently as the reduction in greenhouse gas emissions, which in turn will lead to abatement of global warming (IPCC, 2007). This term (mitigation) needs to be harmonised if DRR and CCA need to use it harmoniously without confusing the general public.

PREVENTION

Disaster prevention involves activities carried out to impede or completely avoid the occurrence of a disaster, or from making an emergency event/hazard not to turn into a disaster. Such measures normally include:

- Dam or levee construction to control flood water that may have devastating effects on human lives, livelihoods, properties and the environment.
- Avoiding or controlling burning in a bushfire-prone area prior to high fire-risk seasons or days with high fire-rating indexes (red, orange and even yellow days in South Africa).
- Using land-use regulations to avoid developments in hazards pathways like floodplains or steep slopes prone to landslides, mud flow and avalanches.

It is sometimes very difficult to prevent certain naturally occurring hazards like lightning. It is also difficult to separate prevention measures from those of mitigation. For these two reasons, many authors lump up prevention and mitigation measures into disaster mitigation (Syed, 2013; UNISDR, 2013). Disaster prevention and mitigation using hard designed structural engineering can be very expensive. For example, flood barriers built in England over recent years to protect the city of London cost some 700 million pounds or approximately 1 173 million US dollars (Carter, 2008). Such high cost and other considerations have led to an emerging paradigm shift that now advocates the use of the natural environment (green engineering) to mitigate disaster risk and adapt to climate change. This new approach is popularly referred to as the Eco-DRR/CCA (PEDRR, 2013; Renaud *et al*., 2016). This research follows the new Eco-DRR/CCA approach.

4.2.3.2 Post-disaster activities

RESPONSE

These are actions intended to save lives, alleviate suffering and provide basic care during a disaster or immediately after a disaster. The term 'disaster relief' is often used as a synonym to 'disaster response'. Disaster response measures are mainly directed towards saving lives, protecting property, dealing with the immediate disruptions, damages, and other effects caused by the disaster and would typically include:

- Early warning systems (which is also a preparedness measure).
- Activating and implementing the counter-disaster system or response plan.
- Search and rescue.
- Providing emergency food, shelter, medical assistance.
- Surveying and carrying out the initial damage assessment.
- Evacuating.

The first respondents in a disaster situation are the local community members. Therefore, it is important to recruit and train the local volunteers to better equip them as first responders to a disaster. Other role players include the civil society and national governments with support from the international community as well as NGOs (De Groeve *et al*., 2014).

RECOVERY

Disaster recovery is the process of restoring the community back to its pre-disaster or improved pre-disaster state. The first phase of recovery after a disaster when essential services are restored so that the community can start functioning normally again is called **rehabilitation**, while the stage of restoring all functional systems in the community and even building better infrastructure is referred to as the **reconstruction phase**. If well-planned, the recovery phase normally opens a window of opportunity for development when better services and infrastructure are provided to the community than was the case before the disaster. This is popularly referred to as the Build Back Better concept (IFRC, 2013; UNISDR, 2009; 2015). Activities covered under the recovery process would typically include:

- Restoring essential services.
- Providing temporary housing.
- Restoring of repairable homes and other buildings/installations.
- Claims processing and grants.
- Measures to assist the physical and psychological rehabilitation of persons who have suffered from the effects of the disaster.
- Long-term measures of reconstruction, including the replacement and improvement of buildings and infrastructure that have been destroyed by the disaster (Carter, 2008).

Humanitarian assistance is often provided during the post-disaster phase and should not be confused with development aid. Humanitarian deals with immediate needs in on-going emergencies (response), while development aid ensures preparedness for future events (recovery). However, the two are related in that more of the former call for the need for more of the later (De Groeve *et al*., 2014).

4.2.3.3 Cross-cutting issues in disaster management

RISK IDENTIFICATION AND ASSESSMENT

These are activities undertaken to address the risk factors. Examples include hazard assessment/analysis, vulnerability assessment/analysis, capacity assessment, risk prioritisation and risk mapping. These are the first steps in disaster management planning. These measures are fully covered in Chapter 6 under wetlands risk and vulnerability assessment (6.5.2).

Legislative and institutional arrangement

This deals with issues on law and cooperative governance. Examples include disaster management legislation and policies, multi-stakeholder engagement and arrangements for integration of disaster management into development plans (RSA, 2002). The legislation and institutional arrangements form part of the comprehensive disaster management planning and were covered in Chapter 3.

All disaster management activities (Figure 4.2) should take place within the overall framework of sustainable development and, therefore, DRR activities should be integrated into the development plans of the community (RSA, 2005).

4.2.4 Disasters and development

The relationship between disasters and development can most often be regarded as negative, but it can also bring about positive effects.

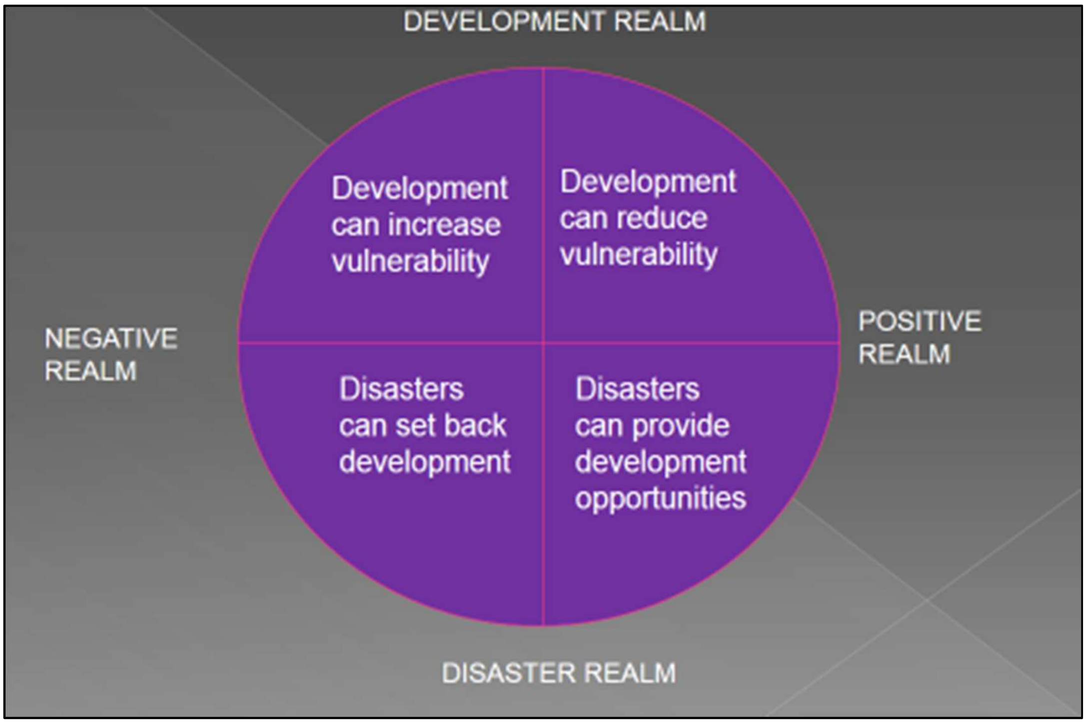
Development programmes can increase the vulnerability of a community or a system to disasters, for example, constructing an oil company in a residential area that emits lots of gas fumes, or building a mining company in a residential area which affects the health of the local community (Kesten, 2008).

Development programmes can also reduce vulnerability to disasters, for example, the construction of houses using proper building codes designed to withstand earthquakes that can then result in less destruction during the next disaster occurrence. The Great East Japan earthquake and tsunami of 2011 is a classic example.

Most often and always remembered is the fact that disasters set back development. Critical infrastructure that is destroyed during a disaster takes time and drain resources to reconstruct. Since 1900 disasters have caused global economic damages worth US$7 trillion (EM-DAT, 2016). There were 376 registered natural disasters globally in 2015 that caused 22 765 deaths, affected 110.3 million people and caused economic damages worth US$70.3 billion. The number of disasters were higher in 2015 compared to the 330 registered in 2014 (Guha-Sapir *et al*., 2015). The 2015/16 drought was the costliest drought in the South African history at US$1 billion worth of economic damages (Guha-Sapir *et al*., 2016).

Lastly, disasters may provide windows of opportunities to initiate development programmes. For example, the Build Back Better during reconstruction, if properly planned, brings in development (UNISDR, 2015). Rebuilding of houses destroyed during an earthquake or tornado teaches new skills to the local builders to build better and more resistant houses

(Kesten, 2008). Disasters can also function as a catalyst for change, for example reorganisation and improved learning processes in communities or societies, often accelerating underlying policy and social trajectories (Birkmann *et al.*, 2013; Pelling and Dill, 2010, in Birkmann *et al*., 2013).



Source: Kesten (2008)

Figure 4.5 The relationship between disaster and development

4.2.5 Disaster trends

4.2.5.1 Global perspective

Every year, the lives and livelihoods of millions of vulnerable people are pushed to the brink by natural and man-made hazards and disasters. According to the Centre for Research on the Epidemiology of Disasters (CRED), more than 96 million people in 115 countries were affected by natural disasters in 2013 alone (De Groeve *et al*., 2014). The economic costs of these disasters were concentrated in the industrialised countries, while the impact on people in terms of those killed, injured and left homeless was mostly concentrated in developing countries (De Groeve *et al*., 2014). In the same year (2013), 14 million people in the Philippines were affected by Typhoon Haiyan, pushing already poor Filipinos deeper into poverty. The economic cost of the crisis was estimated in the region of $12–15 billion, equivalent to five percent of the country's GDP (UK DFID, 2014). Between 1992 and 2012, disasters caused US$2 trillion of damage in the developing world, more than the total development aid given over the same period (UK DFID, 2014). Man-made disasters such as the conflict in Syria have produced more than three million refugees and a further 2.4 million internally displaced people. In Africa, conflicts in South Sudan and the Central African Republic remain unresolved, contributing to 1.4 million refugees in Africa. Some experts predict that the Ebola virus could infect up to 1.4 million people by January 2015 if left unchecked (UK DFID, 2014). All these disasters affect people, their assets, livelihoods, the environment and set back development initiatives.

The number and seriousness of disasters in terms of people affected and property losses has been increasing since the 1960s when reliable data started to be recorded (UK DFID, 2004). It is also becoming increasingly evident that the impacts of disaster are disproportionately shared where poor countries and poor communities are more affected than rich countries and rich communities, for example, it is estimated that poor countries constitute only 11% of the current more than seven billion people in the world, but they suffer more than half of all the disaster deaths and suffer greater economic losses relative to their GDP than the rich countries (UK DFID, 2004). It is also estimated that about 60 000 people die from disasters per year. This figure fluctuates and is very conservative since in 2003 alone, an estimated 90 000 disaster deaths were recorded (UK DFID, 2004). Major disaster data-capturing agencies like EM-DAT of the CRED, based at the Catholic University of Louvain in Brussels, only capture major disasters with at least 10 reported deaths. This means several minor disasters in the world, and especially those occurring in poor rural areas with inadequate reporting mechanisms, may be missed in the disaster impact data capturing system.

Weather-related hazards are increasing in scope, frequency and intensity (IPCC, 2012), while exposure to hazards is also increasing, as more people, infrastructure, assets and livelihoods are present in hazard-prone areas resulting in a general rise in disaster damages (Mitchell *et al*., 2012). While Mitchell *et al*. (2014) claimed that the death toll from disasters increased from an average of 65 000 in 1980 to 72 000 in 2013, other authors claimed that disaster mortality showed a decrease over the last decade (CNRD/PEDRR, 2013; EM-DAT, 2012; UNISDR, 2013). Earthquakes as a single hazard accounted for 38% of global mortality from disasters between 1980 and 2013 (Mitchell *et al*., 2014).

Between 2000 and 2012, disasters have killed 1.2 million people, affected 2.9 million people and have caused damages worth 1.7 trillion US dollars (UNISDR, 2013). Table 4.1 shows statistics of some of the peak years.

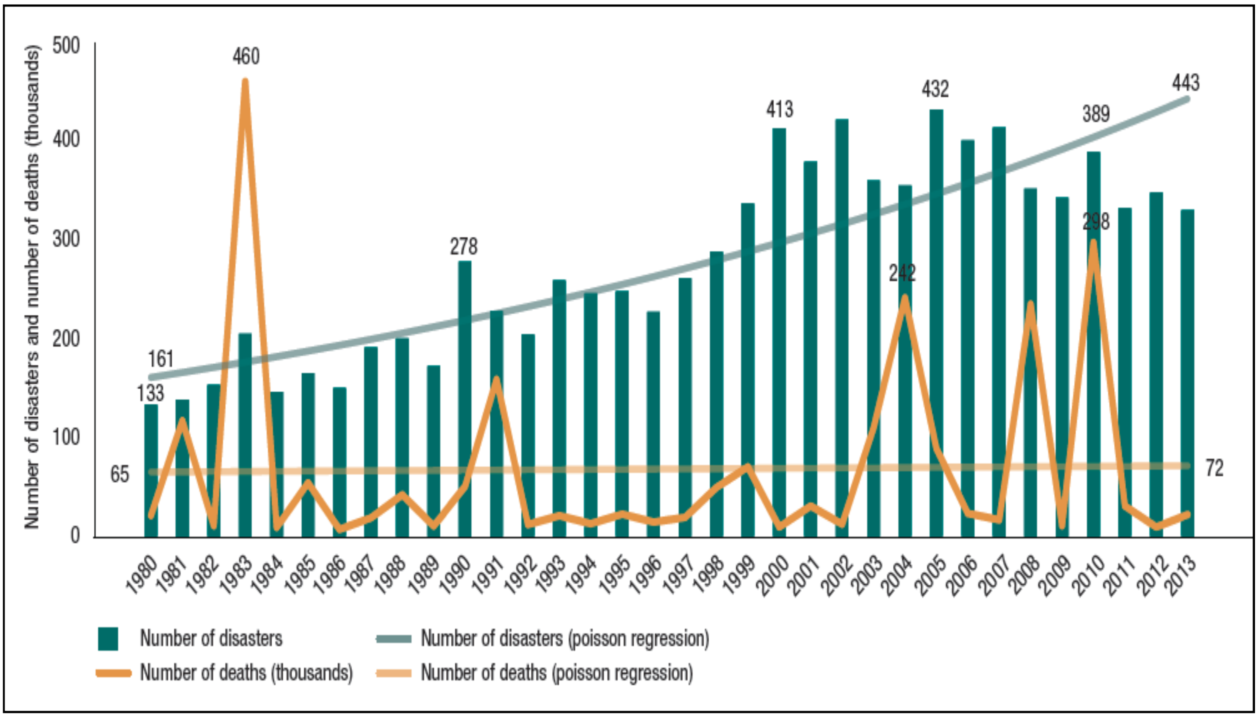
TABLE 4.1: SOME MAJOR DISASTER PEAKS IN THE WORLD

Killed		
Year	**Number killed**	**Notable events**
2004	244 880	Earthquakes and tsunamis like the Indian Ocean tsunami of December 2005
2008	241 567	Storms, for example Cyclone Nargis of May 2008
2010	304 812	Earthquake in Haiti in December 2010; Pakistan floods
Affected		
Year	**Number affected**	**Major events**
2005	251 billion people	Storms, for example Hurricane Katrina
2008	203 billion people	Earthquakes, for example the Sichuan earthquake in China
2011	371 billion people	Earthquakes, for example the Great East Japan Earthquake and nuclear failure of March 2011
Damages		
Year	**Damage in US dollars**	**Major events**
2005	214 billion	The Kasmir drought of October 2005 and Hurricane Katrina of August 2005
2008	190 billion	The Sichuan drought and Hurricane Nargis, both in May 2008
2011	363 billion	The Japan earthquake of March 2011

Source: Adapted from UNISDR (2013).

In 2012 alone, 9 330 people were killed in disasters, 106 million people were affected and damages worth 138 billion US dollars were suffered worldwide (UNISDR, 2013). Between 1980 and 2011, the world witnessed 3 455 floods, 2 689 storms, 470 droughts and 397 instances of extreme temperature (UNISDR, 2012). Within the same period, floods, storms and extreme temperature showed an increasing trend in frequency, while droughts did not show any remarkable trend, except for Southern Africa that witnessed the worst drought on record in 2015/2016 associated with the effects of El Niño. In 2015 alone, there were 346 reported disasters in the world, with 56 occurring in Africa. These disasters killed 22 773 people globally, affected 98.6 million people and caused economic damages worth 66.5 billion US dollars (CRED/UNISDR, 2016). The top five most affected countries in terms of number of major disasters in 2015 were China (26), USA (22), India (19), Philippines (15) and Indonesia (11). The earthquake in Nepal killed 8 831 people and was the worst in terms of deaths. The highest number of affected people was from the Democratic Republic of Korea with 18 003 541 people while the USA suffered the highest economic damages at 24.88 billion US dollars (CRED/UNISDR, 2016). Amongst the top ten disasters reported in 2015, heatwave was the second highest killer after earthquake (CRED/UNISDR, 2016). It is likely that the unprecedented effects of heatwaves in 2015 could easily be associated with the increasing impact of climate change caused by rising temperatures (IPCC, 2014).

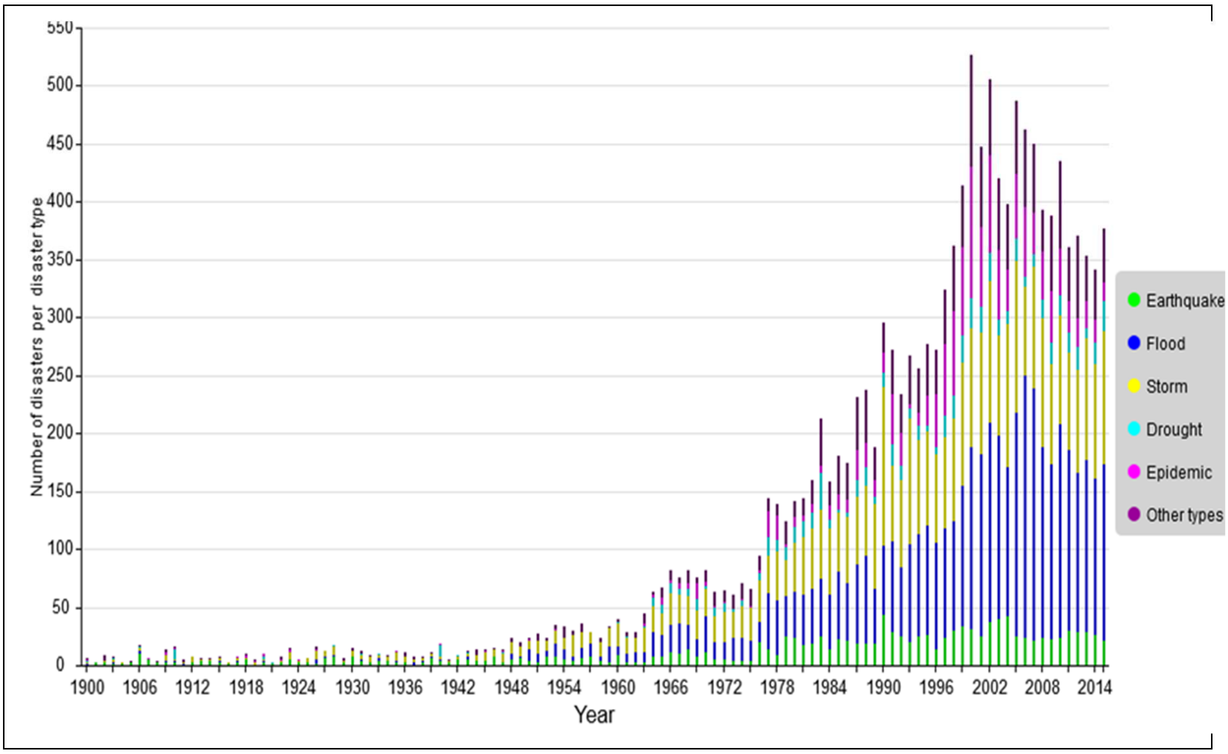
The number of disastrous events has increased substantially since 1980 because of meteorological, hydrological and climatic hazards. The rise in disaster risk in recent years is due to factors such as an increase in population, rapid and unplanned urbanisation, poverty, environmental degradation, climate change, development and settlement in high risk zones such as steep slopes, riverbeds and floodplains, conflicts and competition over scarce resources such as water and oil, diseases and epidemics (Coppola, 2011; EM-DAT, 2012; IFRC, 2013; Munich Re, 2011; UNISDR, 2013; Wisner *et al*., 2013).



Source: Mitchell *et al*. (2014:vi) as adapted from www.emdat.be

Figure 4.6 Global trends in disastrous events and death tolls, 1980-2013

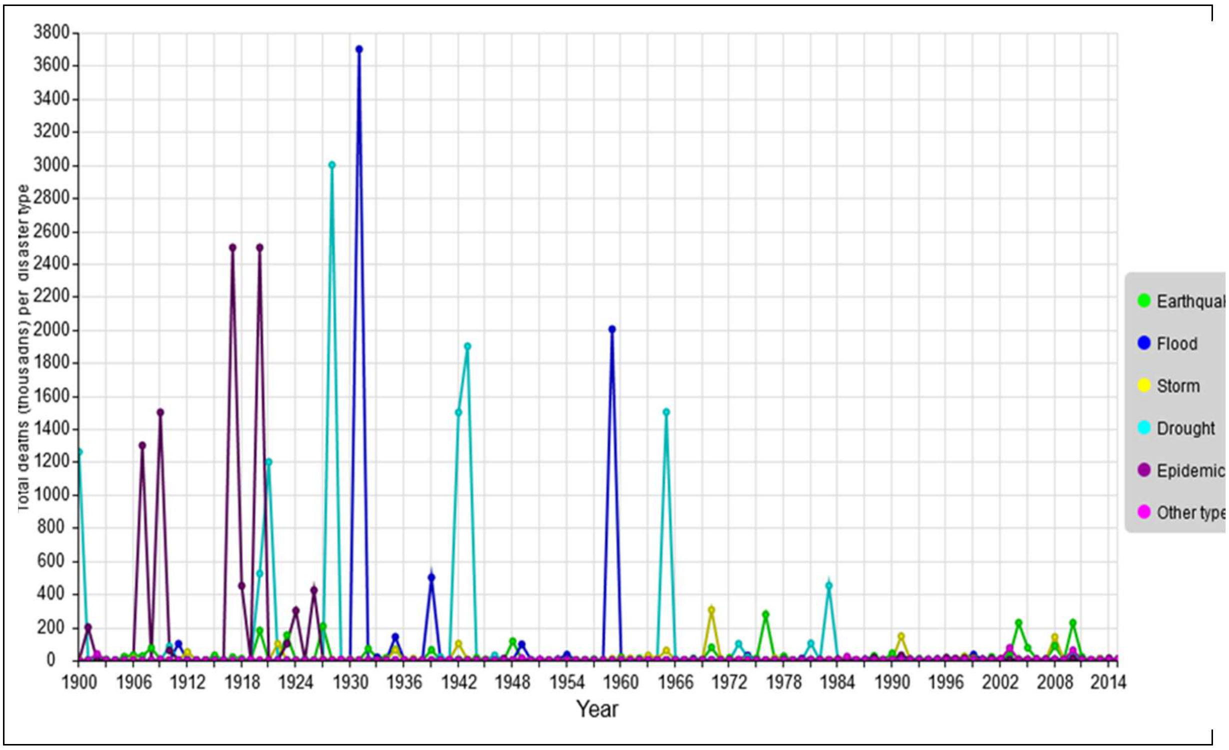
An analysis of disasters by type since 1900 shows a general rise since the 1970s, but also that geophysical disasters have remained fairly constant since the 1970s when reliable data was first recorded. There has been a remarkable increase in floods, epidemics, storms, and droughts which also happen to be the most common hazards affecting the majority of people in the world (EM-DAT, 2012).



Source: EM-DAT (2016)

Figure 4.7 Number of natural disasters by type from 1900−2015

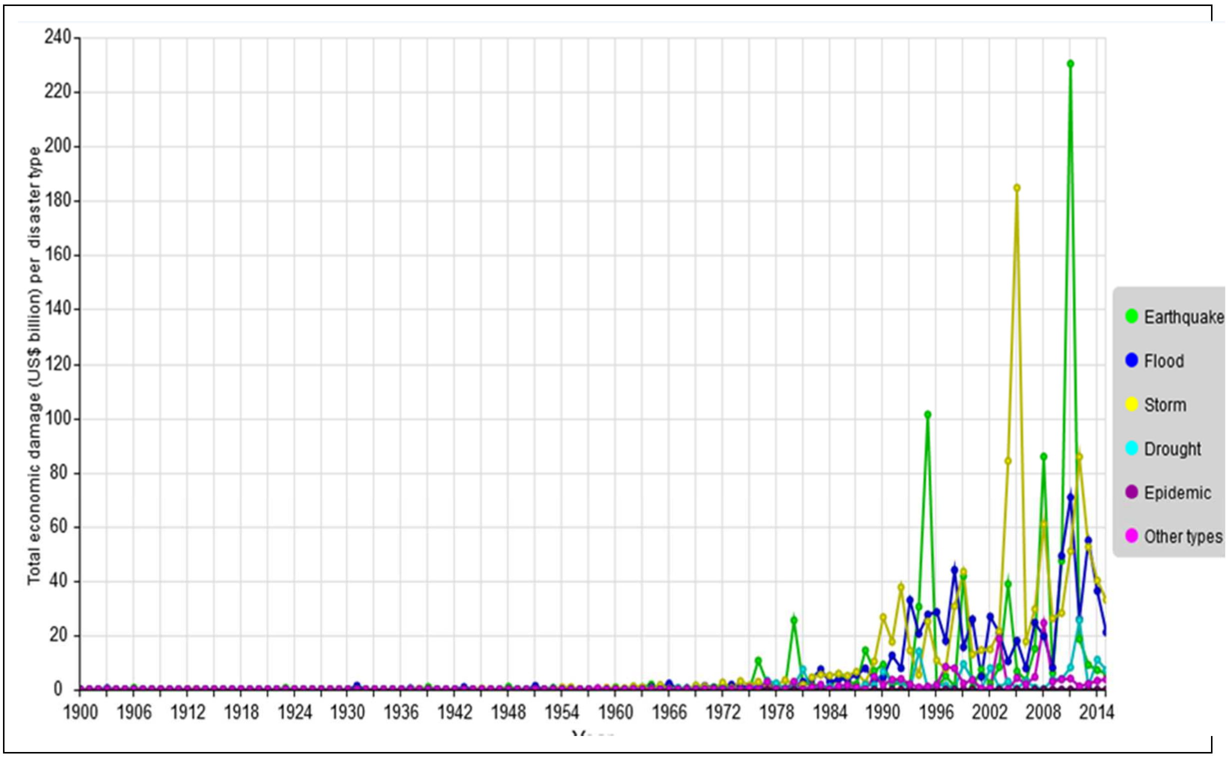
Despite the general increase in the number of natural disasters since the 1970s, this has not translated into an increase in the number of people killed. Instead, there has been a remarkable drop in the number of people killed by natural disasters since the 1970s. This drop has been attributed to improvement in non-structural mitigation measures such as better early warning systems, effective evacuation plans and improved risk communication (EM-DAT, 2012; 2016; CNRD/PEDRR, 2013).



Source: EM-DAT (2016)

Figure 4.8 Number of people killed by natural disasters 1900−2015

Despite the increasing number of natural disasters since the 1970s, but a reducing number of deaths within the same period, this has not been the case in economic losses which has continuously increased exponentially since the 1970s. Earthquakes have not only been the costliest but also the deadliest of all the hazards (EM-DAT, 2012; 2016; CNRD/PEDRR, 2013).



Source: EM-DAT CRED (2016)

Figure 4.9 Estimated economic losses from natural disasters from 1900−2015

4.2.5.2 Disasters in Africa

Compared to regions like Southeast Asia, Africa witnesses moderate frequencies in disasters, but these disasters have high impacts on people and their livelihoods. Since 2000, there has been an average of two disasters per week in Africa and though most of them do not attract international attention, they, however, take away lives, destroy livelihoods, degrade the environment and set back economic development in Africa (UNISDR, 2014). In 2011 and 2012, Africa recorded 147 disasters, of which 19 were droughts and 67 floods that affected millions of people and the cost of economic losses were estimated at 1.3 billion US dollars. Hydrometeorological hazards cost the most economic damages, while biological hazards (epidemics) consume five out of every seven total deaths estimated at 6,833 each year (UNISDR, 2014).

Multiple and interdependent vulnerabilities, income poverty and food insecurity, poor health status and the high HIV/AIDS prevalence rate, rapid population growth and rapid-unplanned urbanisation, together with global dynamic forces such as climate change, makes Africa very vulnerable, even to minor hazards that easily transform into a disaster (IPCC, 2015; UNISDR, 2014). About 400 million Africans live below the poverty line, while 200 million are under-nourished. Africa has the highest rate of urbanisation as currently 40% of the population in Africa lives in cities and urban areas. With the current trend, 50% of the African population will live in urban areas by 2050 (UNISDR, 2014). Most will live in urban slums that lack basic services, thus increasing their vulnerability to hazards like floods, landslides, epidemics, land degradation and pollution.

4.2.5.3 *The South African disaster profile*

South Africa is normally considered as a stable and medium risk country in terms of disaster effects, but as Table 4.2 shows, natural and technological disasters have huge human and material effects in South Africa.

TABLE 4.2: SUMMARY OF NATURAL AND TECHNOLOGICAL DISASTERS IN SOUTH AFRICA FROM 1900 TO 2013

Disasters	Number of events	Total number of people killed	Total number of people affected	Damage (US dollars)
Natural disasters				
Drought	8	–	17 475 000	1 000 000
Floods (flash, general and other unspecified)	32	1 227	565 150	1 621 029
Earthquake	8	70	1,448	20 000
Epidemic	7	405	139 950	–
Extreme temperature (cold fronts)	2	52	–	–
Mass movement (landslide)	1	34	–	–
Storm (local, tropical cyclone and other unspecified	25	272	641 145	764 041 (plus missing figures)
Wildfire (bush, forest and grassland fires)	9	128	7 380	440 000
Total (Natural)	**92**	**2 188**	**18 830 073**	**3 845 070**
Technological disasters				
Industrial accidents (collapse, explosion, fires and other)	32	1 406	11 547	–
Transport accidents (air, rail, road and water)	131	2 705	5 236	–
Total (Technological)	**163**	**4 111**	**16 783**	–
Grand Total	**255**	**6 299**	**18 846 856**	3 845 070 (with many missing figures)

Source: EM-DAT (2013)

These are only major recorded events, according to EM-DAT specifications. The first major event captured in Table 4.2 was recorded in February 1920 for natural disasters and January 1941 for technological disasters. The last event was recorded in October 2012 for natural disasters and December 2012 for technological disasters.

Some discrepancies were noticed in the records, but as the system of reporting disasters in South Africa improved, more reliable data was captured by EM-DAT. The top ten natural disasters in terms of number of people affected, number of people killed and economic damages caused between 1980 and 2010, are presented in Table 4.3.

TABLE 4.3: TOP 10 NATURAL DISASTERS REPORTED IN SOUTH AFRICA

No.	Disaster	Date	Number of people
People affected			
1	Drought	2004	15 000 000
2	Drought	1988	1 320 000
3	Drought	1986	850 000
4	Storm	1984	500 000
5	Drought	1995	300 000
6	Storm	2002	100 00
7	Epidemic	2000	86 107
8	Flood	1987	65 000
9	Flood	2001	42 356
10	Flood	2007	38 000
People killed			
1	Flood	1987	506
2	Flood	1995	207
3	Epidemic	2000	181
4	Flood	1981	104
5	Flood	2000	83
6	Epidemic	2002	72
7	Epidemic	2008	65
8	Storm	1984	64
9	Wildfire	2008	34
10	Mass movement wet	1996	34
Economic damages (US$ × 1 000)			
1	Drought	1991	1 000 000
2	Flood	1987	765 305
3	Wildfire	2008	430 000

No.	Disaster	Date	Number of people
4	Storm	1990	393 000
5	Storm	1998	165 000
6	Flood	2000	160 000
7	Flood	2006	71 000
8	Storm	1984	92 000
9	Flood	2006	71 000
10	Storm	1984	50 000

Source: Adapted from PreventionWeb (2014)

Floods killed more people in South Africa (Table 4.3) and caused more economic damages than any other disaster, while droughts affected more people. The worst flood occurred in 1987 killing 506 people and causing 765 305 000 US dollars' worth of damages. The worst drought in terms of economic damages was in 1991, with about one billion in economic damages, though it was not among the ten disasters in terms of people killed. The worst drought in terms of number of people affected was in 2004 that affected about 15 million South Africans.

This disaster situation in South Africa, as explained above, masks the reality on the ground since it does not consider small local disasters with high cumulative effects that may kill many people, destroy livelihoods and impoverish a good number of South Africans over time. There were also some discrepancies in the figures as two floods were recorded in 2006 and two storms in 1984. These figures are, therefore, indicative and not definite, but all the same paint a picture of the South African disaster profile.

4.2.6 Effects of disasters on ecosystems such as wetlands

Disasters can affect ecosystems through habitat loss and species extinction, thus biodiversity is affected. Poorly planned post-disaster clean-up activities can also negatively impact on ecosystems through direct environmental degradation like trampling, poor waste disposal and other forms of pollution. Disasters, especially disaster relief, divert funds earmarked for environmental protection and ecosystem maintenance into relief assistance, thus affecting also other development efforts. Degraded ecosystems reduce community resilience and hinder disaster preparedness and recovery (Sudmeier-Rieux and Ash, 2009).

Any disaster such as a drought, flood, wildfire, oil spill or even climate change would affect the hydrology, soil, vegetation or species composition of a wetland in varying degrees depending on the intensity and magnitude of the hazard, as well as the inherent characteristics of the wetland such as the type, ecological status and size of the wetland.

The 1993 Great Midwest Flood in the upper Mississippi River Basin was the worst in US history and had devastating effects on wetlands due to massive inflow of water and prolonged inundation (Kolva, 2002). Many trees were destroyed, there was a lot of soil erosion, emergent and submerging wetland plants were destroyed, the nesting and lifestyle of many wetland bird species were affected leading to death or migration such as that of the green-backed herons. Heavy sedimentation buried many freshwater mussels and many mammals were forced out of wetlands (Kolva, 2002). However, sedimentation also brought a lot of alluvial deposits into the wetland which was a positive benefit.

The worst drought of 2015/16 in southern Africa had serious repercussions on wetlands. For example, the iSimangaliso Wetland Park witnessed low water levels in the lakes and high salinity levels which affected many wetland species such as flamingos (Zululand Observer, 2015).

Environmental emergencies like heavy metal pollution and oil spills affect wetland hydrology, plants, animals and soil through contamination. The BP oil spill disaster in the Gulf of Mexico in 2010 affected many species in the coastal wetlands. Wetland birds, coastal freshwater and coastal mangroves were severely affected.

Climate change affect the physical, chemical and biological processes and species in wetlands, thus changing the ecological structure, function and biodiversity of wetlands (Jin *et al*., 2009). Depending on the area, climate change would affect the quality of wetland water. Where precipitation is reduced with high temperatures and increased evapotranspiration, there will be less dissolved oxygen in the water that could cause anoxia. Water turbidity will be high. Areas with high rainfall might witness more soil erosion, and more sediment loads with high runoffs. Groundwater-fed wetlands may become more acidic, while surface-fed wetlands could become more alkaline (Jin *et al*., 2009). Climate change could affect the biota of the wetland depending on the sensitivity to changes in the habitat. More vulnerable and less adaptive species will be seriously affected, leading to changes in biodiversity of the wetland. Climate change will also create favourable conditions for the more adaptable opportunistic invasive species which are always first to invade new and changing habitats (Jin *et al*., 2009).

4.2.7 How to reduce disasters and build resilience

Disasters erode development efforts and undercut communities and the systems' ability to be resilient. By reducing disaster risks, resilience could be enhanced through the following generic actions:

- Reduce vulnerability (physical, social, economic, environmental and political).

- Reduce exposure to hazards (avoid developments in high risk areas).
- Reduce poverty and inequality in the society.
- Increase risk-informed humanitarian assistance to disasters.
- Maintain healthy ecosystems such as wetlands.
- Avoid environmental degradation (deforestation, soil erosion and pollution).
- Increase climate change mitigation and strategies (reduce greenhouse gas emissions, increase carbon sinks, green the economy).
- Ensure proper land use planning and zoning.
- Strive for good governance and international cooperation.
- Put in place effective DRR planning and implementation tools.
- Adopt effective CCA strategies.
- Ensure effective education, training and awareness on disaster risks.
- Incorporate community participation and use of indigenous knowledge on disaster risks issues.
- Ensure the formulation and adherence to effective safety measures.
- Put in place proper medical, hygiene and sanitation measures.
- Use adapted and appropriate technologies (Coppola, 2011; EM-DAT, 2012; IFRC, 2013; IPPC, 2012; UNISDR, 2013; Wisner *et al*., 2013).

Proper planning using the list above, with good indicators and a good monitoring system in place, will go a long way to build community and system (such as wetlands) resilience.

4.3 ENVIRONMENT AND ECOSYSTEM MANAGEMENT

4.3.1 Environment and environmental management

The word ‘environment’ comes from a French word *‘environner’,* meaning to encircle. The environment is the sum of natural, social and cultural conditions that influence the life of an individual or community (Shelton and Kiss, 2005). Geographically, an environment may be a small area or may extend to the entire planet, including the atmosphere and stratosphere (Shelton and Kiss, 2005). The Bulgaria Environmental Protection Act (1991) defines the environment as a complex combination of natural and anthropogenic factors and elements that are mutually interrelated and affect the ecological equilibrium and quality of life, human health, the culture and historical heritage and the landscape (Bulgaria Environmental Protection Act, 1991 Section 1(1) in Shelton and Kiss, 2005). In simple terms, Aucamp (2009:1), defines the environment as *“the world we live in, work in and play in, and includes all living (and non-living) things that we encounter on earth”*.

The term ‘environment’ is therefore complex, broad and dynamic. It can denote different things to different people. Environment can be seen as the external factors, conditions, and influences that affect an organism or a community. The environment may also mean everything that surrounds an organism or organisms, including both natural and human-built elements. This study focuses on the natural environment and the complex interactions and flow of services between the natural environment and human beings or the society. For a better understanding of the environment and human interface, focus is placed at the level of ecosystems; noting that different natural ecosystems are subsets of the natural environment or the earth. The earth has four overlapping spheres that make up the natural environment, namely atmosphere, hydrosphere, biosphere and lithosphere (Arbogast, 2011; Strahler and Strahler, 2005).

The equilibrium of the natural environment can be maintained by nature itself, but various negative anthropogenic activities have disturbed the harmonious relationships between the environment and human beings, thus necessitating careful environmental management.

Environmental management is the process to improve the relationship between human beings and the natural environment which may be achieved through check on destructive activities of humans, conservation, protection, regulation and regeneration of nature. Environmental management also entails the rational adjustment of man with nature through judicious exploitation and utilisation of natural resources without disturbing the ecosystem balance and ecosystem equilibrium. Environmental management must then try to balance the ecological principles and socio-economic needs of the society (Park, 1981 in Environmental Pollution, n.d.: Online). Environmental management can also mean the application of skills and techniques on the earth in order to achieve the desired goals of a sustainable society (Fuggle and Rabie, 1992). All these definitions focus on two main things, namely maintaining a healthy natural environment and satisfying human needs in a sustainable manner.

4.3.2 Objectives of environmental management

The main objective of environmental management should be to improve the quality of human life without degrading the environment. Environmental management should then use the systems approach (Turner *et al*., 2003), whereby humans are considered as part of the natural system because developments in one part of the natural system could positively or negatively impact on other parts or constituents of the natural system. Though environmental management is very wide in scope, its broader objectives include the following:

- To identify the environmental problems and to find solutions to the problems identified.
- To regulate the exploitation and utilisation of natural resources.

- To regenerate the degraded environment and to renew natural resources that are renewable.
- To control environmental pollution and gradation.
- To reduce the impacts of extreme events and natural disasters on the environment.
- To make optimum use of natural resources.
- To assess the impacts of proposed projects and activities on the environment through environment impact assessments.
- To review and revise the existing technologies and make them eco-friendly.
- To formulate laws for the implementation of environmental protection and conservation programmes (Environmental Pollution, n.d. Online).

Most of these stated environmental management objectives are covered directly or indirectly, partially or fully in this research.

4.3.3 Environmental degradation

Environmental degradation occurs when the ability of the environment to meet social, economic and ecological objectives and needs are reduced or destroyed. Some examples include land degradation, deforestation, desertification, wild-land fires, loss of biodiversity, land, water and air pollution, climate change, erosion and soil deterioration, sea level rise and ozone depletion (Tietenberg and Lewis, 2012). Environmental degradation increases community vulnerability as well as the frequency and intensity of natural hazards. A degraded environment exacerbates disastrous events or could be disasters in their own merits, such as soil erosion in Lesotho and the Republic of Congo. A degraded environment will lose its capacity to provide local livelihoods and other environmental services, as well as loose its ability to act as a buffer against hazards, thus increasing vulnerability of the local communities.

As the world is becoming more crowded, more polluted, less ecologically stable and more vulnerable to natural hazards, this has led to the reduction in the quality of life for most people (Fuggle and Rabie, 1992). There is much environmental deterioration caused by depletion of resources, deterioration, modification and destruction of natural processes that are aggravated by rapid population increase. In the past three decades, environmental problems such as the depletion of the ozone layer (20 km above the earth), rise in global temperature, rainfall becoming more acidic, agricultural practices eliminate genetic diversity and the harvest from ecosystems and animal population outweighing their sustainable yield, have been observed (Fuggle and Rabie, 1992). We need to care for the Earth and build sustainable societies.

4.3.4 Environmental management and disaster risk management

It is important to highlight the bi-directional relationship between managing the environment and reducing disaster risks. A healthy natural environment is a frontline buffer to reduce disasters. Meanwhile disasters can seriously damage the environment (IPCC, 2014; UNISDR, 2013). Rehabilitation and restoring wetlands to maximise flood regulation, safeguarding biodiversity and livelihoods in a changing climate, managing forests to stabilise slopes in order to protect communities against landslides; introducing environmental technologies that combine hard engineering solutions with afforestation (soft engineering) for coastal protection, are some examples how environmental management can reduce disaster risk (UNEP/UNISDR, n.d.).

The HFA 2005−2015 encouraged the sustainable use and management of ecosystems through better land-use planning and sustainable development activities to reduce risk and vulnerabilities. HFA promoted the implementation of integrated environmental and natural resource management approaches that incorporate DRR and CCA. For these reasons, the PEDRR was established to promote Eco-DRR as a green approach to support the implementation of the HFA (UNEP/UNISDR, n.d.).

The UNISDR Working Group on Environment and Disaster Risk Reduction maintains that:

- Natural hazards are physical processes that can directly be affected by social processes.
- Healthy ecosystems often provide natural defences.
- Degraded ecosystems reduce community resilience.
- Although the environment itself is often well-adapted to natural hazards (with timescales for recovery varying significantly), disasters can lead to secondary environmental impacts.
- Environmental degradation is a hazard in itself (UNEP/UNISDR, n.d.).

The concept of sustainable environmental management which, amongst others, can reduce disaster risks dates far back. For example, in 1992, at the United Nations Conference on Environment and Development in Rio de Janeiro, world leaders endorsed *'Agenda 21'*, as a global programme that emphasise the importance of environmental protection in sustainable development. Meanwhile in 2002, at the Johannesburg Summit, world leaders acknowledged poverty eradication, change in consumption and production patterns, as well as managing the natural resource base for economic and social development, as essential ingredients for sustainable development (UNEP/UNISDR, n.d.).

Managing the environment for DRR shows that environmental managers are or should also be disaster risk managers. Environmental management for DRR is best executed through the ecosystem approach. Ecosystems management is part of general environmental management, and the ecosystems approach demonstrates that natural processes sometimes cross administrative boundaries and thus encourages transboundary cooperation (UNEP/UNISDR, n.d.).

4.3.5 Mainstreaming environmental management for disaster risk reduction and climate change adaptation

According to the UNEP/UNISDR (n.d.), there are seven entry points for engaging with environmental managers to support DRR and CCA:

4.3.5.1 Environmental governance

Environmental governance includes policies, legal and regulatory frameworks and institutional structures to promote sustainable resource management. Well-planned and executed at national, regional and global levels, environmental governance offers a good entry point for managing the environment for DRR/CCA.

4.3.5.2 Integrated planning

Integrated planning takes into account environmental considerations in land-use decisions in rural/agricultural areas (for example crop planning, irrigation and resettlement), as well as in urban areas (for example, water and sanitation and zoning for new development). Practical examples could include integrated wetlands management at catchment scale, integrated coastal zone management and integrated water resource management involving multiple stakeholders. Integrated planning is important for DRR, because it provides a framework for identifying high risk areas, vulnerable populations and how changing land use, levels of agricultural production and loss of vital ecosystems, could affect community resilience against potential disasters and climate change impacts.

4.3.5.3 Environmental monitoring and assessment

Environmental monitoring and assessment generate relevant information that assists environmental and disaster managers in identifying risks, vulnerabilities and opportunities to promote community resilience. For example, monitoring and observing environmental factors such as environmental degradation can signal the onset of a hazard and can act as an early warning systems. Severe deforestation can signal high probability of drought or floods.

Environmental assessments show current and future environmental conditions, and identify drivers of environmental change using various assessment tools and methods. For example, SEA determines potential environmental consequences of development plans and policies while EIA determines potential environmental consequences of specific development projects. Post-disaster assessments identify environmental damages and needs. All this information can be included in early warning systems to address DRR and CCA. Currently integrating DRR in EIA is strongly recognised worldwide, but quite lacking in application in South Africa.

4.3.5.4 Environmental advocacy, education and communication

Advocacy include providing policy briefs or raising issues in public, or more formalised professional lobbyists actively making the case for the environment. The media plays an important role in advocacy through targeted communication campaigns which can influence public opinion on environmental issues. Environmental managers can influence policy and planning decisions through *ad hoc* campaigns or formal public consultations during SEA or EIA processes. Well-planned environmental education in communities is another environmental advocacy tool that help reduce disaster risk and adapt to climate change.

4.3.5.5 Protected areas, ecosystem rehabilitation and natural resource management

Healthy ecosystems act as natural barriers that can moderate the effects of a hazard, protect communities and their livelihoods. Ecosystems are socio-ecological systems, and managing ecosystems wisely and sustainably is important for DRR. Cross-cutting issues such as protected areas management, ecosystem restoration and natural resource management reduce underlying risk factors for disasters by maintaining the resilience inherent in ecosystems (Renaud *et al*., 2013; UNISDR, 2015).

Some examples to support how protected areas reduce disaster risk include the protected forests in Switzerland that produce estimated benefits of between US$2–3.5 billion per year, because of risk mitigation against avalanches, landslides, rockfalls and flooding (UNEP/UNISDR, n.d).

The floodplain of the Lužnice River in the Czech Republic is a natural flood mitigation system which well-maintained at almost no cost, is capable of retaining 10 251 m^3 ha-1 in volume in a real flood situation, compared to artificial systems at a cost of US$23 per cubic metre of water retention during a flood. Other benefits of the floodplain include biodiversity, production of hay, wood, fish and carbon sequestration. All these produced a combined benefit estimated at US$27 000 per hectare per year in the Lužnice River floodplain (UNEP/UNISDR, n.d).

In the USA, the Wetlands Reserve Program embarked on restoring and conserving nearly 750 000 ha of wetlands as anti-flood measures, while in the UK, a balanced risk approach using the restoration of peat bogs, natural floodplains, and lowland marshes as a complement to human-made anti-flood methods has been adopted (UNEP/UNISDR, n.d.).

Ecosystem rehabilitation or restoration may include post-disaster clean-up such as after an oil spill or replanting of forests or mangroves after a landslide or tsunami. Restoring ecosystems following natural and human-made disasters reduces the underlying risk factors and mitigates future disaster impacts (UNISDR, 2005).

Japan has since 1939 used river restoration and improvement to mitigate against recurrent floods due to typhoons. Recently the Japanese ministry of construction introduced the Naturally Diverse River Improvements programme. In Pakistan, deforestation, over-grazing, poor terracing, as well as inadequate housing development in proximity to exposed slopes led to many landslides. In response to this, slope stabilisation through reforestation was used as a mitigation measure against landslides and floods. The governments of Azad Jammu and Kashmir declared 2007 as the *'Year of Plantation'* (UNEP/UNISDR, n.d).

In 2005, the RAMSAR Convention issued a statement that encouraged all contracting parties to manage wetlands for disaster prevention, mitigation and adaptation to climate change (RCS, 2010b). In response to this, the USA Coastal American initiative brought the government, the private sector and other partners together to support broad-ranging wetlands management efforts, while in Australia, the Queensland Wetlands Programme provides best practices and knowledge hub on wetlands management (UNEP/UNISDR, n.d.).

Poor natural resource management such as deforestation or conversion of wetlands can provoke serious disasters, while on the other hand good management of these resources that takes into consideration a proactive and holistic approach can be very sustainable, for example, the integrated watershed management approach that includes the local community, is a promising area for DRR, CCA and building community resilience. In 2013, the researcher participated in one such project in Yaounde, the capital of Cameroon.

4.3.5.6 Environmental innovation, technology and industry

The world is now turning towards green engineering solutions for sanitation, energy, water use/management, structural defences from hazards and construction planning that is environmentally sound. Bio-engineering solutions and eco-materials can be used instead of, or in conjunction with, hard engineering solutions (UNEP/UNISDR, n.d.). This is the central tenet of the principles and practice of Eco-DRR/CCA and in this research the focus is on management of wetlands for DRR and CCA.

Eco-netting is effective in controlling erosion and risk of landslides, while coastal afforestation complements the use of human-made sea-walls to fight sea level rise and coastal flooding. In Darfur in Western Sudan, turf roofs are used to mitigate extreme temperatures and heatwaves while fuel-efficient stoves are used to reduce deforestation and mitigate against the risks of flooding and droughts (UNEP/UNISDR, n.d.).

Structurally engineered defences do protect communities against hazards, but their cost, efficacy and damages downstream or on the environment are always questioned (CNRD/PEDRR, 2013; Renaud *et al*., 2013). The world is thus moving towards soft or green technologies. For example, the government of Japan is moving away from constructing concrete river walls and shifting towards natural river restoration for flood protection. The disaster management centre of Sri Lanka adopted ‘soft engineering’ approaches to coastal defence. In the US, communities in California rejected several proposed flood mitigation plans and opted for innovative combination of bank terracing, parkland bypass channels and restoration of downstream tidal wetlands (UNEP/UNISDR, n.d.). The Indian Ocean tsunami in 2004 was a key turning point in shifting international attention towards DRR and ecosystem-based approaches, in particular. The Indian Ocean tsunami also focused global attention on the environmental impacts of the disaster and highlighted the potential role of coastal ecosystems in providing hazard protection and mitigation (Renaud *et al*., 2013). However, there are debates on the exact potential of green as opposed to grey infrastructure on mitigating disaster risks, especially after the Great East Japan Earthquake and Tsunami or the Tohoku Earthquake and Tsunami of 2011 and other disasters such as Hurricane Matthew of 2016. The consensus seems to favour multiple lines of defence with a hybrid of green and grey infrastructure (Environment and Disaster Management, 2017; NSTC, 2015; Renaud *et al*., 2013).

4.3.5.7 Building capacities in environmental management

Capacity-building in environmental management comprise three aspects:

- Human resources development through training, education and other forms of human development.
- Financial resources through grants, seed money or capital investment.
- Institutional development through institutional policies and structures for effective delivery of services, coordination and promotion of research (UNEP/UNISDR, n.d.).

Building capacity in environmental management supports DRR by increasing awareness and maximising opportunities for engaging in joint or integrated activities like joint environmental and disaster reduction training. Besides, working through established networks and partnerships in the field of environmental management can be a useful means for integrating DRR (UNEP/UNISDR, n.d.). For example, Wetland International, IUCN, UNEP and PEDRR are today working together to champion the principles and practices of Eco-DRR/CCA (Renaud *et al*., 2013). When environmental management and DRR work in silos, many joint opportunities are missed.

4.3.6 Strategic environmental assessment and environmental impact assessment as tools for disaster risk reduction

EIA and SEA have been successfully mainstreamed and institutionalised in most countries around the world, therefore, SEA which is mainly for policy and area development planning, and EIA used for individual project appraisals, should be used as a vehicle to hardwire DRR into development plans, programmes and projects (Aucamp, 2009; Renaud *et al*., 2013; PEDRR, 2014).

EIA and SEA are tools that have been used for long by many countries to reduce the negative impacts of development initiatives. However, DRR has hardly been incorporated into EIA and SEA policies, processes or project development (PEDRR, 2014). The ecosystem approach advocates for the integration of DRR and CCA into EIA and SEA or *vice versa*. Such an approach will have the following benefits (PEDRR, 2014):

- EIA and SEA legislations are well-developed in most countries and decision-makers and investors are both familiar with the process. Incorporating DRR into the EIA process will be easier from a legislative point of view and will receive less resistance from the investment community.
- EIA, and recently SEA, are conducted as a multidisciplinary exercise so experts, governments and stakeholders are familiar with expanding the EIA process to include other disciplines like DRR and CCA.
- EIA processes currently capture both government investments and private investments, and linking EIA with DRR will capture a broad range of government policy initiatives and the majority of public and private sector investments.
- Through EIA and SEA, disaster risk assessment can be easily integrated technically into development planning and thus into risk-sensitive land-use planning (PEDRR, 2014).

It was, however, observed in South Africa, in general, and the eFS, in particular, that the implementation of SEA policies and EIA processes leaves much to be desired. The problem is that the EIA process is often politicised and therefore bias and, secondly, EIA is performed by many incompetent EIA practitioners. There is a general lack of competent EIA practitioners in the FS. These weaknesses, notwithstanding DRR, should be incorporated into SEA and EIA policies and processes (IPCC, 2012; PEDRR, 2014; UNISDR, 2013).

4.4 ECOSYSTEM APPROACH

The Coupled Human–Environment System framework or model (see 2.4.1) partly explains the fact that the natural environment has an impact on human beings and, on the other hand, human beings have an impact on the natural environment. It is therefore important to use the systems perspective in order to solve current human-environment problems.

A system is normally made up of interrelated parts that function and form an aggregate whole. Wetlands are ecological systems with many parts and in the frame of the Coupled Human–Environment system, wetlands impact on the local communities through wetland services, while the local community impacts on the wetlands through various anthropogenic activities taking place on-site and off-site the wetland. It is therefore important to manage wetlands using the systems approach or systems thinking. The ecosystem management approach has two main objectives, which include management to maintain or improve on the ecosystem and managing to sustain the range of goods and services for the current and future generations. This is lumped in the concept of wise and sustainable management of wetlands (RSC, 2010b).

4.4.1 Ecosystems, disaster risk reduction, climate change adaptation and sustainable development

An ecosystem is a community of plants (flora), animals (fauna) and microorganisms – both flora and fauna – that are linked by energy and nutrient flow (Arbosgast, 2011; Strahler and Strahler, 2005; Tietenberg and Lewis, 2012). An ecosystem can range from a small pond to the universe. The ecosystem under consideration in this study are wetlands in the eFS in relation to DRR and CCA.

Well-managed ecosystems can reduce the impact of many natural hazards and extreme events, such as droughts, landslides, flooding, avalanches and storm surges. This buffering role will depend on the type, health and size of the ecosystem, as well as the intensity and magnitude of the extreme event. Coastal mangroves play a great role in mitigating coastal storms (Renaud *et al*., 2013; UNISDR, 2005, 2013). In the same vein, wetlands play a critical role in abating drought impacts by serving as fodder reserves and grazing pastures in the eFS. They also act as firebreaks in normal as well as very dry periods.

Ecosystems are the foundation of all life and livelihoods, and major industries such as agriculture, fisheries, timber and other extractive industries depend on ecosystems (Tietenberg and Lewis, 2012). The goods and services that people get from ecosystems contributes to the ability of communities to absorb, withstand and recover from disasters. Ecosystem goods and services are synonymous to ecological infrastructure which are the nature-based equivalent of built or hard infrastructures that underpin socio-economic development (Kotze, 2013; WRC, 2013). Ecological infrastructure services are mostly felt in the poor rural areas where they influence the livelihoods of many people (Kotze, 2013; MA, 2005; WRC, 2013). Maintaining healthy ecosystems such as wetlands therefore assists in reducing rural poverty and thus promote the achievement of the MDG 1(though now replaced by SDGs) of halving poverty by 2015.

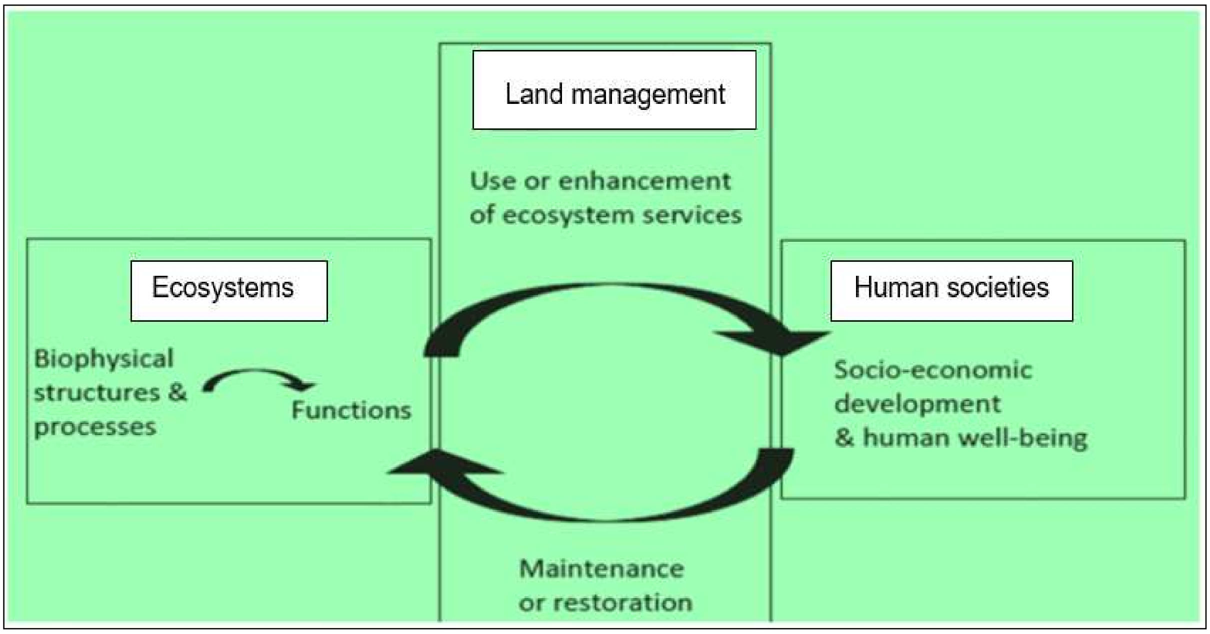
Healthy or sustainable ecosystems reduce the vulnerability of people to natural hazards (MA, 2005). The ecosystem services provide livelihood to many people, especially the very poor who live and closely depend on their natural environment either in rural areas or in urban slums. Healthy ecosystems help to reduce poverty which is the major underlying risk factor to disasters (UNISDR, 2015). The direct buffering role of healthy ecosystems to natural hazards and extreme climate events has been emphasised by many researchers (MA, 2005; TEEB, 2010; Tietenberg and Lewis, 2012).

Healthy and diverse ecosystems are more resilient to extreme weather events. Well-functioning ecosystems such as wetlands are less likely to be impacted upon by, and more likely to recover from, the impacts of extreme events. Healthy ecosystems, especially those of peatlands and forests, have the natural capability to sequester carbon, thus reducing the incidence of global warming, the impacts of climate change, and climate change related disasters (IPCC, 2007; 2014).

The ecosystem concept supports the development of policies and instruments that integrate social, economic and ecological perspectives into sustainable development (Seppelt *et al*., 2011 in Beltrame *et al*., 2013). It is partly for this reason that this study has devoted an important chapter which looked at the legal and institutional arrangement for wetlands management in the eFS (see Chapter 3).

4.4.2 Ecosystems and the society

The ecosystem concept shows a bidirectional relationship between ecosystems such as wetlands and human societies (Beltrame *et al*., 2013). Though Beltrame *et al*. (2013) focus on general ecosystems, the concept equally holds for wetlands. Firstly, ecosystems provide, or are used to provide, services to human societies. Ecosystem management is aimed at using or enhancing the services delivered by these systems. Land use can impact the state of ecosystems in a positive (e.g. regulated grazing) or negative (e.g. overexploited fisheries) way.



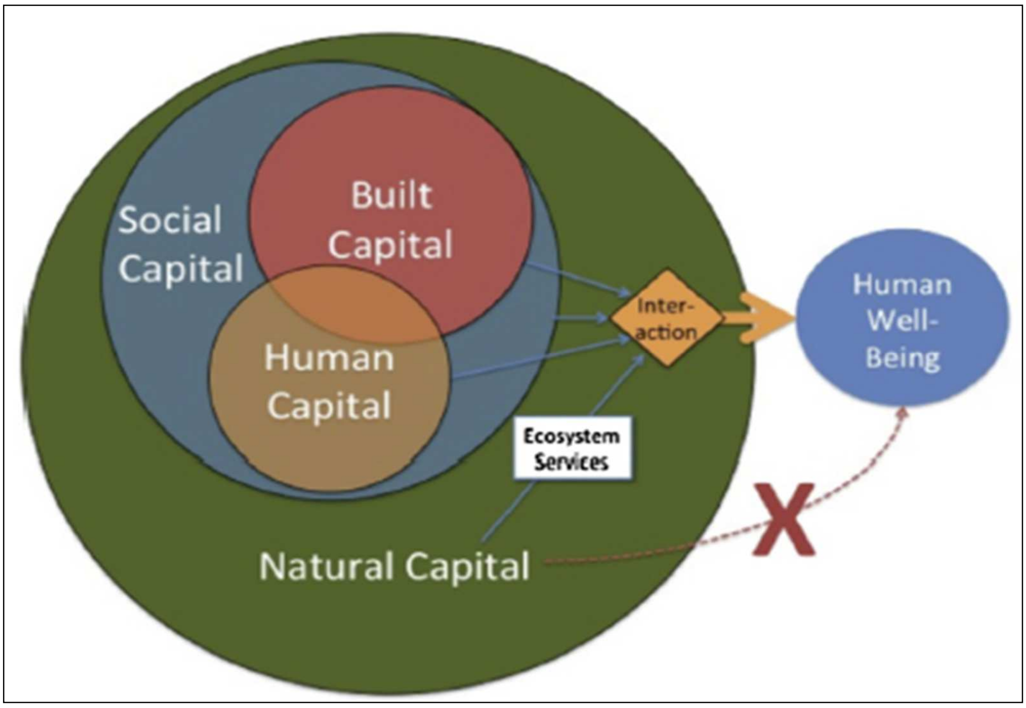
Source: Adapted from Beltrame *et al*. (2013)

Figure 4.10 Conceptual framework linking wetlands and human societies through land management

Secondly, societies can decide not to do anything or to conserve and restore ecosystems. In this last case, land management is performed to maintain the ecological integrity or to restore such integrity. Ecosystems such as wetlands provide better services only if they are well-maintained. Therefore, to evaluate the sustainability of ecosystems, and particularly those of wetlands, it is important to disentangle these two sides of land management and apply the right approaches (Beltrame *et al*., 2013).

Human well-being involves the interaction between built, social, human and natural capital (Figure 4.11). Built and human capital, which constitute the economy, are embedded in society and the society is embedded in the rest of nature from which ecosystem services flow. Ecosystem services are the relative contribution of natural capital to human well-being, but they do not flow directly because ecosystems cannot provide any benefits to people without the presence of people (human capital), their communities (social capital), and their built environment (built capital) (Costanza *et al*., 2014). This argument is also supported by the

Sustainable Livelihoods Model (see Figure 2.10) which also displays a pentagon of capital similar to that of Costanza *et al*. (2014).



Source: Costanza *et al*. (2014)

Figure 4.11 Interaction of various forms of capitals for human well-being

The contribution of ecosystems to human well-being has often been very significant as Table 4.4 proves.

TABLE 4.4: THE ECONOMIC VALUE OF GLOBAL ECOSYSTEM SERVICES

Year	Average amount in US$ per year
1995	33 trillion
1997	46 trillion
2011	145 trillion

Source: Costanza *et al*. (2014)

The value of ecosystem services has been increasing as indicated in Table 4.4. This can partly be attributed to improved techniques of valuing ecosystem services. The value of global ecosystem services was estimated to be about 4.5 times the value of Gross World Product in 2000, and for a 2014 global GDP of $75 trillion per year, the total value of ecosystems would be about $347 trillion year (Costanza *et al*., 2014). These figures could be a gross underestimation given the fact that most ecosystem services are public goods or common pool resources and that most of the services cannot be evaluated in monetary terms on the conventional markets (Renaud *et al*., 2013; TEEB, 2010). It is also worthy to note that between 1997 and 2011 ecosystem services that were lost due to land-use changes were estimated at between 4.3 and 20.2 trillion dollars per year (Costanza *et al*., 2014; MA, 2005; TEEB, 2010). Ecosystems therefore contribute immensely to human well-being and the alleviation of poverty.

4.4.3 Ecosystem–Smart disaster risk reduction and climate change adaptation

The use of ecosystems and natural resources management in reducing disaster risk and adapting to climate change is referred to as Ecosystem-Smart DRR/CCA (Van Leeuwen *et al*., 2014). This concept is the same as the Eco-DRR/CCA (CNRD/PEDRR, 2013; Renaud *et al*., 2013). Wetland International has developed a series of criteria for Ecosystem–Smart DRR/CCA. The criteria are divided into three sections and they serve as a guide for Ecosystem–Smart DRR/CCA projects, ranging from the inception to the implementation and down to the monitoring and evaluation of the project which, if well-followed, results in sustainable development (Van Leeuwen *et al*., 2014).

The Ecosystem–Smart DRR/CCA criteria demonstrate that expertise from the humanitarian, development and environment sectors can be harnessed into a holistic DRR and CCA programme (Van Leeuwen *et al*., 2014). The Ecosystem–smart DRR/CCA highlights the shift in paradigm, namely that well-managed ecosystems such as wetlands can play a significant role in reducing disaster risk, reducing rural vulnerabilities, building community resilience, providing rural livelihoods, reducing rural poverty and adapting to the negative impacts of climate change (CNRD/PEDRR, 2013, MA, 2005; Renaud *et al*., 2013; Van Leeuwen *et al*., 2014).

Ecosystem–Smart DRR/CCA involves multiple stakeholders such as the local community, land-use planners, engineers, DRR practitioners and environmentalists, and aims to accomplish a paradigm shift towards an approach where the sustenance and restoration of ecosystem services and the maintenance of the natural dynamics that underpin ecosystem health are firmly incorporated into other risk reduction approaches (Van Leeuwen *et al*., 2014).

Different ecosystems such as forests, floodplains, marshes and coastal wetlands, together with human settlements and the land used for food production and other resources, form interdependent socio-ecological systems that are connected across landscapes (Van Leeuwen *et al*., 2014). This is why the landscape approach to DRR and CCA is encouraged and endorsed in this study. The human settlements from farmsteads to cities depend to a great extent on the natural environment for livelihoods and functioning of its economies. The natural environment provides an important resource base for vulnerable communities, allowing them to cope in times of crisis and to actively adapt to on-going global changes such as climate change (Van Leeuwen *et al*., 2014).

However, while wise and sustainable land-use planning may be cost-effective in mitigating hazards and disasters and in preventing people from being exposed to extreme events, in certain circumstances, large-scale engineering works such as dams and dykes are needed to mitigate extreme events that cannot be buffered by nature (CNRD/PEDRR, 2013; Renaud *et al*., 2013; Van Leeuwen *et al*., 2014). Unwise land-use often results in an increase in vulnerability. For example, deforestation and conversion of wetlands may cause massive erosion and increased exposure to storms and floods. In other circumstances, even well-intended land-use practices may result in negative unintended consequences. For example, water diverted upstream to support agriculture or hydro-electricity power installations may lead to less water downstream, which in turn can lead to the loss of wetlands and their valuable services which are vital to downstream communities. These examples demonstrate the need for a holistic catchment approach in natural resources management, involving tools such as EIA, Disaster Risk Assessment, Integrated Natural Resources Management and Eco-DRR/CCA tools, such as payment for ecosystem services (CNRD/PEDRR, 2013; Renaud *et al*., 2013; RSC, 2010; TEEB, 2010; Van Leeuwen *et al*., 2014).

4.5 CHAPTER SUMMARY

This chapter discussed the linkages between disaster management (and its sub-sections) and environmental management (and its sub-sections). The nexus between environmental management (including ecosystems management) and disaster management (including DRR) was thus exploited in this chapter using various processes and tools as they relate to this study. This approach was important because a review of literature proves that the environment and disasters are much related. Disasters can seriously impact on the environment, while environmental degradation can accelerate disaster processes such as soil erosion, floods and landslides. Environmental degradation is itself a hazard that needs to be carefully managed. On the other side of the coin, healthy natural environments and ecosystems such as wetlands can act as buffers for many disaster risks.

To build synergy, environmental management processes and tools such as EIA and SEA need to be incorporated into disaster management, or *vice versa*. In this way, disaster managers should start incorporating environmental management processes and tools in their core business, while environmental managers should start using and incorporating disaster management processes and tools such as risk and vulnerability assessment into environmental management. This will be a ‘win-win and no regret’ approach.

The systems approach is the best approach to manage wetlands as illustrated by the Coupled Human–Environment System Framework, the social−ecological system model and the pentagon of capital (Sustainable Livelihoods Model) concept (see 2.4.6). Wetlands as an ecosystem have various impacts on local communities, while the local communities also impact on wetlands through various anthropogenic activities both on-site and off-site the wetlands. Like disasters and the environment, wetlands and humans have symbiosis relationships that need to be managed through a systems thinking perspective. The whole section 4.4 and its four sub-sections appeared to be repeating ideas, but this was purposefully designed in order to highlight the important role of ecosystems such as wetlands in reducing disaster risks, adapting to climate change impacts, promoting ecosystem–smart sustainable development, enhancing human well-being and contributing in solving several societal problems. Managing wetlands for DRR and CCA is the focus of this study and other chapters expand on this idea.

Chapter 5

UNDERSTANDING THE BASICS OF WETLANDS

5.1 INTRODUCTION

This chapter discusses basic information about wetlands. It includes the basic definitions and types of wetlands, the morphology of a wetland, the value and valuation of wetland services, wetlands as natural ecosystems and stressors leading to wetland degradation.

5.2 DEFINITION OF WETLANDS

It is not easy to have a common definition of a wetland because of the enormous variety of wetland types and problems of delineating wetland boundaries (Barbier *et al*., 1997). Wetlands cover a wide range of habitats from freshwater marshes and wet meadows to estuarine mangrove swamps (Kotze, 2008). Known as *mokhoabo* in Sesotho, *umgxobhozo* in Isixhosa, *vlei* in Afrikaans and *wetlands* in English, wetlands are fascinating types of ecosystems and offer a wide range of ecological services.

The South Africa National Water Act (1998) defines a wetland as follows:

> *Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or land that is periodically covered by shallow water and which in normal circumstances support or would support vegetation that is typically adapted to saturated soils (RSA, 1998b:9).*

This is a descriptive definition which uses hydrology, soil and vegetation to define wetlands. On the other hand, Article 1 of the Ramsar Convention (RCS, 1971:1) defines wetlands as follows:

> *wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.*

Article 2 of the Ramsar Convention (RCS, 1971:1) adds that wetlands

> *may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands.*

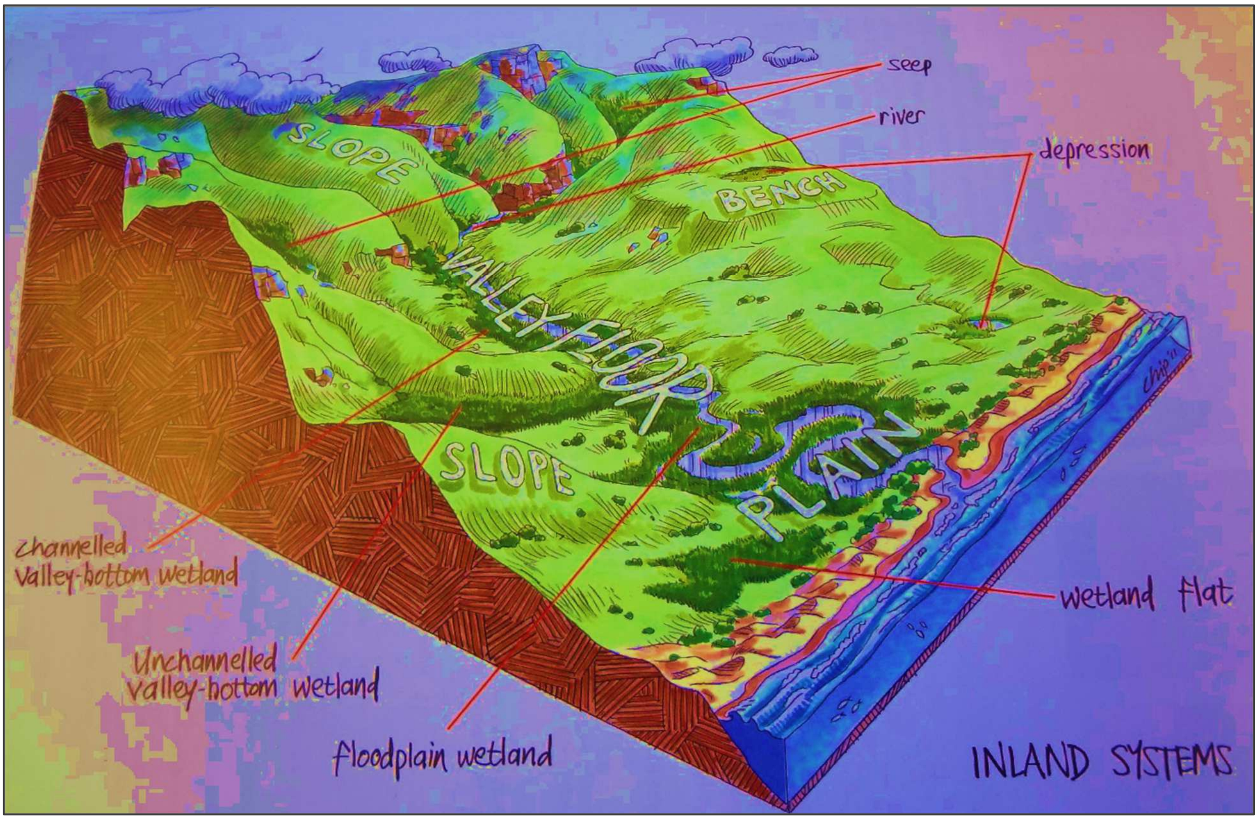
According to this broad definition, all areas where there is water, except for the open seas and oceans that are deeper than six metres could qualify as wetlands. The definition further recognises human-made or artificial wetlands such as fish and shrimp ponds, irrigated agricultural land and reservoirs (RCS, 2013). The Ramsar definition does not directly use the soil and vegetation to delimit wetlands as seen in the National Water Act (RSA NWA, 1998). The Ramsar definition could pose a problem when demarcating the boundaries of wetlands.

According to Kotze (2008) and Sullivan *et al*. (2008), wetlands are any part of the landscape where water accumulates long enough and in sufficient quantities to influence the plants, animals and soil in that area. This definition, which is almost similar to that of the NWA, goes further to add the element of animals and birds to define wetlands. Wetlands are also defined as lands with soils that are periodically flooded (Williams, 1990 in Wilby, 1997). This is a very simple definition, but the same author uses hydrology and flora to describe wetlands and further stresses the relationship between plant and hydrology to explain a new emerging sub-discipline called Ecohydrology (Wilby, 1997).

It can be concluded from the above stated definitions that the key elements that define a wetland are therefore water (hydrology), soil and vegetation (Ayoade, 2004; Pennington and Cech, 2010; Wageningen International, 2009). Wetlands include swamps, marshes, fens, peatlands, bogs, moors and even estuaries and they are found in all geographic regions from the poles to the tropics (WI, 2013). They are normally found on a flat topography, but may also exist on mountains and hill slopes such as seeps (Pennington and Cech, 2010; MWP, 2012; WI, 2013).

Common to all definitions of wetlands is the fact that water (acting as the driving force), soil and vegetation are the key elements used to define wetlands. The saturated soils (hydric soils) allow for the process of reduction (depletion of oxygen in the soil through chemical processes) to take place. The soil may be saturated through surface water retention or groundwater recharge as well as seepage (Collins, 2006; Kotze, 2008; Nel *et al.*, 2011). Soil types commonly associated with wetlands in South Africa include Champagne, Katspruit, Willowbrook and Rensburg. However, Kroonstad, Westleigh, Longland and Estcourt as well as other hydric soil-forms may be found in seasonal wetlands (Kotze, 2008). On the other hand, the vegetation side of the definition describes wetlands as land dominated by hydrophytes. The presence of water for some significant period causes changes in the soil, the microorganisms, plants and animal communities that best thrive in transition areas between aquatic and terrestrial zones (Barbier *et al*., 1997; Ollis *et al*., 2013). The permanent or prolonged presence of water should occur within the upper 50 cm of the soil (root zone) to create anaerobic conditions that will favour plants that are adapted to waterlogging. If the water is below the 50-cm zone, then the area may be well-aerated to permit non-wetland plants to strive (Kotze, 2008; Reynolds *et al*., 2015).

This study adopted the definition of the NWA (RSA, 1998b) as it incorporates the three elements of hydrology, soil and vegetation to describe wetlands. This definition is also the most popularly used in South Africa. The NWA definition is however restrictive as not all inland aquatic ecosystems for example rivers and dams, qualify as wetlands (as seen in Figure 5.1); unlike the Ramsar definition or the approach by Ollis *et al*. (2013). Note is also taken of the fact that wetlands are part of the aquatic ecosystems which include both marine and inland aquatic systems and therefore coastal wetlands formed part of the literature study in this research.



(Ollis *et al*., 2013)

Figure 5.1 Wetlands as part of the inland aquatic systems

5.3 TYPES OF WETLANDS

Different parameters could be used in the classification of wetlands. For illustrative purposes, Barbier *et al.* (1997) and RCS (2013) identified five broad wetland systems as presented in Table 5.1 below:

TABLE 5.1: FIVE BROAD WETLAND SYSTEMS

Systems	Description	Example
1. Estuaries	Where rivers meet the sea and salinity is intermediate between salt and freshwater	Deltas, mudflats, salt mashes
2. Marine	Areas not influenced by river flows	Shoreline, coral reefs
3. Riverine	Land periodically inundated by river overtopping	Water meadows, flooded forests, oxbow lakes
4. Palustrine	Areas with more or less permanent water	Swamps, marshes, fens
5. Lacustrine	Areas with permanent water with little flow	Ponds, kettle lakes, volcanic crater lakes

Source: Adapted from Babier *et al.* (1997); RCS (2013)

5.3.1 Hydrogeomorphic types

South Africa have adopted the hydrogeomorphic classification system initially developed by Brinson (1993). Hydrology and geomorphology are the most influential factors in inland aquatic systems (which wetlands are part of) regardless of the vegetation, climate, soil or origin (Ollis *et al*., 2013). Hydrogeomorphic classification of wetlands is based on the hydrological and geomorphological characteristics of wetlands and includes three key elements:

- *Geomorphic setting* – the landform, its position in the landscape and how it evolved, for example through the deposition of river-borne sediments).
- *Water source* – the source of water that maintains the wetland such as precipitation, groundwater flow and streamflow, but their relative contributions will vary amongst wetlands.
- *Hydrodynamics* – which refers to how water moves through the wetland (Kotze, 2009).

The Hydrogeomorphic Classification System was developed by scientists from the US Army Corps of Engineers Waterways Experiment Station, using seven wetland types that include riverines, slopes, depressional, mineral soil flats, organic soil flats, tidal fringes and lacustrine fringes. Riverine wetlands transition into a river, slope wetlands develop on hillsides and depression wetlands develop in holes. Flat wetlands can be inland in any low area. Tidal and lacustrine fringe wetlands are transitioned to oceans and lakes, respectively (Brinson, 1993; Pennington and Cech, 2010).

Ollis *et al.* (2013) divides South African wetlands into three broad categories as indicated in Table 5.2.

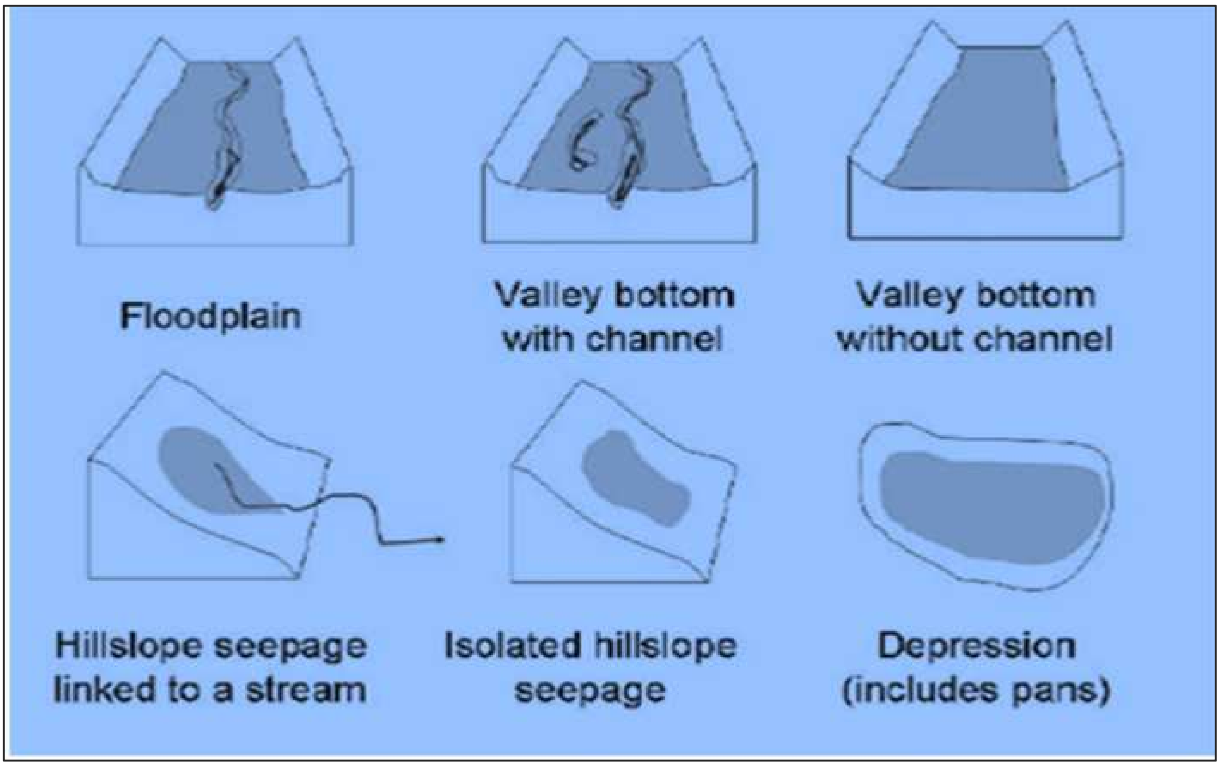
TABLE 5.2: SOUTH AFRICA WETLANDS INVENTORY CATEGORIES

Category	Description	Examples
Marine system	Are part of the open ocean overlying the continental shelf and/or its associated coastline, but not exceeding a depth of 10 m at low tide, i.e. not extending beyond the shallow photic zone	Coral reefs, rocky shores, wave cut platforms and sandy or pebble beaches
Estuarine systems	Partially enclosed ecosystems that are permanently or periodically connected to the ocean, which are influenced by tidal fluctuations and within which ocean water is at least occasionally diluted by fresh water derived from surface or subsurface land drainage	Lagoons, estuarine lakes and river mouths
Inland systems	Are permanently or periodically inundated or saturated systems that has no existing connection to the ocean and complete absence of marine exchange and/or tidal influence. Most wetland fall in this category	Rivers, seeps, pans, floodplains, marshes, peatlands

Source: Adapted from Ollis *et al*. (2013).

Based on their position in the landscape, their design, their sources of water, and characteristics of water flow into and out of the area and using the three principal factors that influence the formation of wetlands (hydrology, topography and geology), six hydrogeomorphic wetland types were identified in South Africa (Kotze *et al*., 2009; Ollis *et al*., 2013). They include floodplains, valley-bottom with channel, valley-bottom without channel, hillslope seepage linked to a stream, isolated hillslope seepage and depression (pans) (see Figure 5.2).

The term '*wetland*' is therefore a generic name for places that are water-logging, dominated by hydrophytes and underlain by hydric soils. Wetlands can occur in any geographical area and may not necessary be in a lowland or flat area as some occur on hill slopes. According to the NWA (RSA, 1998b) areas such as seeps, valley-bottom, floodplains, coral reefs, mangroves, marshes and swamps qualify as wetlands. It should however be noted that some wetland systems may start as hillslopes and end up as valley-bottom wetlands and thus become a composite wetland system with different HGM units. Each of this unit may fall under different ownership as observed during this research.

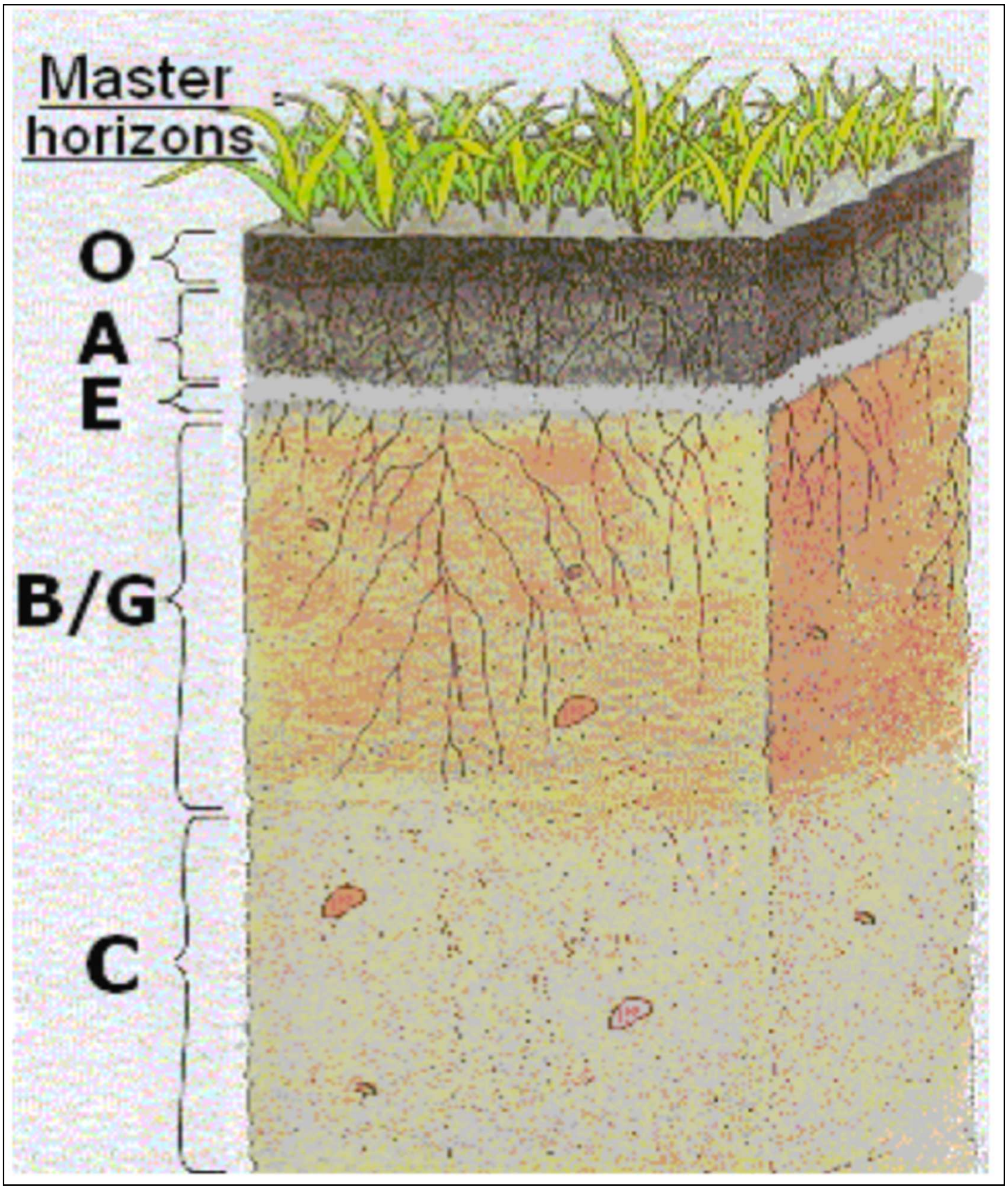


Source: Kotze *et al*. (2007)

Figure 5.2 The hydrogeomorphic classification of wetlands

5.4 FACTORS THAT INFLUENCE THE FORMATION OF WETLANDS

Two important factors are necessary for the formation of wetlands, namely the topography or morphology of the place and the presence of water. A third factor, which is vegetation (hydrophytes) that may range from herbs and grasses to giant trees like coastal mangroves, tropical riverines and riparian raffia palms is the consequence of the first two factors (Collins, 2011; Nel *et al.*, 2011; Pennington and Cech, 2010). However, the soil and geology of the place can also play a role. Wetlands naturally occur in flat or gentle gradient-low energy areas (except seeps) on anaerobic or hydric soils that are deficient in oxygenated air (WRC, 2013). The flat topography also helps in the retention of soil particles which build up to form deep wetland soils (Collins, 2006; Kotze, 2008; Spray and McGlothlin, 2004; Reynolds *et al*., 2015). A typical wetland soil profile is shown in Figure 5.3 below.



Horizon	Description
O	An organic horizon which occurs on the surface of some wetland soils due to the accumulation of organic matter under saturated conditions
A	Mineral horizon lying underneath an O horizon comprised of mineral particles interspersed with organic matter
E	Leached, sandy mineral horizon below the A horizon
B	Mineral horizon underneath the A or E horizon with bright colours, and an accumulation of clay or lime (carbonate).
G	Mineral horizon lying under an A or E horizon and with clear signs of redoximorphic features
C	Mineral horizon under the deepest B horizon with parent rock materials

Source: Collins (2006)

Figure 5.3 A typical soil profile

5.5 WETLAND DELINEATION

It is important to know the boundary of a wetland from dryland as separate ecosystems. Wetland specialist use physical, functional and biotic indicators to map out the outer boundary of a wetland (Turpie, 2010). There are four specific indicators used in the delineation of wetlands which include:

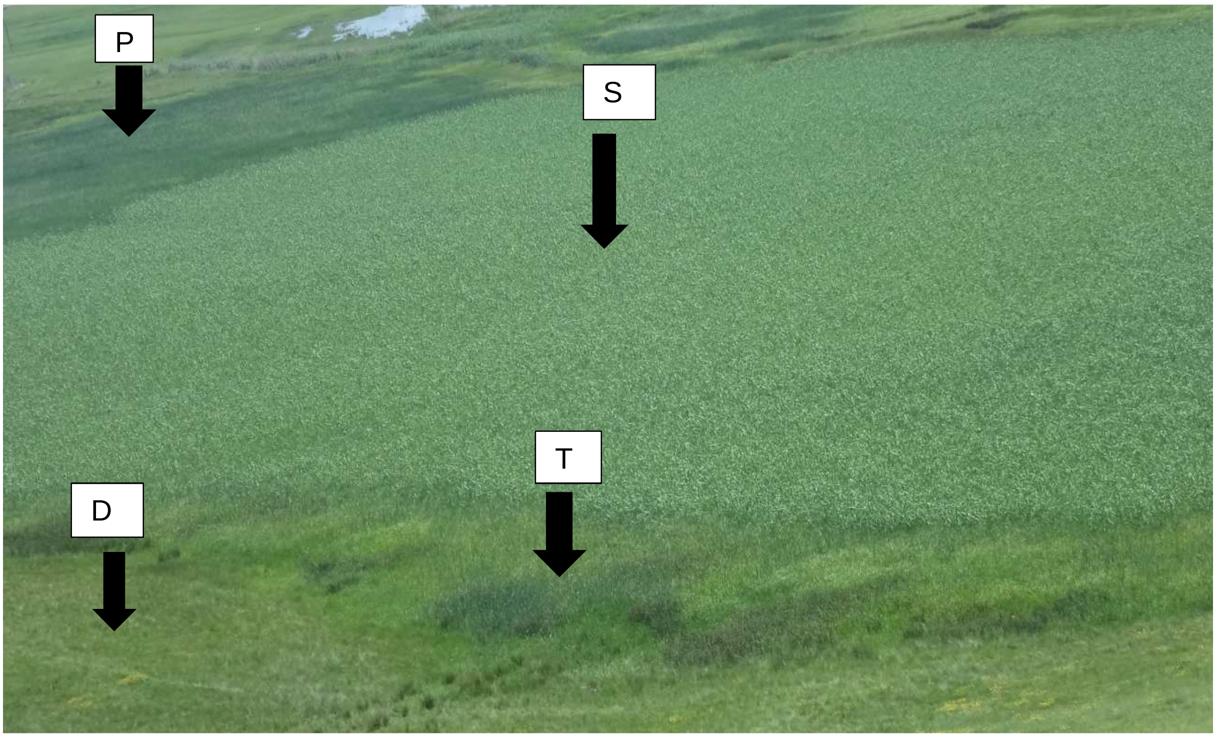
- Terrain unit indicator.
- Soil form indicator.
- Soil wetness indicator.
- Vegetation indicator (DWAF, 2005).

Spray and McGlothlin (2004), on the other hand, claim that wetlands are delineated from non-wetlands by three key criteria which include hydrophytic plant community, wetland hydrology and hydric soils.

Of the indicators mentioned by the Department of Water Affairs and Forestry (2005), the soil wetness indicator is the most important when making a delineation decision, with the other indicators used in a confirmatory role (Collins, 2006; Kotze, 2008; Nel *et al*., 2011). The point where the wetland indicators are no longer present is regarded as the edge of a wetland. When delineating a wetland (finding its extent), it is advisable to start where the permanent water ends and take soil samples with a soil auger at equal intervals along a transect perpendicular to the water flow (Kotze, 2008).

In a typical natural wetland, the area of the wetland with permanent water is characterised by dark grey, clay soil. This is because of the lack of oxygen, which is required for the reduction of minerals like iron in the soil that normally give dry-land soils their red-brown colour. Towards the edges the seasonally wet zone may be encountered. This zone is characterised by grey soils, but there are lots of orange and black mottles in the soil. This shows that for some time of the year the soil is exposed to the air and oxidation of the minerals occurs. Then the soil in the temporarily wet zone tends to be lighter and browner, with deeper mottles, while the non-wetland or dry-land soils are characteristic red-brown in colour with very few mottles (Collins, 2006; Kotze, 2008; Nel *et al.*, 2011).

Figure 5.4 shows a cross-section of a wetland with different water regimes.



P = permanently wet; S = seasonally wet; T = temporary wet and D = dryland (not part of the wetland)

Source: Author's own (2016)

Figure 5.4 A cross-section of a wetland showing different water regimes

Table 5.3 attempts to provide a summary of the wetness of wetlands, soil characteristics and typical vegetation that can easily be observed in a wetland.

TABLE 5.3: WETLAND WETNESS, CHARACTERISTIC SOIL AND VEGETATION

Section	Hydro period	Soil characteristic	Typical vegetation
Permanently wet	More than 11 months per year	Dark grey, clay soil, little or no mottles	Phragmites, reeds, papyrus, raffias, water lilies, bulrush
Seasonally wet	5–11 months per year	Grey soils, many orange and black mottles	Sedges
Temporary wet	1–4 months per year	Light grey-brown soil, few mottles	Grass

Source: Adapted from Collins (2006); Kotze (2008); MWP (n.d.)

5.6 WETLAND VALUES OR ECOLOGICAL SERVICES

Ecosystem services are nature's ability to provide various goods and services to the community and such services are also referred to as 'natural capital' (TEEB, 2010; UK DFID, 2006). Wetland values or wetland ecological services are the benefits that the local community derives from the wetland and such benefits are varied and different (MA, 2005; Pennington and Cech, 2010; RCS, 2010a; Reynolds *et al.*, 2015). In the distant past, wetlands were seen as swamps full of slimy creatures, areas that harbour many diseases such as *malaria* or *schistosomiasis* (Barbier *et al.,* 1997). Today, wetlands are among the most productive ecosystems in the world. They are often styled as *'the kidneys of the landscape'* because of their functions in the hydrological and chemical cycle, or as *'biological supermarkets'* because of the extensive food web and rich biodiversity that they support (Barbier *et al.,* 1997; RCS, 2010a; TEEB, 2010). Russi *et al*. (2013) listed twelve items on the economic importance of ecosystems and biodiversity in addressing challenges faced by modern society. Amongst the twelve, ten of them were directly linked to wetlands and the other two were indirectly linked (Russi *et al*. 2013).

Wetlands are not a homogenous ecosystem as many people might think, and therefore their value and ecological services that they provide vary. For example, while floodplain wetlands may be excellent for flood attenuation, it may not be the case for slope wetlands which may be more important for surface water recharge, or valley-bottom wetlands which may be more important for water purification (Kotze, 2012; MA, 2005; Nel *et al.,* 2011; Sullivan, 2008).

Wetland benefits can also be classified into direct and indirect benefits (Kotze *et al*., 2005 in Collins, 2006; MA, 2005; Sullivan, 2008).

5.6.1 Direct benefits of wetlands

These benefits include provisioning and cultural benefits and are explained below.

5.6.1.1 Provisioning benefits

- Water supply from wetlands could be used by the local community for agriculture, domestic, industrial and other uses. The use of wetland water for agricultural purposes is key in the eFS.
- Provision of harvestable natural resources such as sedges for craft-making, reeds and wood for construction, medicinal plants for treatment of illnesses, fibre for construction and handicraft production such as mats, baskets and paper (papyrus, which is a sedge). In South Africa, sedges such as *Cyperus latifolius*, *Cyperus textilis* and reeds (*Phragmites australis*) are used for construction. Bush rush such as *Junco krausii* are also used for handicraft. These activities provide development opportunities for the poor local communities, promote the development of traditional skills, provide employment and immediate cash flow, as well as ecologically promotes the conservation of wetlands (Kotze, 2012)

- Pastoral land for livestock grazing and cultivable land for food crop production provide livelihood for many farmers, especially in the eFS. Paddi rice production in extensive wetlands like in India constitute a major source of livelihood and food security for many rural communities. In China, many animals are raised in wetlands such as fish, shellfish, shrimps, crabs and ducks (Wang *et al*., 2008). Grazing areas for livestock and wildlife rangeland, especially in temporary and seasonal waterlogged areas of the wetland, is a dominant activity in the eFS. Both peasant and commercial agriculture take place within wetlands. The use of traditional agriculture practices such as zero tillage, non-use of fertiliser and pesticides, and hand harvesting as well as planting water-loving plants like *Colocasia esculenta* (Figure 5.5*)*, is sustainable and does not degrade the ecological characteristic of the wetland. The *Colocasia esculenta* is very popular among the Zulu in South Africa, and is a staple food among the Bakossi and other tribes in Cameroon. However, drainage and use of heavy machineries for commercial agriculture has destroyed and continue to destroy many wetlands.

Source: Author's own (2016)

Figure 5.5 A typical wetland tolerant crop – Colocasia esculenta (Madumbe)

- Valuable fisheries: Flood plains, estuaries and coastal mangroves are rich in micro-planktons, therefore good breeding grounds for fish which provide a good source of proteins and vital minerals for human.
- Hunting for waterfowl and other wildlife: Waterfowls are hunted in great numbers in the USA, while ducks and snipes are hunted in South Africa and other places. Wildlife such as reedbucks provide recreation and assist in the conservation of wetlands, for

example the Seekoeivlei wetland in the eFS has many reedbucks and other animal species.

- However, there are also negative provisioning services provided by wetlands such as providing breeding grounds for pests and pathogens (Nel *et al.*, 2011; Turpie *et al*., 2010).

5.6.1.2 Socio-cultural and spiritual benefits

Some wetlands have religious, spiritual, historical or archaeological values that are much cherished by people such that some may be turned into national heritage sites.

The socio-cultural and spiritual benefits of wetlands have not received much attention in previous wetland research in South Africa. Such benefits have been documented elsewhere in the world as a catalyst for the conservation of wetlands as discussed in the pursuing paragraphs.

Culture is understood as the way of behaviour and doing things that characterise a particular society, and is handed down from one generation to another. Though culture may evolve over a long period, some of the core characteristics could still be perpetuated by the society. In this study, culture is strongly associated with traditional or indigenous knowledge.

There are strong cultural and spiritual values associated with many wetlands from when they were inhabited and used by human beings in the ancient times (RCS, 2009). The first Ramsar Convention on wetlands in Iran in 1971, followed by another in Spain in 2002 with Resolution VII.19, and later strengthened by the Convention in Kampala, Uganda, in 2005 with Resolution IX.21, acknowledged the cultural values of wetlands and formulated the guiding principles for considering the cultural values of wetlands for any effective management of wetlands (RCS, 2009). To drive the cultural agenda on wetlands further, the Ramsar Culture Working Group was established and has since 2006 done a lot of research and publications on the cultural importance of wetlands.

It is well-documented in recent literature that any effective and sustainable nature conservation (including wetlands) should consider local community welfare and should encourage their active participation. Such an approach easily leads to the development of natural and cultural heritage sites that could attract many tourists, thus providing livelihood to many local people. In short, such an integrated approach creates a vicious cycle of development.

Water, including those from wetlands, is considered as the bringer and sustainer of life and this concept has been venerated down the ages such that water plays an important role in many of the world's major faiths, including Buddhism, Christianity (for example, the River Jordan in the Bible), Hinduism, Islam, Judaism and Sikhism (RCS, 2009). According to Sullivan *et al.* (2008), wetlands provide religious and spiritual enrichment, aesthetic experiences, historical or archaeological values which are generally referred to as cultural services. Some concrete examples of religious and cultural importance of wetlands are explained below:

China's XIXI Wetland Park near the Hangzhou City in the Yangtze River delta developed a wetland-related culture that dates as far back as 5 000 years, when in AD 233, the Buddhists gathered to drink the XIXI water, built magnificent temples and established the Dragon Boat Festival in 1465. Meanwhile, the products from the wetlands such as persimmon, plums, reeds and bamboos were highly prised and often referred to in poems, writings and paintings. A fishing culture also developed around the area with terrapins and fish used to sustain the livelihoods of many people in the city of Hangzhou (RCS, 2009). There were therefore many economic spinoffs from the cultural importance of this wetlands park.

Peatlands help to preserve the remains of great archaeological importance. For example, the Tollund Man and the pollen grains of the Iron Age were preserved in water-logging peat soil and discovered in a Danish peatbog in 1950. These preserved pollen grains helped scientists to reconstruct the climate and vegetation at the time when the Tollund Man lived (RCS, 2009).

The Donana Wetlands of Andalusia in south-west Spain were developed into the Donana National Park where traditional religious celebrations take place annually. In Australia, the Kakadu National Park which was established many years ago, recently served as an experimental centre where Western science and the traditional burning practices helped to restore a more mixed vegetation type with greater biodiversity.

In South Africa, the Mbongolwane Wetland, about 80 km north of Durban, is home to the famous *Nkanyambi*, a mysterious multi-headed serpent which the local people regard as the ancestral guardian of the wetland, and if not respected and pleased by the people, will inflict a punishment in the form of catastrophic storms. This mythical serpent is also well-represented in many southern Africa cultures and San rock art.

It may be difficult to attach a conventional price tag to the cultural value of wetlands, especially the intrinsic spiritual, religious or zartistic importance, but the use of secondary indicators such as the volume of tourism to cultural heritage wetlands could be enormous. For example, between 2005 and 2007 about 230 000 people visited the Kakadu National Park and spent about 800 000 nights per year in Australia. Most of these visitors were attracted to the spiritual and religious significance in the Aboriginal culture (RCS, 2009).

5.6.1.3 Recreational services

Wetlands also provide a variety of recreational activities such as hunting, fishing, boating and spinoffs from such activities create opportunities for the provision of tourism allied services that overall lead to the economic development of the area. Wetlands offer huge potentials for eco-tourism, both for sightseeing and recreation in China (Wang *et al.*, 2008).

5.6.1.4 Educational and research services

The educational and research value of wetlands cannot be over emphasised. As a transitional ecosystem between aquatic and terrestrial ecosystems, wetlands are rich in biodiversity, which provide an excellent environment for education and research.

5.6.1.5 Wastewater treatment

Natural wetlands have been used for long in the purification of polluted water. Meanwhile artificial wetlands are being created to treat polluted water by trapping pollutants (Kotze, 2012; Nel *et al*., 2011).

5.6.2 Indirect benefits

The indirect benefits of wetlands come from the regulatory and supporting services that they provide to the local community. Most often these indirect benefits are linked to the hydrological role of wetlands which will be discussed in the next sections.

5.6.2.1 Water purification

Wetlands act as natural filters by trapping pollutants such as sediments, excess nutrients such as nitrogen and phosphorus, heavy metals, disease-causing bacteria and viruses, as well as synthetic organic pollutants such as pesticides (Kotze, 2012). Sometimes wetlands act as sponges for the natural purification of contaminated or polluted water. The low-gradient and continuous vegetation cover in wetlands assist them in performing this function of natural water purification. In agricultural areas where nitrate concentration and eutrophication could be a big problem, the water purification role of wetlands is a huge relief to the farmers and the local communities. The use of wetlands as a cost-effective and economically efficient sewage treatment tool has been growing rapidly in recent years in places like China (Wang *et al.*, 2008). Both natural and artificial wetlands act as cost-effective natural wastewater treatment (green engineering), but their ability to treat wastewater depends on the size and ecological state of the wetland, the amount and nature of pollutants compared to the carrying capacity of the wetland, the hydrology pattern within the wetland, as well as the climate affecting the wetland (CNRD/PEDRR, 2013; Kotze, 2012).

5.6.2.2 *Sustaining stream flow*

Many streams and rivers take their rise from wetlands and these streams and rivers flow through settlements and different economic activities like agriculture and industries which make use of the water. Wetlands therefore sustainably retain and later discharge water into these areas on a regular basis. By so doing, they help to sustain the activities taking place downstream and which rely on such water supply-source. The ability of a wetland to feed channel flow will be influenced by the input of water into the wetland, the gradient of the wetland, the underlying soil type, the rate of evapotranspiration and the rate of water extraction from the wetland. Wetlands also store water and ensure that there is supply of water during dry spells and drought episodes and therefore help in mitigating the negative impacts of drought.

5.6.2.3 *Flood attenuation*

Wetlands play a vital role in attenuating flood water and thereby helping to reduce the possible devastating effects of flood water that could result into a flood disaster downstream (CNRD/PEDRR, 2013; MA, 2005). Wetlands reduce the severity of floods by accommodating and slowing down flood waters while coastal wetlands, particularly mangroves, also provide storm protection from causing damages to human life and coastal infrastructure (MWP, 2012). Generally, a catchment with about 15% wetlands is capable of reducing flood peaks by 60–65% (MWP, 2012). However, the ability of a wetland to attenuate floods will depend on the type of wetland (for example, flood plains are good in this function), the size of the wetland, the ecological state of the wetland as well as the magnitude of the flood (Acreman *et al.*, 2011; Collins, 2006; Kotze, 2012; MA, 2005).

5.6.2.4 *Chemical cycling*

Wetlands help in trapping carbon due to their anaerobic conditions which slow down the decomposition of organic matter and leads to the formation of coal in swamp wetlands. Undisturbed, wetlands are good carbon sinks which slow down global warming and possible negative effects of climate change (Kotze, 2012, IPCC, 2014). Wetlands plants help to remove concentrated nitrate in water that could cause eutrophication downstream. Such nitrates could emanate from domestic wastes, industrial and agricultural activities. Other compounds such as phosphate and toxic substances like uranium could be removed by wetlands thus helping to improve the quality of water downstream. Global and local water cycles are strongly dependent on wetlands. Without wetlands, the water cycle, carbon cycle and nutrient cycle would be significantly altered (Reynolds *et al.*, 2015; Russi *et al*., 2013).

5.6.2.5 Erosion control and soil formation

The low gradient and dense wetland vegetation help to reduce the wave and current energy of flowing water, the vegetation help to bind and stabilise the soil, and wetlands have the ability to recover rapidly from flood damages (Kotze, 2012). Wetlands normally trap and deposit soil sediments within them. This eventually leads to the accumulation of alluvial deposits within the wetlands. The accumulated alluvial deposits could ginger primary plant colonisation and thus another ecosystem could be supported. Also by trapping soil sediments and rock fragments which could be used as weapons in fluvial processes and by slowing down the velocity of water flow, wetlands help in fluvial erosion control. The wetlands vegetation has the ability to trap wind-born particles and thus control wind erosion and build sand dunes. The latter helps in abating the impact of sea level rise that is generally attributed to climate change impacts (see Chapter 7).

5.6.2.6 Climate regulation

Wetlands can act as a carbon sink and by doing so help to reduce global warming and climate variability or climate change. This role is supported by the fact that wetlands typically contain higher levels of organic matter than dryland (IPCC, 2014; Sullivan, 2008). By having a denser vegetation cover which is perennial, wetlands have good potentials of trapping and converting atmospheric carbon dioxide that is the main cause of global warming and climate change. Wetlands are invaluable in supporting climate change mitigation and adaption, as well as supporting health, livelihoods, local development and poverty eradication (IPCC, 2014; Russi *et al.*, 2013).

5.6.2.7 Biodiversity benefits

Wetlands support a variety of plants, animals and birds which are both endemic and endangered species. These biodiversities have either direct economic values or supply support services to the surrounding community. Figure 5.6 shows one of these endangered species.

Source: EWT (2014)

Figure 5.6 Wattled Crane – a critically endangered wetland bird species in South Africa; mostly found in the floodplains of central South Africa

5.6.2.8 Groundwater recharge and discharge

Water that comes from various forms of precipitation accumulates in wetlands and then gradually infiltrates through the underlying soil layers to recharge the aquifers and groundwater. On the other hand, wetlands also act as sources of groundwater discharge through seepages.

The Millennium Ecosystem Assessment (2005) summarised the ecological services of wetland discussed above into four broad categories as presented in Table 5.4 below:

TABLE 5.4: SUMMARY OF ECOSYSTEM SERVICES DERIVED FROM WETLANDS

Provisioning	**Harvestable goods**
Food	Production of fish and fish shells, game and meat, wild fruits, aquaculture and grains. Example, the Mbongowane wetland in Eshowe–KZN is used to cultivate many types of crops (using conservation agriculture) such as taro, sugar cane, cabbages, onion. Most of these crops are cultivated by women
Grazing land	Most of the wetlands in the eFS are used for cattle grazing and a few for game. Fodder is also produced from the wetland especially during winter
Fresh water	Storage and retention of water for domestic, industrial, and agricultural use, water supply for hydro-electricity
Fibre and fuel	Timber, firewood, fodder and manure, grasses for construction and artisanal craft, harvestable peat
Biochemical	Extraction of medicines and other materials from biota to cure or prevent diseases. In South Africa and elsewhere wetland plants are used to treat headaches, urinary infections, ulcers, wounds. *Uklenya* is used for menstrual pain relieve or to expel the placenta after birth
Genetic materials	Genes for resistance to plant pathogens or ornamental species
Trade	Tourism, craft industries, sale of locally produced goods; all of which boost household income and contribute to the local GDP
Regulating	**Services responsible for maintaining natural processes and dynamics**
Climate regulation	Source of and or sink for greenhouse gases, thus influencing local and regional temperature; precipitation; act as windbreaks and regulate other climatic processes
Water regulation (hydrological flows)	Groundwater recharge/discharge; water filtering; dilution of pollutants; discharge of pollutants; flushing/cleansing; bio-chemical/physical purification of water; storage of pollutants; flow regulation for flood control; river base flow regulation; water storage capacity; groundwater recharge capacity; regulation of water balance; sedimentation/retention capacity; prevention of saline groundwater intrusion; prevention of saline surface water intrusion
Water purification and wastewater treatment retention	Recovery, and removal of excess nutrients and other pollutants
Erosion regulation	Retention of soil and sediments, prevention of coastal erosion and wave dispersion, for example, the role of coastal mangroves
Natural hazard regulation	Flood control; storm water control; protection against water erosion, protection against wave action, act as windbreaks, act as wildfire breaks
Biodiversity regulation	Habitat for pollinators such as bees which are attracted to wetland plants such as lilies; maintenance of genetic species and ecosystem composition; maintenance of ecosystem structure; maintenance of key ecosystem processes for creating or maintaining biodiversity; suitability for nature conservation
Cultural	**These are services that provide a source of artistic, aesthetic, spiritual, religious, recreational or scientific enrichment, or non-material benefits**
Spiritual and inspirational	Source of inspiration; many religions attach spiritual and religious values to aspects of wetland ecosystems; wetlands pools used for baptism
Recreational	Opportunities for recreational activities such as boat racing, bird watching
Aesthetic	Many people find beauty or aesthetic value in aspects of wetland ecosystems. Beautiful natural landscape, haunting, recreation and bird watching add to this beauty

Educational	Opportunities for formal and informal education and training. Rich in biodiversity, thus offering good research in plants and animals, and education on conservation
Supporting	**Services necessary for all other ecosystem services**
Soil formation	Sediment retention and accumulation of organic matter. The formation of fertile alluvial soils
Nutrients cycling	Storage, recycling, processing, and acquisition of nutrients

Source: Adapted from MA (2005); RCS (2010a)

Despite all these services explained and listed above, many wetlands have been poorly managed and others converted into other land uses without a proper analysis of wetland values and benefits (Kotze, 2008). This study focuses on maintaining healthy wetlands as a management tool to reduce disaster risk and adapt to climate change in the eFS.

5.7 ECONOMIC VALUATION OF WETLANDS

5.7.1 Quantifying the value of wetlands

Wetland economic valuation is a way of attaching quantitative and monetary values to wetland goods and services, whether or not market prices are available, so that they can be directly comparable with other sectors of the economy when activities are planned, policies are formulated, and decisions are made (Kakuru *et al*., 2013). Unfortunately, most wetlands services do not have a direct market value and this has often led to poor and under-evaluation of wetlands values. The consequences have been that most wetlands were converted into other land-use practices without accurate cost-benefits analysis and proper EIA. The next paragraphs describe ways that ecosystems and wetland could be quantified but the actual quantification of wetland services was not the focus of this study.

Recently, direct (marketable) and indirect (non-marketable) economic valuation methods are increasingly being used to estimate the total economic value of wetlands and other ecosystems (TEEB, 2010; Tietenberg and Lewis, 2012). Although these new methods are becoming increasingly popular, they have their own inherent difficulties to apply. Their acceptance and popular use must be supported by massive and aggressive wetlands education, training and awareness campaigns to promote the ‘wise use’ and conservation of wetlands.

To obtain the total economic value of the service from any natural resource (such as wetlands) will necessitate that three components of value be calculated. These include *use value* which can be *direct or indirect*, *option value* and *non-use or passive value* (Oellermann *et al*., 1994; Tietenberg and Lewis, 2012; Turpie *et al*., 2012). *Option values* are like an insurance premium to ensure the supply of the wetland services when the individual decides to use it; the *existence value* is the willingness to pay for the continuous existence of the wetland even when the individual does not intend to use the wetland, while the *bequest value* or *non-use value* is what individuals are willing to pay to ensure that the wetland is preserved for the future generation (Oellermann *et al*., 1994).

To obtain these values, techniques such as direct observation, contingent valuation, contingent choice experiments, travel cost, hedonic property and wage studies, as well as averting or defensive expenditures could be used (Tietenberg and Lewis, 2012). Wetland valuation uses various methods such as market value approaches (which rely on quantification of production), surrogate market or revealed preference approaches (which rely on observation of related behaviour) and simulated market or stated preference approaches (which rely on direct questioning). The simpler methods produce a total value, whereas those that involve construction of models are better for estimating marginal values (the additional value generated by each unit of production) (Turpie *et al*., 2010). Table 5.5 below gives a synopsis of some approaches to estimate the value of wetlands.

TABLE 5.5: SOME APPROACHES OF ESTIMATING WETLAND VALUES

Wetland value	Method to evaluate	Tools that can be used
Consumptive and non-consumptive direct value	Market valuation, i.e. quantity produced, price and cost of inputs	Key informant interviews, focus group discussion, household survey with questionnaires
Marginal value	Change in production	Change in net benefit of production of goods/services due to change in quantity and quality of wetlands services
Regulatory value	Replacement cost or damage cost avoided	Cost of building a dam to replace the wetland flood attenuation function or damage avoided due to the buffer role of a wetland or defensive expenditure avoided such as building dykes
Recreational value	Travel cost	Tourism value, i.e. money and time spent to visit a wetland
	Hedonic pricing	Impact of wetland quality on property around it
Non-use value	Stated preference and contingent valuation method (CVM)	Questionnaire surveys to elicit willingness to pay for the conservation of wetland biodiversity or willingness to accept compensation for loss of wetland biodiversity
	Conjoint valuation	Analyse responses to multiple scenarios to get the marginal value of a wetland
	Benefit transfer	Using results from similar studies to estimate the value of the wetland under investigation

Source: Adapted from Turpie *et al.* (2010)

Quantifying these benefits in monetary terms, especially for environmental resources such as wetlands, is still in its infancy and heralded with many difficulties. Despite these difficulties, the rate of wetlands loss could be reduced by making the public, policy-makers, and private users aware of the full value or benefits of wetland preservation (Oellermann *et al*., 1994).

Decisions on wetlands must weigh the potential long-term consequences of wetland destruction with the immediate benefits associated with proposed transformation (Spray and McGlothlin, 2004). Both efficiency (that eliminates waste) and ethical considerations (that promote equity and fairness) need to be considered as well when managing environmental resources such as wetlands (Tietenberg and Lewis, 2012). Table 5.6 shows the total economic value of wetlands and the possible valuation techniques that could be used.

TABLE 5.6: CLASSIFICATION OF TOTAL ECONOMIC VALUE OF WETLANDS AND METHODS OF VALUATION

Use Value			Non-use Value
Direct use value	**Indirect use value**	**Option and quasi option value**	**Existence value**
Examples: • Fish • Agriculture • Fuelwood • Recreation • Transport • Wildlife harvesting – peat/energy	Examples: • Nutrient retention – flood control • Storm control • Groundwater recharge • Micro-climate stabilisation • External ecosystem support • Shoreline stabilisation	Examples: • Potential future use as per direct or indirect use values • Future value of information	Examples: • Biodiversity • Culture/heritage • Bequest value
Possible techniques for valuation			
Market analysis: TCM, CVM, Hedonic prices Public Prices: IOC, IS, Replacement cost	Damage cost avoidance, Preventive expenditure, value of changes in productivity, relocation cost, replacement cost	ICM, CVI, CVM	CVM

Source: Barbier *et al.* (1997)

Note:
ICM = Individual Choice Methods
CVI = Conditional Value of Information
CVM = Contingent Valuation Method
TCM = Travel Cost Method
IOC = Indirect Opportunity Cost approach
IS = Indirect Substitute approach

It should be noted, however, that market failures exist due to the public-good nature of wetlands goods and services, as well as due to externalities from users such as agriculture and water abstraction upon other stakeholders and even non-users (Turner *et al*., 2000).

Wetland evaluation in South Africa could be done using the functional assessment approach, biological assessment or habitat assessment approach (DWAF, 2004). The *functional assessment* evaluates the potential impacts of developments on wetland ecosystems and examines the wetland functioning over time. *Biological assessment* or *bio-assessment* evaluates a wetland's ability to support and maintain a balanced, adaptive community of organisms having species composition, diversity and functional organisation comparable to that of minimally disturbed wetlands within a region. *Habitat assessment* is often used alongside bio-assessment, to provide information on the quality, quantity and suitability of the physical environment supporting the biota being measured (DWAF, 2004). Details of these assessments are not covered in this research.

In evaluating only the provisioning services of southern African temperate wetlands of Letseng-la-Letsie in Lesotho (rural area) and a peri-urban wetland in Mfuleni, Cape Town in 2009, the estimated total added value from grazing was 180 078 US dollar for Letseng-la-Letsie and 540 286 US dollar for Mfuleni (Turpie, 2010). It was also realised that 63% of the households relied on wetlands in the rural area of Letseng-la-Letsie, compared to only 13% in the peri-urban wetland in Mfuleni (Turpie, 2010). This example is just a tip of the iceberg on what wetlands can provide to the local communities. More of such quantification is needed in the eFS.

5.7.2 Wetlands and food security

Food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (Kakuru *et al.*, 2013). Over 80% of the people living adjacent to wetland areas in developing countries such as Uganda directly use wetland resources for their household food security needs (Kakuru *et al*., 2013). Directly, wetlands promote food security by providing products such as fish, crops grown in and along the wetland edges, wild fruits, vegetables, and game meat. Besides, cash income from the sale of raw materials and processed products such as crafts, sand, clay, bricks, and ecotourism are used to purchase food items (Kakuru *et al.*, 2013).

More than 60% of the population living in the Niger Delta in Nigeria depends on this wetland for their livelihood, especially in fishing and fuel-wood harvesting. The delta is also very rich in oil and gas and has attracted not only a multinational oil company like Shell, but also a high rate of immigration into the area. The Niger Delta in Nigeria is the largest wetland in Africa (with three Ramsar sites) and the third largest mangrove forest in the world (WI, 2014). The delta is home to about three million people (about the size of Lesotho and Swaziland combined). Despite the environmental and social problems, if well-managed, the Niger Delta wetland holds good potential for sustainable local livelihoods and food security. Most of the Niger Delta wetlands have been contaminated with oil spills and Wetland International is busy with restoration projects in the Niger Delta (WI, 2014). Restoring lost or rehabilitating damaged ecosystems such as wetlands help to ensure food security. For example, increased forest produce from forest restoration and wetland restoration leads to, *inter alia*, increased fish stocks, revitalisation of industries, and socio-economic benefits (Takeuchi *et al*., 2014). Well-managed wetlands can therefore contribute significantly to food security in the eFS.

5.7.3 Wetlands and sustainable development

Natural ecosystems such as wetlands which are rich in biodiversity provide a catalyst for sustainable development because of their contribution to human survival and well-being (UNDP, 2012). Most of the 1.2 billion people living in severe poverty and on less than one US dollar per day depend directly on natural ecosystems such as wetlands for food, water, fuel, medicine, shelter and reduced vulnerability to climate change and natural disasters (UNDP, 2012). Well-managed wetlands can thus reduce poverty and contribute to sustainable development.

Sustainable development can be seen as having four pillars: economic, social, political and environmental (UNDP, 2012). All these pillars need to be balanced equitably and in a sustainable manner. If this fails to happen, then in the short to long term there will be an implosion in the development drive, resulting to issues such as economic crises, political and social unrest, environmental degradation, including pollution and even global warming. Wetlands directly or indirectly contribute to all the four pillars of development.

Better management of wetlands is an essential strategy to meet at least seven out of the seventeen SDGs that were adopted in September 2015. These goals include zero hunger, for example crop production such as *madumba*; clean water and sanitation through water purification; sustainable cities and communities, for example, reducing urban flooding; responsible consumption and production, for example, treating chemicals from agricultural production; climate action such as carbon sequestration; life below the water such as breeding ground for fisheries; avoiding land degradation through erosion control; and life on land such as the rich biodiversity in wetlands (WI, 2016). Besides the SDGs, the 2015 Paris Agreement on climate change, and SFDRR 2015−2030 in the same year, all emphasised increased investment to improve the status and condition of wetlands, not only for sustainable development but equally for DRR and CCA (WI, 2016).

Wetlands need to be managed in a sustainable manner. To achieve this, wetland managers need to borrow from sustainable science. Sustainability science focuses on the problems it addresses, rather than on the tools of the disciplines it employs (Kates *et al*., 2001 in Takeuchi *et al*., 2014). Its aim is to improve society's attempts to achieve sustainable development, to sustain the life support systems of the planet, and to reduce poverty (PNAS 2007; Kates, 2011 in Takeuchi *et al*., 2014). A sustainable society functions in harmony with nature and a healthy natural environment is one of the four pillars of sustainable development (UNDP, 2012).

5.7.4 Wetland value in the eastern Free State

A quantitative monetary value of wetlands in the eFS has not been done. A qualitatively, field observation shows that more than 90% of wetlands in the eFS are used for grazing.

Wetlands have a higher fodder yield and higher forage quality for grazing animals than the surrounding veld or dry/non-wetland grassland (Kotze, 2012). Wetlands are important for sustainable farm fodder flow. Most wetlands found in the study area with summer rainfall are grazed highest in spring when surrounding grazing areas are depleted. Sometimes alternative stock is used to graze the wetlands at different seasons. For example, sheep in winter and cattle in spring and summer. Lenient grazing increases the ecological value of wetlands by producing both tall and short grass and this, in turn, creates more variety of habitats. During prolonged dry years (such as the 2015/2016 drought) wetlands are grazed for extended periods since that is the only place where enough forage can be found for the stock. Hay is usually made from wet grassland and meadows in January and February and used on the farm in winter when there is less fodder for the animals. This qualitative appraisal of wetlands reveal their importance in the study area.

5.8 TYPES OF WETLAND TENURE IN SOUTH AFRICA

Four main types of wetland tenure can be observed in South Africa, including the eFS, namely:

- State-owned, protected wetlands such as Seekoeivlei.
- Communal wetlands such as the Monontsha wetland in QwaQwa.
- Private, with a single owner of the entire wetland or with many owners of a single wetland system.
- Mixed (especially in townlands) where, for example, the Provincial Nature Conservation leases the wetland from the local town council and the Provincial Nature Conservation delegates management to a community-based organisation. An example is Wakkerstroom Vlei in Mpumalanga which is managed by the Wakkerstroom Natural Heritage Association.

5.9 WETLAND THREATS AND DEGRADATION

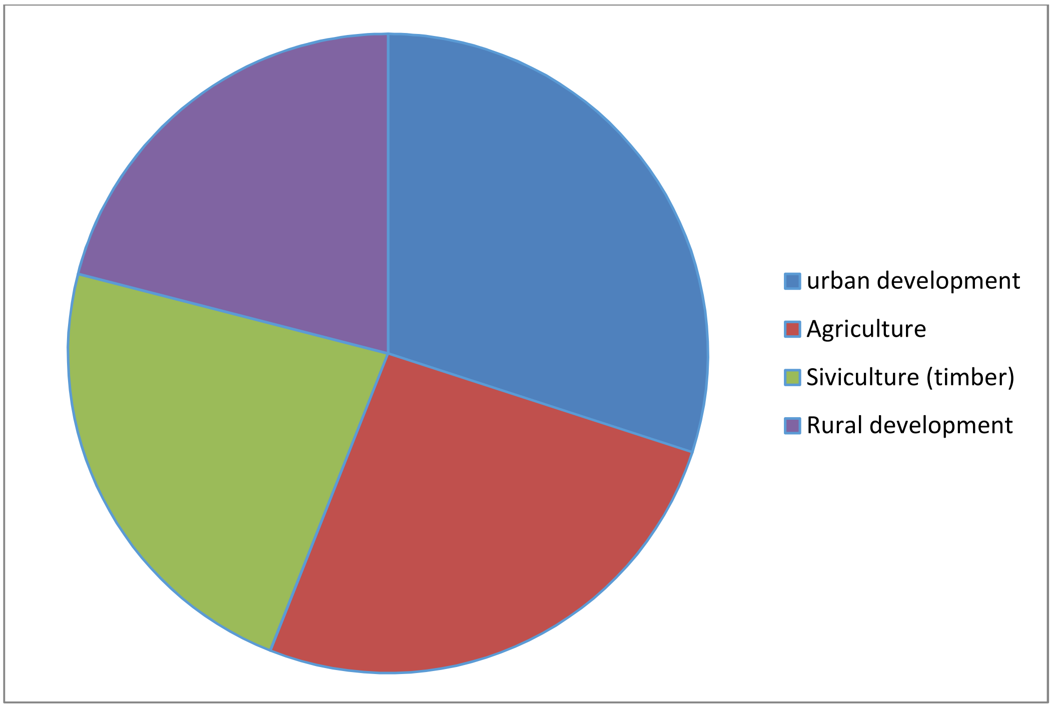
Wetlands were often considered as 'problem areas' that need to be corrected through draining and filling for other uses (Pennington and Cech, 2010). This notion placed many wetlands under severe human and natural stressors. Wetlands stressors can be divided into direct or on-site and indirect or off-site threats. Direct threats happen within the wetland, while indirect threats happen remotely from the wetlands and affect the hydrology of the wetland (Mitchell, 2012).

More than 50% of the world's wetlands were lost by both direct and indirect stressors in the twentieth century. These stressors include uncontrolled grazing; uncontrolled burning; settlement; agricultural activities; irrigation and water abstraction; afforestation; infrastructure development; climate change with associated environmental degradation and sea level rise; natural hazards such as floods, subsidence and droughts; poor catchment management activities; over-harvesting of wetland species; over-exploitation of resources or higher demand for ecosystem goods than can be sustained (such as over-fishing); land use and land cover changes, or changes to habitats due to conversion to croplands and urbanisation; invasive alien species (introduced species that compete and encroach vigorously upon native species, with the potential to degrade ecosystem services and cause severe economic damage); pollution, from chemical waste and agricultural inputs (Ayoade, 2004; Kotze, 2008; MA, 2005; Miththapala, 2008 in Sudmeier-Rieux and Ash, 2009; Nel *et al.*, 2011; Pennington and Cech, 2010; RSA DEAT, 2015; WI, 2014).

Wetland degradation implies the extent to which the current ecological status of the wetland differs from its reference condition (MA, 2005; RCS, 2010c; TEEB, 2010). The ecological status of a wetland refers to the structure and inter-relationships between the biological, physical and chemical components of a wetland. Wetlands in reference condition are those in a pre-impact state or least impacted by anthropogenic activities. This can represent the least-impacted condition for a particular wetland type within a landscape, ecoregion, catchment or area (Butcher, 2003 in DWAF, 2004). Reference wetlands, on the other hand, are those wetlands that display reference conditions. The reference condition of a wetland is used to determine the extent of degradation of the wetlands.

5.9.1 Global perspective of wetland degradation and loss

In the USA, the Netherlands and many other parts of the world, urban development, agriculture, silviculture and rural development are the main culprits of wetland loss as shown in Figure 5.7 below:



Source: Adapted from Pennington and Cech (2010)

Figure 5.7 Main causes of wetland losses in the United States of America

The depth and quality of information for wetlands management at global level is insufficient to support effective management. Besides, the governance arrangements (and hence 'rules of use') differ significantly between communal wetlands and those wetlands on private land in many parts of the world (Finlayson and Pollard, 2009).

Wang *et al*. (2008) identified six other factors that act as threats to wetlands in China, but may also apply to other parts of the world. These include:

- *Lack of public awareness of the value and need for wetland protection*: For example, many Chinese and their community leaders view wetlands as vast open land or waste land and therefore unwilling to sacrifice economic benefits for their protection. This is also evident within communal wetlands in the eFS.
- *Insufficient funding for wetland protection and management*: Though some wetlands, especially Ramsar sites, may be protected, there is generally a lack of funds and trained personnel to carry out comprehensive wetland research so that scientific data can be generated to guide scientific-based decision-making. The highest culprits to this problem are local wetlands that most often exist in poor communities. Some developed countries have made huge investment in wetlands management and protection. For example, the USA carries out the Wetland Reserve Program and the Five Star Restoration Program, while Australia invest a huge budget for the

management of protected wetlands (MA, 2002 in Wang *et al*., 2008). The lack of funding for wetlands management and protection results in poor training of wetland administrative personnel, bad management and ineffective enforcement of wetland laws (LI and Zhang, 2002 in Wang *et al*., 2008). This point was picked up during field visits in the eFS where many agricultural extension workers who assist farmers in whose land most wetlands were located, did not even know the meaning of a wetland.

- *An imperfect legal system to protect wetlands*: The lack of wetland assessment hinders the development of policies, laws and regulations for the protection and sustainable utilisation of wetlands. This problem was elaborated upon in Chapter 3 of this research.
- *Insufficient wetland research*: The lack of basic research and data most often results in qualitative evaluation of the benefits of wetlands. Also, models that may be used to generate quantitative data needs to be adapted to unique local conditions and this may not be possible, especially to poor communities in developing countries.
- *Lack of coordination among agencies and unclear responsibilities*: Wetlands management, protection and utilisation involve many stakeholders such as DAFF, DWS, DEA and land-use planners. Unfortunately, there are no formal mechanisms to promote cooperation and coordination of action. Lack of coordination of stakeholders is a big problem in the eFS, as well as the whole FS province.
- *Undeveloped technologies related to wetland use and protection*: Many land developers are ignorant of the processes and technologies that are required to produce ecologically sound development projects and thus sacrifice wetlands for their economic benefits without a proper impact analysis (Wang *et al*., 2008).

Most of these factors mentioned by Wang *et al*. (2008) also apply in Africa, as well as the local situation in the eFS.

5.9.2 Wetlands stressors in Africa

African wetlands cover more than 131 million hectares of land and are among the most biologically diverse ecosystems on the continent (Mukeredzi, 2015), but wetland areas are experiencing immense pressure across the continent. Wetland stressors include commercial development like tourism facilities, agriculture, settlements, excessive exploitation by local communities and improperly-planned development activities (Mukeredzi, 2015).

Oil, coal and gas deposits in places like Nigeria, Guinea-Bissau and Mozambique have led to an increase in on-shore and off-shore exploration and mining in sensitive ecological areas that include wetlands (WI, 2015). In northern Kenya, port developments in Lamu took place in important mangrove areas with fisheries breeding ground. Wetlands are also being destroyed due to oil exploitation in the tropical rainforest of the Congo Basin and the Virunga National Park, which is a world heritage site and also a Ramsar site. The Okavango Delta in Botswana is one of Africa's most important wetlands, is a world heritage site of UNESCO, is habitat to many threatened species such as the egret and the main water source of regional wildlife in Southern Africa. Yet, it is shrinking due to a drier climate, increased grazing and growing pressure from tourism. Another example of the devastation of major wetlands occurred in the 7 000 square kilometres of the Niger Delta in Nigeria with pollution of farmlands linked to the Shell petroleum company, especially in Ikot Ada Udo in the Akwa Ibom State on the coastal south of Nigeria (Mukeredzi, 2015; WI, 2015).

Wetlands are destroyed in almost all countries in Africa due to population pressure, ignorance about the beneficial role of wetlands as an ecosystem, lack of policies, laws and an institutional framework to protect wetlands. Very few African governments have specific national policies on wetlands. Most often wetlands policies come from different sectors such as agriculture, and national resources such as water and energy (Mukeredzi, 2015). The future of African wetlands lies in a stronger political will to protect them, sound wetland policies, better education and awareness and encouragement of local community participation in wise and sustainable management of wetlands.

5.9.3 Wetlands stressors in South Africa and the eastern Free State

Poor or bad land uses which have negative impacts on wetlands in South Africa, in general, and the study area, in particular, are discussed in the following sections.

5.9.3.1 Overgrazing or poor grazing practices

Overgrazing and poor grazing practices lead to trampling, head cuts (erosion at the knick-point or sudden drop in slope of a wetland) and gully erosion, as well as moribund within wetlands (see Figure 5.8).

Using tools such as remote sensing, a geographic information system, and the normalised difference vegetation index, Sparks (2012) found that overgrazing and urban development caused severe negative impacts on wetland extents and vegetation in the eFS, particularly in the Maluti-a-Phofung Local Municipal area. Communal wetlands such as the Monontsha wetland was cited as severely impacted upon. Over-population, poverty and cultural constraints were challenges facing the rehabilitation efforts in the area (Sparks, 2012).

Source: MWP (n.d.)

Figure 5.8 Trampling and head cut erosion due to bad grazing in permanently wet areas and wet seasons

5.9.3.2 Invasive and alien plants

An alien species is a plant or animal species that does not occur naturally in an area, while an invasive species is a species that has the capacity to outcompete and dominate the naturally occurring species in an area (Kotze, 2009). Both are jointly referred to in this study as invasive alien plants. Invasive alien plants in wetlands often outcompete indigenous plants and this leads to reduction in the goods and services provided by wetlands. According to Kotze (2004), invasive alien plants have the following negative impacts on wetlands:

- The quality of habitat and the biodiversity provided by the wetland are reduced.
- Alien plants (e.g. wattle trees) are less effective in binding soil and controlling erosion, compared to indigenous plants.
- Alien plants are generally less effective in enhancing water quality.
- Some alien plants lose more water through transpiration than the indigenous plants and this may reduce the natural flow of water in streams.
- The grazing value of most alien plants is lower than that of indigenous grasses and sedges in the wetland (Kotze, 2004).

One prominent alien plant observed in the field was the Basket Willow trees which are imported species and are used locally for basket making. This plant consumes a lot of water and invades the valleys of many wetlands in the eFS. Some other invasive species observed in the field were River pumpkin and Wild rhubarb (*Gunnera Perpensa*) and cattail (*Typhaceae Typha Litifolia*). Figure 5.9 below show other invaders in grey patches. These invasive plants reduce the quality of the grazing land and consequently limits the carrying capacity of these wetlands.

Source: Author's own (2016)

Figure 5.9 Invasive species in grey patches avoided by the grazing cattle in a wetland in the Harrismith–Van Reenen Pass

To address the problem of invasive and alien plants, it is advisable to conduct a full survey of alien and invasive plants every three to five years and to draw up a five-year alien plant clearing programme in wetlands (Kotze, 2004).

5.9.3.3 Incorrect burning regimes of wetlands

The impact of fire on wetlands depends on the type of wetland (for example, dry peat burning may result in sub-surface fires which destroy the peat) and its ecological status at the time of burning, but generally burning has both positive and negative impacts on wetlands (Kotze, 2004).

Incorrect burning such as unplanned frequent burning may destroy the eggs and young of wetland dependent species, such as the Wattled Crane, through heat and asphyxiation. Winter and early spring burning may also destroy species such as the grass owl, the African marsh harrier and the marsh owl. Besides, burning can increase the rate of soil erosion as grazing animals may be concentrated in a limited area (Kotze, 2004). However, correctly planned burning of wetlands, such as strip burning and alternative sectoral burning, may have positive effects such as assisting in alien plant control; increasing plant productivity by removing old dead material; improving the habitat value for wetland dependent species and improving grazing value.

According to Kotze (2004), the management of wetlands through burning should promote cool and patchy burning when relative humidity is high and temperatures are low, preferably after rain (days with a low fire-rating index). Using head fires (burning with the wind) rather than back fires (burning against the wind) which reduces ground temperature is also suggested. If the soil is very dry and susceptible to sub-surface fires like in peatland areas, burning should be postponed until the following year. Burn mostly areas with abundant dead (moribund) stem and leaf material that often limit new growth. Protect important bird breeding areas (for example, reed marsh areas used by herons or sedge marsh areas used by ducks) and burn such areas less frequently, may be after four to five years.

As a management tool, most wetlands in the eFS are burnt in late winter and in spring (August or September) to prepare for early summer rainfalls, but with the current climatic variation, this old tradition needs adaptation.

5.9.3.4 Impact of roads, bridges and culverts on wetlands

A road through a wetland may seriously disrupt the hydrology of the wetland. On the upper section, it may create a dam or dry out the area if deep open culverts or bridges are used. In the lower section, it may dry out the wetland and increase conditions for erosion. Birds and animal species may be disturbed and conditions for alien species may be created. According to NEMA (RSA, 1998a), constructing a road through a wetland requires permission from the relevant authority, but the compliance, impartiality and competence of such authority is often questionable. The proposed diversion of the N3 around the Harrismith area with its many wetlands is a case to closely monitor. Sedimentation from these construction activities could result in vertical accretion where the wetland level is raised due to an accumulation of mineral sediments (Gray *et al*., 2013).

5.9.3.5 Improper developments within wetlands

Many wetlands have been reclaimed not only for crop land, urban development and settlement, but equally for different forms of mining activities with the attendant risk of acid mine drainage where heavy mines have closed down.

Sparks (2012) also picked up the negative impacts of urban development in the Monontsha wetland in QwaQwa which concur with the settlements, road construction and uncontrolled sand excavation shown in Figure 5.10.

Source: Author's own (2016)

Figure 5.10: Settlements, road construction and uncontrolled mining (sand excavation) within the Monontsha communal wetland in QwaQwa

5.9.3.6 Heavy pollution

Heavy pollution of both point and non-point sources can overwhelm the coping capacity of wetlands to serve as '*ecological kidneys*'. Figure 5.11 is an example of heavy pollution of a wetland.

Source: RCS (2010b)

Figure 5.11 Example of heavy pollution of wetland

5.9.3.7 Gully erosion and human settlement

Gully erosion and human settlements are some of the threats to wetlands in the eFS (Figure 5.12).

Source: Author's own (2016)

Figure 5.12 Gully erosion and human settlements in and around a wetland in the eastern Free State

Rehabilitation efforts of these wetlands are sometimes marred by poverty, overpopulation and cultural constraints (Sparks, 2012).

5.9.3.8 Forest plantations

In wetlands, the water table is characteristically shallow and water is therefore freely available to transpiring plants. Because of readily availability and high usage of water by trees, forest plantations can rapidly reduce the water table and the baseflow of streams (Kotze, 2004). To mitigate the impact of forests on wetlands and stream flow, a buffer zone of 20 metre should be maintained around the wetland and no trees should be found within the wetland (Kotze, 2004). The Sappi plantation and sugar cane plantations in KZN are classic examples of plantation ripping extensive areas of wetlands.

5.9.3.9 Impoundments

Dam building in South Africa peaked in the twentieth century and in ten years (1980 to 1990) more than 1 200 dams with a capacity of more than 50 000 m^3 were built that store 66% of the mean annual run-off (King and Pienaar, 2011 in Mitchell, 2012). Dams alter the natural hydrology of the area, trap sediments and nutrients that may deprive downstream areas of vital inputs such as deltas which may need sediments to retain their structures and functions, including flood attenuation (Mitchell, 2012). Many dams have been built to supply water for irrigation often at the detriment of downstream wetlands. The Food and Agricultural

Organisation (FAO) has proven that the total economic value of wetlands may far exceed the irrigation schemes for which the inflowing rivers are dammed, diverted and their water used (FAO, 1997 cited in Mitchell, 2012).

5.9.3.10 Climate change

Recently the impact of climate change associated with the changing nature, intensity and frequency of weather related hazards have also added to wetland woes (see Chapter 7 for details).

5.10 CHAPTER SUMMARY

Wetlands are transitional between terrestrial and aquatic ecosystems. Although water is the controlling factor in the formation and delineation of wetlands, soil, vegetation and topography are very important. The wetland size and type, as well as catchment modifications and land use changes, affect the hydrology of the wetland system. Wetlands provide many ecological services which are important in the livelihoods and resilience of most rural communities. Most of these ecological services are difficult to quantify in monetary terms. Wetlands are facing serious threats from both natural and anthropogenic impacts. The eFS has about 54 000 wetlands; most of them are valley-bottom wetlands which are mostly dispersed in privately owned land. The main land use of these wetlands is grazing. As supported by Russi, (2013), understanding and communicating the economic, social, cultural, and environmental value of wetland services are crucial to promoting better management, conservation and restoration of wetlands in the eFS. Despite their well-documented useful ecological services, wetlands are continuously being degraded everywhere including the eFS.

Chapter 6

WETLAND RISK AND VULNERABILITY ASSESSMENT

6.1 INTRODUCTION

Any DRR and CCA interventions begin, or should begin, with a good risk and vulnerability assessment. This is also true of building wetlands resilience to disaster risks and climate change impacts. The destruction and degradation of ecosystems such as wetlands put many communities that depend on natural resources at risk (GWP/INBO, 2009), therefore wetland risk and vulnerability assessment (WRVA) could be a good starting point to put in place risk reduction measures as an important component of wetlands management. The RCS (1971) puts much emphasis on wetlands inventory, assessment and monitoring as key management planning processes for the conservation, 'wise use' and maintenance of the ecological integrity of wetlands (Gitay *et al*., 2011). To address risk and vulnerability, DRR and climate change communities have independently developed concepts for vulnerability assessment which at first focused on the physical and natural science-based approach, but later expanded to include human-related social science approaches (Birkmann *et al*., 2013; Renaud and Perez, 2010; Romieu *et al*., 2010 in Gitay *et al*., 2011). While DRR focuses on reducing disaster risks, climate change experts focus on CCA measures. The close relationship between DRR and CCA disciplines is explained further in Chapter 7 of this research. Any effective DRR and CCA strategy starts with a scientific and evidence-based risk and vulnerability assessment. This chapter therefore explains wetlands risk and vulnerability assessment from the environment, disaster and climate change perspectives using a qualitative evidence-based approach.

6.2 RISK ASSESSMENT

Risk is the probability of a hazard occurring and the resultant extent and intensity of the impacts of the hazard on a system or a community (Gitay *et al*., 2011; UNISDR, 2009). In relation to wetlands management, risk is understood in the same light. While multiple natural hazards may affect wetlands, both Gitay *et al*. (2011) and the RCS (2010c) associate most of these hazards to climate change, while the IPCC (2012) associate climate change to anthropogenic factors. Mitigating and adapting to climate change impacts is of importance in wetlands management. Also important is the fact that climate change can be seen as a hazard in its own right with varying impacts on wetlands. Besides, climate related hazards such as floods, droughts, sea level rise, coastal surges and tropical cyclones are observed to have been increasing in frequency and intensity in recent times (Gitay *et al.*, 2011; IPCC, 2013, 2014; UNISDR, 2013, 2015). Whether these climate related hazards are linked to climate change or not, their existence pose risks to human and natural systems like wetlands and there is universal consensus to mitigate and adapt to the impacts of these hazards, which starts with a risk assessment.

The three main components of risk in disaster management as indicated by many authors include the hazard, vulnerability and coping capacity (Benson *et al.,* 2007; Birkman; 2006; Coppla, 2012; Jordaan, 2012; MSB, 2011; UK DFID, 2006; UNISDR, 2005; Wisner *et al.*, 2004). A hazard poses a risk when it hits a vulnerable community or system that lacks coping capacities. A vulnerable community or system which is not exposed to any hazards faces no potential risk. This is how risk is viewed and assessed in this research. The next section takes a closer look at the risk components and their assessment.

6.2.1 Hazard assessment

Hazard assessment involves the determination of the type of hazard(s), their intensity, frequency, and magnitude. It also involves identifying the past, present and possible future hazards and determining the nature and behaviour of these hazards (Coppola, 2011; Oxley, 2005; UNISDR, 2013). According to the Swiss Confederation (2013), hazard analysis is a process with three steps and many operations. The three steps include a hazard catalogue, hazard dossiers or profile and comparative analysis of hazard scenarios.

6.2.1.1 Hazard catalogue

A hazard catalogue is a list of hazards that had occurred, or could occur, in an area, or hazards which could occur elsewhere but may have significant impacts in the area under study. This latter point explains the need for transboundary cooperation in managing wetlands and disaster risks (RCS, 2013), for example, a veldfire that may originate in Lesotho and cross over into the FS in South Africa, or epidemics in the same direction and *vice versa*. Such identified hazards could be grouped into natural, technical and societal hazards, as well as rapid or slow onset hazards (see Chapter 2).

6.2.1.2 Hazard dossiers or profile

This involves a systematic overview of each identified hazard. For each individual hazard selected from the catalogue, information is collated in a dossier in order to fully understand the hazard. Information to understand the hazard could include:

- Definition of the hazard using internationally or nationally recognised sources such as the IPCC, UNISDR, or national legislation like the South African Disaster Management Act, Act 57 of 2002.
- Examples of such hazards indicating previous instances of occurrence of such hazards.
- Triggering factors that may have an impact on the genesis, sequence of events and extent of damage of the hazard. Information is also gathered on the source of the hazard, the timing, the place, dimensions and course of events.
- Dependencies which looks at the source and possible consequences of the hazard.
- Instances where three scenarios of varying intensity from low, moderate and high are outlined for each hazard. It is important that more details and planning is better on the high intensity scenario.
- Basis and references which include a list of most relevant legislative foundation, as well as sources for further reading (Swiss Confederation, 2013).

For the hazard analysis to gain credibility and acceptance, it is advisable to solicit comments and inputs from the responsible public administration, academia, private experts and most important but often neglected local, traditional and indigenous knowledge and people.

6.2.1.3 Comparative analysis of hazard scenarios

This is the most important aspect of a hazard analysis where for each hazard analysed, the hazard dossier contains information on hazard scenarios. These hazard scenarios are then cross-analysed and compared with regard to their effects on individuals, the environment, economy, the society, as well as their likelihood of occurrence. From experience and historical data, the three top hazards in the eFS include veldfires, droughts and floods. Using hypothetical data with increasing intensity from one (low) to three (high) for which no scientific calculations were made, these hazards are analysed for illustrative purposes in Table 6.1.

TABLE 6.1: EXAMPLE OF A HYPOTHETICAL HAZARD ASSESSMENT

Hazard	Probability	Frequency	Intensity	Sensitivity	Magnitude	Total	Average
Flood	2	2	2	1	2	9	1.8
Veld fire	3	3	3	3	3	15	3
Drought	3	3	3	2	3	14	2.8

Key: 3=High, 2=Medium, 1=Low

Table 6.1 illustrates that veldfires hypothetically scored highest in the assessment, followed by droughts and then floods.

6.2.2 Vulnerability assessment

Vulnerability is the *"characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard"* (UNISDR, 2009:30). Almost similar to this definition is that of Pratt *et al.* (2004) who refer to vulnerability as the tendency of something to be damaged. Wisner *et al.* (2004) define vulnerability as *"the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard"*. Vulnerability can also be seen as the degree to which a system, subsystem, component of a system or a community is likely to experience harm as a result of exposure to a hazard or stressor (Turner *et al.*, 2003). All these definitions point to the fact that vulnerability is a complex issue with no single agreed-upon definition, but generally relates to a harmful event and its ability to cause harm or damage on something or a community. Vulnerability in disaster risk management and CCA research is underpinned by multiple disciplinary theories based upon natural or social science epistemologies (IPCC, 2012), with a range of paradigms supported by qualitative and quantitative methodologies (Birkmann, 2006, Fuchs, 2009 in Birkmann *et al.*, 2013; Pelling and Wisner, 2009). While the natural sciences concentrate on quantifying the various factors of vulnerability, the social sciences adopt a more broader scope by looking at the likelihood that a household or community can suffer harm or loss and what factors influence social vulnerability which most often is driven by social inequality (Phillips and Fordham, 2009 in Birkmann *et al.*, 2013; Papathoma-Köhle *et al.*, 2010; UK DFID, 1999; Wisner *et al.*, 2004).

6.2.2.1 Factors influencing vulnerability

Vulnerability is influenced by many factors which are often grouped into economic, social, environmental, physical and even political factors. These factors give rise to the corresponding forms of vulnerability as follows:

Economic Vulnerability

Indicators of economic vulnerability may include high external dependence (aid, imports) and poor absorption capacity to global economic fluctuations; less diversified economy; small internal markets; limited resource base and high reliance on natural resources; low savings and low investment ratio as well as a high political instability (Pratt *et al.*, 2004). Other indicators include low income levels, few alternative income sources, low employment security, lack of land ownership, small land size, high debt ratio, high product–price sensitivity, low capacity to work, few physical assets, limited production and market opportunities (Jordaan, 2012). Also important is the income distribution in the community as measured by indexes such as the 'Geni Index' (UNDP, 2014).

Social vulnerability

Social vulnerability indicators may include evidence such as high unemployment rates, low level of literacy, rapid population growth; high urban migration and emigration; limited human resource capacity; malnutrition, communicable and non-communicable diseases and food insecurity; negative impact of economic modernisation and globalisation on societies, restrictive cultures and traditional knowledge, little or no social security and social networks (Pratt *et al.*, 2004). Other social vulnerability indicators could include poor state of well-being as shown by poor nutritional status, poor physical and mental health, low security and high stress levels; low literacy and education levels; gender imbalances and biases; large household sizes; low degree of community participation in economic and political issues; poor knowledge and channels of information dissemination; lack of equitable access to resources; lack of press freedom and freedom of association (Jordaan, 2012).

Environmental vulnerability

Environmental vulnerability is the risk of damage to the natural environment, and its vulnerability indicators could include land degradation, pollution, soil erosion and soil infertility, loss of biodiversity, deforestation, climate variability and climate change, geographic isolation, poor land use and land cover systems (Jordaan, 2012; Pratt *et al.*, 2004). Also, a harsh climate and rugged topography can contribute to environmental vulnerability.

Physical vulnerability

Physical vulnerability is indicated by a lack of robustness of physical infrastructure, especially critical infrastructures such as roads, railways, buildings, schools, health care services and communication lines to prevailing hazards. In the context of wetlands management, physical vulnerability will refer to the robustness of physical measures put in place to mitigate, rehabilitate or restore wetlands such as weirs, gabions and earth works.

Political vulnerability

Indicators for political vulnerability could include lack of effective laws and policies, frequent strikes and civil unrest, labour disputes, corruption and embezzlement of state funds, poor and ineffective governments and governance. In the context of wetlands management, political vulnerability will refer to the lack of effective laws, policies and institutional arrangement put in place for effective wetlands management (see Chapter 3 for details).

Most studies focus on the environmental vulnerability of wetlands by looking at the sensitivity and adaptive capacity of the wetland (Gitay *et al.*, 2011; Pratt *et al.*, 2004; RCS, 2010c). It is of paramount importance to look at other dimensions of vulnerability since social, economic, political and even physical vulnerabilities are not mutually exclusive and one will have an impact on the other. This integrated and holistic approach is well-demonstrated in the disaster management discipline and it is for this reason that this research is integrating DRR, CCA and environmental management to build resilient wetlands. Using the top three hazards in the study area, Table 6.2 presents a simple hypothetical vulnerability analysis of wetlands as a system

TABLE 6.2: EXAMPLE OF A HYPOTHETICAL VULNERABILITY ASSESSMENT

Hazard	Physical	Economic	Environmental	Social	Legal and institutional	Total	Average
Flood	2	1	1	1	3	8	1.6
Fire	3	3	2	3	3	14	2.8
Drought	3	2	2	2	3	12	2.4

Key: 3=High, 2=Medium, 1=Low

From Table 6.2 it can be deduced that the wetland is more vulnerable to fires, followed by droughts and then floods.

6.2.2.2 Vulnerable groups

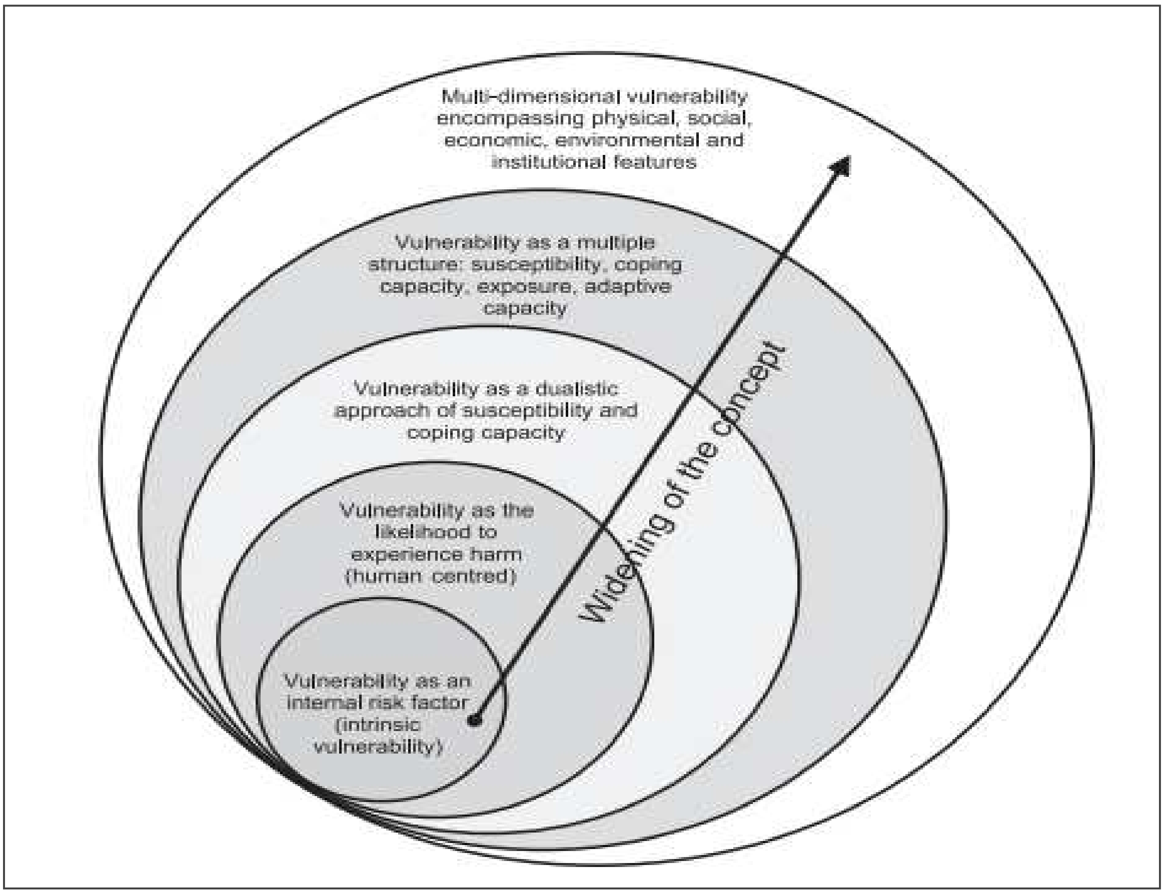
Vulnerable groups are people within a country that have specific characteristics which predisposes them to a higher risk category or are excluded from financial and social services. In a crisis situation, such groups would need additional assistance and extra measures (De Groeve *et al*., 2014). Though vulnerability vary with hazard types and amongst people, certain groups of people are generally more vulnerable than others because of two main reasons:

- *Intrinsic* related to internal qualities of individual themselves like special disabilities, disease and limitations imposed by stages of human life, like children.
- *Extrinsic* related to external circumstances such as (i) social: ethnic, religious minorities, indigenous peoples; (ii) political: like people affected by conflicts; refugees and internally displaced people, and (iii) environmental: people recently exposed to frequent natural hazard events or living in areas difficult to access, like mountainous regions or very remote rural areas (De Groeve *et al*., 2014)

In the context of wetlands management, different components of the wetland may face varying degrees of vulnerability to the same hazard. For example, veldfires may cause more damage to the wetland vegetation than to the hydrology and soil. Wetlands may also differ in their vulnerability depending on the ecological status of the wetland.

6.2.2.3 *Spheres of vulnerability*

Vulnerability does not only differ in relation to specific hazards, different vulnerable groups, segments of the society or components of systems and structures, but it is also broad and occur in spheres as indicated in Figure 6.1. In this study, vulnerability is used in the broadest context involving economic, social, environmental, physical and even political elements as discussed in 6.2.2.1 above.



Source: Birkmann (2005).

Figure 6.1 The various spheres of vulnerability.

6.2.3 Capacity assessment

Sometimes the term 'coping capacity' or 'adaptive capacity' are used interchangeably, but in this study coping capacity is considered as short-term measures, while adaptive capacity is seen as long-term measures to address hazardous shocks, including climate change (Birkmann *et al.*, 2013; IPCC, 2013). In wetlands management, the ability of a wetland to absorb, resist, adapt and bounce back from a shock determines its coping capacity which to an extent also touches on its resilience.

Table 6.3 shows examples of hypothetical capacity assessment.

TABLE 6.3: EXAMPLE OF A HYPOTHETICAL CAPACITY ASSESSMENT

Hazard	Public awareness	Legislation on wetlands	Early warning systems	Respond activities to wetland degradation	Prepared-ness plans	Manage-ment plan	Total divided by 5
Flood	2	1	2	3	2	1	2.2
Fire	3	1	2	3	2	2	2.6
Drought	2	1	2	3	2	1	2.2

Key: 3=High, 2=Medium, 1=Low

The overall risk assessment will then combine the hazard, vulnerability and capacity assessment as indicated in Table 6.4 below.

TABLE 6.4: EXAMPLE OF A HYPOTHETICAL RISK ASSESSMENT

Hazard	Hazard assessment (H)	Vulnerability assessment (V)	Capacity assessment (C)	R = HV/C
Flood	1.8	1.6	2.2	1.8 × 1.6 ÷ 2.2 = 1.3
Fire	3	2.8	2.6	3 × 2.8 ÷ 2.6 = 3.2
Drought	2.8	2.4	2.2	2.8 × 2.4 ÷ 2.2 = 3.0

The above hypothetical data, shows that the risk of a fire is highest in the study area, followed by drought and then flood. The risks could then be prioritised so as to allocate scarce resources to prevent, prepare, mitigate and respond to these risks.

6.3 WETLAND VULNERABILITY ASSESSMENT

Wetland vulnerability shows the relationship between wetland exposure to particular external stressors, the impacts of the stressors on the ecological integrity of the wetland, the temporal and spatial ability of the wetland to cope with the impact or the efforts needed from the surrounding community to minimise the impacts of such stressors and put the wetland in a good functional stage (Gitay *et al.*, 2011). This definition is quite comprehensive in that it incorporates (and rightly so) the role of the surrounding community to determine the final vulnerability of the wetland.

Wetland vulnerability, like those of most ecosystems, is often linked to the sensitivity and adaptive capacity of the wetland to climate change (Gitay *et al.*, 2011; IPCC, 2001; RCS, 2010a). Sensitivity is the degree to which a wetland is affected, either adversely or beneficially, by climate-related stimuli, and the frequency and magnitude of extremes of the stimuli, while adaptive capacity relates to the ability of a wetland to adjust to climate change, to take advantage of opportunities, or to cope with or moderate the impacts (Gitay *et al*., 2011). Wetland vulnerability is thus the degree to which a wetland is sensitive to and is unable to adapt to or moderate the consequences of climate change and anthropocentric pressures (Gitay *et al*., 2011). This definition is very limiting in relation to the holistic approach adopted in this study for wetlands management. Sensitivity and adaptive capacity should be extended to all possible wetland stressors and not only limited to climate change and related hazards.

It is worth noting that vulnerability occur at spatial and temporal scales and is dynamic that changes depending on the local conditions, such as the size of the wetland, the stability and diversity of the wetland vegetation, the adaptive capacity and management institutions. It is therefore not advisable to use the present condition of a wetland as a general indicator of its vulnerability over long-term management planning (Gitay *et al*., 2011).

The vulnerability of a wetland is most often viewed from a pair of lenses that looks at the biological and physical aspect and together are referred to as biophysical vulnerability (Gitay *et al*., 2011). In this study, a third aspect of wetland vulnerability has been included which is the socio-economic consequences for the local communities who depend on the wetland. This system thinking and socio-ecological approach makes wetland vulnerability assessment more holistic and robust for better management planning. The biophysical vulnerability of a wetland is the susceptibility of that wetland to a specified hazard or multiple hazards, where a 'hazard' refers specifically to the physical manifestations of stressors (for example, droughts, floods, wild fires, sea level rise, storms, heavy rainfall, long-term changes in the mean values of climatic variables (Gitay *et al*., 2011). The concept of 'hazard' is, however, extended in this study to include other human-induced stressors that negatively affect wetlands such as wetland pollution.

The approach adopted in this WRVA incorporates a state-pressure-impact-response model which relates the present status and trends in the wetland to the sensitivity and adaptive capacity as a way to determine the response options (Gitay *et al*., 2011) (See Table 6.4). This approach requires an understanding of the ecology, hydrology and geomorphology that determines the structural and functional characteristics of wetlands (Oberholster *et al*., 2014). The outcome of WRVA is then used to determine if the wetland is facing a '*transitory vulnerability'* or '*chronic vulnerability'*, given that wetlands are dynamic systems that can adjust themselves over a given period. In transitory vulnerability, the indications are that the wetland will recover by itself from a given stressor and therefore no action may be required while in chronic vulnerability, the adaptive capacity of the wetland may be overwhelmed, therefore requiring response interventions which could come in the form of wetland rehabilitation or restoration. This approach is more reactive. Borrowing from DRR principles, this study brings out the fact that wetlands should be managed to reduce wetlands vulnerability to actual and potential stressors which can be natural or human-induced, including those stressors related to climate change.

TABLE 6.5: VULNERABILITY AS A MEASURE OF SENSITIVITY AND ADAPTIVE CAPACITY

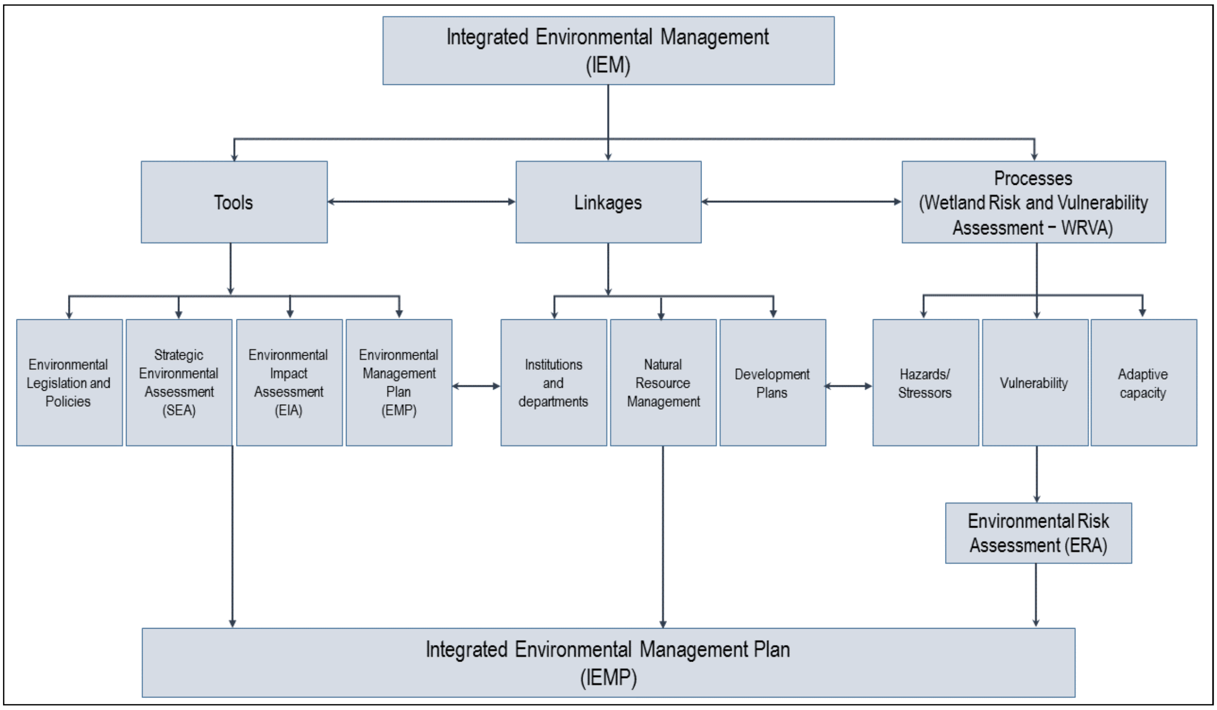
<table>
<tr><td colspan="2" rowspan="2"></td><th colspan="3">Adaptive capacity</th></tr>
<tr><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><th rowspan="3">Sensitivity</th><td>High</td><td></td><td></td><td rowspan="2">Highly vulnerable</td></tr>
<tr><td>Medium</td><td rowspan="2">Not vulnerable</td><td>Vulnerable</td></tr>
<tr><td>Low</td><td></td><td></td></tr>
</table>

Source: Gitay *et al.* (2011)

Gitay *et al*. (2011) used a qualitative approach that depended on experts' opinions and their relative judgments. It is important to use quantitative indicators, but a major constraint in using the quantitative approach is to assign numerical values to ecosystem services provided by wetlands, or lost from the wetland, as a result of climate change and other stressors. Simply put, a wetland is less vulnerable when its adaptive capacity is high and its sensitivity to shock or shocks is low. Wetland risk and vulnerability assessment is vital in establishing the linkages between wetland stressors and wetland responses to these stressors, the balance of which will determine the eco-status of the wetland.

6.4 LINKING DISASTER AND WETLAND RISK AND VULNERABILITY ASSESSMENT

Disaster risk assessment and WRVA can easily be integrated using the IEM approach (Figure 6.2). Wetland risk and vulnerability assessment is part of environmental risk assessment (ERA) and the latter is part of integrated environmental management (IEM), which is a holistic approach to environmental management (Mentis, 2010). The ERA is or should be integrated into conventional environmental management tools like the EIA, SEA and Environmental Management Plans (EMPs) (Mentis, 2010). In this study, the IEM is seen as comprising of three components, which include environmental management tools, linkages and processes (Figure 6.2). Environmental management tools include environmental management legislations and policies (see Chapter 2 of this research), SEA, EIA and drafting of an EMP. The linkages include institutions and departments that play a role in environmental affairs, integrating environmental considerations in natural resource management like water and energy, and integrating environmental issues into development planning such as the IDPs in local municipalities, because any action on the environment has a local underpinning. The third component of the IEM, and which is the focus of this chapter, is the processes. These processes focus on ERA) and in this study the focus is on WRVA. The WRVA comprises of three sub-parts which are the hazard or stressor, the vulnerability and the adaptive capacity of the wetland. The WRVA can be effectively conducted using the disaster risk assessment approach (see 6.2). Then the tools, linkages and processes of the IEM could then be used to formulate an Integrated Environmental Management Plan (IEMP) and not just the simple EMP which has always been the case in South Africa.



Source: Adapted from Gitay *et al*. (2011)

Figure 6.2 Integrated environmental management plan

6.5 RISK AND VULNERABILITY MODELS

The risk is a product of three main factors: hazard, vulnerability and lack of capacity or resilience of a community or a system such as a wetland (Birkmann *et al*., 2013; Coppola, 2011; UK DFID, 2006; Wisner *et al*., 2004, 2013). Vulnerability is therefore a component of risk. In vulnerability studies, it is important to know who and what is vulnerable to which hazard. What changes can these hazards cause to the affected system or community, how can these changes and their impacts be reduced or amplified by different human and environment conditions, what can be done to reduce the vulnerability to these changes? Different models have tried to answer these questions holistically or partially in different ways using different but often related models.

6.5.1 General disaster risk and vulnerability models

6.5.1.1 Methods for the improvement of vulnerability assessment in Europe – The MOVE framework

This is a holistic framework which links different aspects of risk and vulnerability to disaster risk management and CCA as well as social−ecological system (Birkmann *et al*., 2013). The MOVE framework is founded on four factors related to (a) the exposure of a society or system to a hazard or stressor, (b) the susceptibility of the system or community exposed, (c) its resilience and (d) its adaptive capacity. The MOVE tries to establish linkages and relationships between different concepts in disaster risk management and CCA research, and seeks to enhance the DRR perspective by integrating a new understanding of coupling, adaptation and resilience (Birkmann *et al*., 2013).

The MOVE framework looks at the causal factors of vulnerability and the thematic dimensions of vulnerability. The key causal factors of vulnerability include exposure, susceptibility, and lack of resilience (lack of societal response capacities), while the different thematic dimensions of vulnerability include physical, social, ecological, economic, cultural and institutional dimensions (Birkmann *et al*., 2013). Its relevance to this research is that the MOVE studies vulnerability from both a disaster management and CCA perspective. It also considers the '*coupling*' aspect of risk, which examines the relationship between humans and the environment just like the CHESM and the social−ecological system framework (see 2.4.1 and 2.4.2). All these models show the growing interest to link DRR, CCA and the environment as an integrated and holistic approach to build community and system resilience. This is the main focus of this study.

The MOVE framework considers limited capacities to cope or to recover in the face of adverse consequences, as 'lack of resilience', while at the same time it considers 'improving resilience' as part of adaptation (Birkmann *et al*., 2013). This stance is debatable. In this study, coping and adaptive capacities are viewed as part of building resilience and not the other way around. Improving on coping capacities and building strong adaptive capacities both help to reduce vulnerability and build resilience. Adaptive capacity is dynamic and changes as the status of vulnerability and the environment changes when triggered by disastrous events or normal development processes (Birkmann *et al*., 2013). Coping mainly deals with the conservation and protection of the current system and institutional settings, while adaptation denotes a longer term and constantly unfolding process of learning, experimentation and change that feeds into vulnerability (Birkmann *et al*., 2013). While some authors link adaptation narrowly to climate change (Birkmann *et al*., 2013; IPCC, 2007), it is worth noting that communities and systems can adapt to other stressors. Though difficult to separate from capacity or coping capacity, resilience is broader than coping capacity. This is because resilience goes beyond the specific behaviour, strategies and measures for risk reduction and management that are normally understood as capacities. Resilience puts greater emphasis on recognising what communities can do for themselves and how to strengthen those capacities, rather than concentrating on their vulnerability to disaster or environmental shocks and stresses, or their needs in an emergency (Twigg, 2009). Resilience therefore builds on and strengthens indigenous and/or local knowledge and capacities. The concept of building resilience does not see vulnerable communities as passive and helpless in the face of disasters, but as active role players who need to be strengthened. Building community resilience avoids creating a syndrome of dependency associated with most disaster relief initiatives.

The main components of the MOVE framework are briefly discussed below:

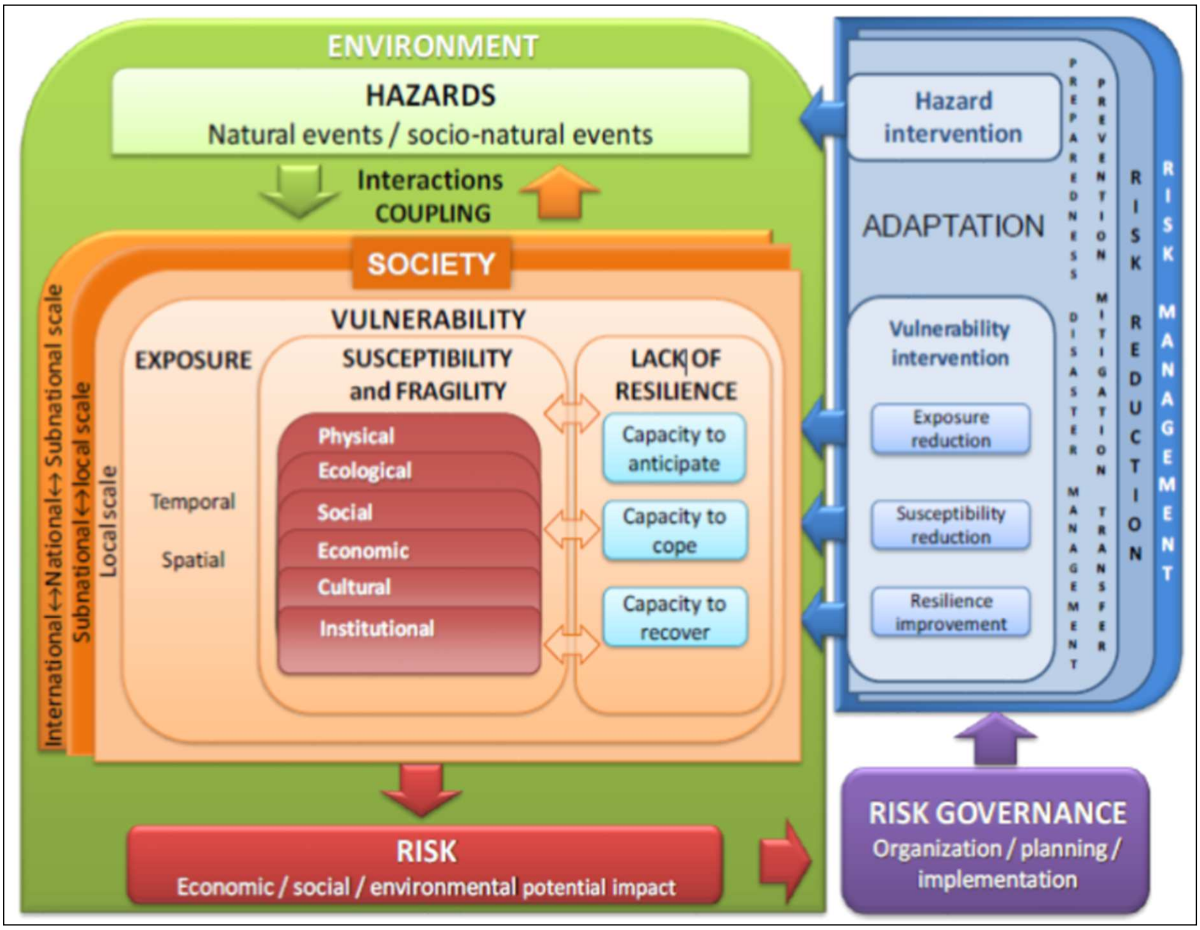
i) ***Causal factors of vulnerability*:** Exposure describes the extent to which a unit of assessment falls within the geographical range of a hazardous event, while susceptibility (or fragility) describes the predisposition of elements at risk (social and ecological) to suffer harm. A system can be exposed but not susceptible to a hazard. Susceptibility is a keyword used to define vulnerability in DRR (UNISDR, 2009). Lack of resilience or societal response capacity is the limitations in terms of access to and mobilisation of resources of a community or a social-ecological system in responding to an identified hazard (Birkmann *et al.*, 2013). This is what Kesten (2008) referred to as the manageability in the risk equation. Finally, the hazard is the potential occurrence of natural, socio-natural or anthropogenic events that may cause physical, social, economic and environmental impact in a given area and over a period of time (Birkmann *et al.*, 2013; UNISDR, 2009).

ii) ***Thematic areas of vulnerability*:** The **social dimension** denotes the propensity for human well-being to be damaged by disruption to individual (mental and physical health) and collective (for example, health and education services), social systems and their characteristics (for example, gender, marginalisation of social groups). The **economic dimension** includes the propensity of economic loss due to damage to physical assets and/or disruption of productive capacity. The **physical dimension** includes damage to physical assets including built-up areas, infrastructure and open spaces, while the **cultural dimension** includes potential damage to intangible values, including value placed on artefacts, customs, habitual practices and natural or urban landscapes. The **environmental dimension** includes potential for damage to all ecological and biophysical systems and their different functions. This includes particular ecosystem functions and environmental services. Lastly, **institutional vulnerability** involves potential damage to governance systems, organisational framework and functions, as well as guiding formal or informal, legal or customary rules that may be forced to change.

iii) ***Risk governance*:** Risk governance includes decisions and actions taken by stakeholders such as governments, different governmental institutions, individual households, NGOs that include tasks on risk reduction, prevention, mitigation, including risk transfer as well as preparedness, and disaster management (Birkmann *et al*., 2013). There are lot of nuances in this definition. For example, DRR include all pre-disaster management activities such as prevention, mitigation and preparedness, while disaster management includes both pre- and post-disaster activities. However, the important fact is that effective risk governance is pivotal for reducing vulnerability and adapting to climate change.

iv) ***Adaptation*:** Adaptation are techniques, assets and strategies used in changing the institutional and structural frameworks that constrain human action to intervene in vulnerability and therefore directed to manage exposure, susceptibility and resilience at any one moment in time. Resilience building and improvement is a component of adaptation (Birkmann *et al*., 2013). This approach has two weaknesses: First, adaptation is used in a very restrictive sense to denote the process that takes place in communities or societies and therefore neglecting the social–ecological aspect of adaptation which is very important. Secondly, adaptation should be part of building resilience and not the other way around. Besides, building resilience is more proactive than reactive as Birkmann *et al.* (2013) claim. Adaptation can be both reactive to current shocks and proactive against future shocks in both human and ecological systems.

v) ***Feedback loop*:** The MOVE framework is contextualised in general systems theory, cybernetics and interlinked systems theory (Vester 2008 in Birkmann *et al.*, 2013) (see Figure 6.3). Risk, vulnerability and adaptation to climate change are embedded in the socio-ecological system thinking (Birkmann *et al.*, 2013). The MOVE framework also views vulnerability (and correctly so) to be very dynamic and changes spatially and temporary. Lastly, it looks at the affected communities and systems as not being passive in the light of vulnerability but imbued with some level of adaptive capacities that should be recognised, nurtured and promoted (Birkmann *et al.*, 2013; Jordaan, 2012). This last point is very close to the incorporation of indigenous knowledge in DRR and CCA programmes and processes. Integrating local and indigenous knowledge into wetlands management, DRR and CCA programmes are strongly supported in this study.

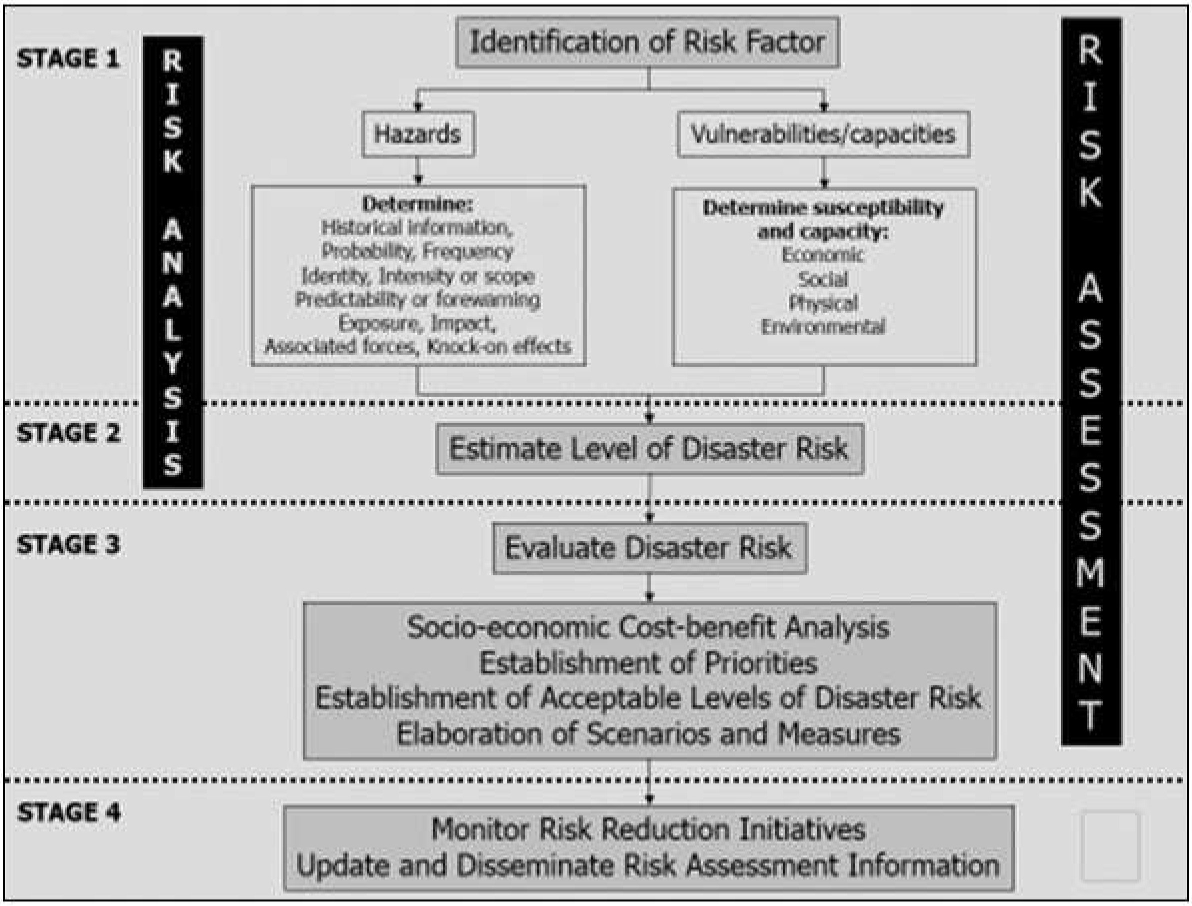


Source: Birkmann *et al*., (2013)

Figure 6.3 The MOVE framework

6.5.1.2 The risk assessment framework

This framework is mostly used by disaster practitioners to conduct both risk analysis and risk assessment (Figure 6.4). It is made up of four stages, where up to Stage 2 make up risk analysis and completing all four stages make up risk assessment. Risk analysis involves the identification of risk factors, conducting hazard and vulnerability analyses, as well as analysing the coping and adaptive capacity of the community or system. This ends with the estimation of the risk level in the community or system. Meanwhile, further evaluation of the risk using different scenarios, conducting cost-benefit analysis to determine the most effective risk reduction options, as well as monitoring the DRR programmes adopted, constitute the risk assessment. Most often risk assessment is used and that is the approach that was adopted in this study to carry out the WRVA, though not all the steps were applicable (see 6.2).

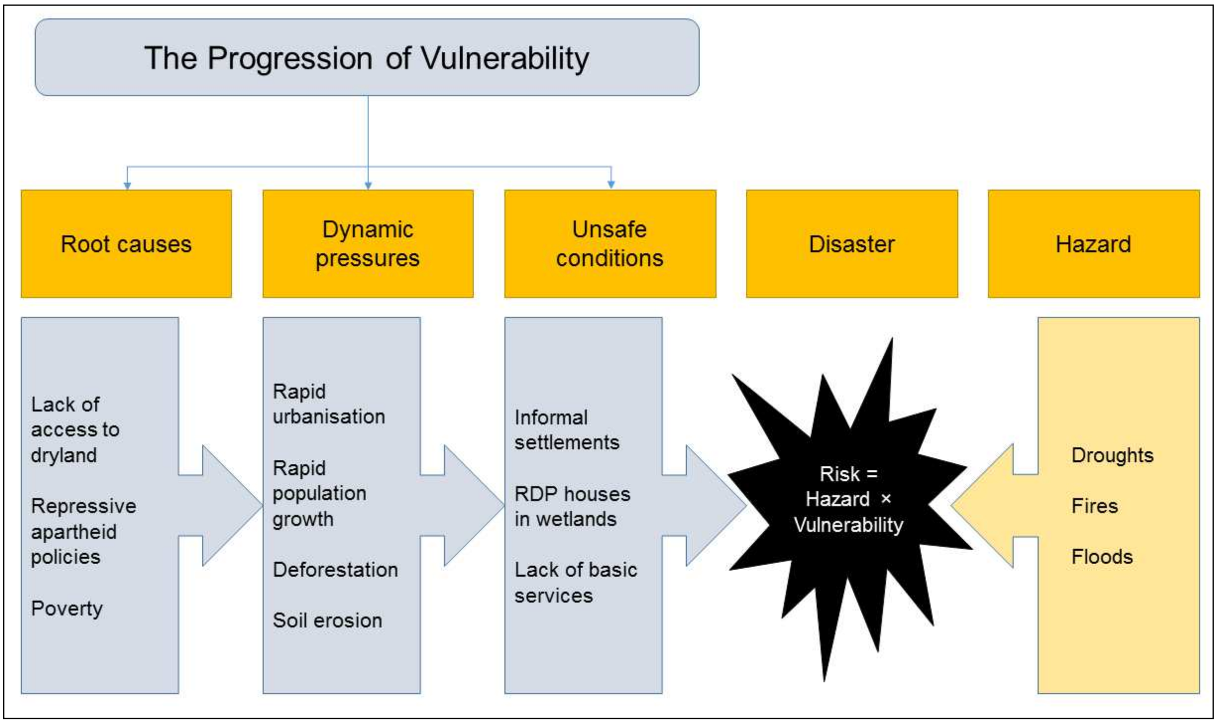


Source: UNISDR (2004)

Figure 6.4 Risk assessment framework

6.5.1.3 The pressure and release model

The Pressure and Release (PAR) model, or the progression of vulnerability model, explains that a disaster occurs when hazards afflict vulnerable societies or systems that lack coping capacities to such as hazards (Wisner *et al.*, 2004). The pressure in the PAR model comes from two opposing directions: the hazard direction and the vulnerability direction, while the release is how the impacts can be reduced by reducing vulnerability (Wisner *et al.*, 2004). The PAR model looks at the progression of vulnerability at three stages in a linear process: root causes, dynamic pressures and unsafe conditions (Figure 6.5). Root causes are the underlying, remote and often distanced causes of vulnerability. Dynamic pressures are factors that transform root causes into unsafe conditions, while unsafe conditions are the various ways the vulnerability manifests itself in the community or system (Twigg, 2001; UNISDR, 2002; Wisner *et al.*, 2004).



Source: Adapted from Wisner *et al*. (2004)

Figure 6.5 The pressure and release model

Applied to wetlands, the root causes of wetland degradation could be attributed to lack of access to dry fertile land, partly caused by the legacy of apartheid as evidenced in communal wetlands in the eFS. The dynamic pressure could be attributed to rapid urbanisation and population growth in and around wetlands, especially communal wetlands where the unsafe conditions can be seen in many informal settlements with Rural Development Programme (RDP) houses in or near communal wetlands in the eFS.

Zoomed into the context of wetlands vulnerability, the PAR model is insufficient for the comprehensive understanding of sustainability science (Turner *et al*., 2003) which prescribes the wise and sustainable management of wetlands. The PAR model has the following weaknesses in relation to this study:

- The PAR model does not address the human-environment system so as to bring out the linkages and understanding of the biosphere systems (Turner *et al*., 2003).
- The model provides little detail on the structure of the hazard, the causal sequence of the hazard and the nested scale of interaction taking place in the affected system.
- The PAR model has insufficient coverage of the feedbacks necessary in the system analysis (Turner *et al*., 2003).
- The model treats vulnerability as a linear progression and fails to recognise the coping and adaptive capacities of the affected system or components of the system.

- It is not clear whether the model works forward from root causes to unsafe conditions, or *vice versa*.
- Lastly, there is no clear demarcation on which factor falls under which category; for example, is poverty a root cause or an unsafe condition of vulnerability? This will depend on which lenses one wear and the place and condition under study.

6.5.1.4 The index for risk management model

The Index for Risk Management (InfoRM) model uses three dimensions of risk which include hazards and exposure, vulnerability and lack of coping capacity (Figure 6.6). These dimensions are operating in a counterbalancing relationship (De Groeve *et al*., 2014).

Source: De Groeve *et al*. (2014)

Figure 6.6 Counterbalancing relationship

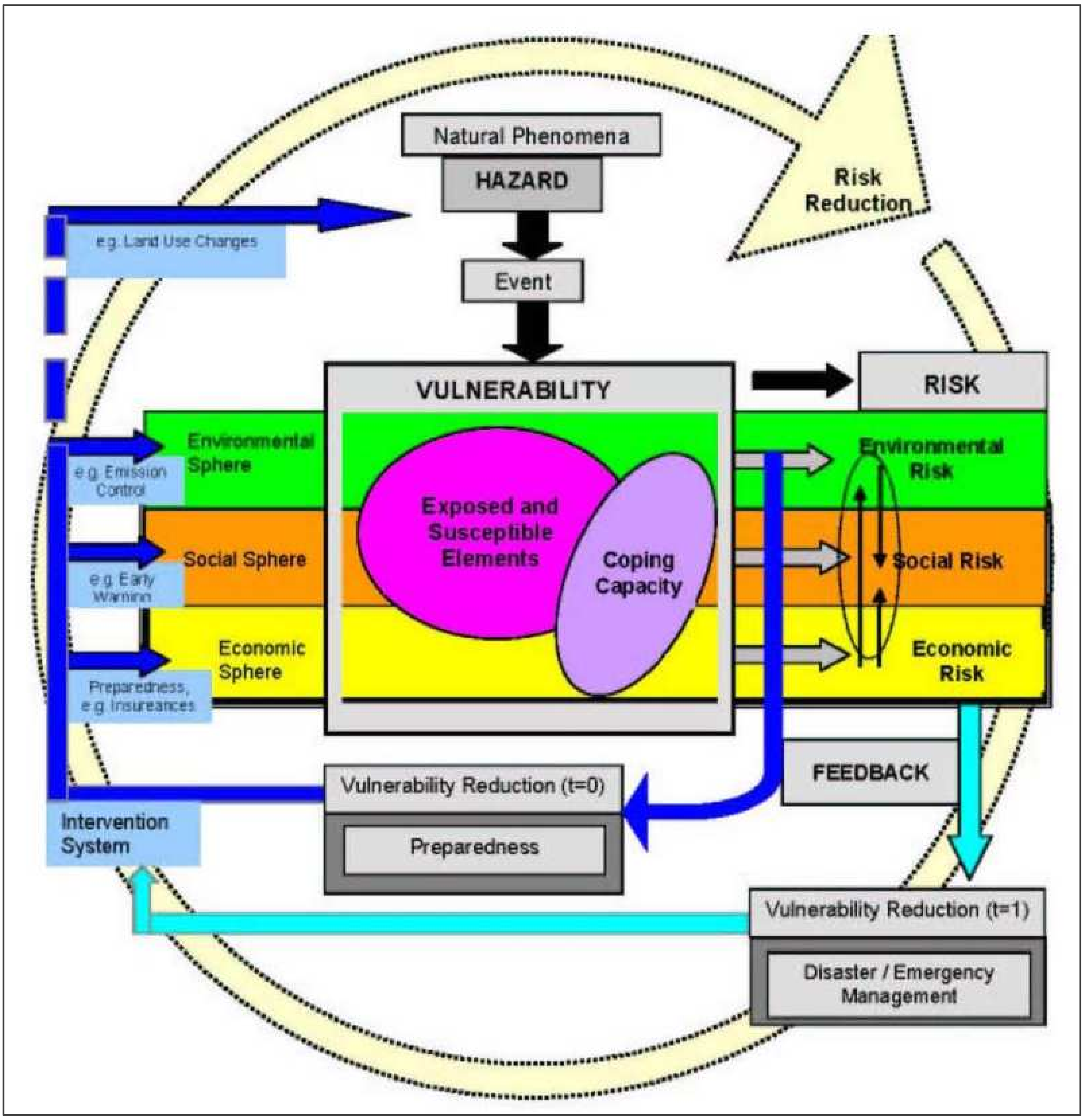
Like the PAR model, the counterbalancing effect of the hazard and exposure dimension, on the one side, compared to the vulnerability and the lack of coping capacity dimensions, on the other side, produce the degree of risk. High vulnerability and low coping capacity, coupled with a high probability of physical exposure to hazard events, contribute to a high risk of a community, country or system (De Groeve *et al*., 2014).

The hazard and exposure dimension reflects the probability of physical exposure associated with specific hazards. There is no risk without physical exposure, no matter how severe the hazard event is. The physical exposure includes the people, environment and other assets or capital stock that are present in the hazard pathways. Hazard pathways are areas prone to the occurrence of an event of a level that can trigger significant damage causing a disaster (De

Groeve *et al*., 2014). Though very simple and limited, the InfoRM model holds a lot of relevance in this study as it touches very important components that were used in the WRVA.

6.5.1.5 The Birkmann, Bogardi and Cardona model

The Birkmann, Bogardi and Cardona (BBC) model (Figure 6.7) illustrates that a natural disaster happens when a hazard hits an exposed vulnerable community (or system) that lacks coping capacity (Birkmann, 2006).



Source: Birkmann (2006)

Figure 6.7 The Birkmann, Bogardi and Cardona model

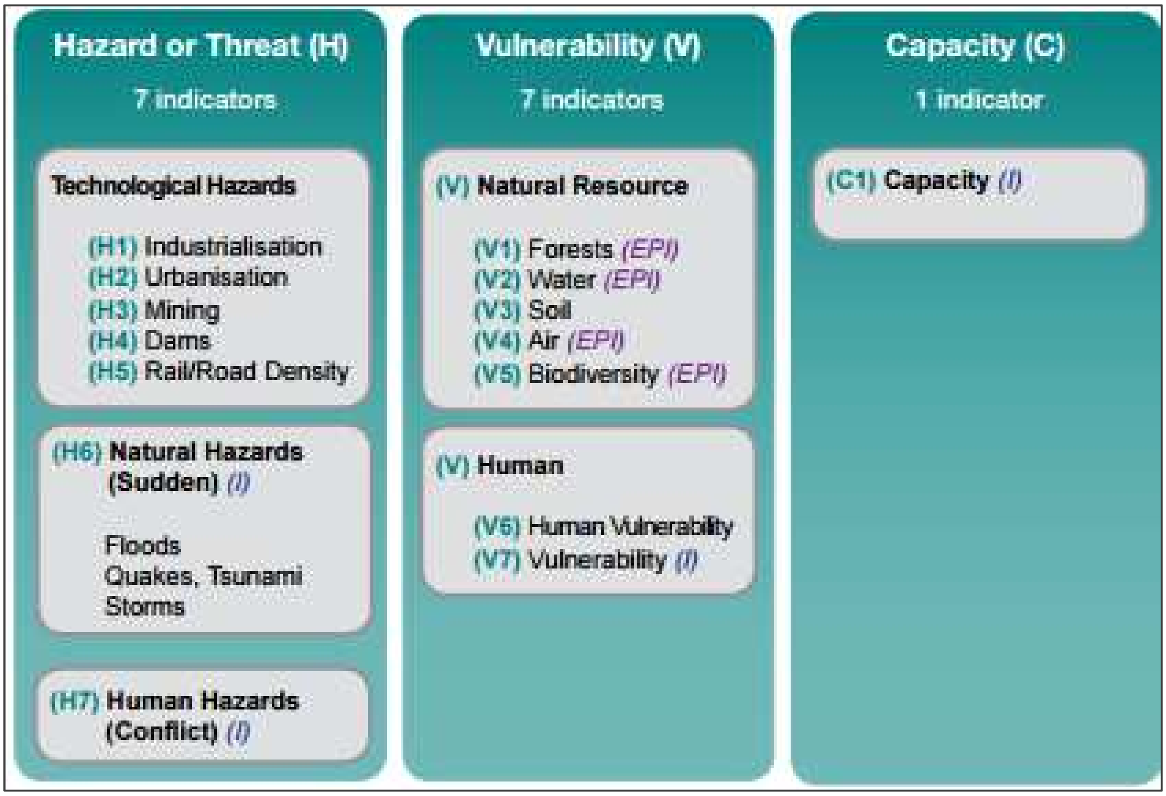
Like in most studies, vulnerability is influenced by a set of interrelated and interactive environmental, social, economic (even physical and political) factors which also produce corresponding disaster risks (environmental, social and economic). Such risks can be reduced at two time frames: before the disastrous event hits the vulnerable community (t = 0) and after the disastrous event (t = 1) (Birkmann, 2006). The t = 1 risk reduction and developmental measures are popularly referred to as Build Back Better (UNISDR, 2015). This BBC model also demonstrates that DRR is a cyclical process, unlike earlier views that it was solely a pre-disaster activity (UNDP, 1992). The BBC, however, focuses on natural hazards, neglecting human-made and even natural disasters that can trigger technological disasters (also known as Natech disasters). This model has a lot in common with the MOVE model, including the feedback loop, and most of its elements were incorporated into the WRVA.

6.5.2 Environment and wetlands risks and vulnerability assessment models

The following risk and vulnerability models relate specifically to wetlands and environmental management.

6.5.2.1 Environmental emergency risk index

The Environmental Emergency Risk Index (EERI) was developed by the Joint United Nations Environmental Programme (UNEP) / Office for the Coordination of Humanitarian Affairs (OCHA), Environmental Unit (Joint UNEP/OCHA Environment Unit [JEU], 2012). The model uses 17 indicators to evaluate hazards (both technological and natural), vulnerability and capacity into a matrix to indicate the level of vulnerability to environmental emergencies of each country (see Figure 6.8). According to EERI, Africa is very vulnerable to environmental emergencies. For example, 17 out of 30 top most vulnerable countries in the world are from Africa (JEU, 2012). This situation therefore requires more effort in environmental emergency preparedness, as well as capacity-building on environmental affairs in Africa. Though based on country level, most of these environmental emergencies. such as pollution. affect wetlands or can be mitigated by wetlands.



Source: JEU (2013:2)

Figure 6.8 Indicators of the environmental emergency risk index

6.5.2.2 Environmental vulnerability index

The South Pacific Applied Geoscience Commission (Pratt *et al.*, 2004) used about 50 environmental indicators grouped into three sub-indices: hazards, resistance and damage, and scored on a vulnerability scale of 1–7 to determine the degree of susceptibility of an ecosystem or an environment to external shocks. This scale (see Figure 6.9) is then used to map the Environmental Vulnerability Index (EVI) of a place or country. Depending on the calculated scores, a country or place can be classified under:

- Extremely vulnerable.
- Highly vulnerable.
- Vulnerable.
- At risk.
- Resilient (Kaly *et al*., 2004; Pratt *et al*., 2004).

Source: Pratt *et al*. (2004)

Figure 6.9 Environmental vulnerability index score

Wetlands are an important part of the natural environment, but details of the EVI are not covered in this study; instead, the Wetland Classification and Risk Assessment Index (WCRAI) (Oberholster *et al*., 2014) was more suitable and easy to use as a field guide in this study.

6.5.2.3 Wetland classification and risk assessment index

The WCRAI examines the ecological processes in natural wetland ecosystems in their broadest landscape scale. It combines both processes taking place in the landscape, as well as those taking place within the wetland, to determine the ecological integrity or eco-status of the wetland under different ecological conditions to indicate the wetland vulnerability. The aim of WCRAI is to permit non-wetland experts from different disciplines to manage wetlands effectively. WCRAI can also help in preventing wetland degradation (an aspect of DRR), thus reducing the financial cost of managing, restoration and rehabilitation of degraded wetlands (Oberholster *et al*.; 2014).

WCRAI uses many parameters grouped into about 11 indicators with different weights to come up with a wetland risk index. Some of the indicators include:

- Wetland types based on the hydrogeormorphic classification.
- Land form and hydrology as fundamental factors in wetlands formation.
- Wetland size or scale that may influence its ability to perform certain functions such as water purification, pollutants and sediment retention, flood attenuation.
- Wetland zone.
- Hydroperiod, which is a major factor in delineating the boundary of a wetland (Oberholster *et al*., 2014).

The field observation data sheet for this research was adapted from the WCRAI. While the WCRAI combines the physio-chemical water quality parameters such as Ph, electrical conductivity, dissolved oxygen and the biological indicators to establish the eco-status of the wetland, in this study not all the components of the WCRAI were applied in the field for wetlands eco-status observation. Only the physically observable parameters such as the vegetation cover, land use system, erosion and plugging, which were relevant to the research and easily observable even by non-wetland specialists, were used. Though WCRAI is said to be designed for non-wetland specialists (Oberholster *et al*. 2014), the framework has technical issues that require advance scientific knowledge of chemistry, biology and ecology to be able to understand and apply the entire framework. The objective of this research is to make wetlands management effectively operational at grassroots level to both the educated and non-educated wetland stakeholders, thus the simplified method was followed.

6.5.2.4 Ramsar wetland risk assessment framework

The RCS (1971) provides a wetlands risk assessment framework that assists contracting parties to predict and assess ecological changes in the wetland as an integral planning process of wetlands management. Such risk assessment assists the stakeholder to develop an early warning system for wetland degradation (RCS, 2010c). The Ramsar proposed risk assessment comprises six steps, which include:

i) ***Identification of the nature of the problem and developing a plan***: Once the nature of the problem is identified, this information gives a lead as to the plan that may be required. This first step defines the objective, scope and foundation of the risk assessment.

ii) ***Identification of the adverse effects***: This step determines the adverse change likely to occur in the ecological character of the wetland as a result of the identified problem. Step 2 is better assessed through field studies using either qualitative or quantitative data.

iii) ***Identification of the extent of the problem***: This step estimates the probable extent of the problem on the wetland of concern by using information gathered about its behaviour and extent of occurrence elsewhere.

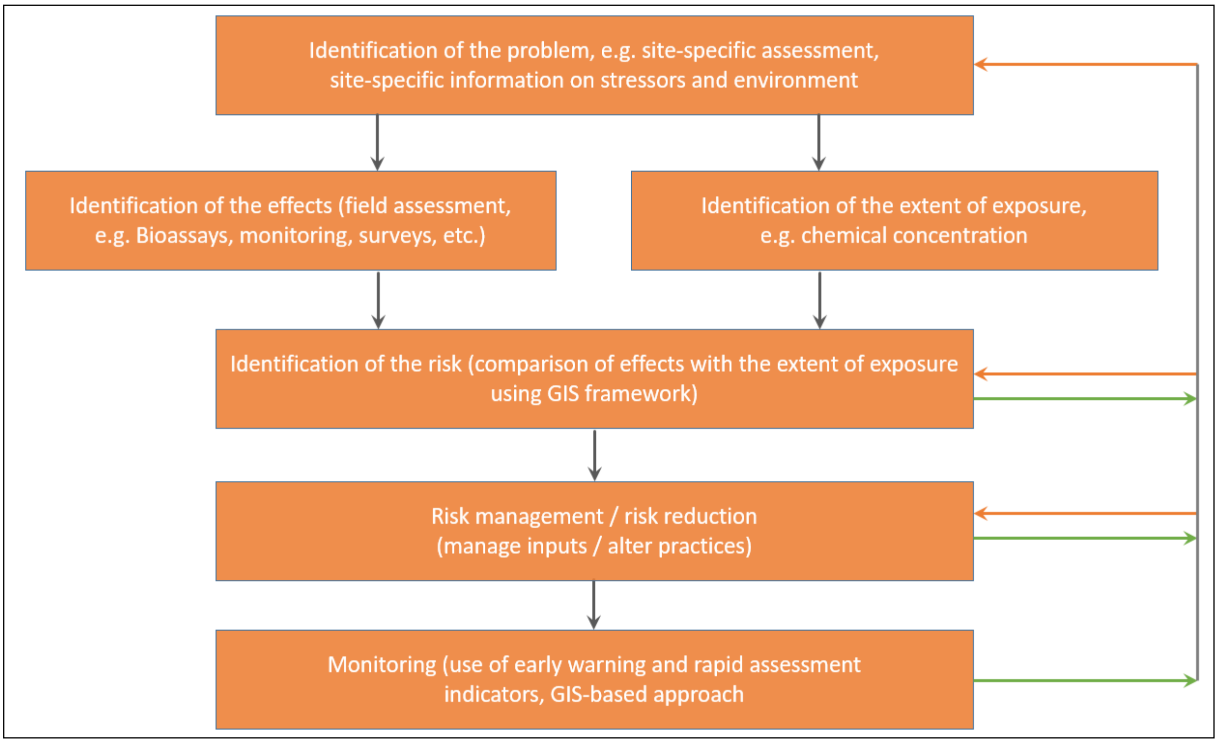
iv) ***Identification of the risk***: This involves integration of the results from the assessment of the possible effects with those from the assessment of the extent of the problem, in order to estimate the likely level of adverse ecological change on the wetland. In other words, this step combines the impact and the extent to determine the level of risk.

v) ***Risk management and reduction***: This step uses the information gathered in the previous risk assessment process to put in place policies and measures that will minimise the impact without compromising other societal, community and environmental values of the wetland; in other words, it promotes the ‘wise use’ concept. Risk management considers political, social, economic, and engineering/technical factors, as well as the respective benefits and limitations of each risk-reducing action. It is a multidisciplinary task requiring communication between wetland site managers and experts in relevant disciplines (RCS, 2010c). This last sentence is evident throughout this research project.

vi) ***Monitoring***: This final step helps to verify the effectiveness of the risk management decisions taken after the risk assessment. Monitoring should act as a reliable early warning system that should quickly point to the failure or poor performance of risk management decisions prior to serious environmental harm occurring (RCS, 2010c).

Though this was a proposed risk assessment model meant for Ramsar sites, the model covers the whole range of wetlands management and can be applied to any wetland. All the aspects of this model (and more) are covered under different sub-sections in the final integrated framework for wetlands management proposed by this study (section 11.4.3).

The diagrammatical representation of the Ramsar risk assessment model is indicated in Figure 6.10 below.



Source: Adapted from RCS (2010c)

Figure 6.10 A suggested model for wetland risk assessment by the Ramsar Convention Secretariat

6.5.2.5 Wetlands vulnerability assessment framework

Gitay *et al.* (2011) looked at existing models and approaches and then formulated a wetland vulnerability assessment framework which is part of wetland risk assessment (see Figure 6.11). The framework comprises the following components and processes:

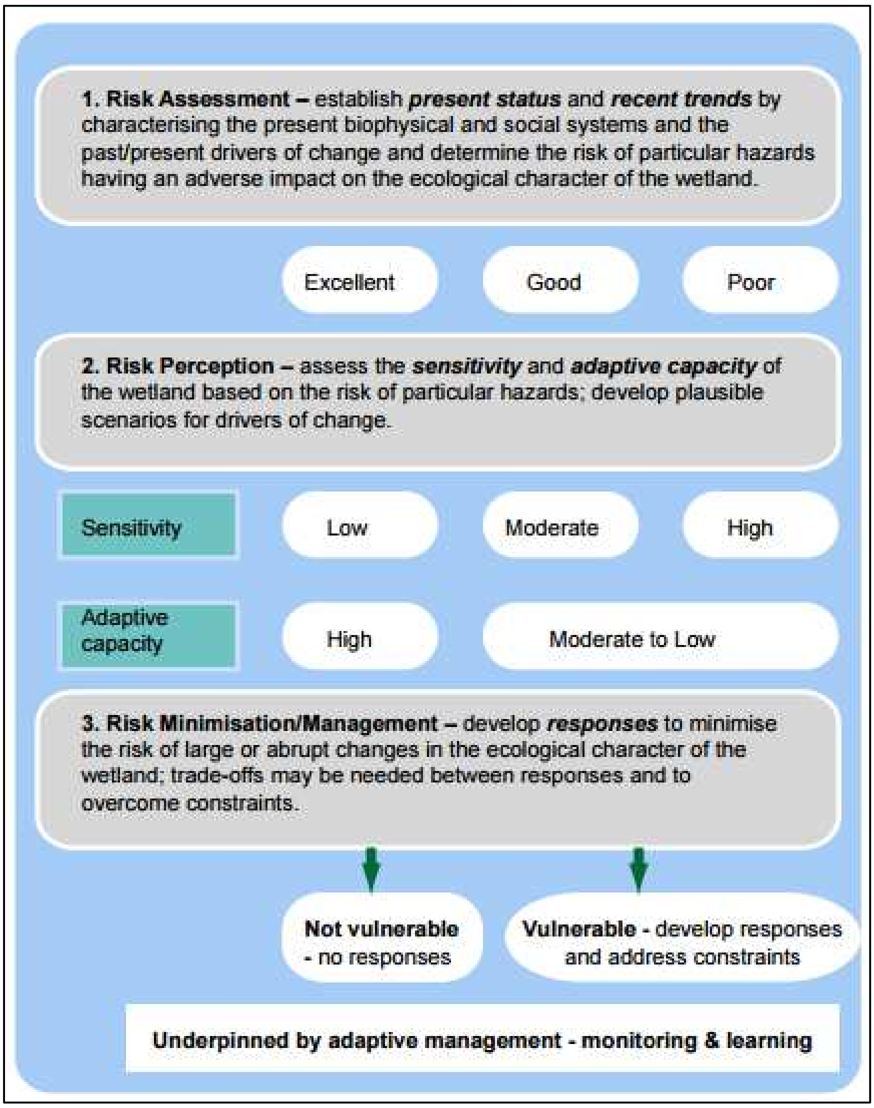
i) ***Establish the present status and recent trends of the wetland***: This involves a description of the present biophysical and social conditions of the wetland, the present and recent pressures that exist within the wetland. Such data can be collected from local/expert knowledge and complemented with scientific data collected in the field.

ii) ***Determine the wetland's sensitivity and adaptive capacity to multiple pressures***: A thorough description of the stressors on the wetland and the development of plausible future changes in order to assess the sensitivity and adaptive capacity of the wetland to multiple hazards or pressures.

iii) ***Develop responses to the identified stressors***: Determine the most probable impacts of these stressors on the wetland and the desired outcomes for it, as well as the responses that must be developed and implemented given its sensitivity and coping and adaptive capacities.

iv) ***Monitor the wetland and apply adaptive management***: Determine the necessary steps that will lead to the desired outcomes (Gitay *et al*., 2011).

Generally, methods to assess wetland vulnerability are complex and not very robust. However, some efforts were made in the 1990s to evaluate wetland vulnerability to climate change, but the methods were prone to a lot of loopholes. The main problem was the lack of quantitative data to determine the sensitivity and adaptive capacity of wetlands in order to come up with scientific-based models. Most often qualitative data was available, but there was a lack of quantitative data. The problem of wetland vulnerability assessment is further compounded by the fact that wetlands are affected by multiple stressors both on-site and off-site, and to come up with a multi-stressor method is challenging. Besides, modelling and scaling down climate change models to determine the future changes in climate and changes in land use and land cover, even make assessment more difficult (Gitay *et al*., 2011)



Source: Gitay *et al*. (2011:11)

Figure 6.11 Wetlands vulnerability assessment framework

The wetland vulnerability framework by Gitay *et al*. (2011) is very similar to that proposed by RCS (2010c). All the aspects of the two models are covered in the integrated model proposed in this research, though quantification of the framework is still a challenge (see Chapter 11).

6.5.2.6 Other environmental vulnerability indicators

Many indicators have been developed to monitor the health of the natural environment, especially at global and national scales, but very little was done at micro-scales. Some of these environmental indicators will be discussed in this section.

The environmental sustainability index which is published by the World Economic Forum, uses 21 indicators that influence environmental sustainability at national scale (Jordaan, 2012; Moldan *et al*., 2004; UNDP, 2008). According to this index South Africa was ranked 93 out of

146 countries in 2005, indicating that South Africa needs to improve on its environmental quality.

The ecological footprint is another indicator that was first published in 1996 by Wackernagel and Rees (Moldan *et al*., 2004). The ecological footprint of a population is the area of an ecologically productive land needed to maintain the population's current consumption patterns and absorb its wastes using the prevailing technology (Moldan *et al*., 2004). The ecological footprint can be extended to the management of wetlands to reduce degradation.

The living planet index, developed by the World Wildlife Fund, as indicators to assess the overall state of the Earth's natural ecosystems, based on national and global data on human pressures on natural ecosystems due to the consumption of natural resources and the effects of pollution (Loh, 2002 in Moldan *et al*., 2004). The living planet index is almost similar to that of the ecological footprint.

The geobiosphere load index by Moldan *et al*., (2004) looks at pressure indicators due to human activities on the environment (Moldan *et al*., 2004).

The environmental performance index uses a method that quantify and numerically assess 25 performance indicators of policies on the environment to rank 163 countries (Emerson *et al*., 2010). The EVI, compiled by the South Pacific Applied Geoscience Commission, uses 50 indicators to determine a country's environmental vulnerability to future shocks (Kaly *et al*., 2004).

All these indicators could be applied to study the ecological status of wetlands. In this study, however, the WCRAI was used to design the field data sheet with indicators that assessed the ecological status of the the wetlands in the eFS.

6.6 THE RISK EQUATION

6.6.1 General disaster risk equation

In disaster and other risk management disciplines, different shades of the risk equation have been adopted. Central to all these equations is the fact that there are three main elements to a risk. First, there should be a threat or hazard, then an element of vulnerability of a structure, community or system, and lastly, there may be some degree of the structure, community or system to resist, fight back or cope with these threats. Mathematically, the risk equation is expressed as:

$$R = H \times V \div C$$

Where

R = is the level of risk
H = the threat or hazard
V = the degree of vulnerability and
C = the capacity to cope with the hazard (Coppola, 2011; UK DFID, 2006; Wisner *et al*. 2004).

A slightly modified equation of risk is presented as:

$$R = H \times V \div (C + M)$$

(Kesten, 2008)

This second equation adds the **M** (to the first risk equation above) which stands for manageability, and this relates to the institutions, laws, disaster preparedness plans and other counter tools put in place by the government or community to address threats or hazards. The M is different from **C** because the latter describes the inherent coping capacities (skills, knowledge, social networks or social capital) of the structure, community or system (Kesten, 2008)

Jordaan (2012) proposed an expanded equation for the calculation of risk

$$\boldsymbol{R = \left(\frac{Hj}{C_H}\right) x \left[\frac{\sum(V_{econ}V_{env}V_{Soc})}{\sum(C_{econ}C_{env}C_{soc})}\right]}$$

Where

R = Disaster risk for disaster
H = Probability and of hazard **j** with a certain magnitude
CH = Capacity or factors that impact on probability and impact or magnitude of hazard j
$\mathbf{V_{econ}}$ = Economic vulnerability
$\mathbf{V_{env}}$ = Environmental vulnerability
$\mathbf{V_{soc}}$ = Social vulnerability
$\mathbf{C_{econ}}$ = Capacity to deal with economic vulnerability
$\mathbf{C_{env}}$ = Capacity to mitigate and limit environmental vulnerability
$\mathbf{C_{soc}}$ = Capacity to mitigate and limit social vulnerability

The main difference here is that structures, communities and systems will have different coping capacities for the hazards and react differently to the various factors of vulnerability (economic, social, environment). Factors of vulnerability may also include a physical and political dimension which can be added to the latter equation to stretch the equation even further.

6.6.2 Proposed wetland risk equation

Building from the known disaster risk equations, a wetland risk can be represented mathematically as:

$$R = H \times V \times E \times S \div (A + M)$$

Where

R = the risks

H = wetland-related stressor/hazards

V = the degree of vulnerability of the wetland

E = the degree of exposure to the stressor/hazard

S = the sensitivity of the wetland to the hazard

A = the ability of the wetland to adapt or cope with the impacts

M = the wise and sustainable management of the wetland.

This equation can also be applied to other ecological risks that may not be wetland-related.

Applied to wetlands management in this study, the risk of wetland degradation and lost would depend on the wetland stressors (both human and natural), the level of vulnerability of the wetland to the stressor as determined by the ecological integrity of the wetland, the degree to which the wetland is exposed to and sensitive to the stressor, the adaptive capacity of the wetland and the way the wetland is managed. The vulnerability and adaptive capacity of a wetland will depend on the ecological health and integrity of the wetland, effective and sustainable management and time. Human action can play a critical role on the **H** (through measures that can prevent or mitigate wetland stressors) and **M** (through wise and sustainable use of wetlands). The focus of this research is to improve on **M** so that **R** can be reduced in the equation adopted above.

6.6.3 Risk severity

According to Mentis (2010), risk severity is a function of the likelihood of the risk happening and the consequence if it happens. Risk severity can range from very low to very high (Table 6.5). This is a very simplistic view given that all the elements of risk as indicated in this chapter are not taken care of in the risk matrix. However, it can be a starting point and simple way to explain risk to non-specialists.

TABLE 6.6: RISK SEVERITY MATRIX

Consequence	Likelihood	
	Low	High
Big	High, e.g. failure of Gariep dam wall	Very high, e.g. HIV infection in South Africa
Small	Very low, e.g. solar eclipse	Low, e.g. winter colds and flu

Source: Mentis (2010)

6.7 CHAPTER SUMMARY

This chapter discussed risk and vulnerability assessment. It started by looking at the general processes and tools used in risk and vulnerability assessment from the disaster management perspective and later zoomed down to environmental management and specifically to wetlands risk and vulnerability assessment. Various risk and vulnerability models were examined and a synthesis of these models was used to build the final integrated wetlands management framework (Chapter 11).

It was important to look at risk and vulnerability assessment in this study because the starting point for any meaningful DRR or CCA should be a meticulous risk and vulnerability assessment. This process will help to highlight the various hazards communities and systems face, as well as their degree of susceptibility to those threats. The same principle was applied for the wise and effective management of wetlands in the eFS where legal and institutional issues were looked into to kick-start the process on a solid legal background. The risk assessment followed by looking at the ecological status of the wetlands before diving into a management approach to integrate DRR and CCA.

Risk involves the interaction of hazards or stressors (natural, human or Natech), vulnerability and the lack of coping/adaptive capacity. Vulnerability of any community or system is influenced by many factors which are grouped under economic, social, environmental, physical, political and even cultural factors. For decades, many distinct and somehow independent research and policy communities such as DRR, CCA, environmental management, poverty reduction and sustainable development have been actively involved in trying to reduce social-economic, physical and environmental vulnerability to natural hazards. Despite the efforts of these communities, the vulnerability of many individuals, communities and systems to natural and human hazards continues to increase considerably (Thomalla *et al*., 2006; UNISDR, 2015). The main problem is that each of these communities drive and defend their individual agenda; they operate in silos and fail to synergise their efforts at both national and international levels.

In South Africa, issues on DRR rest with the Department of Cooperative Governance and Traditional Affairs (CoGTA), while those of CCA are with the DEA with little horizontal linkages or cross-pollination. Legislations and policies follow the same parallel structures. This silo arrangement may create a gap for vulnerability situations to exploit. One of the objectives of this study is to highlight the need to link DRR and CCA. Natural hazards (addressed by DRR) and climate change impacts (addressed by CCA) have much in common and affect all sectors of the economy. Natural hazards and climate change should therefore be handled in a holistic and integrated manner at all scales and at all political levels with the involvement of all sectors of the society (Thomalla, 2006).

Many risk and vulnerability models exist which could be generic disaster risk and vulnerability models and those related to environment and wetlands management. These models have more in common than differences. Wetlands are vulnerable to many stressors which are both natural and human-induced and may be on-site or off-site stressors. An integrated system approach, based on the principle of wise and sustainable management of wetlands, will build wetland resilience and therefore reduce most of these vulnerabilities.

Chapter 7

WETLANDS AND CLIMATE CHANGE: POTENTIAL CAUSES AND EFFECTS

7.1 INTRODUCTION

> *Climate change will magnify existing vulnerabilities to disasters due to changing patterns of some hazards… Maintaining and enhancing ecosystems for natural hazard mitigation and disaster prevention can strengthen local adaptation capacities to counter the effects of climate-related risk* (IPCC, 2012 in PEDRR, 2013).

The above quote summarises the core of this chapter on how natural ecosystems such as wetlands could reduce the effects of climate-related risks. The chapter also examines the possible ways on how the prevailing climatic changes (especially oscillations in temperature and rainfall) could impact on the health and ecological services provided by wetlands in the eFS, because climate change affects wetlands in their spatial extent, distribution and functions (Kraiem, 2002). The last section of the chapter examines the possible contribution of wetlands to changes in climate. For example, disturbed peat deposits could lead to the emission of carbon into the atmosphere that could accelerate atmospheric warming. This chapter however, starts by examining the concept of climate change with the note that the concept of wetlands was well-expanded upon in Chapter 4.

7.2 BACKGROUND TO CLIMATE CHANGE RESEARCH AND THE FORMATION OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

7.2.1 The Intergovernmental Panel on Climate Change

The IPCC is the main international knowledge hub on climate change. The history of the IPCC dates back to 1972 when the United Nations Conference on Human Environment was held in Stockholm and became the first international conference on environmental issues. This conference led to a greater and wider understanding of the nature and scale of human impact on the environment (Guta and Nair, 2012). Seven years later in 1979, a group of scientists set up the World Climate Research Programme to determine if the climate was changing, how the change could be predicted and whether human action was involved in the change. In 1987, the International Geosphere Biosphere Programme that was sponsored by the International

Council of Scientific Unions through its advocacy, led the UNEP and WMO to jointly establish the Intergovernmental Panel on Climate Change (IPCC) in 1988 (Guta and Nair, 2012).

The IPCC is one of the largest bodies of scientists assembled to study a scientific issue. It involves more than 2 500 scientists from more than 130 countries with a focus on climate change issues (IPCC, 2012). These scientists are spread all over the world and therefore their contributions can give a fair global evidence on climate change. The IPCC has issued five assessment reports on climate change: The first assessment report was delivered in 1990, the second (SAR) in 1995, the third (TAR) in 2001, the fourth (AR4) in 2007 and the latest which is the fifth (AR5) in 2014. These reports present persistent evidence of climate change and their consequences.

UNFCCC with its Conference of Parties (COPs) is the main multilateral forum that focused on addressing climate change, with almost universal participation. The main landmark of the UNFCCC is the Kyoto Protocol which bench-marked the objective of the UNFCCC with a carbon emission target to mitigate climate change. However, the COP21 held in Paris (December 2015) and the Paris Agreement which was a follow-up to the Durban platform for enhanced action of 2011, look promising because of a binding agreement, emission targets and monitoring instruments that were agreed upon by the contracting parties (UNFCCC, 2015).

7.2.2 The logic of climate change

Since the Industrial Revolution in 1750, human inputs on the Earth’s ecosystem have been multiple, complex and far-reaching in effects. This has given birth to what is popularly referred to as the Anthropocene era. According to Guta and Nair (2012), ‘*the Anthropocene*’ is a recent and informal chronological epoch that shows evidence and extent of human activities with significant global impact on the Earth’s ecosystem (Guta and Nair, 2012). The Earth’s system comprises of physical, chemical and biological processes and a change in one affects the other components. The human system is part of the Earth’s system and in the Anthropocene, the human system is the main driver of the Earth’s system.

Besides evidences advanced by climate science researchers like those of the IPCC, this study supports climate change based on a simple logic. The whole climate system has two important subsystems: the natural subsystem and the human subsystem. The natural subsystem has elements that can self-regulate this subsystem and keep it constant or near constant. For example, the total energy from the sun which drives the whole climate system may not change over the years and the total surface of the ocean that has a key regulatory role may not change over the years. However, this is not true of the human subsystem of the climate system. The world total population is growing at a tremendous rate, the teeming population needs to be provided with basic needs and growing wants, hence the agricultural and industrial revolutions which relied on and impacted upon the natural system, through the exploitation of natural resources (both renewable and non-renewable), deforestation, rapid urbanisation, increase in chemical products, heavy disposal of waste and pollution. It is therefore logical or illogical (depending on which side one views the climate change debate) to expect the whole climate system to remain constant over the years wherein the human system is changing rapidly. This is a simple logical argument proposed by this study to support that climate is or should be changing. Any contrary view is to refute the changing human subsystem and its impacts on the natural system of the total climate system. The natural climate balance has obviously tilted. The new and widely supported view of climate resilience (UNFCCC, 2015) only gives credence and acknowledgement of climate change if one looks at the very definition of resilience. Sometimes climate change indicators like the changes in seasonal patterns that affect agricultural activities are better evidence of climate change than statistical measurement of climatic factors, such as averages temperatures and rainfall, which often hide the actual perturbations of the climate system and the impacts felt thereof.

7.3 UNDERSTANDING CLIMATE CHANGE

The IPCC defines climate change as any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2007), whereas the UNFCCC (2015) defines climate change as a change of climate that is attributed directly or indirectly to human activity, in addition to natural climate variability. Both definitions acknowledge that there can be natural climate variability, but the shift is on the human contribution to climate change in the latter definition. Important elements of the climate that are often observed over a long period (at least 30 years) to talk about possible changes in the climaten include the following:

- *Precipitation*, which includes all forms of falling water on the earth’s surface, but most importantly rainfall and snowfall.
- *Temperature*, where the minimum and the maximum temperatures are observed to obtain the mean daily, mean monthly and mean annual temperature over a long period.
- Also important is the *wind* where both the direction, speed and content are observed.
- The *atmospheric humidity* as well as the *atmospheric pressure*.
- The amount of *sunshine* is also important in observing the weather and subsequently the climate (Arbogast, 2011; Reynolds *et al*., 2015; Strahler and Strahler, 2005).

7.3.1 Climate change mitigation

Climate change mitigation are actions aimed to reduce greenhouse gas emissions and to enhance sinks aimed at reducing the extent of global warming (IPCC, 2007; SADC, 2010). The meaning of mitigation in climate change discipline is quite different from the way the term is used in disaster rick reduction (see Chapter 2), although climate change is a disaster risk on its own merit.

7.3.1.1 Climate change mitigation solutions

Some generic measures to mitigate climate change include:

- *Carbon sequestration* through afforestation, reforestation, agroforestry, silviculture and increasing carbon stock in biomass.
- *Carbon conservation* through the conservation of biomass and soil carbon in protected areas, improved forest, wetlands and fire management practices and agricultural systems.
- *Carbon substitution* through the sustainable use of biofuel or alternative renewable energy sources such as solar and wind energy, rather than biofuel.
- *Greenhouse gas emission reduction* and avoidance through biodigestion and energy projects such as emission trading schemes and pricing of carbon emissions to discourage emission practices (Akumu, 2011; IPCC, 2007; SADC, 2010).
- *Policies on climate* that are effective and efficient can help mitigate climate change. However, the design of a climate policy is often influenced by how individuals and organisations perceive risks and uncertainties and take them into account (IPCC, 2014).

Mitigation options can help address the extent of climate change but no single option is sufficient by itself. Effective implementation of options depends on policies and cooperation at all scales, and can be enhanced through integrated responses that link adaptation and mitigation with other societal objectives like sustainable wetlands management (IPCC, 2014). Mitigation, and even adaptation responses, are also underpinned by common enabling factors, which include effective institutions and governance, innovation and investments in environmentally sound technologies and infrastructure, sustainable livelihoods, and behavioural lifestyles as well as culture. All of these factors can reduce greenhouse gas emissions and enhance resilience to climate change (IPCC, 2014).

Mitigation options need to yield cost benefits to be very appealing to nations. Co-benefits and adverse side-effects of mitigation could affect achievement of other objectives such as those related to human health, food security, water supply, land use, biodiversity, local environmental quality, energy access, livelihoods, and equitable sustainable development (IPCC, 2014; SADC, 2010). Some mitigation policies raise the prices for some energy services and could hamper the ability of societies to expand access to modern energy services to underserved populations like those living in informal settlements (IPCC, 2014). A classic example is the use of coal for electricity generation in the embattled energy sector in South Africa where substantial reductions in carbon emissions would require large changes in investment patterns, such as investments in low carbon and renewable electricity supplies and energy efficiency in key sectors (transport, industry and buildings), but this may raise cost with other related consequences in the society, especially on the poor. Gradual and careful planning is therefore important.

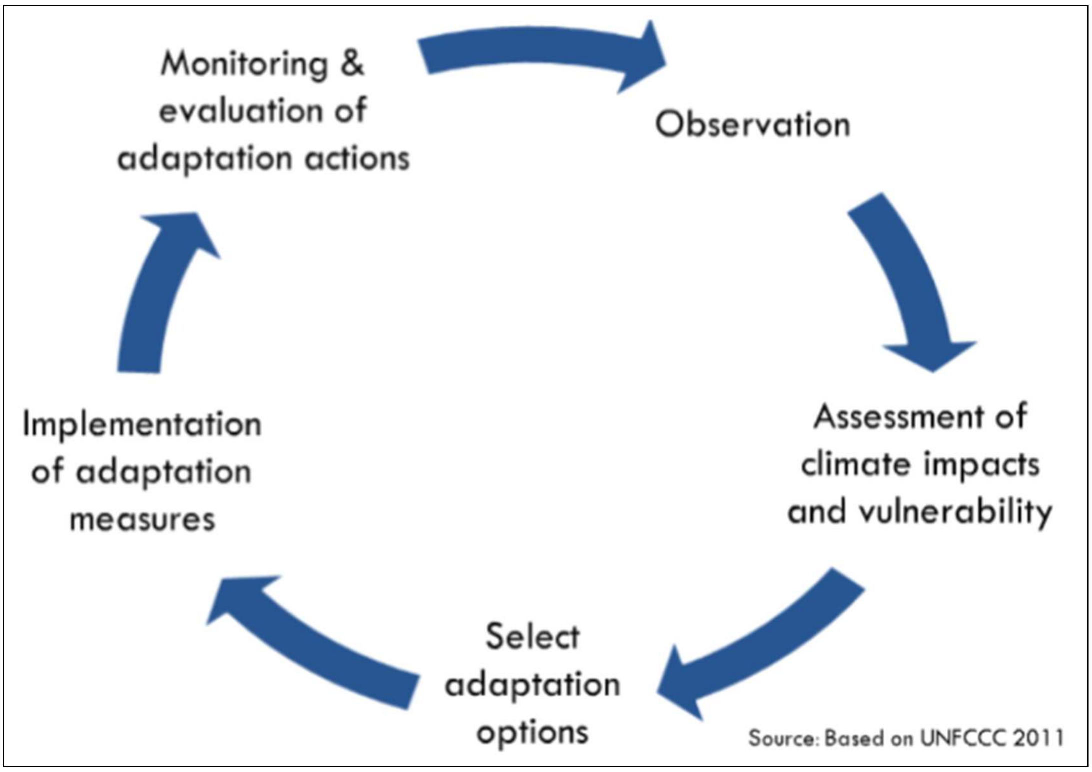
7.3.2 Climate change adaptation

The IPCC (2012) defines climate change adaptation as follows:

> *The adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploit beneficial opportunities.*

Adaptation involves reducing risk and vulnerability, seeking opportunities and building the capacity of nations, regions, cities, the private sector, communities, individuals, and natural systems to cope with climate impacts, as well as mobilising that capacity by implementing decisions and actions (Tompkins *et al*., 2010, in IPCC, 2014). Climate risks and vulnerability assessments help to identify adaptation needs and the types of needs provide a foundation for selecting adaptation options (IPCC, 2014). Adaptation needs include biophysical, social, institutional, engagement with private sector, information, capacity, resource needs, and also involves tackling the underlying causes of vulnerability such as informational, capacity, financial, institutional, and technological needs (IPCC, 2014).

Climate change adaptation is a process with key elements (Figure 7.1).



Source: IPCC (2013)

Figure 7.1 Key elements of climate change adaptation process

While engineered and technological adaptation options are still the most common adaptive responses to climate change, there is growing experience of the value for ecosystem-based and social measures, including the provision of climate-linked safety nets for those who are most vulnerable (IPCC, 2014). Structural adaptation measures can be very expensive and sometimes elusive for developing countries. It is estimated that CCA cost in developing countries could range from 9 to 67 billion US dollars per annum (IPCC, 2007). However, ecosystem-based adaptation measures have proven to be less expensive, can be community driven and affordable for developing countries which are most vulnerable to climate change and disaster risks (CNRD/PEDRR, 2013; IPCC, 2007, 2014; Renaud *et al*., 2013; UNISDR, 2013). Conservation of biodiversity and maintaining healthy fragile ecosystems such as wetlands are important CCA measures (SADC, 2010). This is why this study finds it important to manage wetlands for CCA.

7.3.2.1 Climate change adaptation solutions

A variety and combinations of strategies are possible for CCA as summarised in Table 7.1.

TABLE 7.1: SUMMARY OF CLIMATE CHANGE ADAPTATION OPTIONS

Category		Examples
Structural/ physical	Engineered and built environment	Sea walls and coastal protection structures, flood levees and culverts, water storage and pump storage, sewage works, improved drainage, beach nourishment, flood and cyclone shelters, building codes, storm and waste water management, transport and road infrastructure adaptation, floating houses, adjusting power plants and electricity grids
	Technological	New crop and animal varieties, genetic techniques, traditional technologies and methods, efficient irrigation, water saving technologies and rainwater harvesting, conservation agriculture, food storage and preservation facilities, hazard mapping and monitoring technology, early warning systems, building insulation, mechanical and passive cooling, renewable energy technologies, second-generation biofuels
	Ecosystem based	Ecological restoration, including wetland and floodplain conservation and restoration, increasing biological diversity, afforestation and reforestation, conservation and replanting mangrove forests, bushfire reduction and prescribed integrated fire management, green infrastructure (e.g., shade trees, green roofs), controlling over-fishing, fisheries co-management, assisted migration or managed translocation, ecological corridors, ex-situ conservation and seed banks, community-based natural resource management ,adaptive land use management
	Services	Social safety nets and social protection, food banks and distribution of food surplus, municipal services including water and sanitation, vaccination programmes, essential public health services, including reproductive health services and enhanced emergency medical services, international trade
Social	Education	Awareness raising and integrating into education and gender equity in education, extension services, sharing local and traditional knowledge including integrating into adaptation planning, participatory action research and social learning, community surveys, knowledge-sharing and learning platforms, international conferences and research networks, communication through media
	Information	Hazard and vulnerability mapping, early warning and response systems, including health early warning systems, systematic monitoring and remote-sensing, climate services, including improved forecasts, downscaling climate scenarios, longitudinal data sets, integrating indigenous climate observations, community-based adaptation plans, including community-driven slum upgrading and participatory scenario development
	Behavioural	Accommodation; household preparation and evacuation planning; retreat and migration which has its own implications for human health and human security; soil and water conservation; livelihood diversification, changing livestock and aquaculture practices; crop-switching; changing cropping practices, patterns, and planting dates, sylvicultural options; reliance on social networks

Category		Examples
Institutional	Economics	Financial incentives including taxes and subsidies, insurance, including index-based weather insurance schemes; catastrophe bonds; revolving funds; payments for ecosystem services, water tariffs, savings groups; microfinance, disaster contingency funds, cash transfers
	Laws and regulations	Land zoning laws, building standards and codes, easements; water regulations and agreements, laws to support DRR; laws to encourage insurance purchasing; defining property rights and land tenure security, protected areas; marine protection, fishing quotas; patent pools and technology transfer, effective environmental laws
	Government policies and programmes	National and regional adaptation plans including mainstreaming climate change; sub-national and local adaptation plans; urban upgrading programmes; municipal water management programmes; disaster planning and preparedness; city-level plans, district-level plans, sector plans which may include integrated water resource management , landscape and watershed management, integrated coastal zone management, adaptive management, ecosystem-based management, including sustainable forests and wetlands management, fisheries management and community-based adaptation

Source: Adapted from IPCC (2014)

Wetlands hold good CCA options if well-managed through actions such as:

- Maintaining natural biodiversity of wetlands and introducing highly resilient wetland species that adapt to climate change.
- Improving the vegetation cover within wetlands that will allow more wetland recharge through more infiltration and less evaporation from reduced rainfall, especially during dry spells.
- Creating corridors habitation for wetlands wildlife.
- Using legislation, regulations and policies to conserve and prevent wetlands loss.
- Retreating from inundated high risk areas caused by climate-induced sea level rise.
- Protecting coastal wetlands from sea level rise by building dykes and levees.
- Encouraging more risk-based climate change impact assessment research (Akumu, 2011).

Climate change mitigation has always taken preference and the lion share in climate change funding at the previous COPs. Apparently CCA and the use of nature-based adaptation strategies such as wetlands, was very prominent at the COP21 in Paris (UNFCCC, 2015). Also to be noted is that the adaptation strategies indicated in Table 7.1 are very similar to those of DRR and this is one of the areas that has been highlighted in this research.

7.3.2.2 *Maladaptation and adaptation deficit*

While advocating for CCA, care should be taken of situations of maladaptation and adaptation deficit. **Maladaptation** is where intervention in one location or sector could increase the vulnerability of another location or sector, or increase the vulnerability of the target group to future climate change. On the other hand, **adaptation deficit** is the gap between the current state of a system and a state that would minimise adverse impacts from existing climate conditions and variability (IPCC, 2014). For example, the degradation of wetlands will create an adaptation deficit to climate change.

7.3.3 Similarities between climate change mitigation and climate change adaptation

Climate change mitigation and adaptation use complementary strategies to reduce and manage the risks of climate change. Complementing the two helps to build climate resilient pathways that lead to sustainable development (IPCC, 2014).

Both CCA and mitigation options cut across all sectors, but their implementation and ability to reduce climate-related risks differ across these sectors and regions. Some adaptation responses result in significant co-benefits, synergies and trade-offs. Adaptation options are also associated with vulnerability reduction, disaster risk management or proactive adaptation planning. Effective strategies always consider the potential co-benefits and opportunities within wider strategic goals and development plans (IPCC, 2014).

Mitigation options exist in every major sector and are more cost-effective when integrated with measures that reduce energy use and the greenhouse gas intensity, decarbonise energy supply, reduce net emissions and enhance carbon sinks (IPCC, 2014).

To mitigate climate change through reduction in carbon emission and to build short- and long-term adaptation strategies needs strong political commitments and effective and implementable local, national, regional and international policies (IPCC, 2014).

7.4 CAUSES OF CLIMATE CHANGE

Human activities have been the main cause of climate change (IPCC, 2007). Recent anthropogenic emissions of greenhouse gases are the highest in history. More than half of the observed increase in global average surface temperatures from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic drivers of global warming (IPCC, 2014). The three main greenhouse gases related to climate change are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Of the three, CO_2 is the most important (Guta and Nair, 2012; IPCC, 2014). Between 1750 and 2011, cumulative anthropogenic CO_2 emissions to the atmosphere were 2 040 ± 310 $GtCO_2$. About 40% of these emissions have remained in the atmosphere (880 ± 35 $GtCO_2$), while the rest was stored on land (in plants and soils) and in the ocean. The ocean has absorbed about 30% of the emitted anthropogenic CO_2, leading to another problem of ocean acidification. About half of the anthropogenic CO_2 emissions between 1750 and 2011 occurred in the last 40 years (IPCC, 2014). This rapid concentration of CO_2 in the last few decades should be a concern, even to those who do not believe in climate change.

7.4.1 Anthropogenic greenhouse gases and global warming

Global warming is the overall warming of the planet based on average temperature over the entire earth, though at different regional intensities (Guta and Nair, 2012). Though global warming could be caused by the earth's natural warming and cooling cycles, the current human addition of the greenhouse gases has set the global warming on an unprecedented rate in recent times (Climate and Development Knowledge Network [CDKN], 2014; IPCC, 2007). There is 95% certainty that the human production of greenhouse gases is the main cause of global warming that has prompted climate change since the mid-twentieth century, and if greenhouse gases are not reduced global temperature is predicted to rise by between 2.6 ^{o}C to 4.8 ^{o}C by the end of the twenty-first century.

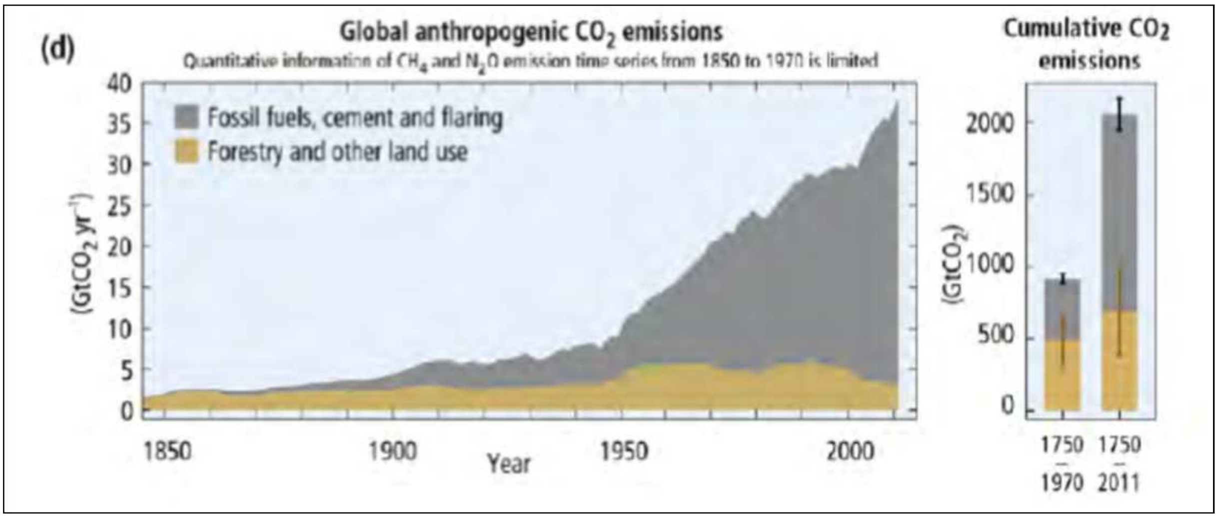
Normally, the average temperature on earth is 15 ^{o}C and without greenhouse gases such as CO_2 and water vapour, the average temperature of the earth could have been −18 ^{o}C, which could have been unbearable for most life on earth. Greenhouse gases are therefore a natural phenomenon by which the earth regulates the conditions that will be suitable for most life on earth (Ayoade, 2004). The problem is that since the Industrial Revolution, human action has been pumping too much greenhouse gases such as CO_2, N_2O, CH_4 and chlorofluorocarbons (CFCs) into the atmosphere that has been upsetting the natural atmospheric gaseous composition, leading to unprecedented global warming and climate change. For example, fossil fuel burning for various reasons adds five billion tons of CO_2 into the atmosphere annually, while the destruction of the natural vegetation adds another one billion tons of CO_2 to the atmosphere annually. N_2O is also increased through burning of fossil fuel, denitrification of fertilisers used by farmers to improve crop yields, but the growing population of livestock such as cattle, pigs, sheep through their digestive system, and the increase of cultivated areas of rice paddies in wetlands are the main culprits for the emission of CH_4. CFC gasses used as coolants in refrigerators, as insulant foams and as propellants in aerosol sprays also contribute to global warming (Ayoade, 2004).

The seven most important greenhouse gases that cause global warming, include CO_2, CH_4, N_2O, HFCs, PPCs, SF_6, and NF_3 (IPCC, 2007). Some of these greenhouse gases are discussed below.

7.4.1.1 Carbon dioxide

According to the WMO (2013), global CO_2 concentration in the atmosphere increased by 40% since 1750. Though CO_2 has a low radiative forcing compared to other greenhouse gases, the fact that it constitutes 64% of total emission and has the potential of staying in the atmosphere for about a hundred to even thousands of years, makes it the number one warming greenhouse gas. Most CO_2 emissions are due to anthropogenic activities such as burning of fossil fuel, deforestation and forest degradation, iron and steel production and cement production, while a small portion occurs naturally like CO_2 from solar systems and volcanic eruptions (IPCC, 2013).

China is the world's biggest emitter of carbon at 6.83 billion tonnes per year, followed by the US at 5.2 billion tonnes. In *per capita* terms China is behind the US with 5.14 tonnes per person, compared to the US with 16.9 tonnes. Historically, China has emitted 80.4 tonnes of CO_2 compared to 1 127.2 tonnes per person for the UK and 1 125.7 for the US. This situation has presented serious international debates at UNFCCC conferences on the effective implementation of the Kyoto Protocol as to whether carbon cuts should be based on current or historical emissions (IPCC, 2013). Whatever the case, the decisions made today will have far-reaching consequences in the future. All-in-all, the remarkable increase in CO_2 since the 1950s is clear (Figure 7.2)



Source: IPCC (2014)

Figure 7.2 Global anthropogenic carbon dioxide emissions

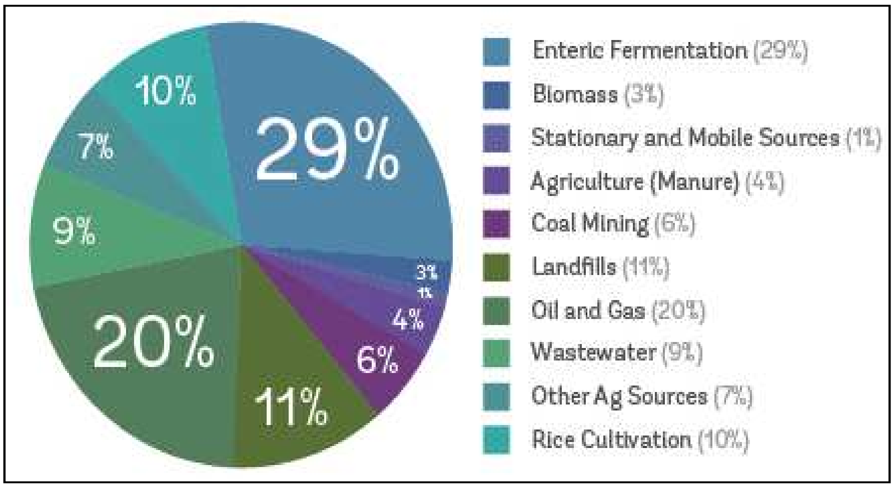
The efficiency of natural sinks to remove CO_2 has decreased by 5% over the last 50 years (about 1% per decade) and this trend will continue into the future. Fifty years ago, for every 1 000 kg (1 ton) of CO_2 emitted to the atmosphere, natural sinks removed 600 kg, but currently the sinks are removing only 550 kg for every 1 000 kg of CO_2 emitted, and this amount is falling (UNEP, 2010).

In Southern Africa, the main sources of CO_2 emission are fossil fuel burning (liquid fuels and especially coal in the thermal power stations of South Africa), deforestation (second largest global emitter after fossil fuel) and land degradation, including carbon from the soil, cement manufacturing (that contribute about 2.5% of global CO_2 emissions) (SADC, 2010).

7.4.1.2 Methane

The concentration of CH_4, the second most warming potential greenhouse gas, has increased in the atmosphere by 150% since 1750. About 40% of methane is emitted naturally, while 60% is through human activities such as cattle breeding and rice production. Methane has the potential of remaining in the atmosphere for only 12 years, compared to CO_2 for about 100 years or more years, though its radiative forcing is 286 times more than that of CO_2 (IPCC, 2013; Motavalli, 2015; WMO, 2013).

Methane is produced naturally by forest fires, permafrost, wild animals, rivers, lakes and wetlands, but more than 50% of the methane entering the atmosphere comes from human activities (Motavalli, 2015). Figure 7.3 below shows the key human activities that emit methane.



Source: Global Methane Initiative cited by Motavalli (2015)

Figure 7.3 Estimated global anthropogenic methane emissions by source, 2010.

The amount of methane emitted into the atmosphere has been rising steadily since 2007 (IPCC, 2012). Motavalli (2015) used the example of the Blue Spruce Farm in Bridport in the

US, to support the fact that methane can be harnessed into an efficient source of energy for household consumption. This example shows that wise use of greenhouse gases could be turned into beneficial opportunities.

7.4.1.3 Nitrous oxide

Nitrous oxide (N_2O) concentration in the atmosphere has increased by 20% since 1750, and 40% of this is due to human activities such as fertiliser production and usage. N_2O has the ability to stay in the atmosphere for 114 years. The FS is dominated by crop production and the use of fertiliser to improve crop yield, results in substantial emissions of N_2O.

7.4.1.4 Fluorinated gases

The fourth important greenhouse gas in terms of global warming are the fluorinated gases which include the HFCs, the PFCs and SF_6. Though these greenhouse gases are reducing due to the Montreal Protocol of 1989 which addressed the depletion of the ozone layer, they still contribute to global warming with a radiative forcing of 12%, and can stay in the atmosphere for about 50 000 years. HFCs are mostly used to manufacture aerosol sprays, blowing agents for foam, packing materials, solvents and refrigerants (IPCC, 2007, 2013; WMO, 2013).

Human activities have therefore shown a clear trend of increasing radiative forcing as opposed to the natural radiative effect since the Industrial Revolutions, leading to an unequivocal global warming and general climate change (IPCC, 2013).

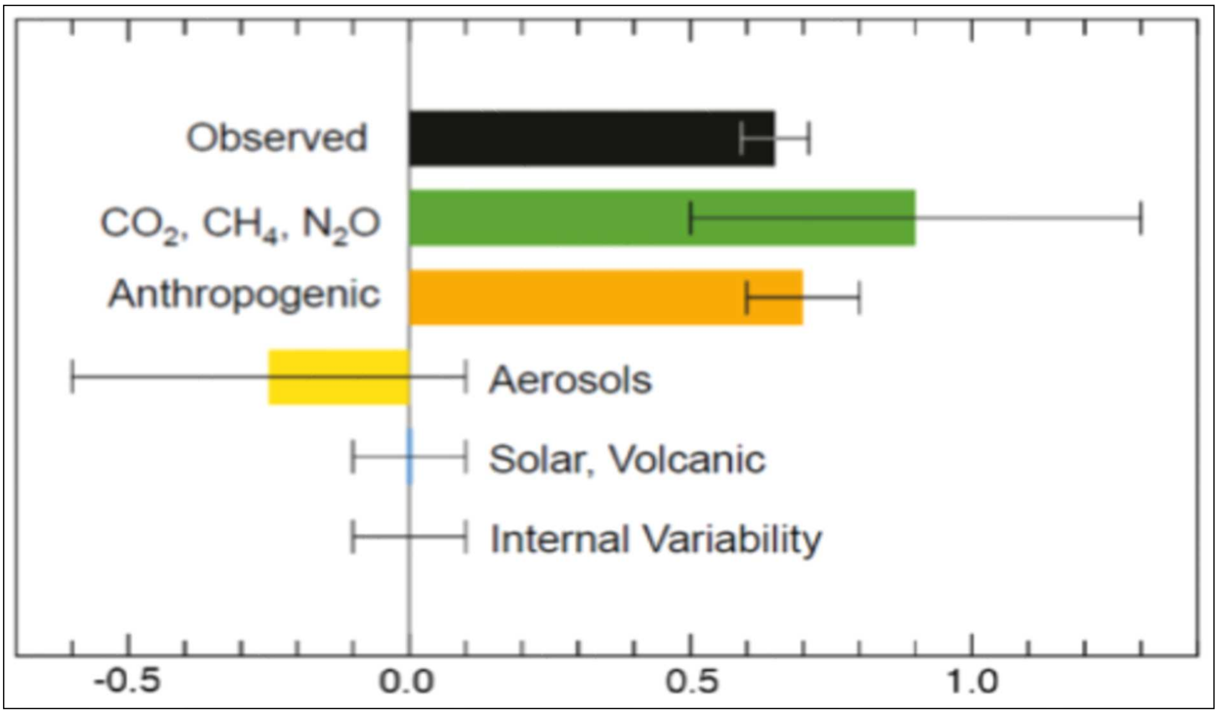
Table 7.2 lists the seven most important greenhouse gases that contribute to global warming.

TABLE 7.2: THE SEVEN MOST IMPORTANT GREENHOUSE GASES FOR GLOBAL WARMING

Greenhouse gas	Global Warming Potential (over 100 years)	Percentage of total anthropogenic greenhouse gas emissions (2010)
Carbon dioxide (CO_2)	1	76%
Methane(CH_4)	25	16%
Nitrous oxide (N_2O)	298	6%
Hydrofluorocarbons (HFCs)	124–14 800	<2%
Perfluorocarbons (PFCs)	7 390–12 200	<2%
Sulphur hexafluoride (SF_6)	22 800	<2%
Nitrogen trifluoride (NF_3)	17 200	<2%

Source: IPCC (2007)

Figure 7.4 shows the clearly observed global warming depicted by the dark colour, most of which is caused by CO_2, CH_4 and N_2O as a result of mainly anthropogenic activities. Though aerosols are decreasing and have the potential cooling effect, this cooling effect cannot be offset by about 1 °C of global warming. The global warming effects are mostly evident in the polar areas with the melting of artic ice and this contributes to sea level rise (IPCC, 2013; WMO, 2013).

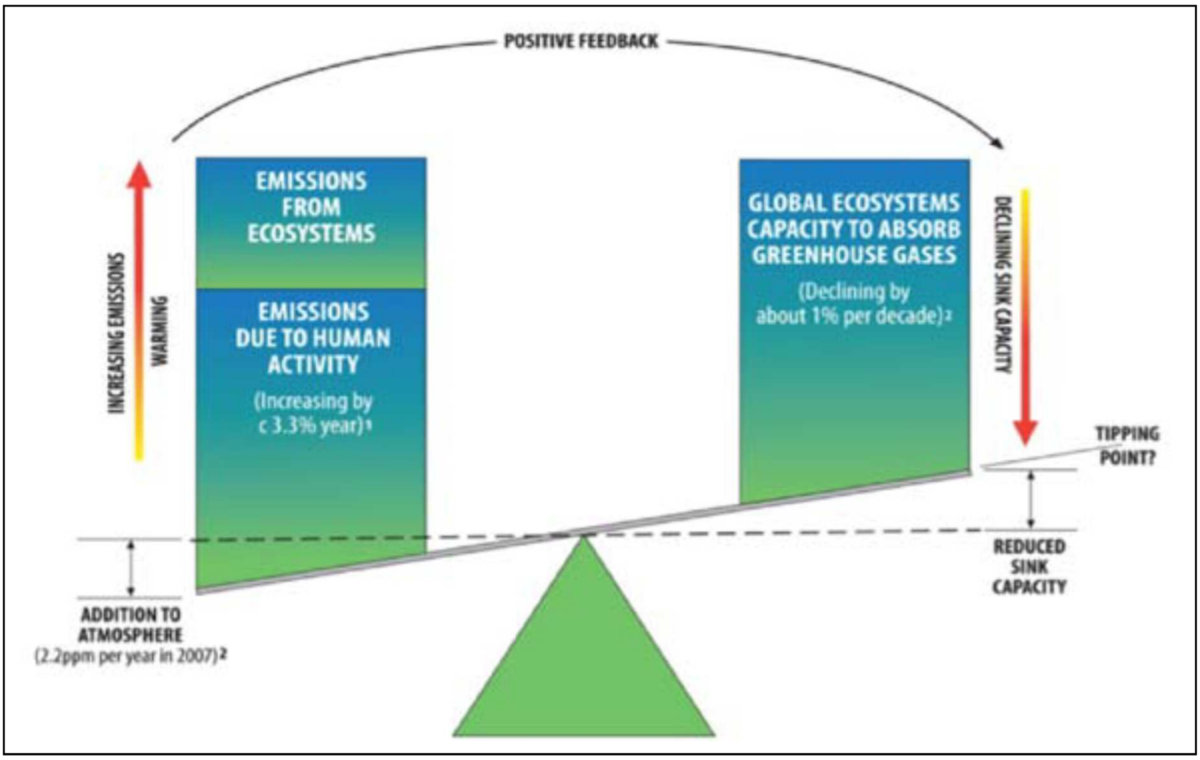


Source: WMO (2013)

Figure 7.4 Global mean warming since 1951

7.4.2 Natural causes of climate change

There is ample scientific evidence that the natural system involving the rotation of the earth as well as other thermic changes in the position of the sun causes natural warming. Other natural processes release CO_2. The counter-argument concerning the natural warming is that these natural processes could self-regulate the earth's temperature had it not been for the tipping effects of anthropogenic causes of climate change that sky-rocketed (Figure 7.5), especially following the Industrial Revolution (IPCC, 2007, 2014).



Source: UNEP (2010)

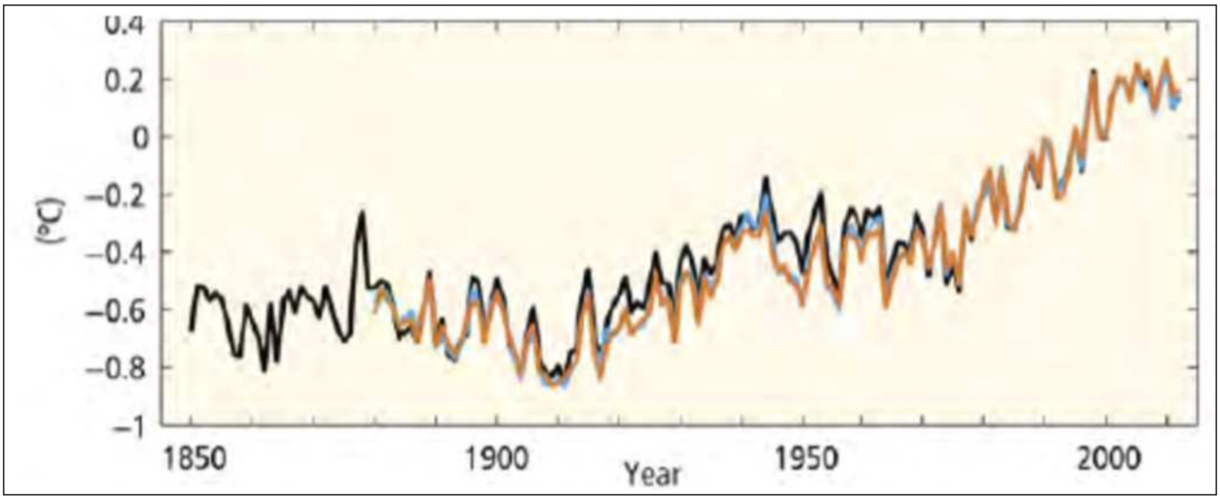
Figure 7.5 The tipping effect of the global greenhouse gases budget

7.5 EFFECTS OF CLIMATE CHANGE

According to IPCC (2014), since the 1950s, there has been the warming of the oceans and atmosphere, the accumulated quantity of snow and ice have reduced, and the sea level has risen to unprecedented levels that have not been observed for decades to millions of years; ocean acidification is taking place and there are recorded changes in biological, physical and human systems. Climate change has stressed and will continue to affect critical ecosystems such as wetlands and lead to water and food shortages in the twenty-first century (IPCC, 2007; UNEP/UNISDR, 2008). Though scientists do not want to blame any single abnormal atmospheric event to climate change, they do, however, agree that climate change is real and is occurring and affects different parts of the world in different ways and in varying degrees of intensity based on local conditions such as the state of the local natural environment. Scientists also agree that the frequency and intensity of hazards are increasing and partly associate this to changing climatic patterns (UNEP/UNISDR, 2008).

7.5.1 Effects on temperature

The global average surface temperature indicates substantial decadal and inter-annual variability. However, the combined land and ocean surface show a warming of 0.85 °C [0.65 °C to 1.06 °C] from 1880 to 2012 (see Figure 7.6).



Source: IPCC (2014)

Figure 7.6 Global averaged combined land and ocean surface temperature anomaly

The past three decades have been successively warmer than any decade since 1850. The most remarkable warming is occurring in the arctic region where the polar ice and the artic sea ice are shrinking, causing sea levels to rise. There is also a remarkable loss of permafrost (IPCC, 2013; 2014)

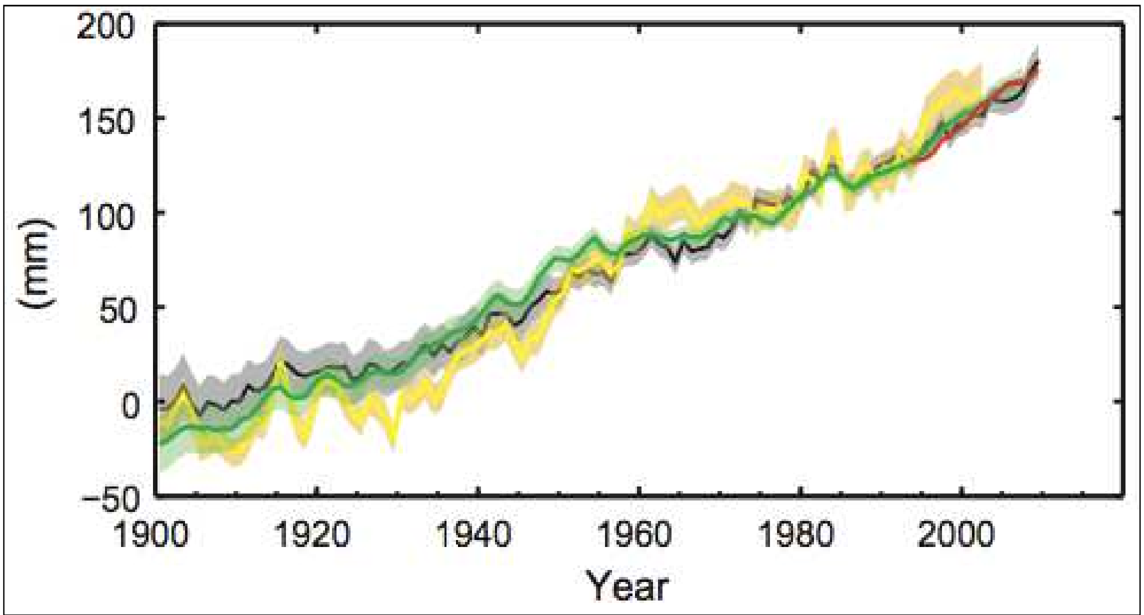
The twenty-first century is less than 17 years old, but 14 of 15 hottest years occurred in this century with 2014 being the hottest year on record (WMO, 2015). Hot years are normally associated with El Niño episodes, but the hottest year ever recorded of 2014 happened without the El Niño episode (WMO, 2015).

Another uncertainty created by the extreme heat in 2014 was that there were heavy floods in some parts of the world such as in Pakistan, Bangladesh and Philippines, while there were droughts in other parts like the Horn of Africa (WMO, 2015). This is the central problem associated with climate change and climate variability which makes forecasting and planning very challenging to the current world body of scientists.

Rising temperature has led to the reduction of permafrosts, expansion in the surface area of glacial lakes in the Himalayas and increase risks of avalanches (Lallanila, 2014; Ludwig et al., 2009).

7.5.2 Effects on sea level rise

The rate of sea level rise since the mid-nineteenth century has been higher than the average rate during the previous two millennia. Between 1901 and 2010, the global mean sea level rose by 0.19 m [0.17 m to 0.21 m] and 75% of this rise was caused by warming and melting of polar ice (IPCC, 2014). The situation is worrying because nearly a quarter of the world's population currently live within 100 km of a coast and that is expected to rise to 50% by 2030 (Adger *et al*., 2005 in Takeuchi *et al*., 2014). Coastal areas with a high number of people are therefore in increasing risks. Resilient coastal wetlands will play a key role in mitigating these risks associated with sea level rise (see Figure 7.7).



Source: IPCC (2014)

Figure 7.7 Global average sea level change

7.5.3 Effects on precipitation

Precipitation has increased since 1901 over the mid-latitude land areas of the Northern Hemisphere, but there is variation over other latitudes (IPCC, 2014). Changes are evident in the amount, intensity, frequency, pattern and type of precipitation. These changes can be influenced by natural variability like the effects of El Niño, but important long-term trends have been picked up where eastern North and South America, northern Europe and north and central Asia are becoming wetter, while the Sahel region, southern Africa, the Mediterranean and South Asia are becoming drier. Also noted is that precipitation is increasing in intensity even in places where total rainfall is decreasing (IPCC, 2013). Great regional and seasonal contrasts in precipitation are clear. This erratic nature of precipitation makes emergency planning very difficult.

7.5.4 Effects on ocean acidification

About 30% of atmospheric CO_2 emission is absorbed by the ocean, and increased CO_2 concentration since the Industrial Revolution has led to ocean acidification. A 26% increase in ocean acidity (measured as hydrogen ion concentration) was observed since the industrial era with a corresponding fall in the ocean pH value of 0.1%. This has serious negative consequences on marine species like coral reefs (IPCC, 2013, 2014).

7.5.5 Effects on human and natural systems

In recent decades, climate change has made widespread impacts on human and natural systems, indicating the sensitivity of natural and human systems to changing climate. For example, increased precipitation and snow melt has changed the hydrology in many areas in terms of water quantity and quality. Many terrestrial, freshwater, and marine species have shifted their geographic bands, seasonal activities, migration patterns, abundances, and species interactions in response to ongoing climate change. There are reported evidence of loss of certain species and changes in ecosystems. The negative impacts of climate change on crop yields is more common than positive impacts. There is evidence of a drop in food production, especially cereals in many low latitudes; shift and spread of vector-borne diseases like mosquitos with a corresponding shift in the malaria band zones (IPCC, 2007, 2014).

7.5.6 Effects on extreme events

Climate change exacerbate or alter existing hydrometeorological hazards, such as droughts, floods, storms and heatwaves (UNEP/UNISDR, 2008). Extreme events such as cyclones, floods and droughts showed an upwards trend since the 1980s. Climate scientists predict more extreme weather events and other environmental disasters that challenge traditional notions of protection, based on strength or resistance alone (Dessai *et al*., 2007 in Takeuchi *et al*., 2014; IPCC, 2014). The DRR and CCA practitioners therefore need to start thinking out of the box.

The frequency of heatwaves has increased in many parts of Europe, Asia and Australia due to increased frequency and intensity of extreme temperature observed since the mid-twentieth century. Warming has increased heat-related human mortality and decreased cold-related human mortality in some regions.

There are many regions where the number of heavy precipitation events has increased than where it has decreased, resulting in more extreme flood episodes. There is also a rise in coastal flooding due to a rise in sea levels. Impacts from recent climate-related extremes, such as heatwaves, droughts, floods, cyclones and wildfires, reveal significant vulnerability and exposure of some ecosystems and many human systems to current climate variability (IPCC, 2014).

According to IPCC (2007), the number of intense hurricanes (Category 4 and 5) has increased over the last decades and the most affected regions include southern America and northern Australia (Usman and Reuson, 2004 in Ludwig *et al*., 2009; Webster *et al*., 2005).

7.5.7 Effects on water

Water is one of the basic needs of humans and the water sector is one of the most sensitive sectors to climate change. Climate variability (natural cycle) and climate change (anthropogenic plus natural factors) have serious impacts on precipitation and rainfall. Some areas receive more rainfall while others, especially subtropical areas, receive less (IPCC, 2007; Ludwig *et al*., 2009). Therefore, global water availability in rivers, lakes and groundwater has changed significantly over the past decades. These changes, especially on surface water discharge, can be partially linked to climate change, though other factors like increased water demand and water withdrawal due to population growth and expanding economic activities, should also be considered (Ludwig *et al*., 2009). For example, the water level in Lake Chad in northern Cameroon has declined over the years due to both human activities and reduced rainfall (Ludwig *et al*., 2009).

The timing of river-flow in regions with winter snowfall has changed significantly (Barnet *et al*., 2005 in Ludwig *et al*., 2009). High temperatures, early snowmelt, increase precipitation in winter in the form of rainfall instead of snowfall, have resulted in higher early river discharge during springs and less stream discharge in summer when the demand for water is usually high. This has resulted in water shortages and poses a problem in water resource management (Ludwig *et al*., 2009). There is a good relationship between surface flow and groundwater levels through recharge and discharge. Arid areas which are most dependent on groundwater may face serious water problems with increased reduction in rainfall, as predicted by the IPCC (2007).

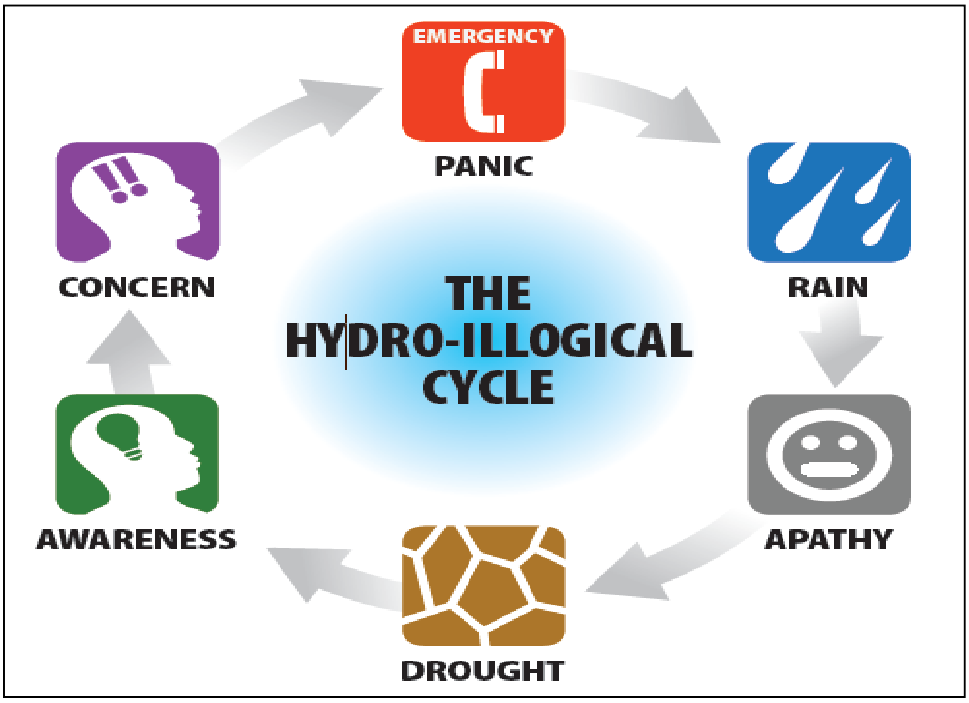
7.5.8 Effects on dry spells and droughts

The intensity and duration of dry spells and droughts have increased globally since 1970, especially in the tropics and subtropics (IPCC, 2007; Ludwig *et al.*, 2009). The increase in duration and intensity of droughts can be attributed to a drop in rainfall and an increase in temperature in most areas, especially the semi-arid and Sahel regions. However, Nicholson (2005) claims that rainfall has recovered in the Sahel areas since 1998, but semi-arid areas like eastern Australia are becoming drier with records of worst droughts since 2003 (Smith, 2004 in Ludwig *et al*., 2009). Other semi-arid regions like the south-western USA and part of southern Canada have also recorded increased drought episodes in the past decades due to reduced rainfall (Ludwig *et al*., 2009). However, it should be noted that poor agricultural practices, poor land use and land cover systems could be the root cause of many agricultural droughts, while extreme vulnerability to droughts could turn simple dry spells into drought disasters (Jordaan, 2011).

There are current and projected increases in the incidence of drought frequency, severity and duration as a result of climate change (De Groeve *et al*., 2014; GWP/WMO, 2014). The global trends in the management of droughts have always been reactive, based on the hydroillogical cycle as discussed in the next section.

7.5.8.1 The hydro-illogical cycle

The hydro-illogical cycle of the National Drought Mitigation Center at the University of Nebraska-Lincoln, shows how drought, as a slow-moving natural disaster, tends to emerge slowly and then intensifies until people can no longer ignore it or wish it away (Figure 7.8). When a drought ends, people are often glad to forget about it and to resume business as usual, forgetting to stop and learn from past experiences that will help them ease up pain during the next drought (Jordaan, 2012; WMO/GWP, 2014). There is a great need for a paradigm shift from crisis management to risk management with regard to droughts (WMO/GWP, 2014). This shift requires good drought policies, effective preparedness and early warning systems, drought risk reduction and response planning.



Source: WMO/GWP (2014)

Figure 7.8 The hydro-illogical cycle

Droughts affect many sectors such as agriculture and food security, water and energy, transportation, health, recreation, tourism and the general natural environment. These cross-sectoral impacts of droughts necessitate integrated drought management programmes (WMO/GWP, 2014). Like most natural disasters, the economic, social and environmental impacts of droughts have increased significantly in recent decades (WMO/GWP, 2014). According to the Food and Agricultural Organization, droughts are the world's most destructive natural hazard with devastating impacts on food security and food production. The frequency as well as intensity of droughts has increased over the past 20 years due to climate change and it is expected that this trend will intensify in the future (De Groeve *et al*., 2014).

The main problem with water is that it may exist in three undesirable states, namely too much resulting in floods, too little leading to droughts or too dirty as a result of pollution. Another important consideration about water is the affordability of increasing scarce water that exists in an undesirable state. A series of drivers push water into such undesirable state and of paramount importance to water resource managers is how to redress these drivers. Natural ecosystems such as wetlands, provides affordable solutions to water-related dilemmas in many areas and this is one of the reasons for this research. There is therefore need to rethink the management approaches that are more holistic and proactive. It also means looking at approaches that can be community-driven and that uphold the tenets of living in symbiosis with our natural environment. Eco-DRR/CCA is one of such approaches and is the philosophical approach of this research.

7.5.9 Effects on tropical cyclones

Tropical cyclones can cause a lot of damage to human life, their assets and the environment and for the past 30 years, the location where tropical cyclones reach maximum intensity has been shifting toward the poles in both the northern and southern hemispheres at a rate of about 56 km, or one-half a degree of latitude, per decade (National Oceanic and Atmospheric Administration, 2014).

As tropical cyclones move into higher latitudes, some regions closer to the equator may experience reduced risk, while coastal populations and infrastructure pole-ward of the tropics may experience increased risk. With their devastating winds and flooding, tropical cyclones can especially endanger coastal cities which are not adequately prepared to respond to cyclones. Additionally, regions in the tropics that depend on cyclone rainfall to help replenish water resources may be at risk for lower water availability as the storms migrate away from them (IPCC, 2007; National Oceanic and Atmospheric Administration, 2014).

7.5.10 Effects on ecosystems

Ecosystems are dynamic and fragile systems that are very sensitive to climate change. Climate change is altering ecological systems, biodiversity, genetic resources, and the benefits derived from ecosystem services. Ecosystem services that are already under threat from the impacts of climate change include pollination, pest, and disease regulation, climate regulation services; and potable water supply (IPCC, 2014). Climate change is also inducing shifts in habitats that often cannot be followed by species, leading to changed ecosystems, to local and global extinctions, and to the permanent loss of unique combinations of genes. The effects of climate change on wetlands is explored in section 7.9.2 below.

7.6 CLIMATE CHANGE PROJECTIONS

Climate prediction is the estimation of the climate in the future based on actual observation, while climate projection is the simulated responses of climate systems to an emission scenario based on assumptions of future economic growth and development. Mostly used are climate projections. The IPCC (2014) models use the representative concentration pathways (RCPs) with four possible scenarios:

- One mitigation scenario with low forcing levels (RCP 2.6).
- Two stabilisation scenarios with an RCP of 4.5 and 6.0.
- One high greenhouse gas emission scenario with an RCP of 8.5 (IPCC, 2013).

The big question about climate change projection is whether the worst is still to come and the IPCC latest report warns that:

> *Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems* (IPCC 2014:7).

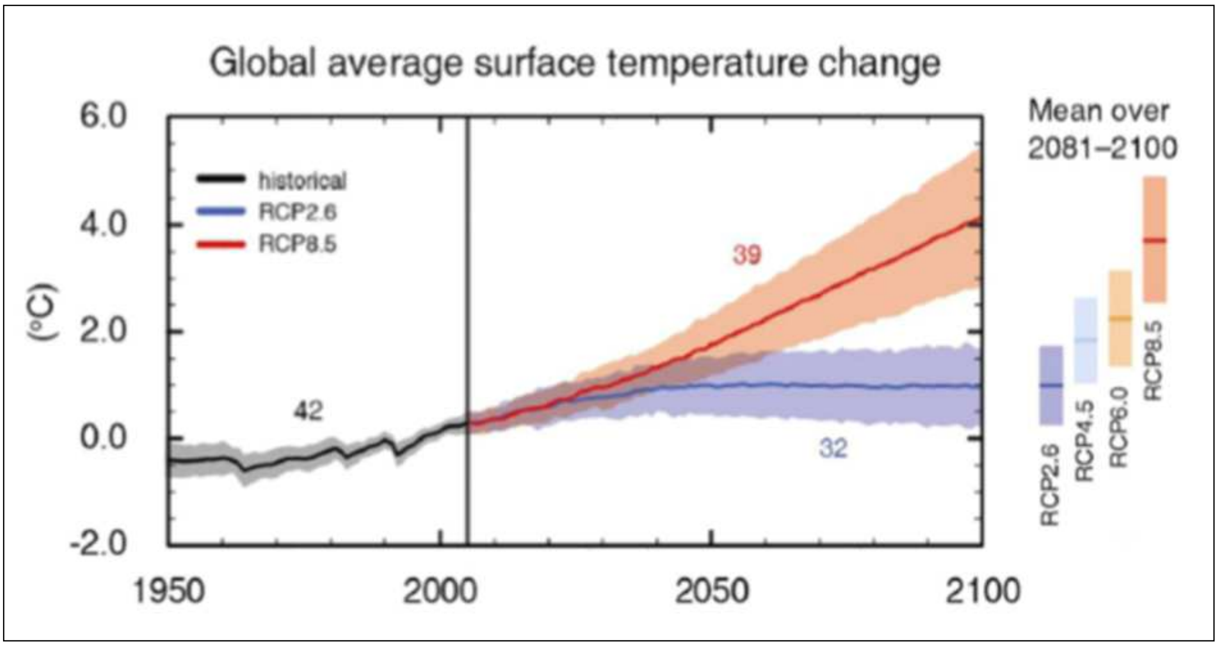
As if the above statement is not enough warning, the 2014 IPCC report further states that:

> *Many aspects of climate change and associated impacts will continue for centuries, even if anthropogenic emissions of greenhouse gases are stopped. The risks of abrupt or irreversible changes increase as the magnitude of the warming increases* (IPCC, 2014:11).

Some of these projections are important to note so that proper management of ecosystems such as wetlands can be highlighted.

7.6.1 Projected temperature

With no action to reduce the emission of global CO_2 surface temperature is projected to increase by 4 °C by the end of the twenty-first century, at an RCP of 6.0; temperature is projected to increase by 2 °C at an RCP of 8.5 while at all possible emission reduction scenarios the global temperature will increase by 1.5 °C by the end of the twenty-first century (IPCC, 2013) (Figure 7.9).

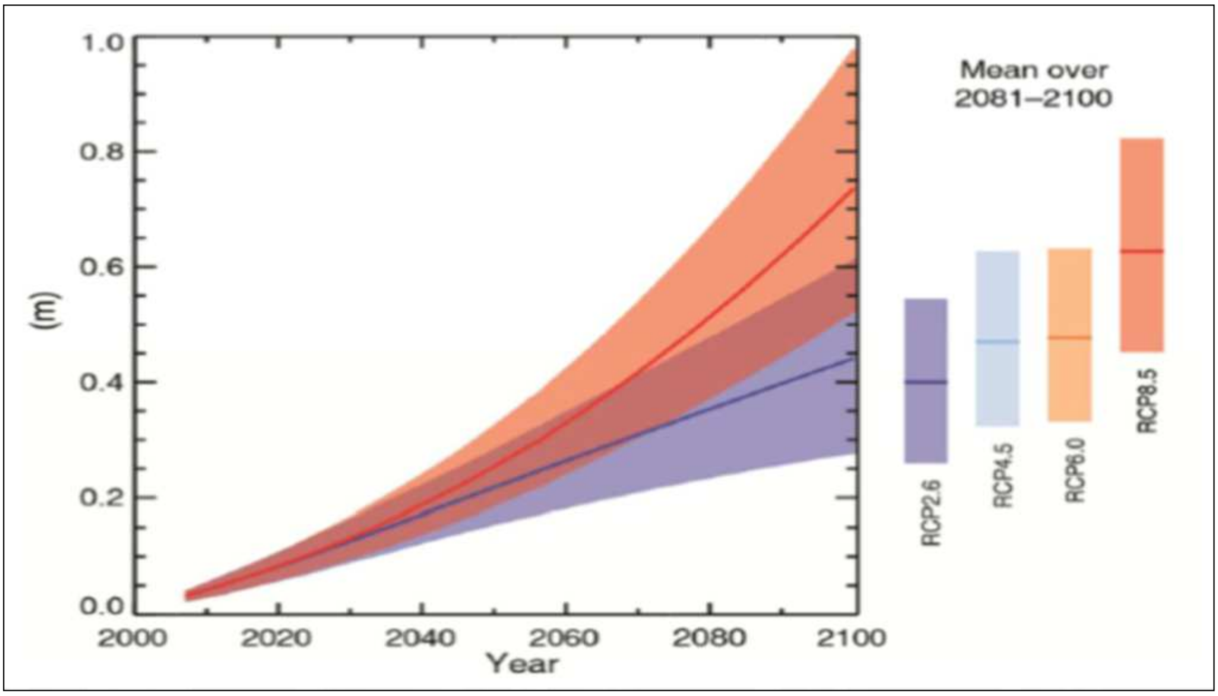


Source: IPCC (2013)

Figure 7.9 Projected global average surface temperature change at different RCPs

7.6.2 Projected global sea level rise

Sea level rise will continue to increase in the twenty-first century under all possible scenarios in the range of 0 m to 0.98 m (Figure 7.10). This rise will exceed what was observed between 1971 and 2010 as a result of rising global temperatures and their impacts, especially in the arctic region (IPCC, 2013).



Source: IPCC (2013)

Figure 7.10 Projected sea level rise at different representative concentration pathways

7.6.3 Projected precipitation

Great contrast in precipitation should be expected between wet and dry regions and wet and dry seasons. The risk of both flood and drought will increase. Extreme precipitation events are most likely to intensify and become more frequent over most arid land masses and over wet tropical regions.

7.6.4 Projected ocean acidification

While ocean acidification is projected to change very little, high carbon emissions at an RCP of 8.5 will cause the ocean pH value to fall and this will have high impacts on marine species with shells including coral reefs (IPCC, 2013).

7.7 CLIMATE CHANGE IN AFRICA

Climate change will significantly affect the risk profile of Africa. Africa is considered the most vulnerable continent to the impacts of climate change (IPCC, 2007, 2014; UNEP, 2009; UNISDR, 2015). Half of the 37 African cities with a population of more than one million are located in low-lying coastal areas and face high risk of sea level rise, coastal storms, coastal erosion, flooding and saline sea water intrusion. Sea level rise will affect most low-lying coastal cities such as Alexandria, Cairo, Lagos, Lome and Cotonou (UNEP, 2009).

Most parts of Africa are projected to witness less precipitation, except the east central regions. An increase in precipitation of 5% to 8% is projected for arid and semi-arid regions under many scenarios. By 2020, between 75 and 250 million Africans will be water stressed due to climate change and this will have severe consequences on agricultural production and access to food. A 50% drop in yield from rain-fed agriculture is projected for some African countries. Changes in rainfall will also lead to increase in the risk of diarrheal infection due to floods and droughts. Meanwhile, general temperature increases will lead to increased risk and spread of malaria as the mosquito band increases (IPCC, 2014; UNEP, 2009).

7.8 CLIMATE CHANGE IN SOUTHERN AND SOUTH AFRICA

7.8.1 Climate change in southern Africa

There has been a general trend of warming in southern Africa over the last few decades. Temperatures has risen by over 0.5 ºC over the past 100 years; the Indian Ocean has warmed by over 1 ºC since 1950. There has also been a general decrease in rainfall in southern Africa with below normal rainfall periods becoming more frequent (SADC, 2010). Between 1988 and 1992, droughts have become more recurrent, while the frequency and intensity of the El Niño episodes have increased. Southern Africa is predicted to be hotter and drier in the future and like the rest of Africa, southern Africa is very vulnerable to the impacts of climate change (SADC, 2010). Climate change has affected, and will continue to affect, especially climate-sensitive sectors such as agriculture, water, infrastructure and transport, coastal zones, health, energy, urban planning and management, tourism, biodiversity and ecosystems, forests, fisheries and the general environment. All these effects require adaptation and mitigation measures (SADC, 2010).

7.8.2 Climate change in South Africa

South Africa is very vulnerable to the impacts of climate change and at the same time South Africa is one of the highest emitters of greenhouse gases *per capita* of GDP in the world (Winkler, 2010).

Climate change projections show that in the next 50 years, the western part of South Africa will become drier, while the eastern part will become wetter. There will be increased temperature in the interior of South Africa and there will be an increase in the frequency and intensity of extreme weather and climate events (IFRC, 2012; IPCC, 2012). Sub-continental warming is expected to be greatest in the northern region; temperature is expected to increase between 1 ºC to 3 ºC in the twenty-first century, and the highest rise in temperature will occur in the most arid regions (Grundling, 2012; IPCC, 2007). There will be a general reduction of rainfall between 5% and 10% in the summer rainfall regions like the FS, while there will be marginal increase in early winter rainfall for the winter rainfall regions like the Western Cape (Grundling, 2012). There will be increase incidents of both drought and floods as prolonged dry spells (at times accompanied by poor land use management) will be followed by intense storms (Grundling, 2012; IPCC, 2007; Jordaan, 2011). All in all, South Africa might witness a drier north and west, marginal wetter south and east, but rainfall will become more erratic accompanied by intense storms (Grundling, 2012; IPCC, 2007).

Until 2012 South Africa, like most developing countries, had no binding greenhouse gas emission mitigation obligation under the Kyoto Protocol, but the country is taking measures to reduce greenhouse gases and green the economy under the direction of the RSA DEA with key role players like the Energy Research Centre (Winkler, 2010). Targeted sectors for greenhouse gas reduction in South Africa include the energy sector with emphasis on the use of renewable energy sources like wind energy, the agricultural sector, the transport sector, and manufacturing industries such as the cement industry (Winkler, 2010).

Under the UNFCCC and the Kyoto Protocol, South Africa has decided to take very ambitious steps in climate change mitigation using long-term mitigation scenarios (Winkler, 2010). South Africa agreed to peak (by 2020–2025), plateau (by 2030–2035) and decline (by 2040–2050) her greenhouse gas emissions (Winkler, 2010). Wise and sustainable management of wetlands can contribute immensely to the realisation of these targets set by South Africa. Note should, however, be taken that there is a tricky balance between greenhouse gas emissions and sustainable development, especially for developing countries that require careful analysis and international support, for example, how South Africa would move from coal with high carbon emissions to renewable energy like wind and solar energy.

7.9 WETLANDS AND CLIMATE CHANGE

There is an important two-dimensional relationship between wetlands and climate change that needs efficient management practices. Wetlands biodiversity is affected by climate change with negative consequences on human well-being, but wetland biodiversity, through the ecosystem services also makes an important contribution to climate change mitigation, CCA and DRR (De Souza Dias, 2015).

7.9.1 Effects of wetlands on climate change

Wetlands occupy about 1 280 million hectares or about 3% of the global surface (Dudley *et al*., 2010; Grundling, 2012; RSC, 2010c; Spray and McGlothlin, 2004). However, wetlands store about 33% of soil organic matter, making them the largest global soil carbon reservoir with a carbon storage rate ranging from 23 g to 50 g of carbon per square metre per year (Eswaran *et al*., 1993; MWP, 2012; Schlesinger, 1997 in Spray and McGlothlin, 2004). The current climate changes are putting much of this stored carbon at risk (Dudley *et al*., 2010).

Carbon dioxide and methane account for 80% of global warming potential of all greenhouse gases (IPCC, 2007) and their release from wetlands can have significant impacts on global climate change (Spray and McGlothlin, 2004). The draining of wetlands, especially peats, for agricultural and other activities changes wetlands from carbon sinks to carbon sources because the soil conditions change from anaerobic to aerobic; soil temperature increases and soil water content reduces (Spray and McGlothlin, 2004). Wetlands release methane as an end product of methanogenesis which account for 20% to 40% of annual global atmospheric methane flux. Methane has many times more warming potential than carbon dioxide. Tropical wetlands with higher temperature and microbial activities year-round produce 51% of global wetlands atmospheric methane flux (Spray and McGlothlin, 2004).

Wetlands, especially peatlands, are the largest stores of carbon estimated at 1 300 ton of carbon per hectare or 550 gigatons of carbon globally. Most of these peatlands are located in the tropical forest of Southeast Asia, especially in Indonesia, as well as the tundra permafrost of far north Russia, Canada, Alaska and Scandinavia (Dudley *et al*., 2010). The current global warming may eventually lead to the release of the abundantly stored carbon in tundra regions (Dudley *et al*., 2010). Peatlands store twice the amount of carbon than all global forest biomass combined and, globally, natural peatlands are destroyed at a rate of 4 000 km^2 per year, with 50% attributed to agriculture, 30% to forestry and 10% to peat extraction (Moses, 2008). If continually disturbed by various development activities, wetlands would become a major source of global warming.

The complex biogeochemical processes in wetlands, natural variation in wetland soil chemistry and the hydrological regimes in wetlands make it difficult to predict the response of wetlands to climate change (Spray and McGlothlin, 2004). Generally, wetlands, particularly peatlands, are sinks for carbon and nitrogen, but sources for methane and sulphur are such that the balance between these various interactions determines whether the wetland system as a whole is a net source or sink of carbon (Dudley *et al*., 2010). Knowledge about this balance is very poor, especially with tropical wetlands, but continuous draining and burning of peatlands for palm plantations is a major source of carbon emission (Dudley *et al*., 2010).

Pressure on wetlands resources by local communities which depend on these resources for their livelihoods may increase climate change effects. For example, continuous degradation of the lowland ranges in Lesotho has affected the traditional transhumance systems that interspersed cattle grazing in these areas with grazing in upland areas. This system is now replaced by a more sedentary grazing that concentrates livestock in wetlands in the mountains which contains a lot of peat. This puts pressure on wetlands, because cattle trample on the peat, thus increasing carbon loss, while the more resident human population in upland areas has increased the harvesting of peat for fuel as well as cultivation in the wetlands for food production (Dudley *et al.*, 2010). It is therefore important to manage wetlands holistically and carefully using a systems thinking approach.

South Africa has some of the oldest peat wetlands that have accumulated carbon over thousands of years (MWP, 2012). South Africa's peat wetlands occur mostly in the wetter eastern and southern part of South Africa and are mostly groundwater systems dependent for recharge.

About 50% of South Africa's wetlands have been degraded, including 25% of peatlands. The degradation of peatlands leads to the release of CO_2 into the atmosphere. For example, 300 000 tons of CO_2 was released from peatlands in 2008 alone. About 194 million tons of CO_2 still lie in peat wetlands, while 2 200 million tons of CO_2 are stored in other wetlands types in South Africa (Grundling, 2012). All these carbon stores in wetlands will be released if present healthy wetlands are degraded. It should be noted that even in a healthy state wetlands emit methane, which potentially offsets a lot of the wetland's positive contribution as a carbon sink (MWP, 2012). The management of wetlands as both carbon sink and carbon sources and the cause and effects of climate change on wetlands need careful consideration and planning.

7.9.2 The potential effects of climate change on wetlands

The impact of climate change on wetlands will mostly be measured on the alteration of the hydrological regime or hydro-period of the wetland (the periodic of saturated conditions or inundation that differentiates wetlands from terrestrial and fully aquatic habitats) (Acreman *et al*., 2011; Erwin, 2009). The type and magnitude of these impacts of climate change on wetlands vary and depend on the local natural conditions, the impact of human activities on the wetland, the current state and type of the wetland, the environmental requirements and species tolerances of the wetland, the level of sea level rise and the changes in the depth of inundation of the wetland, the severity of extreme events, as well as the biochemical changes within the wetland as a result of elevated temperatures (Akumu, 2011; Erwin, 2009; MWP, 2012). Acreman *et al*. (2011) suggest that the impact of climate change on wetlands will broadly depend on three elements:

- The likely chances, magnitude and direction of climate change.

- The changes in the catchment water pathways and whether the wetland is rain-fed, river-fed or groundwater-fed.
- The sensitivity of the wetland ecosystem to hydrology alteration, that is the magnitude of hydrological change required to cause an ecological impact.

The climate change impacts on the wetlands will affect the interest features of the wetland. The interest features are the main values of the wetland such as the importance of the vegetation community of the wetland, and each of these interest features may require a different hydrological regime to conserve the interest feature (Acreman *et al*., 2011).

This therefore makes wetlands management a complex process, requiring a holistic and forward-planning approach.

Climate change impacts on wetlands also include change in the base flow, increased heat stress on wetland wildlife, extended activity of pest and disease vectors, increased flooding, increase soil erosion and sediment load, decrease recharge of floodplain aquifers, decrease in water quantity and quality, increase risk of fires, increased coastal erosion, increased damage to coastal ecosystems such as coral reefs and mangroves (Ramsar, 2002 in Erwin, 2009). Climate change also alters the biogeochemistry of wetlands, alter the amount and pattern of suspended sediment loadings in wetlands, oxidation of organic sediments and physical effect of wave energy. Climate change may also affect wetlands indirectly through land use changes (Erwin, 2009).

In a study of the impact of climate change on wetland functions in Korea, Kim *et al*. (2012) concluded that about 10% of wetland functions will change in future due to climate change. Rise in temperature and precipitation resulted in change in the surface area of wetlands resulting in the change in the number of water birds in the wetland (Withey and Van Kooten, 2011; Kim et al., 2012). Climate change reduced the functions of wetlands as it affected the average depth of inundation, tree density, tree basal area and canopy gap, thus the individual number of water birds were reduced (Kim *et al*., 2012).

Day *et al*. (2008) note that climate change impacts can disrupt the complex ecogeo-morphological and biological processes in wetlands systems when they occur at a rate and time scale that does not allow the wetland to naturally adjust to the impacts, and worse, if such climate change impacts are accompanied by human stressors on the wetland (Day *et al*., 2008). Though wetlands could naturally adjust to the impacts of climate change, for example vertical accretion due to sea level rise, the additional burden from human impacts could restrict this ability, thus management of wetlands for climate change must strike a balance between promoting material and energy into the wetland to sustain wetland goods and services, while protecting human structures and activities within the wetland (Day *et al*., 2008).

In a study of the effects of climate change on coastal wetlands in New South Wales in Australia, Akumu (2011) found out that a rise of the mean annual temperature beyond 7 °C could likely lead to a complete loss of suitable habitats for wetland species by the end of the twenty-first century. A sea level rise of a meter could considerably decrease the extent of inland fresh marshes and force them to migrate into adjacent uplands, while mangroves and salt marshes could easily adapt and increase in extent aided by continuous sedimentation that will increase vertical elevation of these coastal wetlands.

In a study of climate change impacts on British wetland vegetation communities, Acreman *et al*. (2011) concluded that reduced summer rainfall and increased summer evaporation (the same conditions as predicted for the eFS) would put stress on wetland plant communities in later summer and autumn. The authors further concluded that rain-fed wetlands were more negatively affected than river-fed wetlands (Acreman *et al*., 2011). Wetlands in the eFS are likely to face these same effects because the area has the same summer rainfall regime, the wetlands are mostly seasonal and rain-fed valley-bottom wetlands and temperature and evaporation are predicted to increase as a result of climate change (RSA DEAT, 2004). The direct effects of temperature rise and the increased concentration of CO_2 into the atmosphere, as well as the indirect effects in the global and regional distribution of precipitation, change the functioning of wetlands (ACC, 2011). Rising temperatures will reduce the water quality in aquatic ecology by reducing the oxygen concentration in water, release of phosphorous from sediments, increased thermal stability and alter mixing patterns. Higher temperatures will also negatively affect micro-organisms, benthic invertebrates as well as the distribution of many fish species (ACC, 2011).

Water levels in wetlands are expected to reduce in the low latitudes where climate models indicate a decrease in annual precipitation, and dryland wetlands will be the most vulnerable due to their sensitivity to the balance between inflow and evaporation from the wetlands. Reduced inflow due to a decrease in precipitation, and increased evaporation due to rising temperatures may have serious consequences, like biodiversity loss within wetlands and at the extreme leads to the drying up and even the disappearance of some wetlands (ACC, 2011).

7.9.3 Effects of climate change on wetlands in South Africa

South Africa is very vulnerable to climate change and water, disease, food security and environmental migration are key areas where climate change will exacerbate existing development challenges (Africa Development Bank and WWF, 2012). A drier subtropical region like South Africa experiences warming more than the moister tropical areas. Wetlands are sensitive to the amount and seasonality of water they receive, and need a positive water balance for at least part of the year to maintain their functioning. Climate is an important external driver which influence the quantity and timing of rainfall and streamflow into wetlands (MWP, 2012).

Many wetlands in South Africa, and especially those in the eFS, are seasonal in character, flooding only during the wet season (in summer in the case of eFS) or for a short period when there is a temporary abundance of water in the area. Many of South Africa's wetlands are also connected to the aquifer (groundwater systems) that recharge them during periods of no rainfall, and changes in temperature and rainfall due to climate change will alter recharge rates to groundwater stores, thus reducing the discharge of water from these aquifers into wetlands. Wetlands without water or with considerably less water may become dry-lands, thereby losing many of their ecological attributes that make them valuable ecosystems to people (MWP, 2012).

Wetlands in drier regions of South Africa will receive less rain and will suffer from desiccation and fire. Meanwhile there will be accelerated erosion in drought-prone areas, as well as areas experiencing intense storms and flooding. The situation will pose serious wetlands management challenges at catchment level (Grundling, 2012).

Erratic rainfall patterns with prolonged droughts will increase the vulnerability of wetlands to land use changes as wetlands may now compete with societal need for water. Most affected wetlands will be those dependent on primary aquifers like the karst in the drier west and unconsolidated sands in the Cape West Coast (Grundling, 2012). Land changes that may affect wetlands in the face of climate change include water abstraction for agricultural and domestic consumption, expansion of timber plantations and woodlots, uncontrolled subsistence farming within and near wetlands, as well as poor grazing practices (Grundling, 2012; Kotze, 2012).

With climate change, some wetland services are becoming increasingly important. There is therefore the growing need to appreciate how society, wetlands and climate are closely connected in direct and indirect ways. While wetlands are affected by human-induced climate change, the same wetlands also provide a buffering role to climate risks and help communities to adapt to climate change (MWP/WESSA, 2012).

Human-induced climate change affects the hydrology and carbon flux in South African wetlands. Rainfall is predicted to decrease for much of the winter rainfall region (Western and Northern Cape and parts of the Eastern Cape) and western margins of the South Africa, but better rainfall is predicted on the eastern margins (MWP/WESSA, 2012). Even small shifts in climate may alter not only the quantity of water into wetlands, but also the timing of the water input. Because ecological processes in wetlands are mainly regulated by the quantity and timing of flows, major climate change-driven changes in water flows are likely to lead to change in wetland structure and functioning and therefore the ecological services that wetlands provide to the local communities (MWP/WESSA, 2012). Changes in rainfall and temperature also affects the seasonality of most South African wetlands, as well as the rate of groundwater recharge that feeds many wetlands in the country (MWP/WESSA, 2012).

7.9.4 Effects on the carbon fluxes in wetlands

The saturated conditions in wetlands promote soil organic matter accumulation that over many years formed peat, and South Africa has some of the oldest peatlands in the world (Grundling, 2012; MWP, 2012). However, when peatland is dried out, a lot of the accumulated carbon over many years is lost within a few years. Thus, peatlands need to be conserved and well managed to avoid emission of large quantity of carbon into the atmosphere. Some sources suggest the building of artificial wetlands to counteract the emission of carbon burning fossil fuels. However, a counter argument is that wetlands emit methane, which could potentially offset a wetland's positive contribution as a carbon sink. Thus, wetland creation may not be a good solution to address the burning of fossil fuels which has accumulated much carbon over the years (MWP/WESSA, 2012).

7.10 BUILDING WETLANDS RESILIENCE TO CLIMATE CHANGE

Resilience mean the capacity of a system to absorb disturbance and reorganise, while undergoing change so it still retains essential functions, structure, identity, and feedbacks (Adger, 2000 in Takeuchi *et al*., 2014; Walker *et al*., 2004). Climatic extremes are predicted to become worse, and wetlands can play an important role in mitigating the effects of these extreme events (MA, 2005). Coastal wetlands, especially mangroves provide protection against storms. For example, research has shown that when a coastline is battered by a tsunami, sections with intact mangroves are generally less severely impacted than those without mangroves (IPCC, 2012, Renaud *et al*., 2013). Wetlands store water in the local landscape especially during dry spells and this stored water support plant growth which becomes critical source of food for livestock or cultivated crops for the direct human consumption. In this way, a wetland can be a life-saving safety-net for poor rural communities.

7.10.1 Climate-smart conservation of wetlands

Climate-smart conservation is described by Stein *et al*. (2014) as:

The intentional and deliberate consideration of climate change in natural resource management, realized through adopting forward-looking goals and explicitly linking strategies to key climate impacts and vulnerabilities.

Climate-smart conservation is context-specific, but some characteristic indicators could show if the conservation of the natural resource such as wetlands is taking climate change impacts into its policy and operational activities (Stein *et al*., 2014). These characteristics are indicated in Table 7.3.

Because of its increasing and far-reaching effects on ecosystems such as wetlands, climate change is now becoming the primary lens through which conservation and natural resource management must be evaluated. The traditional practice of protecting and managing wetlands (like other ecosystems) in order to maintain their current states, or to restore degraded wetlands back to a historical state, needs to change to adopt forward-looking goals. To meet these goals, strategies which are specifically designed to prepare for and adjust to current and future climatic changes and the associated impacts on wetlands and human communities needs to be efficiently implemented. This new philosophy and discipline find expression in the emerging CCA discipline (Stein *et al*., 2014).

TABLE 7.3: CHARACTERISTICS OF CLIMATE-SMART CONSERVATION

Indicator	Action
Linking actions to climate impacts	Conservation strategies and actions specifically tackle the impact of climate change in line with existing threats and are backed by scientific evidence
Formulating forward-looking goals	Conservation goals are long term and not influenced by the past, while short-term challenges are built into transitional strategies
Considering broader landscape context	Appropriate geographical scales are used to take care of on-site and off-site influences and impacts In the case of wetlands, a catchment approach will be suitable
Adopting strategies robust to uncertainty	Strategies and actions are varied to account for future uncertainties in climatic conditions, and in ecological and human responses to such climatic changes
Employing agile and informed management	Continuous management skills development, flexibility and acquisition of new knowledge and making necessary adjustments are vital ingredients to enable natural resources managers to cope with climatic changes and the ecological and socio-economic responses to such changes
Minimising carbon footprint	Manage ecosystems such as wetlands to minimise greenhouse gas emissions, to cycle, sequester and store carbon
Accounting for climate influence on project success	Consider how foreseeable climate impacts may negatively affect the success of a project and mitigate such impacts or avoid such projects, except they are part of an international strategy Proper EIA could be very helpful in this situation

Safeguarding people and nature	Management strategies and actions should enhance the health of the ecosystem in order that they protect the human community from the negative impacts of climate change, while maintaining their ecological integrity
Avoiding maladaptation	Strategies and actions should not exacerbate other climate related vulnerabilities or undermine conservation goals and broader ecosystem (wetlands) sustainability

Source: Adapted from Stein *et al*. (2014)

The future fate of wetlands depends on current steps taken by international organisations, national governments, civil societies and the local communities to prepare for and cope with the growing impacts of climate change. Linking climate impacts to conservation actions on ecosystems such as wetlands is at the very heart of climate-smart conservation (Stein *et al*., 2014). Climate-smart conservation of wetlands is therefore one way of building wetland resilience to climate change.

7.10.2 Green economy and wetlands resilience

UNEP (2012) defines *Green Economy* as one that leads to improvement in human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. It is an economy with low carbon, resource efficient and is socially inclusive. Practically in a *Green Economy* there is growth in income and employment driven by public and private investments; there is reduced carbon emissions and pollution; enhanced energy and resource efficiency, and prevention in the loss of biodiversity and ecosystem services. Building of natural capital is critical in a *Green Economy* as a source of public benefits, especially for poor people whose livelihoods and security depend strongly on nature (UNEP, 2012).

From the above explanation, the link between effective wetlands management and *Green Economy* is brought to the fore. Effective wetlands management is about preventing, and where impossible, mitigating the loss in biodiversity and wetlands ecosystem services. Effective wetlands management is all about wise and sustainable use of the wetland that helps to conserve and build the natural capital on which many poor rural masses depend for their livelihoods.

The link between CCA, *Green Economy* and wetlands management is that the efficient management and conservation of wetlands is part and parcel of the new concept of *Green Economy* since it helps to build the stock of natural capital on which many, especially the poor, depend for their livelihoods. Meanwhile, the philosophy and practices in the concept of *Green Economy* is one excellent way of adapting to climate change. Such adaptation promotes local community and ecological resilience and thus ensures sustainable development.

Green Economy is centred on harmonious co-existence between humans and the sustainable use of natural resources. For example, the concept of *Green Village* (WRC, 2014) is based on developing and integrating alternative green options that promote sustainable use of natural resources for human well-being without degrading the natural ecosystem such as wetlands. This principle is similar to the concept of *Green Landscape* (WRC, 2014) where nature co-exists in harmony with residents, is respected and enjoyed, resources are recycled, ecosystems are not degraded, use of renewable energy such as windmills and solar energy, proper sanitation and waste management (WRC, 2014).

Green Economy is sustainable, because it balances natural resource values with other values, and takes into account the loss in value of ecosystem services due to environmental impacts of human actions. The *Green Economy* provides a chance to ‘get the balance sheet right’ by accounting for both the current and future value of the benefits that ecosystems provide to people. For example, the deforestation of a watershed often only account for the price of the timber and the cost of transportation, while neglecting the water purification value and the carbon sequestration value of the forest. It is estimated that the extractable value of Cameroon’s tropical forests is about $700 per hectare per year (for timber, fuel wood and non-timber products), but this figure is less than the forests’ climate and flood benefits, which amounts to about $900 to $2 300 per hectare per year (UNEP, 2010). Only the *Green Economy* principle that includes the ecosystem approach, can produce such a balanced view (TEEB, 2010; UNEP, 2010).

7.10.3 Carbon trading

The carbon market is the buying and selling of emission permits from a regulatory body or a greenhouse gas emission reduction project. Greenhouse gas emission reduction are traded in carbon credits where greenhouse gases equal one metric ton of CO_2 (Carbon Link, 2013). Carbon trading may hold good prospects in building wetland resilience through wetland conservation, especially peat wetlands.

Carbon credits can be accrued in two ways:

- Emission avoidance like reduction in the use of fertiliser in farming operations, but which has the pitfall in that it does not remove the accumulated atmospheric CO_2.
- Sequestration where carbon is removed from the atmosphere and stored in biomass, especially trees and the soil using a natural carbon cycle. This is normally a long-term investment which may take up to 100 years.

A single carbon credit represents the reduction of one ton of CO_2 equivalent emissions. There is no set price for carbon credits. There are two markets that exist for the trading of carbon credits, mandatory markets and voluntary markets:

i) ***Compliance or regulatory market***: Compliance or regulatory market have a legally mandated carbon reduction obligation such as the Kyoto Protocol and uses mechanisms like Carbon Tax (for example, the carbon tax floor price in Australia was $21.75 per ton CO_2 in 2013). Mandatory markets are run by mandatory carbon reduction regimes such as the Kyoto Protocol and the European Union's Emissions Trading Scheme. In these markets, governments and companies can buy carbon credits in order to comply with the caps that have been placed on their carbon emissions as set under the Kyoto Protocol. Mandatory carbon credits are traded through the Clean Development Mechanism and other schemes. At this stage, no South African organisation is legally required to reduce their carbon emissions.

ii) ***Voluntary carbon markets***: These are markets where a buyer purchases carbon credits for social or marketing reasons in order to reduce their carbon footprints or purchase carbon offsets. These investors show commitment to environmental and climate change issues (Carbon Link, 2013). The voluntary market allows for companies and individuals to trade carbon offsets on a voluntary basis. The voluntary market helps to achieve emission reductions with projects that are too small to be registered under mandatory schemes or where countries do not have a Kyoto target. One of the difficulties with the voluntarily market is the surety that carbon emission reduction has actually taken place. To increase surety regarding carbon credits many sellers either get their credits verified by a third party or subscribe to a voluntary standard.

Charisma play an important role in voluntary carbon markets. Charisma is the actual or perceived co-benefits of projects that generate carbon credits. For example, credits from a windmill may differ from cell/rotatory grazing in a farming community like the eFS (Carbon Link, 2013).

Purchasing carbon credits enables businesses to offset their emissions to achieve carbon neutrality. Although organisations should first look at mitigating their emissions, carbon credits can assist with making up the balance of their emissions that cannot be reduced in the short term. For organisations in South Africa, the purchase of carbon credits is currently voluntary. There are many options when it comes to the purchase of carbon credits, but it is important that the credits purchased are from legitimate projects.

In 2009, South Africa committed to reduce greenhouse gas emission from business as usual by 34% in 2020 and up to 42% in 2030. South Africa adopted a National Climate Response policy in 2011, and the National Development Plan of 2012 emphasised the importance of creating an environmentally sustainable low carbon economy (RSA, 2014). In 2013, the Carbon Tax and Incentives paper was published, though postponed for implementation in 2016, while the DEA was charged to develop desired emission outcomes that include the use of carbon tax.

Beside carbon tax, there are complementary carbon offset schemes whereby firms can reduce their carbon tax liability by reducing actual emission. South Africa operates both mandatory or compliance standards under the Kyoto Protocol such as the Clean Development Mechanism and voluntary standards such as the Verified Carbon Standard, Gold Standard and Climate, Community and Biodiversity Standard (RSA, 2014).

The use of carbon trading is an area of opportunity to conserve wetlands, especially peat wetlands in South Africa (see 11.4.4).

7.10.4 Use of local and indigenous knowledge

The role of indigenous knowledge in CCA and DRR can be illustrated with the example of the Care project in Uganda. Care Uganda adopted a Climate Proof Disaster Risk Reduction by combining indigenous knowledge and scientific forecast (Africa Climate Change Resilience Alliance [ACCRA], 2015).

Indigenous knowledge is rooted in the culture, beliefs and systems of a community and can be harnessed to improve the adaptive capacity of the rural vulnerable communities to climate change and disaster risks. Indigenous knowledge involves knowing how to speak and listen to the environment that will then guide you to decide what to do, when, why, with whom and how to do it, but rarely explain the mechanism behind the action (ACCRA, 2015).

The implementation of the Climate Proof Disaster Risk Reduction Project by farmers was done through a series of participatory learning activities, to identify indigenous indicators (signs and signals) for weather forecasting that can be related to the science forecast provided on a quarterly basis by the national weather services. This innovation and involvement of the local community increased appreciation, understanding, ownership and willingness to receive and use the scientific data for improved planning at household and community level.

No Regret Actions activities were undertaken to reduce risk or tap into opportunities based on the indications in the scientific forecast that is compared with indigenous knowledge so as to plan for farming activities in the wake of climate variability. Farmers now adopted farming practices that conserve water and soil moisture for better crop growth, increased investment and cultivation of drought tolerant crop varieties, growing of food security crops, as well as participation in income diversifying activities (ACCRA, 2015). Village Saving and Loan Associations provided cheap access to credit for the rural poor farming community to invest in No Regret Actions and also serve as a platform for disseminating and discussion of weather forecasts.

In Ghana, traditional beliefs are used to conserve wetlands (see 3.2.4). Therefore, combining indigenous knowledge with scientific research can help in building wetland resilience to climate change and other risks.

7.11 CHAPTER SUMMARY

Chapter 7 discussed the relationship between climate change and wetlands, how climate change may affect wetlands and how wetlands may contribute to climate change if poorly managed. On the other hand, well-managed wetlands can reduce the impact of climate change through mitigation and adaptation measures. To establish these facts, the chapter first looked at the issues around climate change before linking wetlands to climate change mitigation and adaptation.

Natural ecosystems have a natural process of recovery from an environmental disturbance such as climate change. Though this process may be slow, the greatest problem is that humans have now fundamentally altered the natural recovery process through their various impacts on the environment (Del Moral and Walker, 2007). It is very unlikely that global issues such as climate change, which are strongly attributed to anthropogenic factors (IPCC, 2007; Winkler, 2010), could receive enough time to enable the natural environment to recover. Besides, anthropogenic factors like rapid population growth, rapid urbanisation, technological advances with high energy consumption, mass production and consumption of resources that produce a lot of waste are mounting increasing pressure on natural resources such as wetlands.

Human civilisation will continue in the future, but we should remind ourselves of the factors that led to the collapse of past civilisations (fight over resources), as well as the warning signs that were shown. The degradation and abuse of natural resources such as wetlands in the midst of the current climate change could just be the warning signs about the likely fate of our current civilisation.

Chapter 8

WETLANDS AND DISASTER RISK REDUCTION

8.1 INTRODUCTION

Effective ecosystem management, including the management of wetlands, play an important role in DRR. Disasters can have serious negative impacts on the environment and, on the other hand, degraded environments can exacerbate the negative impacts of disasters (CNRD/PEDRR, 2013; RCS, 2010a). Healthy and well-managed ecosystems like healthy wetlands reduce disaster risks by acting as natural buffers against multiple hazards (CNRD/PEDRR, 2013; RCS, 2010a; Renaud *et al*., 2013; Dudley *et al*., 2015). Healthy and fully functioning ecosystems like wetlands can also build local resilience against disasters by sustaining local livelihoods through the provision of important products like fish and padi rice to the local population (CNRD/PEDRR, 2013; Kotze, 2008; MA, 2005; RCS, 2010a). The regulatory role of wetlands such as climate regulations also helps to reduce the intensity and frequency of weather and climate-related hazards (IPCC, 2014; UNISDR, 2015). This chapter examines the link between wetlands and DRR, with a focus in the eFS, to establish whether the natural environment through healthy and functional ecosystems, particularly wetlands, can be used as a natural and cost-effective mechanism to reduce disaster risk. This new approach to DRR is attracting international attention (Dudley *et al*., 2015; Renaud *et al*., 2013) and has been branded variously as Eco-DRR in disaster risk management (CNRD/PEDRR, 2013) and as EbA in climate change research (IPCC, 2013). Adopting an integrated approach to ecosystem management for DRR and CCA is therefore the way forward, according to CNRD/PEDRR (2013). While the concept of wetlands was elaborated on in Chapter 4 and that of CCA in Chapter 7, DRR will be examined in detail in this chapter. Unsustainable use of wetlands has in many cases led to the disruption of natural hydrological cycles resulting in higher frequency and severity of flooding, drought and pollution. The degradation and loss of wetlands and their biodiversity has, in addition to provoking disasters, imposed major economic and social losses and costs to vulnerable communities (Wageningen International, 2009). This research, and particularly this chapter, aims at highlighting the need to preserve wetlands in their healthy ecological integrity so that they can effectively provide services that reduce disaster risks, support livelihoods and build local resilience in South Africa in general and in the eFS in particular.

8.2 THE HISTORY OF DISASTER RISK REDUCTION

The concept of DRR was explained in the glossary of terms and in this sub-section the global and national milestones in the genesis of DRR is presented.

8.2.1 The International Decade for Natural Disaster Reduction and paradigm shift in disaster management

Until the late 1990s, the national and international approach to disaster management was always reactive with a clear focus on disaster response and recovery (see Chapter 4). At national level, disaster management was military-driven and most often the function was placed under the civil protection unit. Many countries, such as Cameroon, Uganda and Zimbabwe, are still using the civil protection system today.

After the International Decade for Natural Disaster Reduction (IDNDR), proclaimed by the United Nations from 1990 to 1999, there was an international paradigm shift in disaster management from the predominantly reactive and military-led approach to a more proactive and more civilian-led approach, from emphasis on relief and recovery, to emphasis on DRR and building community resilience. Despite this international reorientation on the emphasis in managing disasters, many countries in the world, and especially developing countries, are still grappling to install and run national organs to manage disasters proactively. Some disasters could be prevented but many, especially ‘natural’ disasters, may be difficult or impossible to avoid; however, their impacts could be reduced through better DRR measures.

A literature scan from the UNISDR (2012) reveals that much attention to disaster was in the form of disaster relief to the affected communities. In the 1960s, the United Nations General Assembly adopted measures regarding severe disasters such as the earthquake in Buin Zara in Iran in 1962 where 12 000 people were killed, the earthquake in Skopje in Yugoslavia in 1963 where more than 12 000 people were killed, and another earthquake in Iran in 1968 which killed more than 10 000 people. In all these cases, the affected communities needed outside relief assistance. In 1971, therefore, the UN created the United Nations Disaster Relief Office to handle relief assistance to disaster affected communities.

Between 1972 and 1978, the UN reports showed that contingency planning, prevention and preparedness were vital to lessen both the impact of disasters and assistance to disaster prone countries. In response to this realisation, the UN declared the IDNDR from 1990 to 1999. During this decade, the international community was invited to pay special attention in fostering international cooperation in the field of natural disaster reduction.

Almost mid-way within the decade, from 23 to 27 May 1994, the first world conference on disaster reduction was held in Yokohama in Japan. To mark the end of the IDNDR, the Yokohama forum was held in 2000 which culminated into the creation of the UNISDR on the advice of the UN Economic and Social Council.

The UNISDR was thus created to succeed the IDNDR and is based in the UN headquarters in Geneva, Switzerland, with five regional branches, sub-branches and liaison offices in the world. The African regional branch of the UNISDR is based in Nairobi, Kenya. The UNISDR is an inter-agency task force with an inter-agency secretariat to handle DRR.

Another historic milestone in DRR happened in 2002. The World Summit on Sustainable Development that was held in Johannesburg in 2002, highlighted the need for the integration of DRR into sustainable development projects, as well as reaffirmed the principle of the Rio Declaration on the environment and development (UNISDR, 2015).

8.2.2 The Hyogo Framework for Action (2005−2015

At the second world conference on DRR held in 2005 in Kobe in Japan, the UNISDR framework for action was adopted by 168 countries. This agreement was popularly referred to as the HFA 2005−2015 under the theme "*Building the Resilience of Nations and Communities to Disasters*" (UNISDR, 2005). The HFA 2005−2015 had three strategic goals and five main priority areas. These priority areas had benchmarks to assess the level of attainment of these priorities by each country, region or the international community. The three strategic goals included:

- The integration of DRR into sustainable development policies and planning.
- The development and strengthening of institutions, mechanisms and capacities to build resilience to hazards.
- The systematic incorporation of risk reduction into the implementation of emergency preparedness, response and recovery programmes (UNISDR, 2005).

The five priority areas of the HFA2005−2015 included the following:

- Ensure that DRR is a national and local priority with a strong institutional basis for implementation.
- Identify, assess and monitor disaster risks and enhance early warning.
- Use knowledge, innovation and education to build a culture of safety and resilience at all levels.
- Reduce the underlying risk factors.
- Strengthening disaster preparedness for effective response at all level (UNISDR, 2005).

These priorities were used as international yardsticks for DRR activities. The HFA 2005−2015 was endorsed by 168 UN member states and the agreement was that all countries should make major efforts to reduce disaster risk by 2015 (UNISDR, 2012). The mid-term review and the 2013 UNISDR Global Assessment Report of HFA highlighted that least implementation progress was made in Priority 4 of *Reducing underlying risk factors* (PEDRR, 2014). Reducing underlying risk factors depends to a large extent on how the environment is managed.

The link between DRR, the environment and CCA, which forms the very foundation of this research, is highlighted by the following quote from the head of the UNISDR:

> *Rio+20 calls upon governments to accelerate implementation of the first global disaster risk reduction plan, the Hyogo Framework for Action; to integrate disaster risk reduction into policies, plans, programmes and budgets; to integrate risk reduction and climate change adaptation into public and private investments; and to undertake comprehensive risk assessments as well as strengthen disaster reduction instruments (Margareta Wahlström, at the 14th regular session of the African Ministerial Conference on the Environment (AMCEN) held from 10-14 September 2012 in Arusha, Tanzania)* (UNISDR, 2012).

The above quote that was made in an environmental conference supports another new and emerging paradigm shift which combines reducing disaster risk, managing the natural environment sustainably and adapting to the effects of climate change. This holistic approach is popularly referred to as the Eco-DRR/CCA (CNRD/PEDRR, 2013; Renaud *et al*., 2013). This conceptual approach is strongly supported in this research on managing wetlands in the eFS.

8.2.3 The Sendai Framework for Disaster Risk Reduction 2015−2030

As the HFA 2005−2015 drew to an end in 2015, the international community was busy with proposals, consultations and preparation for the successor of the HFA, popularly referred to as the HFA−2. The Third United Nations World Conference on Disaster Risk Reduction was held from 14 to 18 March 2015 in the Sendai City of Japan. At the last day of the conference (18 March), the global community adopted the successor of the HFA 2005−2015, which was then called the SFDRR. The new agreement was said to be more concise, focused, forward-looking and action oriented (UNISDR, 2015). Unlike its predecessor, the post-HFA or the SFDRR has a 15-year life-span (2015−2030), has one compressed expected outcome, one goal, seven targets and four priority areas.

The expected outcome:

> *The substantial reduction in disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries* (UNISDR, 2015:12).

Goal:

> *Prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience* (UNISDR, 2015:12).

The seven global targets include:

> *(a) Substantially reduce global disaster mortality by 2030, aiming to lower the average per 100,000 global mortality rate in the decade 2020–2030 compared to the period 2005–2015;*
>
> *(b) Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 in the decade 2020–2030 compared to the period 2005–2015;*
>
> *(c) Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030;*
>
> *(d) Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030;*
>
> *(e) Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020;*
>
> *(f) Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the present Framework by 2030;*
>
> *(g) Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030* (UNISDR, 2015:12).

The four priorities for action are:

> ***Priority 1**: Understanding disaster risk.*
>
> ***Priority 2**: Strengthening disaster risk governance to manage disaster risk.*
>
> ***Priority 3**: Investing in disaster risk reduction for resilience.*
>
> ***Priority 4**: Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction* (UNISDR, 2015:14).

These priority areas have a series of activities and monitoring indicators divided between local and national, as well as regional and global levels. Some targets are set for 2020, while others are set for 2030. Also of note is the new emphasis on health and cultural issues in the SFDRR (Aitsi-Selmi *et al*., 2015; UNISDR, 2015). The new SFDRR still acknowledges the important cross-cutting role of the environment in DRR as indicated in its expected outcome and goal. However, the researcher is of the opinion that one of the seven global targets or one of the four priority areas could have been specifically devoted to the environment, because anything we do should directly or indirectly focus on people and the environment or planet.

After a series of international, regional and national consultations and evaluation of the HFA, the DRR international community hopes and thinks that a better and more action-oriented SFDRR has been adopted for implementation over a longer period than its predecessor. The stage has now been set for the implementation, monitoring, evaluation and critique of the SFDRR. Only time will prove that a better DRR framework was adopted at Sendai in 2015.

8.2.4 The special role of Japan in disaster risk reduction

Japan has always made headlight news when it comes to DRR. In 1994, Japan hosted the first international conference on DRR in Yokohama that led to the Yokohama declaration and action plan. In 2005, Japan hosted the second world conference on DRR in Kobe that led to the establishment of the HFA 2005−2015: Building the Resilience of Nations and Communities to Disasters. Recently, from 14 to 18 March 2015, Japan again hosted the third world conference on DRR at Sendai that led to the adoption of the post-HFA or the SFDRR 2015−2030 (Kelman and Glantz, 2015).

Japan demonstrated a best-case scenario on DRR when on 11 March 2011, Japan was hit by an unprecedented earthquake measuring 9.8 on the Richter scale. The earthquake was accompanied by many landslides, but very few lives were lost with only a few damages (mostly old buildings were destroyed). However, the same earthquake taught the world that a lot still needs to be done on DRR, following the tsunami that was triggered by the same earthquake and the unprecedented cascading nuclear disaster that followed where about 15 000 people were killed (Kelman and Glantz, 2015). One can say Japan is the world amphitheatre of DRR where ‘the good, the bad and the ugly’ can be traced in DRR and disasters.

8.3 INTERNATIONAL PRIORITY AND FINANCING OF DISASTER RISK REDUCTION

8.3.1 International financing of disaster risk reduction activities

This sub-section is included to highlight the fact that DRR occupied a very low priority status in international financing over the past two decades, despite the embracement of the HFA since 2005. For example, over the past twenty years, the international community committed over $3 trillion in aid. About $106.7 billion was allocated to disasters, and of that just about 12% or $13.5 billion were devoted to risk reduction measures, compared to $23.3 billion spent on reconstruction and rehabilitation and $69.9 billion spent on response. For the past 20 years, the $13.5 billion spent on DRR accounts for just 0.4% of the total amount spent on international aid (Rowling, 2013). For every $100 spent on development aid, just 40 cents have been invested in defending that aid from the impact of disasters. For every $1 spent on DRR, more than $160 000 has been spent on response (Kellett and Caravani, 2013).

It has been recently estimated that every dollar invested in risk reduction could save up to ten dollars in disaster response and recovery (IFRC, 2007 in TEEB, 2010). Despite this advantage of DRR over disaster response, the international community is still disaster−response oriented.

Sub-Saharan Africa is at a double disadvantage when it comes to DRR. Ten out of the 19 low income countries that received only $2 *per capita* of DRR financing over the past 20 years, are Sub-Saharan African countries. The world ten top most affected countries by drought are the sub-Saharan countries and paradoxically, the international donors do not fund DRR for drought (Kellett and Caravani, 2013).

Sub-Saharan African countries only receive a fair share of DRR funding when it comes to adaptation funds. This includes adaptation to climate change. It makes sense to propose that CCA and DRR be pursuit together in Africa in order to attract a comparable share of international DRR funding. Funds should also be allocated to prepare and mitigate the effects of droughts. The post-HFA (UNISDR, 2015) has postulated new and revitalised funding arrangements for DRR and it is left to be seen how this will unfold at both national and international levels.

It is also observed that large-scale (mega) projects consume the bulk of international DRR funding as indicated in Table 8.1 below.

TABLE 8.1: DISASTER RISK REDUCTION EXPENDITURE ON MEGA PROJECTS

Number of projects	Value of project	Total volume (million US$)	Proportion (%)
33	More than $100 million	6 839.1	50.5
135	$10−100 million	4 629.9	34.2
331	$1.5−10 million	1 320.4	9.8
3 188	Less than $1.5 million	749.5	5.5
3 681		**13 539.0**	

Source: Adapted from Kellett and Caravani (2013).

There is equal concentration and fragmented distribution of DRR funding from 1991−2010 as indicated in Table 8.2 below:

TABLE 8.2: CONCENTRATION OF DISASTER RISK REDUCTION FUNDING

Countries	Amount received in million US dollars	Proportion (%)
China and Indonesia	3 017.6	22.3
Next eight countries	4 907.3	36.2
Next twenty countries	3 538.3	26.1
Remaining 117 countries	1 276.7	9.4
Regional and global	796.7	5.5

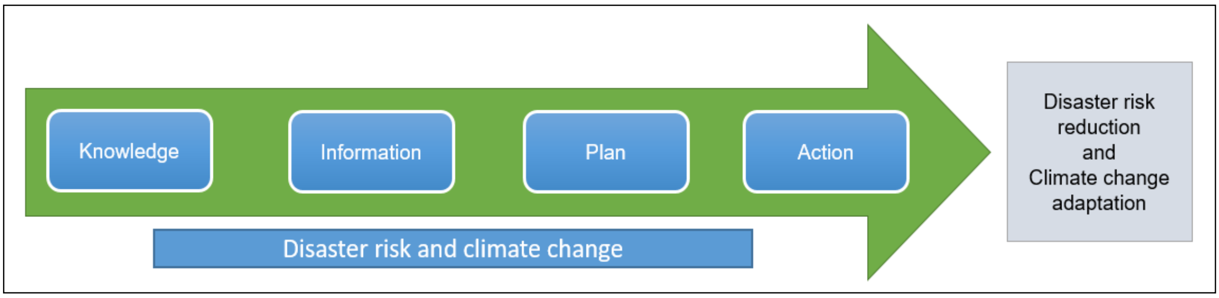
Source: Adapted from Kellett and Caravani (2013).

The aim of DRR is to reduce the negative impacts of hazards such as earthquakes, floods, droughts, fires, epidemics and cyclones, through actions such as prevention, mitigation and preparedness. International funding for DRR appears skewed as observed from the two tables presented above. Risk, hazard and vulnerability assessments should inform an all-inclusive international funding for DRR and CCA, and small disasters with cumulative negative impacts, especially in the developing countries of Africa, should be included and funded. The international community should look at means of funding DRR measures on drought, especially in Africa.

8.3.2 Knowledge, information and action on disaster risk reduction

There is knowledge fragmentation in DRR. There is a lot of research on disaster risk, but these researches hardly translate into adequate information for decision-making in DRR so as to limit the upward trend in disaster damages (Spiekerman *et al*., 2015). As White *et al*. (2001, in Spiekerman *et al*., 2015) eloquently put it, we are in a situation of 'Knowing better and losing even more'. There are gaps between what is known about disaster risk and how research findings are translated into policies and programmes. There are also differences between what households and communities understand as disastrous events and the way locally developed coping and preventive measures are appreciated (Spiekerman *et al*., 2015). Though Spiekerman *et al*. (2015) do not state from whom this appreciation should come from, it should apparently be from disaster management stakeholders, and the issues raised here are closely linked to insufficient use and incorporation of local and indigenous knowledge in DRR and CCA.

Information may be available but it may not necessarily be known, accepted and acted upon to bring about the desired changes that is needed in DRR and CCA (Spiekerman *et al*., 2015). Understanding and greasing the interlink between knowledge (from scientific research as well as local and indigenous knowledge), information (shared through different and appropriate media) and action (from various stakeholders, including policies and institutions) on disaster risk and thclimate change causes and impacts are vital for any meaningful DRR and CCA measures (Figure 8.1).

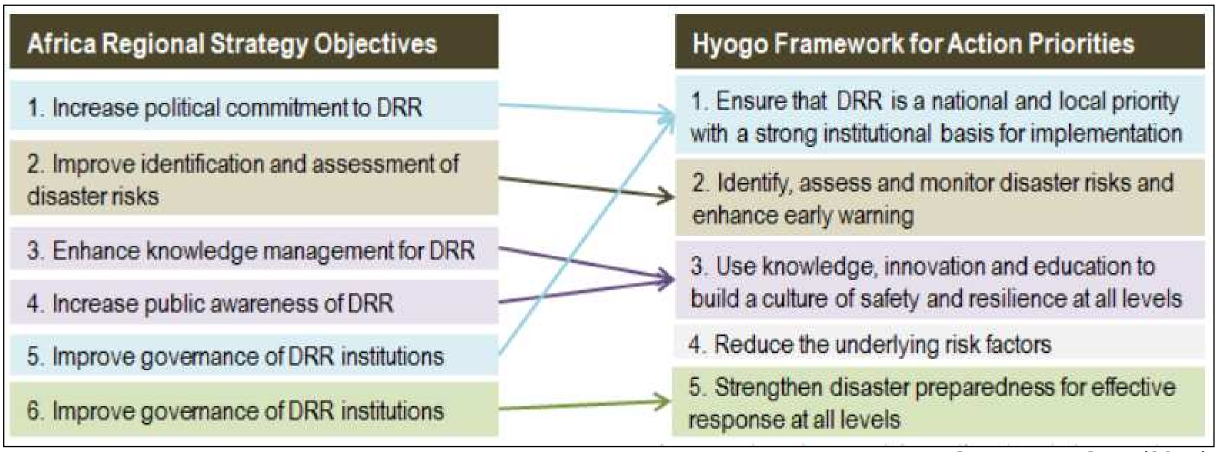


Source: Author's own (2016)

Figure 8.1 Basic process of disaster risk reduction and climate change adaptation

8.4 DISASTER RISK REDUCTION IN AFRICA

Many African countries have embraced the spirit of DRR in line with the HFA 2005−2015 and are beginning to endorse and implement the SFDRR, while other are still very reactive in managing disasters. At regional level, Africa through the Africa Union Commission, adopted the Africa Regional Strategy for DRR in 2004 and the following year adopted the African Plan of Action for the implementation of the strategy in 2005, which was extended in 2010 to align with the international benchmark of the HFA (See Figure 8.2).



Source: UNISDR (2014)

Figure 8.2 Alignment of the Africa disaster risk reduction strategy objectives and the Hyogo Framework for Action priorities

As noted earlier, DRR is everybody's business.

> *The more governments, UN agencies, organizations, businesses and civil society understand risk and vulnerability, the better equipped they will be to mitigate disasters when they strike, and thus, save more lives* (Ban Ki-moon, UN secretary-general, in UNISDR, 2011).

However, there are many cases in Africa where the lead institution or platform for DRR does not yet bear sufficient influence upon all relevant sectors of government (UNISDR, 2014). This is the case in South Africa where the National Disaster Management Centre (NDMC) is facing challenges of making all sector departments come on board to address DRR issues with well-developed plans. Decentralised models of governance and administration are important for effective multi-sectoral and multi-level DRR implementation. The challenge is that of limited resources and poor management of the available resources.

8.5 DISASTER RISK IN SOUTH AFRICA

South Africa has one of the best DRR legislations and DRR platforms in the world, founded on multidisciplinary and multisectoral institutional architecture. This was shaped by both internal transformation (from apartheid to democracy in the mid-1990s), the international paradigm shift from disaster response to DRR in the same period (the international decade for disaster reduction and the World Conference on Disaster Reduction, Kobe 2005, the HFA 2005−2015), and lastly, by natural triggering and awakening events such as the devastating Cape floods of 1990 (Pelling and Holloway, 2006; RSA, 2002; RSA, 2005). The legal and institutional arrangement for DRR in South Africa followed a sequential development as indicated in Table 8.3 below.

TABLE 8.3: KEY STAGES IN THE DISASTER RISK REDUCTION LEGISLATIVE REFORM PROCESS IN SOUTH AFRICA

Period and Event	Activities	Outcomes
Policy re-orientation June 1994 – January 1999	Focus on broad stakeholder consultation and policy reorientation through: • national discussion paper • national policy document	February 1998: Green Paper on Disaster Management January 1999: White Paper on Disaster Management
Legislative process February 1999 – January 2003	Focus on the legislative process through: • drafting of legislation and public comment • Portfolio Committee debate	January 2000: Disaster Management Bill September 2001: Disaster Management Bill, Bill 58 of 2001 May 2002: Disaster Management Bill, Bill 21 of 2002
Implementing framework February 2003 – April 2005	Focus on developing a national implementing framework through: drafting of national implementation framework	April 2004: National Disaster Management Framework April 2005: National Disaster Management Framework
Implementation May 2005+	Piloting roll-out of implementation framework	

Source: Pelling and Holloway (2006)

Lack of financial, human or technical resources, inadequate capacities, lack of political by-ins from local politicians, lack of understanding and engagement of all DRR role players, lack of shared awareness and responsibility, as well as lack of integration of DRR into existing and future policies at national, provincial and local levels, are some of the obstacles in implementing DRR in South Africa (Pelling and Holloway, 2006; RSA, 2002; UNISDR, 2013).

8.6 WETLANDS AND DISASTER RISK REDUCTION

8.6.1 Overview of wetlands and disaster risk reduction

Wetlands can reduce disaster risks if properly managed, but they can also exacerbate disaster risk if poorly managed and degraded. The role of ecosystems in disaster mitigation is gradually gaining international attention since healthy ecosystems such as forests, mangroves, wetlands, floodplains and coral reefs protect local communities against natural disasters as well as significantly contribute to both climate change mitigation and provide effective CCA opportunities for the local communities (Dudley *et al*., 2015; TEEB, 2010). About 95% of disasters are linked to water-related hazards and it is possible to reduce these disaster risks by managing wetlands sustainably (UNISDR, 2015). Wetlands can reduce disasters by influencing hazards, exposure, vulnerability and providing livelihoods and building resilience (PEDRR, 2014; Renaud *et al*., 2013). Mangroves, marshes, coral reefs and other forms of wetlands provide buffers against hazards such as hurricanes, tropical storms, floods, strong winds, tsunamis, sea level rise, drought, desertification, dust storms and wildfires; all of these hazards are associated with the increasing impacts of climate change (Dudley *et al*., 2015; IPCC, 2014; UNISDR, 2014). The fact that these hazards are increasing in frequency and intensity due to climate change (IPCC, 2014; UNISDR, 2014), and the fact that damages from natural disasters are increasing tremendously (Dudley *et al*., 2015; UNISDR, 2014), support the argument for the protection, wise management and conservation of wetlands and other natural ecosystems in order to prepare for, prevent and mitigate disaster risks, protect the natural environment and adapt to climate change impacts.

However, not all natural disasters can be prevented by natural ecosystems (Dudley *et al*., 2015) and the extent to which ecosystems mitigate the impact of disasters and climate change depend on a series of factors such as the ecological state of the natural ecosystem, the intensity, magnitude and frequency of the natural hazard and the degree of vulnerability or resilience of the affected system or community.

Natural ecosystems such as wetlands can absorb and deflect natural hazards, but 60% of global ecosystem services have been degraded contributing to a significant rise in floods, wildfires and droughts (MA, 2005). IPCC (2012) estimates show an increase in precipitation intensity and rainfall variability that will result in increased events of floods and droughts. Therefore, degraded ecosystems such as wetlands will lack the ability to mitigate hazards and thus exacerbate the number and intensity of disasters. These disasters have a greater effect on the poor community who lack the money, effective emergency services and other safeguards to withstand and recover from disasters (IPCC, 2012; TEEB, 2010; UNISDR, 2013).

Ecosystem services provided by healthy wetlands are fundamental in reducing vulnerability to disasters and strengthening community resilience (UNISDR, 2013). For example, the value of wetlands in terms of annual flood damages avoided in the city of Vientiane in the Lao People's Democratic Republic, was estimated at US$ 5 million. Coral reefs, mangroves and marshes help in mitigating the impact of storm surges and coastal erosion. For example, the Indian Ocean tsunami of 2004 with an average height of six meters and inland penetration of about one kilometre in some areas was highly dissipated and its impacts reduced in coastal areas which had healthy well-functioning ecosystems such as coastal mangroves (UNISDR, 2013).

Eco-engineering has proven to be more cost-effective than structural engineering in mitigating disasters (PEDRR, 2013). For example, in Vietnam an estimated US$ 1.1 million was spent planting mangroves which saved an estimated US$ 7.3 million in annual dyke maintenance (TEEB, 2010). The Netherlands has a history of recurrent floods due to the low-lying nature of the country. Consequently, huge structural engineering in the form of dykes, levees and sea walls were constructed to protect the coastal cities. However, the 1953 floods and the extreme high river tides of the 1990s made the Dutch realise that structural engineering alone was no longer an adequate solution to their flood problems. The Dutch therefore made a paradigm shift and adopted the 'Living with Water' approach whereby large river channels were opened up to allow for the free flow of water. In addition, green roofs, recreational space and water plazas were created to lower flood peaks (Dione, 2014). This is an example of an Eco-DRR/CCA approach to mitigate flood disasters. The UNEP and the EU are currently implementing ecosystem-based approaches for DRR (Eco-DRR) demonstration projects in Afghanistan, Haiti, Democratic Republic of the Congo and Sudan (Renaud *et al*., 2013). The aim of Eco-DRR projects is to improve ecosystems management in order to enhance their regulatory and provisioning services for risk reduction, demonstrate the cost-effectiveness of ecosystem-based approaches, and boost local and national capacities to integrate Eco-DRR in national and local development planning (UNISDR, 2015). The summary point here is that while international focus is shifting towards DRR from reactive response and recovery, a further paradigm shift is gradually emerging (supported in this study) that advocates the use of natural ecosystems such as wetlands to reduce disaster risk, adapt to climate change and build resilience, hence promoting the concept of Eco-DRR/CCA.

8.6.2 How wetlands mitigate disasters

The CNRD/PEDRR (2013) advanced the following summary points to support how various wetlands reduce disaster impacts:

- Wetlands such as floodplains control floods in coastal areas, inland river basins, and mountain areas that are subject to glacial melt.
- Peatlands, wet grasslands and other wetlands store water and release it slowly, reducing the speed and volume of run-off after heavy rainfall or snowmelt.
- Coastal wetlands, tidal flats, deltas and estuaries reduce the height and speed of storm surges and tidal waves.
- Coastal ecosystems function as a continuum of natural buffer systems protecting against hurricanes, storm surges, flooding and other coastal hazards – a combined protection from coral reefs and seagrass beds. Sand dunes, coastal wetlands and coastal forests are particularly effective. Research has highlighted several cases where coastal areas protected by healthy ecosystems have suffered less from extreme weather events than more exposed communities.
- Coral reefs and coastal wetlands such as mangroves and saltmarshes absorb (low-magnitude) wave energy, reduce wave heights and reduce erosion from storms and high tides.
- Coastal wetlands buffer against saltwater intrusion and adapt to (slow) sea level rise by trapping sediments and organic matter.
- Non-porous natural barriers such as sand dunes (with associated plant communities) and barrier islands dissipate wave energy and act as barriers against waves, currents, storm surges and tsunami (CNRD/PEDRR, 2013; Renaud *et al*., 2013; Renaud et al., 2016).

8.6.3 Coral reefs and disaster risk reduction

Coral reefs are considered a form of wetland, according to the Ramsar definition of wetlands (RCS, 2010a). More frequent and stronger storms, rising sea levels, and frequent flooding which are cited as evidence of climate change (IPCC, 2007, 2012), are putting millions of people at risk around the world. The solution to decrease these risks can partly be found offshore where, for example, coral reefs are reported to reduce the wave energy that would otherwise impact coastlines by 97% (United States Geological Survey, 2014). About 200 million people in more than 80 nations are at risk if coral reefs are not protected and restored. These are people living in villages, towns and cities found in low-lying, risk-prone coastal areas (below 10 m elevation) and within 50 km of coral reefs.

The restoration and conservation of coral reefs is an important and cost-effective solution to reduce risks from coastal hazards and climate change. The median cost for building artificial breakwaters is estimated at US$19 791 per metre, compared to $1 290 per metre for coral reef restoration projects. In other words, restoration of coral reefs for coastal defence may be as low as one-tenth the cost of building artificial breakwaters (United States Geological Survey, 2014).

The top 15 countries in terms of number of people who receive risk reduction benefits from coral reefs are indicated in Table 8.4 below.

TABLE 8.4: CORAL REEFS RISK REDUCTION BENEFITS (TOP 15 COUNTRIES)

Order	Country	Number of people in millions
1	Indonesia	41
2	India	36
3	Philippines	23
4	China	16
5	Vietnam	9
6	Brazil	8
7	United States of America	7
8	Malaysia	5
9	Sri Lanka	4
10	Taiwan	3
11	Singapore	3
12	Cuba	3
13	Hong Kong	2
14	Tanzania	2
15	Saudi Arabia	2

Source: United States Geological Survey (2014)

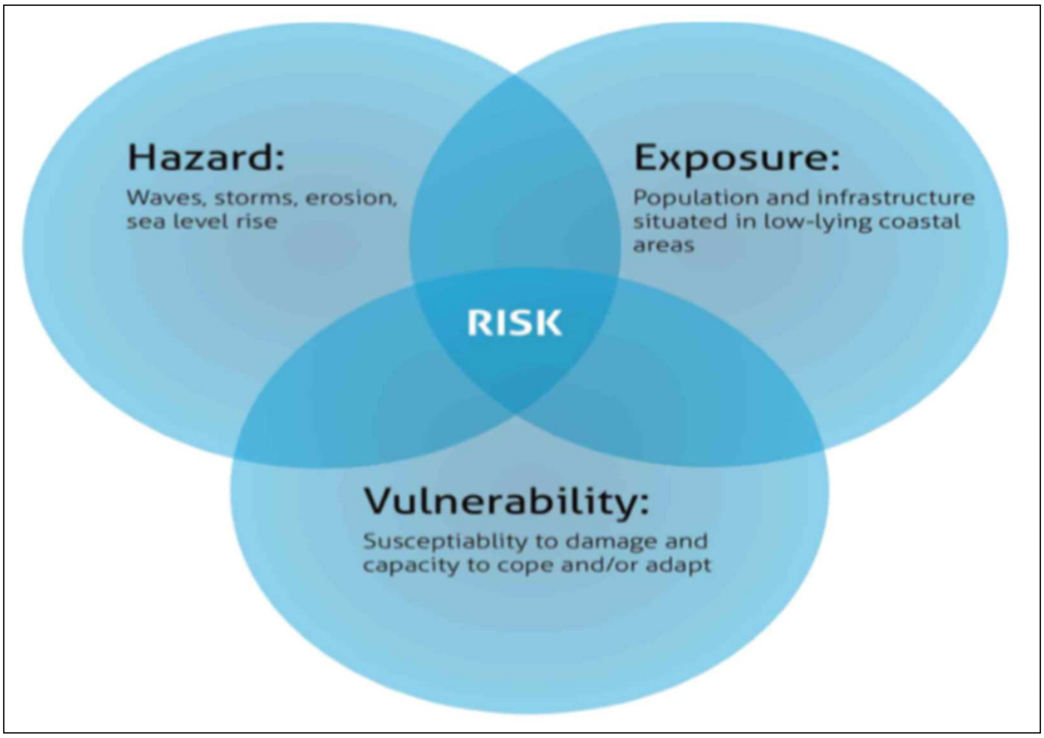
Only one African country (Tanzania) features among the top 15 countries in the world, while Asian countries dominate the list.

Despite the advantages of coral reefs in reducing disaster risk, climate change is putting pressure on these natural disaster buffers. For example, the coral reefs off the coasts of Mozambique, Tanzania and South Africa are under threat of bleaching because of rise in sea temperature due to El Niño events and global climate change (SADC, 2010).

8.6.4 Mangroves and coastal risk reduction

About 75% of the world's largest cities are located at the coast, and coastal areas are particularly very vulnerable to multiple hazards often associated with climate change such as sea level rise, tsunamis, storm surges and cyclones (Spalding *et al*., 2014; UNISDR/WMO, 2012). Mangroves are a form of wetland vegetation and can act as buffer against coastal hazards.

Coastal risk, like any other risk of a disaster, is the product of a hazard, vulnerability and exposure (Figure 8.3).



Source: Spalding *et al*. (2014)

Figure 8.3 Coastal risk

To reduce any coastal risk, the three components of risk need to be addressed. The construction of a seawall may in some case offer effective protection but it may also increase vulnerability in other locations, such as when it triggers erosion further down the coast making that area more susceptible to storms. Meanwhile, the degradation of coastal ecosystems may exacerbate the impact of hazards like flooding by increasing people's exposure. Understanding these interrelationships helps to assess the risk context and design better integrated approaches to risk reduction and coastal zone management (Spalding *et al*., 2014).

Coastal mangroves are typical vegetation of coastal wetlands (Figure 8.4) and they play a critical role in mitigating the damage from strong sea waves, storm surges, tsunamis (like the

2004 Indian Ocean tsunami), coastal erosion and the coastal effects of sea level rise (Spalding *et al*., 2014). Mangroves therefore reduce the intensity and exposure of coastal hazards. They also provide many other benefits that reduce the vulnerability of coastal communities and support recovery. All these benefits will however depend on many environmental, social and economic conditions of the individual locations where the mangroves are found (Spalding *et al*., 2014).

Source: Spalding *et al.* (2014)

Figure 8.4 Coastal mangroves

According to Spalding *et al*. (2014), the important role that coastal mangroves play in reducing disaster risk and adapting to climate change, include:

- Reducing wind and swell waves as they pass through mangroves, lessening wave damage during storms.
- Reducing flood impacts from storm surges (cyclones, typhoons or hurricanes) especially if the mangrove belt is wide enough.
- Wide areas of mangroves can reduce tsunami heights, helping to reduce loss of life and damage to property in areas behind the mangroves.
- The dense roots of mangroves help to bind and build soils. The above-ground roots slow down water flows, encourage deposition of sediments and reduce erosion (Spalding *et al*., 2014).

However, it is important to note that:

- Mangroves do not always provide a stand-alone solution; they may need to be combined with other risk reduction measures to achieve a desired level of protection.

- For mangroves to optimally contribute to risk reduction, their conservation needs to be incorporated into broader coastal zone management planning. They need to be protected and restored, allowing wise use where possible (Spalding *et al*., 2014).

Though coral reefs and mangroves are not found in the eFS, their role as wetlands (green infrastructure) in DRR could be applied to South African coastal cities like Durban, East London and Cape Town within the Eco-DRR/CCA paradigm that guides this research.

8.6.5 Advantages of green infrastructure over grey infrastructure

Green infrastructure is the purposeful design and management of land with the purpose of obtaining a variety of benefits from well-functioning ecosystems (European Environment Agency [EEA], 2015). In urban settings, green infrastructure comprises "*all natural, semi-natural, and artificial networks of multifunctional ecological systems within, around, and between urban areas, at all spatial scales*" (Tzoulas *et al*., 2007 in Talberth *et al*., 2013).

Wetlands and other natural ecosystems act as green infrastructure or green engineering that mitigates disaster risk. The use of the natural environment to mitigate environmental hazards and adapt to climate change has long been neglected by planners in favour of mechanical measures such as building of dykes and sea walls (grey infrastructure). Despite the difficulty in comparing the green and grey infrastructure in an apple-to-apple manner, there is growing evidence of greater cost/benefit gains of using green infrastructure over grey infrastructure. A few examples of green infrastructure include using healthy floodplains, forests and reafforestation, natural and artificial wetlands, riparian woodlands, barrier beaches, porous pavements, stream restoration, and best-management practices for agriculture and forestry (EEA, 2015; Talberth *et al*., 2013).

Investment in Eco-DRR and green infrastructure provides benefits for innovative risk management approaches, reducing vulnerability, adapting to climate change, maintaining sustainable livelihoods, fostering green growth and improving on biodiversity (EEA, 2015). Green infrastructure is multifunctional. It provides many benefits for the same area, which can be environmental (conserving biodiversity and adapting to climate change), social (providing green space and water drainage), and even economic (creating jobs and increasing the value of properties). This is unlike grey infrastructure which is normally used for a single purpose such as flood control dykes (EEA, 2015). An example of green infrastructure such as the green roofs in cities can reduce storm water, run-offs, pollutant loads in the water, reduce urban heat and improve insolation of buildings, as well as provide a habitat for a variety of species (EEA, 2015).

The Great East Japan Earthquake and Tsunami of 2011 demonstrated that disaster mitigation based solely on grey infrastructure and engineering is insufficient in the long term. The 1:1 000 years' tsunami left 60% of north-east Japan's seawalls in ruins (Bird, 2013 in Takeuchi *et al*., 2014; Suppasri *et al*., 2013). Both engineering resilience and ecological resilience are therefore important to mitigate disasters which are often complex and occur under a changing environment such as the Great East Japan Earthquake and Tsunami (Takeuchi *et al*., 2014). This disaster proved that sustainable defence for the future is likely to be one that is based on social−ecological resilience that provides flexibility in managing systems, can absorb and accommodate future elements in whatever form they may take (Holling, 1973 in Takeuchi *et al*., 2014).

In a trade-off study between the green and grey infrastructure of the Portland Water District in Maine, Talberth *et al*. (2013) demonstrated that green infrastructure yielded more financial cost-benefits besides ancillary benefits like carbon sequestration. The green−grey analysis by Talberth *et al.* (2013) revealed that investing in five green infrastructure options led to a cost savings of up to 71% over constructing a new filtration plant.

In April 2007, the USEPA did a green−grey comparison for the purification of the City of New York, drinking water from the Catskill Mountains and found out that by investing $300 million over ten years in green infrastructure (maintaining healthy forests and reserved areas such as wetlands), the city could save the building of a water filtration plant that cost $8 billion. Furthermore, the New York City found that green roofs and bioswales could help meet water quality goals with savings of more than $1 billion compared to conventional infrastructure. The City of Philadelphia found that the net present value of green infrastructure for storm water control ranged from $1.94 to $4.45 billion, compared to only $0.06 to $0.14 billion for conventional grey infrastructure over a 40-year period. Using wetlands, it could cost North Carolina 47 cents per thousand gallons of treated storm water run-off, compared to $3.24 per thousand gallons for the conventional grey option. These are classic examples of the superiority of green over grey infrastructure in not only financial benefits, but also other environmental services laden in green infrastructure options which even appreciate over time, unlike grey infrastructure which depreciate over time. Many cities in the world are today considering the green option (Talberth *et al*., 2013).

8.6.5.1 'Making space for Water' programme

Many European countries (Germany, the Netherlands, the UK), eastern European countries bordering the Danube River as well as Switzerland have embarked on 'Making space for Water' programmes to mitigate the impacts of floods by removing built infrastructure on natural river channels and restoring wetlands and rivers to manage natural flow of rivers. For example, Netherlands invested €2.3 billion to re-establish floodplains, resulting in reduced flood risks for four million people along its main rivers (Deltacommisie, 2008 in CNRD/PEDRR, 2013). In the UK, the Environment Agency estimated that over five million people and two million homes and businesses valued at £250 billion were at risk of flooding in England and Wales. This prompted the initiation of the 'Making space for Water' initiative in 2004 (CNRD/PEDRR, 2013). This type of initiative can save many lives and damages to property in other parts of the world, especially in developing countries where a lot of informal settlement occur in floodplains. It is also a form of building community resilience *with* nature and not *against* nature.

Ecosystems and socio-economic resilience, such as transformation to sustainable agriculture, forestry and fisheries, provide communities with flexible barriers and protection against disasters in the long run, rather than hard engineering solutions such as high seawalls aimed at ensuring only physical security (Takeuchi *et al*., 2014).

There are strengths and weaknesses in protection benefits provided by the built infrastructure; natural ecosystems, and therefore innovative opportunities to combine the two into hybrid approaches to build system resilience against hazards like storms, tsunamis and sea level rise, is key (Suppasri *et al*., 2013; Sutton-Grier *et al*., 2015). However, better information needs to be collected and an accurate cost-benefit analysis made in order to incorporate ecosystem protection and restoration, for example coastal resilience planning (Sutton-Grier *et al*., 2015). The bottom line is that neither the grey nor the green engineering provides 100% security against hazards, but there is a need to look at a hybrid approach for better mitigation and building of community resilience. Through a better cost-benefit analysis, which include ecosystem services to the local communities, as well as long-term flow of benefits, planners can take better decision and a better mix of the two approaches. The argument should not be to either defend the comfort zone of structural engineering with its structural defects that abound in history, or ecosystem-based risk reduction measures that has not really proven the test of time, but exploring synergy from both approaches to build more resilient communities.

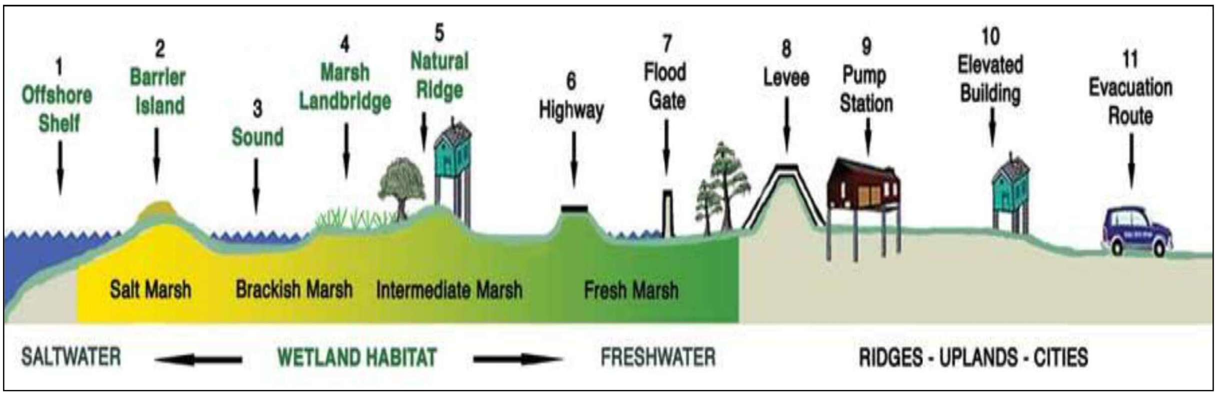
8.6.5.2 Hybrid approach

Hybrid infrastructure approaches strategically combine non-natural structures (grey infrastructure) with natural and/or nature-based elements (green infrastructure). These approaches exploit the strengths of both types of infrastructure, while compensating for the weaknesses of each in proper benefits and trade-offs analysis (Bouma *et al*., 2014 in National Science and Technology Council [NSTC], 2015; Suppasri *et al*., 2013; Takeuchi *et al*., 2014).

Hybrid approaches are receiving increasing recognition in the US. For instance:

- The U.S. Army Corps of Engineers supports planning for coastal resilience through an integrated approach that includes natural and hybrid features, as well as non-structural elements (Bridges *et al*., 2013).
- The Rebuild by Design challenge overseen by the US Department of Housing and Urban Development emphasised the importance of green infrastructure. Rebuild by Design competitively awarded a total of $930 million to support six innovative infrastructure projects designed to enhance coastal resilience in the region affected by Hurricane Sandy. Each of these projects has a significant hybrid infrastructure component.
- The U.S. Climate Resilience Toolkit of 2014, which is part of the President's Climate Action Plan, provides a collection of online tools and resources to help the US nation to prepare for climate-related changes and impacts, including tools and resources that support hybrid infrastructure approaches (NSTC, 2015).

The use of 'Multiple Lines of Defense' by the U.S. Army Corps of Engineers since 2009 to protect Louisiana's coasts, strategically combine the hybrid infrastructure approaches. It is an efficient and effective way to protect against climate related hazards such as Hurricanes Rita and Katrina. In New Orleans, overtopped embankments fronted by marshland survived Hurricane Katrina better than those without forward defences (Government Printing Office, 2006 in NSTC, 2015). The major impacts of these events have accelerated the adoption of a 'Multiple Lines of Defense' approach to coastal protection in Louisiana (Figure 8.5). The 'Multiple Lines of Defense' strategy involves using environmental features such as barrier islands, marshes, and ridges to complement structures such as highways, levees, and flood gates, as well as non-structural measures such as raised homes and evacuation routes.



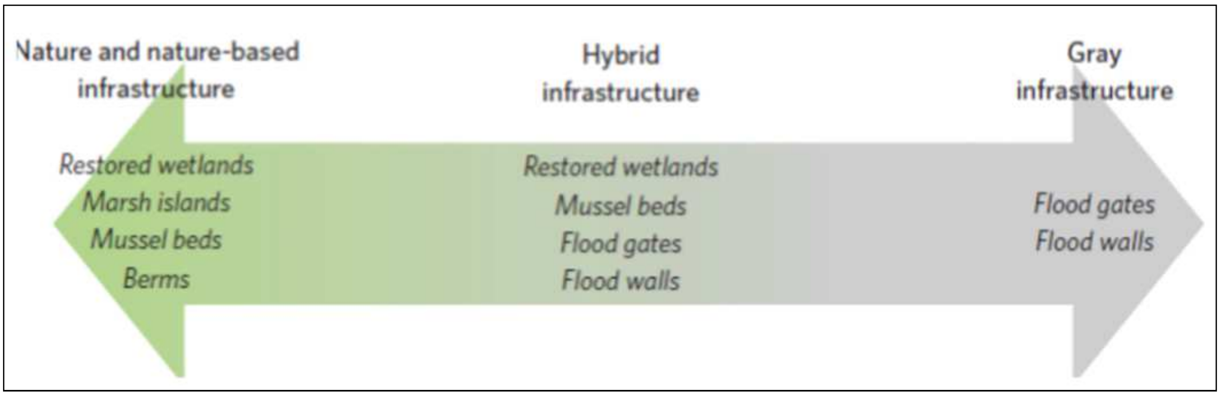
Source: NSTC (2015)

Figure 8.5 Multiple lines of defense, an example of a hybrid approach

The salt marshes, mangroves, seagrasses, reefs, beaches, and dunes that enhance coastal resilience by providing protective services also contribute raw goods and materials, plant and animal habitats, water and air quality regulation, carbon sequestration, nutrient cycling, and opportunities for tourism, recreation, education, and research (Barbier *et al*., 2011 in NSTC, 2015). Besides, coastal Green Infrastructure projects that reduced vulnerability and enhanced resilience also simultaneously advance other societal, environmental, and economic objectives and can help planners and decision-makers to better achieve policy and regulatory goals.

Using only grey infrastructure to mitigate disaster risks such as floods cost more and leads to missed opportunities for generating additional economic benefits and ecosystem services, such as recreation, carbon sequestration and enhancing biodiversity. However, the use of nature and nature-based infrastructure alone, such as wetlands, may not optimally mitigate the impacts of disasters such as floods (The Nature Conservancy, 2015). The Nature Conservancy (2015) therefore demonstrated that combining nature and nature-based infrastructure such as wetlands with grey infrastructure, provides the most cost-efficient mitigation to sea level rise, floods, storm surges and other climate-related disaster risks to build urban resilience, using the example of Queen Beach in the New York City. The combination of DRR, CCA and the supply of wetlands ecosystem services to build resilience was clearly demonstrated in the case study of Queen Beach of the New York City (The Nature Conservancy, 2015). Though the example above is based on a coastal city, the approach can be replicated in other areas like the inland eFS or coastal cities in South Africa such as Durban, Port Elizabeth and Cape Town.

Nature and nature-based infrastructure such as wetlands contribute to DRR, CCA, increase ecosystem and social resilience by enhancing both the environment such as water quality, air quality, and biodiversity, as well as improve the quality of life in surrounding communities (The Nature Conservancy, 2015) (Figure 8.6).



Source: The Nature Conservancy (2015)

Figure 8.6 Green versus grey infrastructure to mitigate storm surges

Non-natural structures that are consciously integrated into hybrid approaches can support, rather than impede, provisioning services by natural features (NSTC, 2015). Grey infrastructure is initially robust when constructed, but over time, requires continual maintenance or eventual replacement to offset deterioration caused by the physical impacts of waves and wind. By contrast, green infrastructure can, if well-managed, strengthen over time. It is therefore possible to design hybrid infrastructure approaches in which grey components protect green components initially, while growth and entrenchment of green components lessen degradation or allow removal of the grey components in the longer term (Sutton-Grier *et al*., 2015 in NSTC, 2015).

When designed strategically, green infrastructure can also absorb wave and wind energy and storm surges so as to extend the life of grey infrastructure and reduce the height and cost required for grey infrastructure to provide adequate protection from climate-related hazards (Palmer, 2013 in NSTC, 2015; U.S. Army Corps of Engineers, 2004, 2009). The consensus, therefore, is to use the hybrid approach, but where cost does not permit to use both and where grey infrastructure is expensive, then green infrastructure can be used as the first line of defence against hazards.

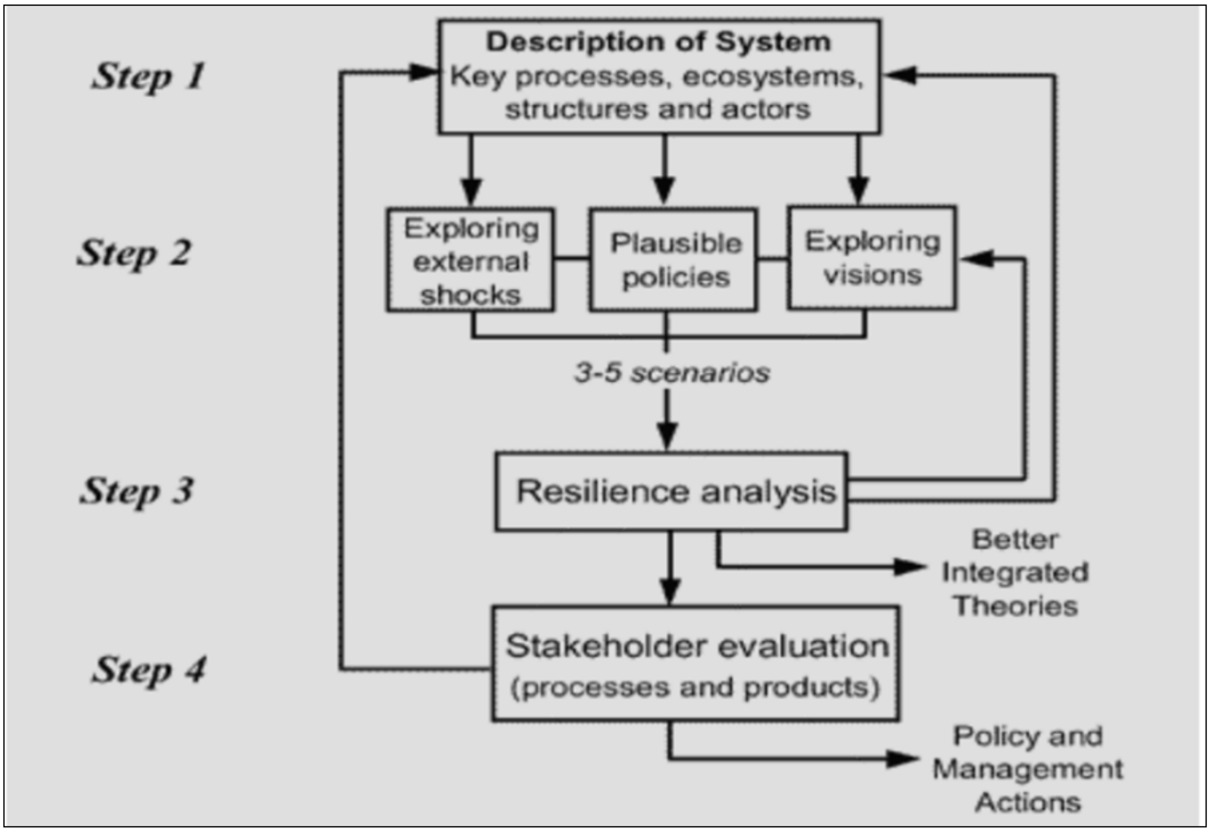
8.7 WETLANDS AND RESILIENCE

Wetlands need to be resilient in order for them to provide their ecological services effectively. While the concept of resilience is well-integrated in DRR and CCA studies, this is not the same with environmental management. The main objective of this study is to bring DRR, CCA and environmental management together to build resilient wetlands.

By reducing risks and vulnerability we build resilience to climate change, and against future disasters (Takeuchi *et al*., 2014). Resilience can be general or specific. General resilience refers to the capacity of socio-ecological systems to adapt or transform in response to unfamiliar, unexpected and extreme events, while specific resilience is the resilience of a particular group or part of a system to respond to an individual stress at a particular time or place (The Royal Society of Science [RSS], 2014). Both general and specific resilience need to be considered in wetlands management because focusing on high resilient to only one stress or shock can increase general vulnerability to other shocks.

Twigg (2009) looks at community or system resilience as the capacity to anticipate, minimise and absorb potential stresses or destructive forces through adaptation or resistance, manage or maintain certain basic functions and structures during disastrous events and recover or ‘bounce back’ after an event (Twigg, 2009). In social−ecological systems, resilience is the ability of a social−ecological system such as a wetland to maintain its functionality when hit by a shock, or maintain the basic characteristics needed to renew or reorganise itself if a large stressor seriously alters its structure and function (Walker *et al*., 2002; Takeuchi *et al*., 2013). Though this concept is applied to a SES, it holds for any other system or community. In the long-term, sustainability management of social−ecological systems involves complex adaptive systems, where the managers are integral components of the system, unlike in natural resource management approaches where the manager is excluded in the analysis (Walker *et al*., 2002; Takeuchi *et al*., 2013). This research uses the social−ecological system approach grounded in systems thinking to come up with a framework on wetlands resilience.

The management of social−ecological systems such as wetlands involves plans for complex changes that take place in the environment in order to maintain long-term sustainability and ecological resilience of the system. Walker *et al*., (2002) proposed a four-step framework for the analysis of resilience in social−ecological systems (Figure 8.7). Such a framework has many similar elements with the one proposed at the end of this research. While policies are seen as outcomes in the framework by Walker *et al*. (2002), policies and institutions come at the beginning of the proposed framework in this research. One can argue that writing in 2002, Walker *et al*. had not been well-exposed to later developments in the disciplines of DRR and CCA. This study brings in tools such as effective legal and institutional framework, risk and vulnerability analysis, DRR, CCA to build resilience in social ecological systems using wetlands in the eFS.

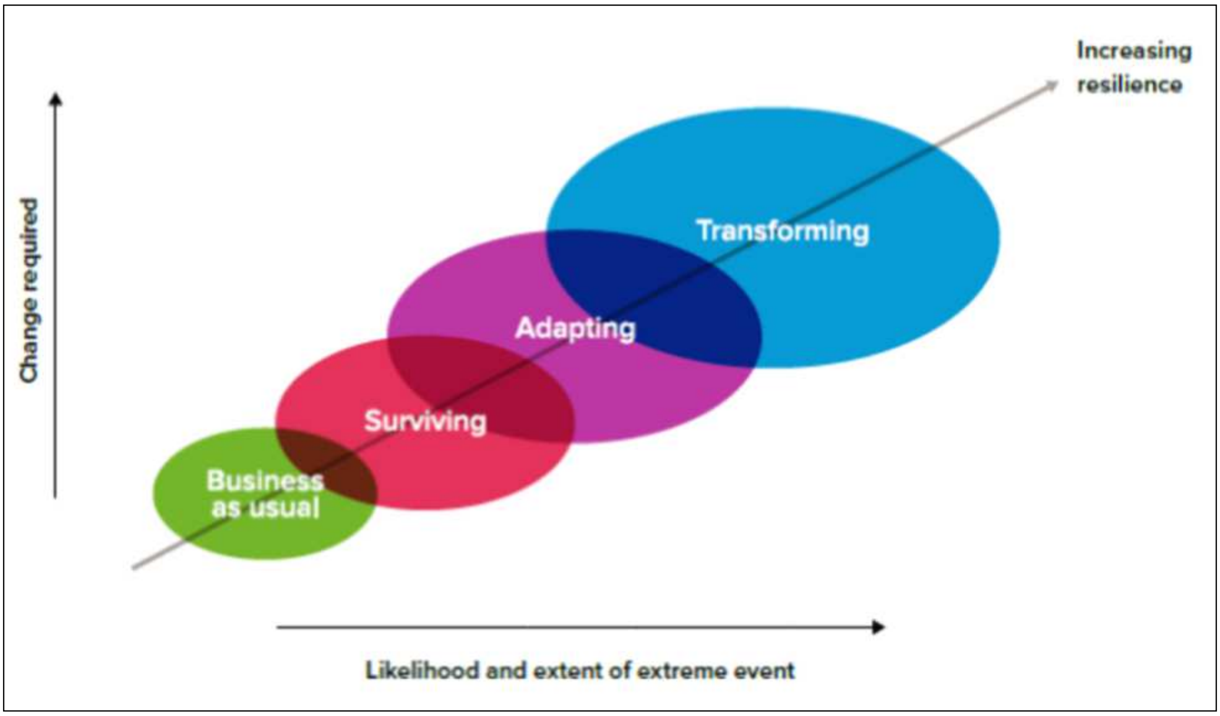


Source: Walker *et al*. (2002)

Figure 8.7 A framework for the analysis of resilience in social−ecological systems

8.7.1 Components of resilience

There are different components of resilience and the RSS (2014) identifies three of them: surviving, adapting and transforming. Though these three are not mutually exclusive, they could occur in progression and are processes rather than outcomes (Figure 8.8). Resilient response start with **surviving**, also known as absorbing, which involves coping with stress and shock at a more reduced quality of life. RSS (2014) claim that most DRR efforts focus on this, but that may not be true as many DRR efforts can really strengthen livelihoods and coping capacities. A more active resilience response involves **adapting** which includes making changes to structures, lifestyles and livelihoods in response to the stress or shock and may lead to altered and potentially improved quality of life. The third resilience response is **transforming** which goes a step further and involves making fundamental and not marginal changes to the system on a long-term basis (RSS, 2014). Like adaptation, transformation can be positive or negative, but in resilience studies, emphasis is placed on positive adaptation and transformation.



Source: RSS (2014).

Figure 8.8 Components and progress of resilience

Resilience is also relative, complex and multi-faceted because different features or levels of resilience are needed to deal with different kinds and severities of risk, shock, stress or environmental changes (Twigg, 2009).

8.7.2 Building blocks of resilience

While Twigg (2009) developed a community resilience framework based on the five priority areas of the HFA 2005−2015, the Partners for Resilience Alliance (comprised of CARE Netherlands, Cordaid, the Netherlands Red Cross, the Red Cross/Red Crescent Climate Centre and Wetlands International) developed four building blocks on ways to achieve community resilience in a holistic manner. These building blocks can be applied at household, community, civil society up to landscape levels and they encourage communities to:

- anticipate the risks they face by building on existing capacities;
- respond when disaster strikes, while maintaining basic structures and functions;
- adapt to changing risks and to a changing location situation and its livelihood options;
- transform themselves to address the underlying factors and root causes of risk; an
- to be active partners to governments in implementing DRR (Van Leeuwen *et al*., 2014).

The last block should actually be the foundation on which the other blocks should lie since it touches on the issues of community vulnerability. Addressing the environmental root causes of disaster risk is a *sine qua non* to strengthening community resilience (Van Leeuwen *et al*., 2014). The natural environment most often is the solution or part of the solution to our disaster risk and climate change problems. Acknowledging and understanding the strong interdependency between land-use types and ecosystems, human well-being and the dynamic risk patterns, are at the centre of community resilience. Measures that improve land use and sustain ecosystem health at the landscape level provide the basis for DRR and CCA practices to which more localised approaches could be incorporated (Van Leeuwen *et al*., 2014). Building community or system resilience is therefore a complex and multifaceted process, all of which need to be addressed in a holistic manner using systems thinking.

8.8 THE CONCEPT OF ECOSYSTEM-BASED DISASTER RISK REDUCTION AND CLIMATE CHANGE ADAPTATION – EXPLANATION, RELEVANCE AND APPLICATION)

The whole concept of ecosystem-based disaster risk reduction (Eco-DRR) and climate change adaptation (CCA) is built from two sub concepts which include ecosystem-based adaptation (EbA) and ecosystem-based disaster risk reduction (Eco-DRR) (Renaud et al., 2016). The EbA addresses climate-related natural hazards, long-term mean changes in climate and future uncertainties. EbA incorporates biodiversity and ecosystem services into an overall adaptation strategy to help communities adapt to the negative effects of climate change (Lo, 2016). Meanwhile Eco-DRR involves the sustainable management, conservation and restoration of ecosystems to reduce disaster risk and achieve sustainable and resilient development (CNRD & PEDRR, 2013; Renaud *et al*., 2013). Eco-DRR uses ecosystems to manage risks of both climate and non-climate related hazards such as earthquakes (Lo, 2016). Despite these differences, EbA and Eco-DRR have many similarities because they both focus on ecosystem management, restoration and conservation to increase community and ecosystem resilience (Lo, 2016). The Eco-DRR/CCA approach adopted in this study therefore embraces the main focus of EbA and Eco-DRR which is the sustainable management of wetlands to reduce vulnerability to disaster risks and negative climate change impacts with the aim of building community and ecosystem resilience.

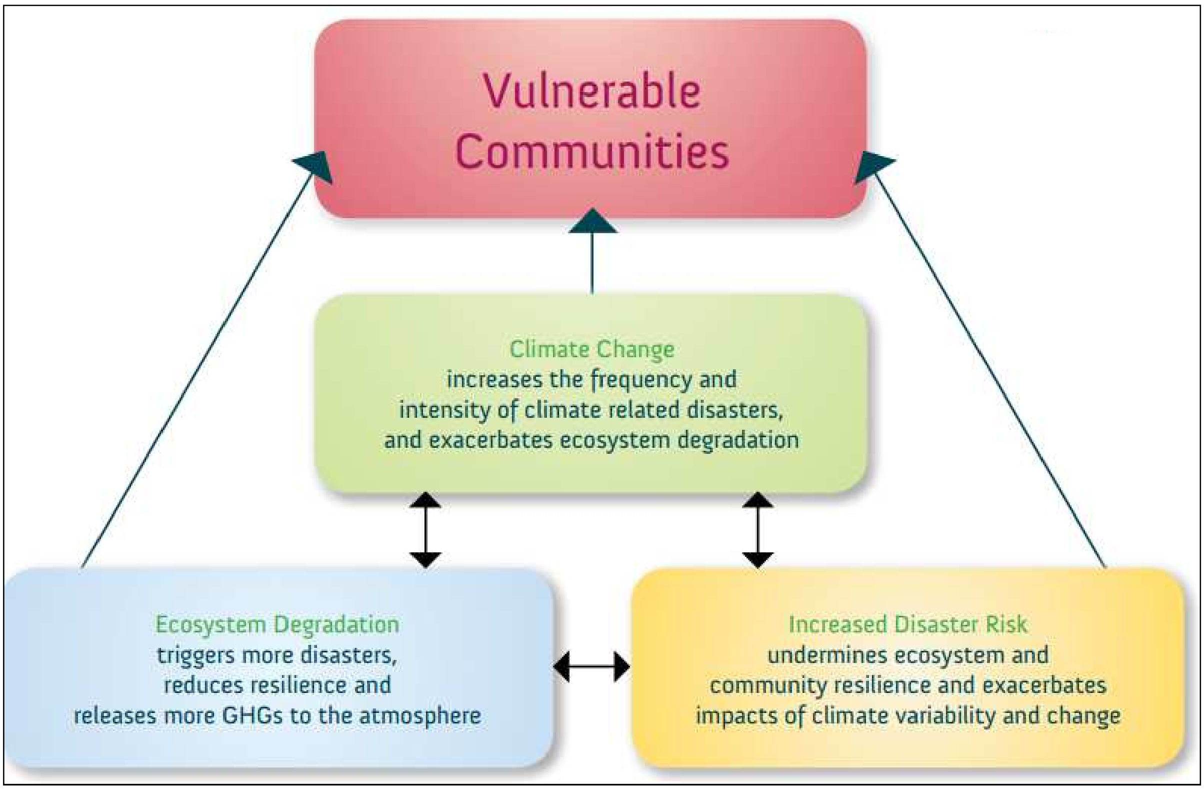
An ecosystem approach in DRR and CCA involves effective strategies for maintaining and restoring well-functioning ecosystems in order to provide livelihoods, mitigate disaster risks, adapt to climate change and promote healthy environments (Renaud *et al*., 2013; UNEP, 2010). The whole approach should be integrated in all phases of the disaster management cycle or spiral, as well as development programmes. Well-managed ecosystems like wetlands mitigate most natural disasters, provide sustainable livelihoods to most communities, especially rural poor communities which rely so much on nature for survival and these ecosystems also provide back-up support services during the aftermark of most disasters (Chen and Huang, 2012; Estrella and Saalisma, 2011; Gupta and Sreeja, 2012; MA, 2005; Sudmeier-Rieux and Ash, 2009; Sudmeier-Rieux *et al.*, 2006; Renaud *et al*., 2013). Eco-DRR involves the sustainable management, conservation and restoration of ecosystems such as wetlands to reduce disaster risk, with the aim to achieve sustainable local livelihoods and resilient development (Estrella and Saalismaa, 2011; Sudmeier-Rieux and Ash, 2009).

There is a vicious spiral between climate change impacts, ecosystem degradation and increased risk of climate-related disasters, and it is important to demonstrate the central role of ecosystem management in CCA and DRR through their multifaceted linkages (UNEP, 2009). Spinoffs from such integrated management approach include building community resilience, promoting sustainable development, reducing poverty, providing sustainable livelihoods and promoting healthy environments rich in biodiversity. These are the central tenets of Eco-DRR/CCA and are the focus of this research.

The Eco-DRR/CCA approach requires political commitments at the highest level, adequate financial, technological and knowledge resources and policy-setting, capacity-building, planning and practices at national level (UNEP, 2009). Fortunately, 2015 presented the best opportunity for the integration of Eco-DRR/CCA at international level. The HFA 2005−2015, which was the global agreement to reduce disaster risk and the MDGs both came to an end in 2015, while the effort of the UNFCCC to create a legally binding climate agreement for global action on tackling climate change also took place in 2015 (IPCC, 2015; Mitchell *et al*., 2014, UNISDR, 2015). The year 2015 therefore created a window of opportunity to effectively mainstream Eco-DRR/CCA into many international arenas.

Mitchell *et al*. (2014) suggest that a common target, indicators and monitoring system for both SDGs and the SFDRR be jointly determined, not only because disasters and development are strongly interrelated, but also to reduce the burden on countries and monitoring organisations. Though global targets may be set, they should be adapted to national risk profiles. The system of reporting progress should also be transparent with an independent body to monitor the progress reports supplied by national governments, as well as encouraging peer review from different countries within each region. A 20% reduction in disaster loss by 2030 was proposed as a realistic target (Mitchell *et al*., 2014). The addition of healthy ecosystems or environmental management targets to the proposed indicators and monitoring system by Mitchell *et al*. (2014) will bring the whole concept and practice of Eco-DRR/CCA into international limelight.

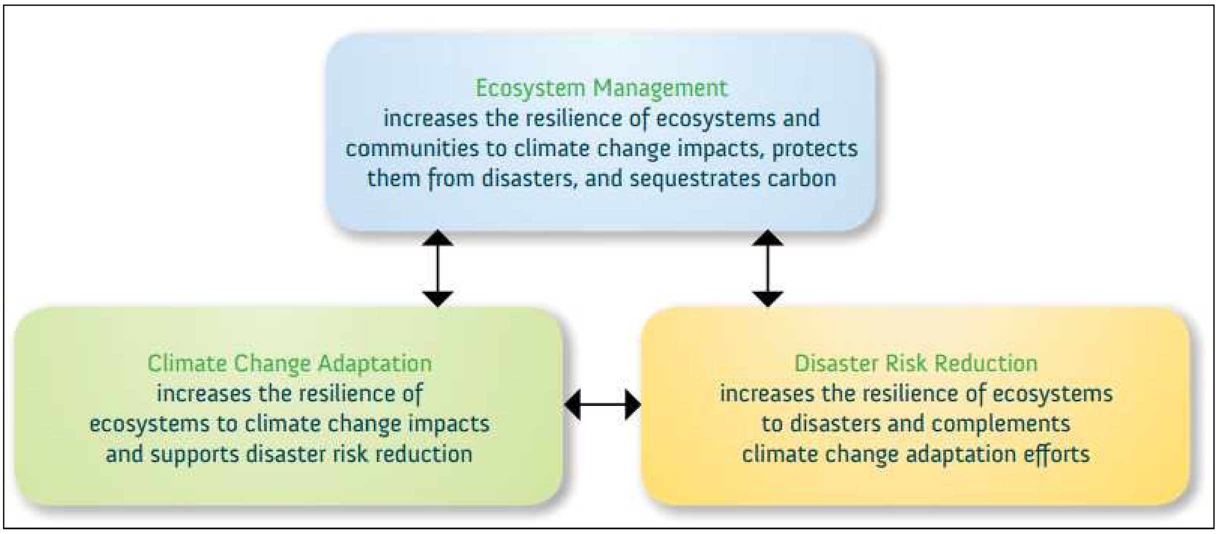
Climate change, ecosystem degradation and increasing disaster risks are interlinked in a vicious cycle as indicated in Figure 8.9, and all of these increase community vulnerability (UNEP, 2009). This, therefore, necessitate wise and sustainable management of ecosystems, especially wetlands, in the case of this study.



Source: UNEP (2009)

Figure 8.9 Linkages between climate change, ecosystem degradation and increased disaster risk

The central role of ecosystems such as wetlands in reducing disaster risk and adapting to climate change is summarised in Figure 8.10 below.



Source: UNEP (2009)

Figure 8.10 The role of sustainable ecosystem management in disaster risk reduction and climate change adaptation

While the role of ecosystems in DRR is gaining ground and becoming popular, the addition of CCA seems to have run into the territory of EbA. EbA mainly focused on using ecosystems to adapt to climate change. The need to synergise DRR and CCA measures and institutions also apply to Eco-DRR and EbA. International role players such as the UNISDR, the UNEP, the PEDRR, the IPCC and the UNFCCC need to sit around the table to sort out the perceived rather than real differences between DRR, CCA, Eco-DRR, EbA and now Eco-DRR/CCA. The latter seems to be the way forward, but apparently not all the role players are yet on board to take forward the new approach which is currently spear-headed by UNEP and the PEDRR.

8.9 DISASTER RISK REDUCTION, CLIMATE CHANGE ADAPTATION AND DEVELOPMENT

Despite the relationship between DRR, resilience and development, this relationship has not been adequately exploited in the MDGs and now the SDGs. Disasters can erode and destroy decades of development gains, while development can create or increase vulnerability (UNISDR/WMO, 2012). Disasters and poverty are much linked because the poor and most marginalised are the worst prone to disaster areas, suffer the impacts most and are the least to recover from disastrous events with no means to diversify risks of disaster through measures like insurance. Disasters exacerbate vulnerabilities and social inequalities and harm economic growth. Disasters can destroy years of economic gains of a country or community. Disasters can also increase impoverishment of many people within the disaster stricken area by bringing many victims of disasters who were formerly above the poverty datum to below the poverty line (Mitchell *et al*., 2014). There is growing evidence that disasters are hindering development and poverty alleviation efforts. Therefore, sustainable development planning and programmes must integrate DRR and CCA (Mitchell and Van Aalst, 2008).

DRR is a cross-cutting issue and in the context of sustainable development it is an important element for the achievement of internationally agreed upon MDGs and the SDGs (Renaud *et al*., 2013; UNISDR, 2005; UNDP, 2015). It is important to mainstream DRR into development policies, planning and programmes in order to achieve sustainable development (UNISDR, 2013). The South African Local Government: Municipal Systems Act, Act 32 of 2000, and the IDP that guides the operationalisation of DRR and development exist on paper, but experience has shown a lack of integration and implementation on the ground and grassroots levels.

Reducing the risks of disasters (for example, prevention, preparedness, and early warning systems) for predictable events like cyclones, large storms, heavy precipitation events, droughts, heatwaves and cold fronts, helps to protect both human and economic assets (UNISDR/WMO, 2012).

Since the 1970s, the world population has increased by more than 87% and vulnerability and exposure to disasters are increasing as more people and assets locate in areas of high risk. Therefore, the impact of disasters caused by natural hazards and vulnerability will continue to intensify, presenting an increasingly significant challenge to development. About three-quarters of the world's largest cities are located at the coast, and coastal areas are particularly very vulnerable to multiple hazards often associated with climate change like sea level rise, tsunamis, storm surges and cyclones (UNISDR/WMO, 2012). Any sustainable coastal planning should therefore integrate DRR strategies.

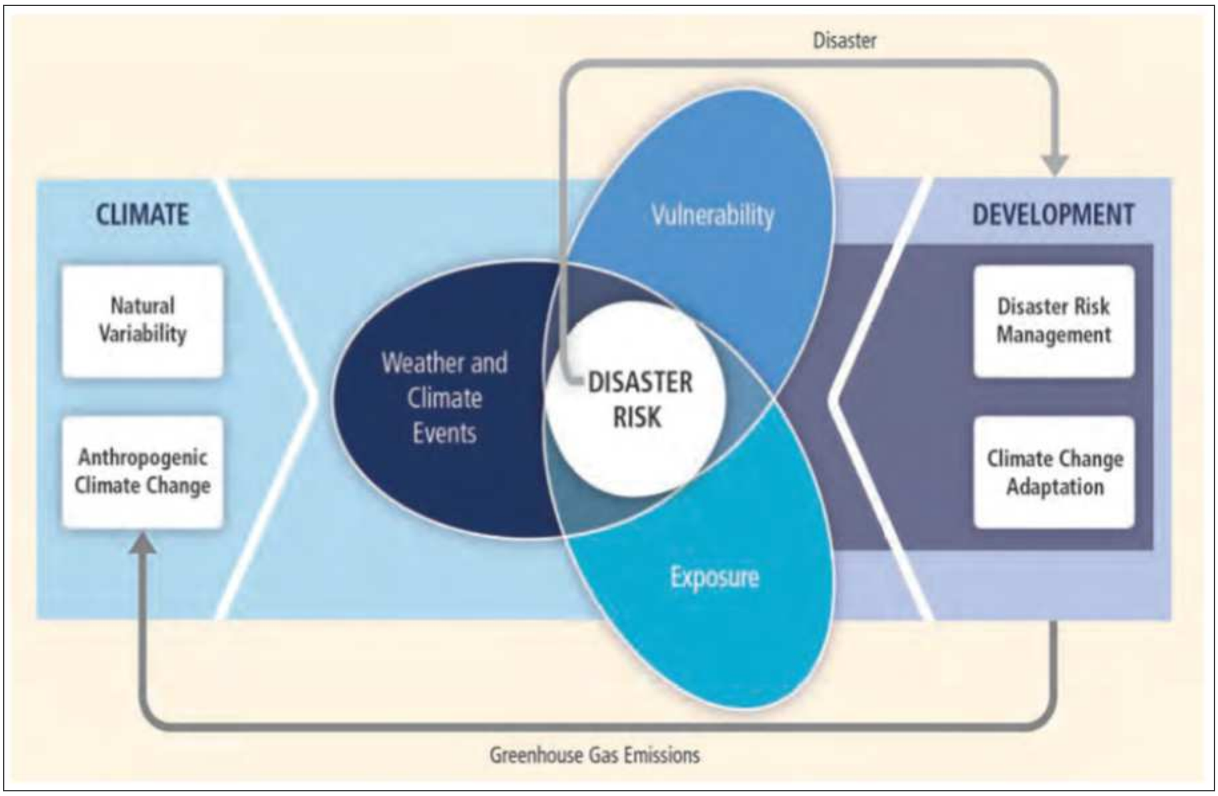
Generally, proper DRR planning and execution help to build resilient societies and resilient societies are better equipped to carry out sustainable development, so the nexus between DRR, resilience and sustainable development is thus created. This is the focus theme of the HFA 2005−2015. The multi-stakeholder and multi-sector HFA serves as the guiding instrument for international cooperation, DRR and resilience building and provides guidance on how DRR contributes to sustainable development (UNISDR/WMO, 2012). The new SFDRR 2015−2030 still echoes the basic tenets of the HFA 2005−2015 of reducing vulnerabilities, improving on DRR activities, and more specifically, building resilience.

DRR is developmental when policies and strategies for risk reduction (preparedness, hazard mitigation and human vulnerability reduction) are integrated into development policies and practices such as the recommended practice of 'Build Back Better' during reconstruction following a disaster. This practice is also aligned to the MDGs, the Poverty Reduction Strategy Papers and now the Sustainable Development Goals (Pelling and Holloway, 2006; UNISDR, 2013; UNDP, 2015).

The Rio+20 Conference explicitly links DRR, sustainable development and climate change. It also advocates for more comprehensive and coordinated strategies that integrate DRR and CCA into public and private investment for development (PEDRR, 2014). The nexus between DRR, CCA and sustainable development is well-articulated in this research on wetlands management.

CCA and DRR are essential ingredients for meaningful development because CCA and DRR reduce the negative impacts of climate change and disaster risks on humans, their assets, on the environment and on the overall development of the affected communities. Globally, risk reduction initiatives have failed to keep pace with the increase in exposure to natural hazards and higher levels of vulnerability. This trend is likely to continue into the distant future as the impacts of climate change continue to alter many natural systems (IFRC, 2013; IPCC, 2012; UNISDR, 2013). Climate change is altering the face of disaster risk, not only through increased frequency and severity of hydro-meteorological events, sea level and temperature rise (IPCC, 2012; IPCC, 2007), but also through increases in societal vulnerabilities (IFRC, 2013; Wisner *et al.*, 2013). As a result of global warming, climate-related hazards like floods, droughts, heatwaves, tropical cyclones/hurricanes and storms are expected to become more frequent and more intense. Climate change has and will continue to damage livelihoods, increase poverty and affect food security. Some climate-related hazards such as tropical cyclones, storms, floods, droughts, heatwaves and cold fronts will affect places that have not experienced them before. All these will lead to increased vulnerabilities (IFRC, 2013).

Generally speaking, DRR is an important element of CCA and may be *vice versa*, while both contribute to healthy environments and sustainable development. On the other hand, healthy environments or ecosystems are fundamental for DRR and CCA which together form the foundation for sustainable development. The central message and main aim of this research is to highlight the critical and cyclical nexus between ecosystems, DRR and CCA for development within the current changing local and global environment. To realise this aim requires good operational policies, careful planning, and efficient, holistic and adaptive management of natural resources such as wetlands.



Source: IPCC (2012)

Figure 8.11 The link between climate change, disasters and development

Climate change that can produce extreme climate events can be caused by natural climate variability, but most importantly, by anthropogenic climate change (IPCC, 2012). Such extreme climate events can easily lead to a disaster where both exposure to the extreme event and the vulnerability of the people and assets are high. Disasters can set back many years of development efforts, but at the same time the integration of disaster risk management, including better environmental management and CCA strategies into development plans, can drastically reduce disaster risk and produce lasting and sustainable development. It is therefore very important that climate change specialists, disaster management specialists, development planners and environmentalists work in close cooperation to synergise efforts and tackle climate, disaster, environment and development issues in a holistic approach. The whole essence of the Special report on managing the risks of extreme events and disasters to advance climate change adaptation (known as the SREX report) (IPCC, 2012) is based on building such synergy and adopting the holistic approach as discussed.

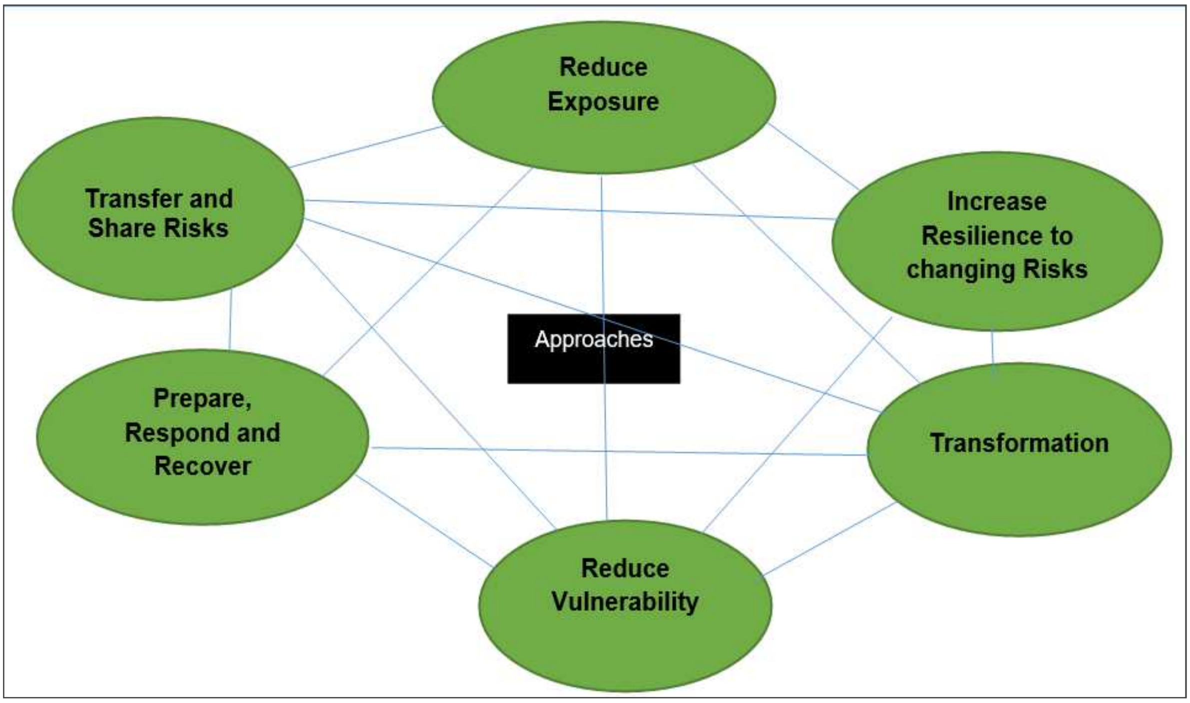
8.10 GENERAL CHARACTERISTICS, SIMILARITIES AND DIFFERENCES BETWEEN DISASTER RISK DEDUCTION AND CLIMATE CHANGE ADAPTATION

There is increasing recognition of the strong synergy between DRR and CCA initiatives (Doswald and Estrella, 2015; IPCC, 2014). DRR and CCA have always grown in silos with different stakeholders, expert groups, funding mechanisms and processes. However, the Rio+20 outcomes emphasised that DRR and CCA should be institutionally linked to encourage more integrated planning, efficient and effective results, leverage financial resources and investment, reduce redundancies and administrative bottlenecks at national and international levels, as well as donors and multilateral agencies (PEDRR, 2014).

DRR measures can deal with current climate variability and act as first line of defence against climate change, which is part of adaptation. On the other hand, for DRR to be successful, it needs to accommodate the shifting risks associated with climate change and ensure that DRR measures do not increase vulnerability to climate change in the medium to long term (Mitchell and Van Aalst, 2008; UNISDR, 2015). Despite these overlaps, DRR addresses a much wider range of hazards than those relating to climate, whilst CCA’s scope extends to issues beyond DRR, such as changes and loss of biodiversity (Twigg, 2009). The complimentary role of DRR and CCA in reducing local vulnerabilities of both ecosystems such as wetlands and human societies is emphasised in this research.

DRR and CCA have been handled as two parallel issues at international level by both the UNISDR and the UNFCCC. At national levels the same is replicated where CCA and DRR typically have separate institutional ‘cupboards’, often ministries of environment for CCA and ministries of the interior, civil protection units or similar agencies for DRR, each with their own intersectoral coordination groups, each with their own channels of funding, and each with separate entry points into different international agreements, mainly UNFCCC and UNISDR (Mitchell and Van Aalst, 2008). Some researchers argue that since DRR and CCA communities have been working in isolation, they have thus failed to reduce increasing vulnerability because the scale and the underlying causes of vulnerability have often been ignored (Thomalla *et al*., 2006). Both communities have developed assessment tools, but baseline assessments of vulnerability are still lacking. There is little formal evaluation of vulnerability assessment techniques and experiences as to whether the baselines actually inform decision-making and result in meaningful changes is still a hiccup (Thomalla *et al*., 2006).

However, the close relationship between DRR and CCA is such that one cannot talk about DRR without implicitly diving into CCA. Both focus on reducing exposure to hazards, vulnerability and increasing resilience to the potential adverse impacts of stressors. Adaptation and to a greater extent mitigation strategies which are common to both can complement to significantly reduce the risks of climate change and other non-climate change related risks (IPCC, 2012; Mitchell and Van Aalst, 2008; World Risk Report, 2011). The Bali Action Plan (Mitchell and Van Aalst, 2008) emphasised the importance of using disaster reduction strategies and to address negative impacts associated with climate change. DRR and CCA are actually intertwined, but the problem lies in the recognition and approach of both. The IPCC (2012) proposes approaches to address disaster risk and adapt to climate change as indicated in Figure 8.12 below:



Source: IPCC (2012)

Figure 8.12 Interlinked approaches to manage disaster risk and adapt to climate change

Climate change is one of the drivers of disaster risk and CCA is included in DRR (Spiekerman *et al*., 2015). The issue of whether DRR is included in CCA or *vice versa* is not clear amongst scientists, as the two continue to have different institutional and focal orientation at national and international levels. There appears to be more similarities than there are differences in the aims and application of DRR and CCA measures (Birkmann *et al*., 2013; Doswald and Estrella, 2015; Mitchell and Van Aalst, 2008) though the two are under different international supra-structures of UNCCC and UNISDR, respectively. Table 8.5 shows the general characteristics of CCA and DRR.

TABLE 8.5: GENERAL CHARACTERISTICS OF DISASTER RISK REDUCTION AND CLIMATE CHANGE ADAPTATION

Climate Change Adaptation	Disaster Risk Reduction
1. Approach	
• Risk management • Strong scientific basis • Environmental science perspective • Highly interdisciplinary • Vulnerability perspective • Long-term perspective • Global scale • Top-down	• Risk management • Engineering and natural science basis • Traditional focus on event and exposure and on technological solutions • Shift from response and recovery to awareness and preparedness • Short term but increasingly longer term • Local scale • Community-based

2. Organisations and institutions	
• Intergovernmental Panel on Climate Change (IPCC) • United Nations Framework Convention on Climate Change (UNFCCC) • Academic research • National environment and energy authorities	• United Nations International Strategy for Disaster Reduction (UNISDR) • ProVention Consortium (World Bank) • International Federation of Red Cross and Red Crescent Societies (IFRC) • International, national and local civil society organisations • National civil defence authorities
3. International Conferences	
• Conference of the Parties (COP)	• World Conference on Disaster Reduction
4. Assessment	
• PCC assessment reports	• IFRC Vulnerability and Capacity Assessment (VCA) • IFRC World Disasters Report • International disasters databases: EM-DAT NatCatSERVICE (Munich Re) Sigma (Swiss Re)
5. Strategies	
• National communications to the UNFCCC • National Adaptation Plans of Action (NAPA) for Least Developed Countries	• UN International Decade for Natural Disaster Reduction (IDNDR) • Yokohama Strategy and Plan of Action for a Safer World • UN International Strategy for Disaster Reduction (ISDR) • Hyogo Framework for Action 2005−2015 • Sendai Framework for Disaster Risk Reduction 2015−2030
6. Funding	
• Special Climate Change Fund • Least Developed Countries Fund • Kyoto Protocol Adaptation Fund	• National civil defence/emergency response • International humanitarian funding (for instance, UN Office for the Coordination of Humanitarian Affairs (OCHA) • Multilateral banks • Bilateral aid
Emerging Programmes	
Ecosystem-based Adaptation (EbA)	Ecosystem-based Disaster Risk Reduction (Eco-DRR)

Source: Adapted from Thomalla *et al*. (2006)

Though some of these characteristics can be questioned, for example academic research apportioned only to CCA, they, however, paint a good picture of the two. It should also be noted that despite their overlaps, DRR is not the same as CCA (Mitchell and Van Aalst, 2008). Their similarities and differences are summarised in Table 8.6 below.

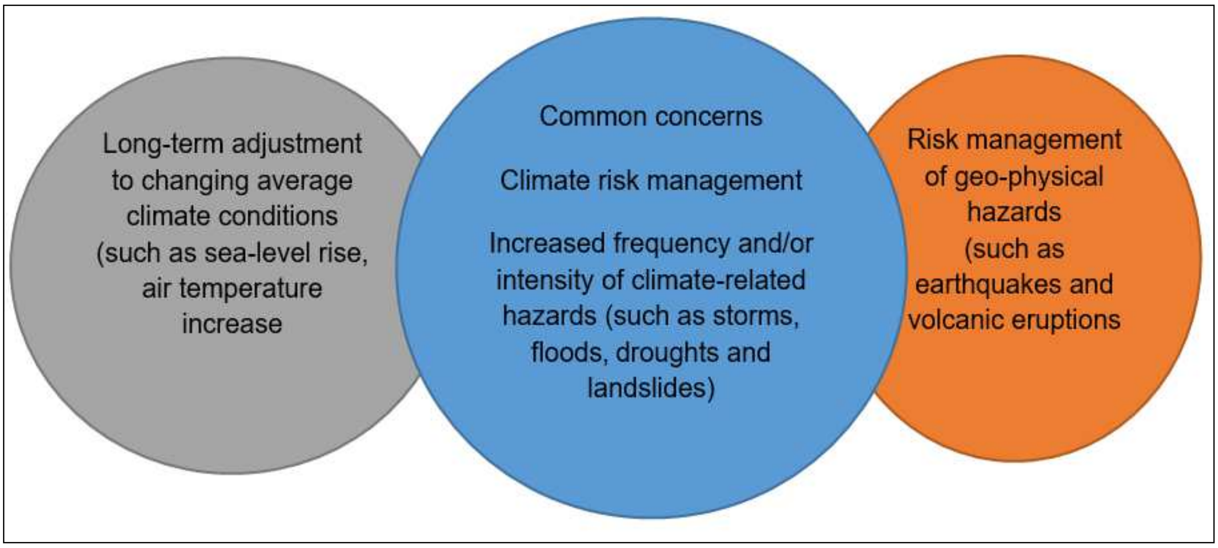
TABLE 8.6: SIMILARITIES AND DIFFERENCES BETWEEN CLIMATE CHANGE ADAPTATION AND DISASTER RISK REDUCTION

Similarities	Differences
DRR and CCA have common concerns in managing climate-related risks DRR and CCA share a common goal of reducing vulnerability and achieving sustainable development They share a common conceptual understanding of the components of risk (product of exposure and vulnerability to hazards) and the processes of building resilience DRR is often the first line of protection against weather- and climate-related disasters For DRR to be efficient, it must take into account climate-related risks or be climate-smart Climate change adaptation specialists are now being recruited from engineering, agriculture, health and DRR sectors DRR is increasingly forward-looking with existing climate variability as an entry point for CCA Both are examples where integration of scientific knowledge and traditional knowledge provides learning opportunities There is increasing recognition that more adaptation tools are needed and must learn from DRR DRR community now beginning to engage in CCA funding mechanisms Both communities have developed a range of analytical tools and methodologies based on risk management approaches to assess risk and vulnerability and to identify opportunities for action The disaster risk management community is Increasingly adopting a more anticipatory and forward-looking approach, bringing it in-line with the longer-term perspective of the climate change community on future vulnerabilities Climate change adaptation increasingly places emphasis on improving the capacity of governments and communities to address existing vulnerabilities to current climate variability and climatic extremes, bringing it within the remit of the disaster risk management community For both communities, poverty reduction is an essential component of reducing vulnerability to natural hazards and climate change because poverty is both a condition and determinant of vulnerability Both communities increasingly recognise the importance of sustainable resource management and biodiversity for ecological resilience and livelihood security	DRR deals with all hazards, including hydro-meteorological and geophysical hazards, while CCA deals exclusively with climate-related hazards associated with changes in the average climate conditions. DRR tackles the risks of geophysical hazards (like volcanoes and earthquakes), whereas adaptation does not Adaptation considers the long-term adjustment to changes in mean climatic condition, including the opportunities that this can provide, whereas DRR is predominantly interested in extreme climate events. DRR has its origin and culture in humanitarian assistance following a disaster event, while CCA had its origin and culture in scientific theory DRR is mostly concerned with the present by addressing existing risks, while CCA is mostly concerned with the future by addressing uncertainty and new risks For DRR traditional/indigenous knowledge at community level is a basis for resilience, while for CCA traditional/indigenous knowledge at community level may be insufficient for resilience against types and scales of risk yet to be experienced DRR traditionally focuses on vulnerability reduction, while CCA traditionally focuses on exposure In DRR community-based process stems from experience, while for CCA community-based process stems from policy agenda DRR has a full range of established and developing tools, while CCA has limited range of tools under development DRR produces incremental development with low to moderate political interests, while CCA is a new and emerging agenda with high political interests DRR funding streams are often *ad hoc* and insufficient, while CCA funding streams are sizeable and increasing, though still not proportionate to size of problem The actors for DRR traditionally come from humanitarian sectors and civil protection, while those for CCA traditionally from the scientific and environmental community DRR activities are generally more wide-ranging, from disaster preparedness (early warning, contingency planning), prevention, disaster response, recovery, rehabilitation and reconstruction, while those of CCA are more restricted to prevention, mitigation,

Similarities	Differences
Climate change adaptation and disaster risk management both need to be linked or mainstreamed into sectoral activities and development processes	preparedness and building adaptive capacities, typically excluding post-disaster activities Many countries prepare National Adaptation Plans (NAPs) following the Cancun Adaptation Framework adopted in 2010, while many countries prepare DRR plans following the HFA adopted in 2005 and succeeded by the SFDR adopted in 2015

Source: Adapted from Doswald & Estrelle (2015); IFRC (2013); Mitchell and Van Aalst (2008); Thomalla *et al*. (2006)

Most CCA measures, such as early warning systems, risk assessment and the sustainable use of natural resources, are in practice DRR activities as well (Doswald & Estrella, 2015; UNEP/UNISDR, 2008). The first step towards CCA is to address existing vulnerabilities to extreme climatic events. In the same vein, DRR is all about reducing vulnerabilities because disasters are all about vulnerabilities of people, their assets, their livelihoods and their environment. There is therefore a lot of convergence between the two practices and this is why both DRR and CCA were incorporated in this research (Figure 8.13).

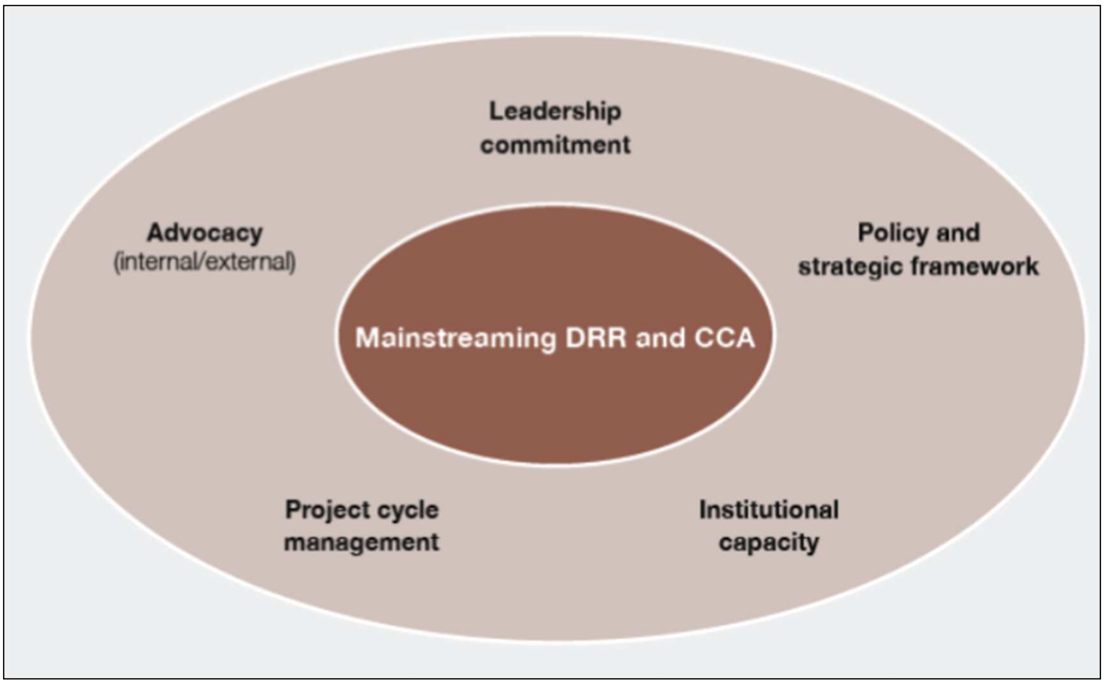


Source: Adapted from IFRC (2013); Mitchell and Aalst (2008)

Figure 8.13 Overlap between disaster risk reduction and climate change adaptation

8.11 CHALLENGES AND OPPORTUNITIES OF INTEGRATING DISASTER RISK REDUCTION AND CLIMATE CHANGE ADAPTATION

The main challenges that may be encountered in an attempt to bring DRR and CCA together into a holistic management approach, include bureaucratic organisational processes, lack of capacity and knowledge, funding arrangement, common terminology, lack of clarity on roles, time frame constraints and a culture of working in 'silos' (IFRC, 2013). Many DRR and CCA approaches produce 'soft' results over longer term periods, while most politicians and humanitarian agencies prefer 'hard' solutions which are often short term. However, an enabling environment can be created by devising a policy framework, ensuring the commitment of leadership and management, reinforcing necessary institutional capacity, integrating DRR and CCA considerations into project cycle management, as well as internal and external advocacy (IFRC, 2013) (Figure 8.14).



Source: IFRC (2013)

Figure 8.14 Enabling environment to mainstream disaster risk reduction and climate change adaptation

This research is a classic example on how DRR and CCA could be integrated to build ecological (wetlands) resilience and promote sustainable development.

8.12 CHAPTER SUMMARY

Chapter 8 discussed the linkages between wetlands and DRR. It started by explaining the genesis, processes and tools of DRR, before discussing the symbiotic relationship between wetlands and DRR which fits perfectly in the Eco-DRR/CCA paradigm and systems thinking approach. After having looked at climate change in Chapter 7, this chapter then discussed the common ground between DRR, CCA and wetlands management for resilience. This Eco-DRR/CCA approach was then linked to other community activities and programmes such as sustainable development and the green economy.

DRR has a long historical development which showed a shift in disaster management approach from a dominantly disaster response up to the 1980s to more proactive DRR in the 1990s. The new approach was championed by the HFA in 2005 which was replaced in 2015 by the SFDRR. Despite this shift in paradigm, the funding arrangement for DRR is still far behind that of post-disaster activities. Disaster risks can be reduced through planning and application of activities such as proper risk and vulnerability assessment, raising awareness on disaster risks, increasing community participation in disaster risk management, education and training in disaster prevention and mitigation, tackling and reducing vulnerabilities to eminent and recurrent hazards, building local capacities to face localised risks, drafting and executing effective early warning systems, and above all, putting in place proper legislative and institutional arrangements for effective and efficient disaster risk management.

Despite its long history, DRR still need to be made a daily choice for everybody. DRR awareness can be raised in schools by including DRR in school curricula at all levels and by engaging learners in DRR activities such as tree planting or building silt traps to reduce soil erosion. For the purpose of sustainability and lasting impact, it will be more effective to start DRR education and awareness from the early schooling ages. Within the local community, DRR awareness campaigns could be organised, community gatherings could have a slot on DRR bill boards, community radios, posters and short films to raise DRR awareness. At national level the government can use the mass media like the national television, radio and newspapers to reach out to the masses with effective DRR messages. Of growing importance is the use of social media such as Facebook, Twitter, Skype and Whatsapp. It is also important to acknowledge the important role of the natural environment in DRR as well as tap into and build on the special role of women in reducing disaster risks in the community.

DRR and CCA have more in common than differences, but are often handled in silos, therefore missing that advantage of synergy. There is also a very strong link between DRR, CCA and development and this needs to be exploited, especially in managing natural resources such as wetlands. The various forms of wetlands play a great role in mitigating disaster risk. The use of wetlands and other natural ecosystems to mitigate disaster risks is cost-effective, but may not be very efficient in eliminating all the unacceptable risks, hence the best is a hybrid approach that combines ‘grey’ and ‘green’ infrastructure after a meticulous risk assessment and cost-benefit analysis.

The use of natural ecosystems such as wetlands to reduce disaster risks and adapt to climate change is gaining international attention and is popularly referred to as the Eco-DRR/CCA approach. Studies show that there are more similarities than there are differences between DRR and CCA but there are hiccups of mainstreaming in both and finding synergy due to strategic rather than operational planning. Both DRR and CCA are found to be cornerstones in building community and system resilience. Resilient wetlands support sustainable development and enhances local community resilience through the various and continued supply of ecosystem services. Degraded wetlands will be inefficient to supply such services, hence the need for a better wetlands management approach such as the one proposed in this study.

Chapter 9

MATERIALS AND METHODS

9.1 INTRODUCTION

This section discusses the research design and methods that were followed to address the research problem and answer the research questions (see Chapter 1). It starts with the research approach that was followed to collect empirical data, then discusses the research methods that were used and included the target population, the sample size, sampling method and sampling process. The data collection tools and processes are then explained before a discussion on how the collected data were analysed and presented. What was included and excluded in the study is then explained in the study delimitation, while problems encountered in the research process are discussed under the limitations. The issues concerning reliability and validity of the collected data were explored, while adherence to the code of conduct that guides academic research is discussed under ethical considerations. This chapter is an expanded methodological section of Chapter 1.

9.2 THE RESEARCH DESIGN

It is estimated that about 1.5 million peer reviewed articles are published annually, but many of them are ignored in the academic arena. It is also estimated that about 82% of published articles are not cited even once (Heleta, 2016). This huge body of knowledge, including those from dissertations and theses, could change the world if the information were tailored to suit the general public consumption. One way of doing this is to bring the language and content down to the understanding of the common person (Heleta, 2016). The whole research approach was handled with the above reality in mind. First, to make sure the product is good and can be easily understood and applied by the local communities, especially private farmers on whose land most of the sampled wetlands are found.

9.2.1 Ontology and epistemology

Philosophically, researchers study what is knowledge under the **ontology**; how the knowledge is known as the **epistemology**; the value the knowledge contains as the **axiology**; the way it is written as the **rhetoric** and the process of studying the knowledge as the **methodology** (Creswell, 2003, 2014). Systems thinking, social−ecological system and coupled human−environment approach within the Eco-DRR/CCA paradigm constituted the foundation for a holistic and integrated wetlands management framework in the eFS, and this formed the ontological thinking and the epistemology of this research project.

9.2.2 Research paradigm

The word 'paradigm' has been used by different authors in different contexts to mean different things, thus creating much confusion (Bertram and Christiansen, 2014). In the context of this research, a paradigm is understood to be a set of beliefs, philosophical thinking or worldviews about what can possibly be known about the world, existence, and what is important in research, as well as how to approach the research (Bertram and Christiansen, 2014; Creswell, 2014; Van Wyk, 2016).

The study was about an empirical or a real-world issue (Mouton, 2001), and a synthesis of the post-positivist and interpretivist approaches shaped the philosophical orientation of the research (Babbie *et al.*, 2008; Bertram and Christiansen, 2014; De Vos *et al.*, 2005; Kitchin and Tate, 2000; Maree, 2007; Okeke and Van Wyk, 2015). The post-positivist approach is suitable for real-world problems such as the one this research investigated in order to come up with remedial solutions. Besides, post-positivists use multiple methods and a variety of measures to capture as much reality as possible (Van Wyk, 2016). Post-positivism permits a small sample size and the freedom for researchers to create measuring instruments (Okeke and Van Wyk, 2015; Van Wyk, 2016). The post-positivism progressively generates cumulative knowledge that can produce objective, generalisable information, using facts (Fabinyi *et al*., 2014). Most of these ingredients of post-positivism are evident in the research method that was followed.

The post-positivism uses the scientific method that involved the systematic observation, measuring and drawing of conclusions in order to test a hypothesis or answer research questions (Bertram and Christiansen, 2014; Van Wyk, 2016). The scientific approach posits that claims should be backed by evidence and evidence should be measurable (Bertram and Christiansen, 2014). However, certain scientific evidence cannot be easily measurable, for example, certain ecological services from wetlands are difficult to quantify and measure in absolute units. Unlike the positivist, the post-positivist claim that the world cannot be known completely. There is truth in it but researchers can only approximate the truth and try to get to the truth as closely as possible (Bertram and Christiansen, 2014). The use of samples and sampling is an approximation of the truth that lies within the population under investigation.

In line with the post-positivist viewpoint, this study was conducted in a natural setting of wetlands in the eFS, a mixed method of data collection was used, it was a survey study involving sampling, the collected data was tested for reliability and validity using triangulation, pilot study and administration of the same set of questionnaires across the respondents, all of which supported the post-positivist approach. Statistical analysis of the collected data was done; which tally with the post-positivist paradigm.

While using mainly the research lens of the post-positivist approach, this study also incorporated the more interpretivist traditions in social science (Creswell, 2003; Fabinyi *et al*., 2014) to create a holistic and balanced outcome, as well as to interpret the collected data using questionnaires (Bertram and Christiansen, 2014). The fact that humans and their experiences are involved in wetlands management brings in the social dimension of this research and this aspect relates very well with the interpretivist paradigm. This paradigm normally seeks to describe and understand how people make use of their world, in this case their wetlands (Creswell, 2003; Bertram and Christiansen, 2014). The close interaction between the researcher and the respondents during questionnaire administration and field observation tallied with the interpretivist approach. Meanwhile, detailed objective description of the collected data that reflected the experiences of the respondents on wetlands management informed the final conclusions in line with the interpretivist paradigm (Bertram and Christiansen, 2014).

This study involved both natural (wetlands) and social sciences (people and the management of wetlands); it was a survey using mixed method and multiple tools for data collection; the study generated both quantitative and qualitative data and the study used a pre-test like the pilot test. Given the fact that surveys are often used in the post-positivist, but also increasingly used in the interpretivist approach in recent years, justified the combination of the post-positivism and the interpretivism paradigms in this study.

9.2.3 Research design

Research design describes the procedure for conducting a study and helps to answer the research questions (Cohen et al., 2001 in Maree, 2007). A research design is a blueprint that explains the type of research undertaken by the researcher (Mouton, 2001; Leedy and Ormrod, 2001). Research designs are often broadly divided into quantitative, qualitative and mixed approaches (Babbie *et al.*, 2008; Bertram and Christiansen, 2014; Creswell, 2003, 2014; De Vos, 2005; Johnson and Christensen, 2004; Kitchin and Tate, 2000; Leedy and Ormrod, 2001; Maree, 2007; Mouton, 2001; Suter, 2006). Based on the ontology and epistemology of the research, the researcher used a hybrid of both quantitative and qualitative approaches to address the research problem and to answer the research questions.

A mixed research design is the process of collecting, analysing and mixing both quantitative (numeric) and qualitative (textual) data at some stage during the same research project for a better understanding of a research problem and answer the research question (Creswell, 2005 in Maree, 2007; Creswell, 2014). In using the mixed research approach, the data and the findings are therefore integrated or connected at one or several stages of the research process (Maree, 2007).

The mixed method research approach was used and this provided strengths that offset the weakness of both quantitative and qualitative research when used independently, and helped to answer questions that could not be answered by qualitative or quantitative approaches alone (Creswell and Clark, 2007; Okeke and Van Wyk, 2015). The mixed method also provided an in-depth understanding of trends and patterns in the data collected and enabled the researcher to study diverse perspectives and complexity amongst variables as a result of the multidisciplinary nature of the research (Creswell, 2003, 2014; Maree, 2007).

The quantitative approach helped the researcher assign numerical values to the data collected, using questionnaires, field observations, as well as secondary data that describes temperature and rainfall changes over 30 years in the study area. On the other hand, the qualitative approach helped to give a vivid perception from the respondents on the research problem. The researcher also used a qualitative description of the observed phenomena in the field and interviews that were conducted with experts on DRR, CCA, wetland issues and the general environment to deepen the understanding of these variables and their interrelatedness.

The study also mixed both the deductive and inductive approaches. The deductive reasoning is often used in quantitative research and is a logical and progressive reasoning from general to specific where, for example, general theories produce specific hypothesis or research questions (Suter, 2006). On the other hand, inductive reasoning is often used in qualitative research where specific ideas or experiences lead to general conclusions or theories (Suter, 2006). The hybrid research approach suited these two forms of reasoning. The literature review, for example, spanned from general to specific or from global to local perspectives.

Mixed method usually uses four popular approaches which include explanatory, exploratory, triangulation and embedded designs (Maree, 2007).

Explanatory mixed design uses quantitative results to help clarify the qualitative results, while the exploratory mixed design first explores the topic using qualitative data before measuring and testing data quantitatively. Exploratory mixed design is often used where no theory pre-exists (Maree, 2007). The embedded mixed method is used to answer secondary research questions that are different from, but related to, the primary research question (Maree, 2007). The triangulation, parallel or concurrent mixed approach uses both quantitative and qualitative methods to better understand the research problem, collects both data at the same time and thus save time, compare, and contrast the different findings in order to arrive at well-validated conclusions (Creswell *et al*., 2003 in Maree, 2007; Creswell, 2014).

The triangulation, parallel or concurrent mixed approach was the approach adopted in this research as both the quantitative data from the questionnaire, secondary data and field observation, as well as the qualitative data from the interviews, were collected at the same time before analysis. Even within the questionnaire, open-ended questions were mixed with closed-ended question to address the issue of a triangulation mixed approach. It should be noted, however, that all four mixed method approaches discussed above have common characteristics and are only distinguishable depending on which approach the research leans on more (Maree, 2007). Thus, asking secondary and primary research questions in this research brought in some elements of an embedded mixed method, but the general orientation of the research design was toward the triangulation mixed method approach.

A holistic and integrated approach to build a resilient and sustainable community, society or system to increasing disaster risks and adapt to the impacts of climate change requires the integration of knowledge from many spheres, including the natural, engineering and social sciences; social−ecological systems analyses, as well as the humanities, psychology and ethics (Birkmann *et al.,* 2013; IPCC, 2014; Takeuchi *et al.,* 2014). A single research method used by one academic discipline for complex multi-faceted problems does not provide a comprehensive understanding of how individuals and communities in dynamic, complex, social−ecological settings react to institutional rules and respond to the ecological systems (Nagendra, 2006 in Takeuchi *et al*., 2014). The multidisciplinary, system-thinking approach and the mixed method adopted in this research closed the gaps mentioned in above.

9.3 METHODOLOGY

9.3.1 Population

According to NFEPA the FS has the highest number of wetlands in South Africa (SANBI, 2010 in Nel *et al*., 2011). About 54 000 natural wetlands have been mapped for the FS and comprise of valley-bottom, slopes and pans (Collins, 2006; Ollis *et al*., 2013; SANBI, 2010 in Nel *et al.*, 2011) (see Figure 9.1). These are inland wetlands (Level 1 classification by NFEPA) found in a grassland biome (Level 2 of NFEPA) and occur in the Highveld and eastern escarpment (DWA classification level 2). The main wetlands-types in the eastern Free State are valley-bottom wetlands and an estimated 2 624 of such wetlands exist in the study area. The wetlands are owned and used by many stakeholders who were identified as private wetland owners/users, communal wetland users and users/managers of wetlands in protected areas.

The dominant ownership style were wetlands in private, single-owned land. This ownership style presented serious problems in terms of data collection because of their geographic dispersion, privacy and property rights, as well as the busy schedules of the owners who were mostly commercial farmers.

9.3.2 Sample and the sampling process

Given the disperse distribution of the estimated 2 624 valley-bottom wetlands over a very large study area, limited access, especially to private wetland owners and the fact that there were much more similarities than differences amongst these wetlands, a sample size of 100 of the natural valley-bottom wetlands were targeted for sampling.

A combination of stratified-simple random sampling and convenient sampling were used and applied as follows:

- This study was carried out in an arbitrary demarcated eFS (Figure 1.2), but which closely followed the 500 mm to 700 mm rainfall datum which permits rain-fed crop production. The study area was also large enough to accommodate a large and representative sample of wetlands.
- The researcher selected all the valley-bottom wetlands in the eFS, using shape files provided by his supervisor who is also a wetland specialist in the FS province. A total of 2 624 valley-bottom wetlands were captured.
- The demarcated study area was subsequently divided into tertiary catchments following the South Africa Catchment Management Agency division, and nine tertiary catchments fell within the study area.
- Four out of the nine tertiary catchments were selected to get a representative sample of the catchments. The selected tertiary catchments included C13, C81, C82 and C83 (Figure 9.1).
- The number of valley-bottom wetlands in each selected tertiary catchment were calculated and the following results were obtained:

  C13 = 272

  C81 = 643

  C82 = 249

  C83 = 645

  This gave a total of 1 809 valley-bottom wetlands.

  To obtain a proportionate representation of the targeted 100 valley-bottom wetlands from the selected catchments, a pro rata system based on tertiary catchment size was used as follows:

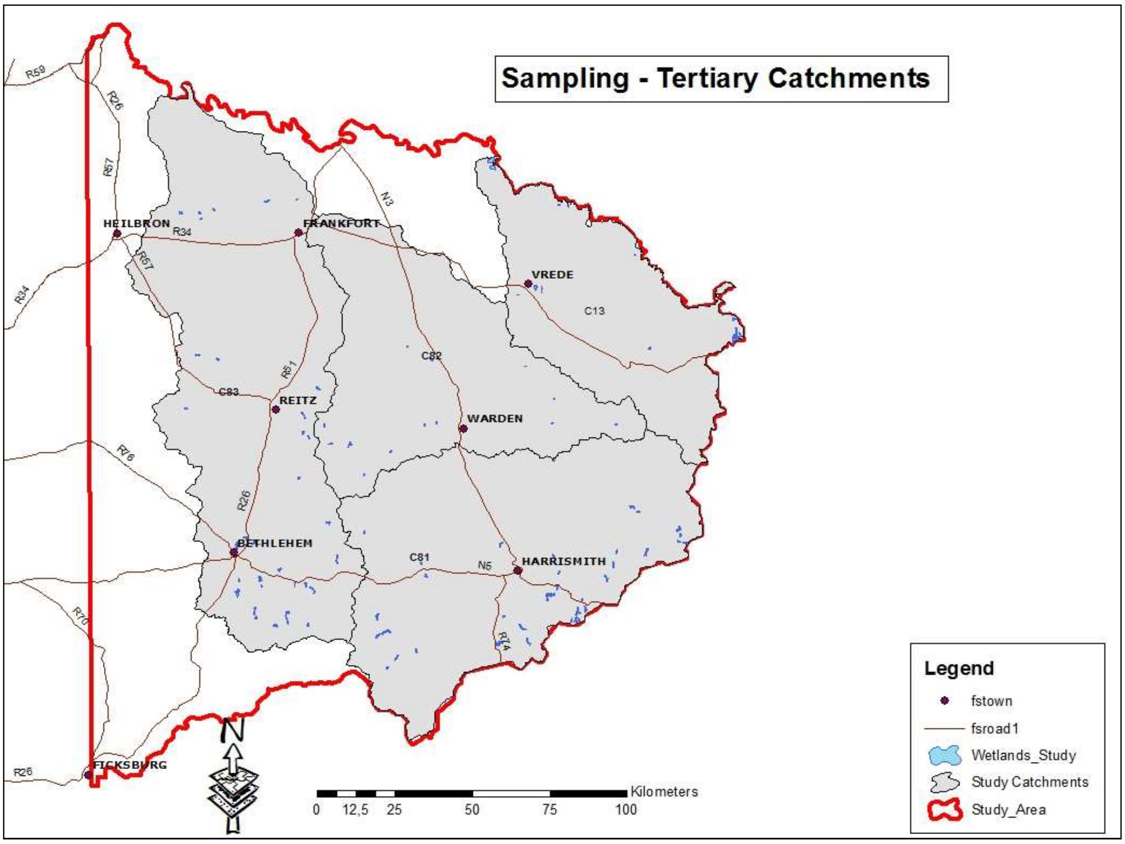
C13 (272/1 809 × 100) = 15 wetlands

C81 (643/1 809 × 100) = 35 wetlands

C82 (249/1 809 × 100) = 14 wetlands

C83 (645/1 809 × 100) = 36 wetlands

Total wetlands = 100.

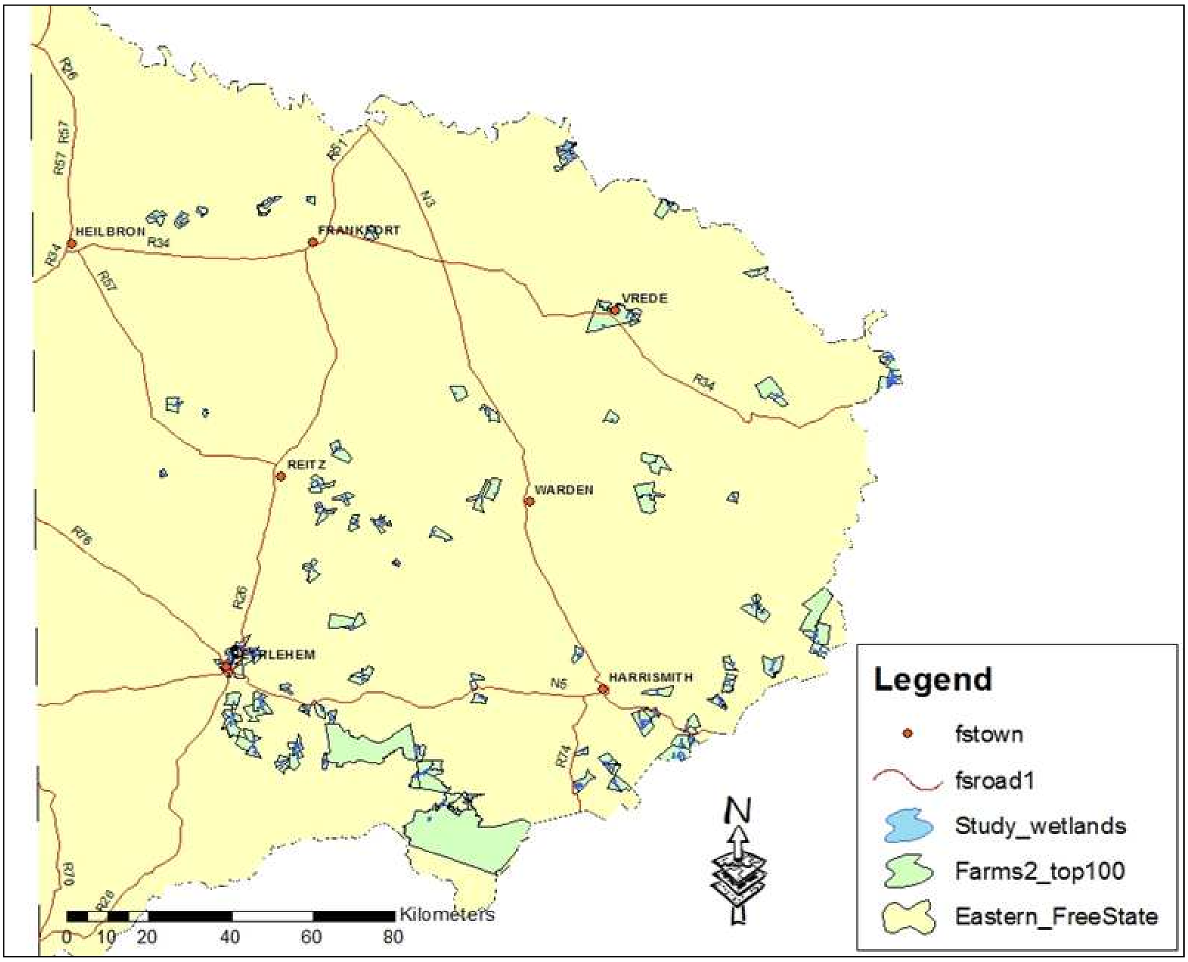


Source: Author (2016)

Figure 9.1 The selected tertiary catchment and the pro rata contribution of valley-bottom wetlands

The intention was to collect data from the 100 largest wetlands by surface area in the selected catchments, but due to difficulties of reaching the specific land owners, a final total of 95 were randomly selected from each tertiary catchment, but not strictly as per the *pro rata* contribution. However top wetlands per surface area in each selected catchment were sampled.

- The geographic coordinates of the selected wetlands were calculated, displayed on a spreadsheet and plotted on a map.
- The coordinates were then overlaid with a land ownership map for the FS to get the contact details of the owners who then became the respondents (Figure 9.2).



Source: Author (2016)

Figure 9.2 Overlaid map of land ownership corresponding to the selected wetlands

- Letters were written and several personal contacts were made with the respondents for permission to visit the wetlands and also to administer questionnaires.
- With the help of two research assistants, questionnaires were distributed to the identified landowners and/or land users of the selected wetlands.

However, it should be noted that the Seekoeivlei wetland (a floodplain wetland), the wetland system at Golden Gate and the Braamhoek (Ingula) wetlands were purposely included in the study to show best cases of wetlands management in the study area. These are protected wetlands, and Seekoeivlei is also a Ramsar site.

9.3.3 Data collection instruments

Five data and information capturing tools were used. The data collection instruments are discussed in the following sub-sections.

9.3.3.1 *Questionnaires*

Two sets of questionnaires were designed. One set was administered to private wetland users, including wetlands in protected areas, and the other set to communal wetlands users. For the purpose of assigning responsibility in wetlands management to an identifiable individual, only two categories of wetland owners/users were used. Where the owner of the wetland could be identified, such a wetland was classified as "private". The private wetland users therefore included those in private commercial farms and government-owned wetlands (i.e. those located within conservation agencies like SANParks) to distinguish them from communal-owned wetlands which are collectively owned without an identifiable manager. A total of 180 questionnaires were administered, but after rejecting four due to incompleteness, the total number that were included in the analysis was 176, of which 93 were from communal wetland users and 83 from private wetland users. The 83 private questionnaires included three from protected areas.

Both questionnaires contained closed and open-ended questions based on the nature and the depth of the information that was needed (see Appendices 2 and 3). The questionnaires were used as the main primary data collection tool about wetland management in the study area.

9.3.3.2 *Interviews with specialists*

Face-to-face and telephonic interviews were used to gather data from four sets of specialists who were purposively selected based on their expertise areas. Accordingly, an interview survey with short questions was designed and administered to 30 specialists as indicated in Table 9.1 below.

TABLE 9.1: SPECIALISTS INTERVIEWED

Specialist Area	Number
Wetlands specialists	05
Climate change specialists	15
Disaster and Environmental management specialists	08
Environmental law specialists	02
Total	**30**

9.3.3.3 *Field observation*

Field observations were carried out on almost all the wetlands during questionnaire administration, but detailed recorded observations on the field data sheet were done on 21 randomly selected wetlands comprising of seven communal wetlands (Monontsha, Bethlehem, Clarens, Heilbron, Petrus Steyn, Edenville and Frankfort) and 11 privately-owned wetlands mostly located in Swinburne and Van Reenen's Pass in the Harrismith area. Meanwhile, three protected wetlands (Seekoeivlei, Golden Gate wetland and Braamhoek) were also observed.

Ten indicators were used to assess the ecological status of these 21 randomly sampled wetlands (Appendix 6). These indicators were adapted from the WCRAI model (see 6.5.2.3). The indicators were not weighted but the various ways they affect wetlands was noted. The indicators were based on wetland characteristics that are easily observable even by a non-wetland specialist. Each indicator was scored from the best value of 5 to the worst value of 1. A zero score was not allocated because there was hardly any wetland where a particular indicator was not present. The maximum total score a wetland could obtain was 50 points. The total score was later converted into percentage and grouped into four ecological status categories. These groupings were subjective but adapted and simplified from a combination of reviewed literature such as the WCRAI (Oberholster *et al*., 2014), the EVI of the South Pacific Applied Geoscience Commission (Pratt *et al*., 2004) and the EERI (JEU, 2012), as well as the researcher's personal experience. The four group then included:

- Excellent = More than 75% (allocated a green colour)
- Good = 65−75% (allocated a blue colour)
- Average = 50−64% (allocated a yellow colour)
- Poor = Less than 50% (allocated a red colour) (see Table 10.16)

This rapid assessment of the ecological state of these wetlands was based on physically observable features such as vegetation, hydrology, land use system, invasive species, erosion and overgrazing. The field observations were also used to justify some of the responses given by respondents in the questionnaires.

9.3.3.4 Secondary data

Rainfall and temperature records for at least the past 30 years from weather stations located within the study area were obtained from SAWS. Though data was available from five weather stations within the study area, lack of continuous data for at least 30 years to describe the climate as prescribed by some researchers (Arbogast, 2011; Strahler and Strahler, 2005; Reynolds *et al.*, 2015) limited the analysis to two weather stations (Frankfort and Bethlehem). The analysis of these data gave a clue of the variability in these climate parameters and possible climate change when compared to other historical information in the study area.

9.3.3.5 Detailed review of literature

A detailed literature review was carried out in six key thematic areas (see 1.9) and the approach was to examine reputed sources and to let the review flow in a hierarchy from global, regional, national and then down to the province and study area. In cases where literature could not be found at local level then provincial and national information was used as proxy. The reviewed literature gave information about what others have written related to the topic of this study. The use of these different data collection instruments helped to triangulate the data for validity and reliability.

9.3.4 Pilot study

A pilot study was conducted in six wetlands, two in a protected area, two in communal and two in private land to obtain a proportional balance of ownership of wetlands sampled. A mix of three Master's, three doctoral students as well as three senior researchers were recruited to test the questions in the questionnaire before the pilot study. The pilot study enabled the identification of some problems which were subsequently addressed. The use of certain words was discovered to be problematic even to the well-educated respondents. In one case, a wetland manager with a postgraduate qualification, when asked to describe the state of health of the wetland, wrote 'medical fitness by medical practitioner'. This reply helped the researcher to rework the wording in the questionnaire and use simple straightforward words like 'the degree of degradation of the wetland'.

The questionnaires were also scrutinised by both the researcher's promoter and co-promoter, a senior researcher from the University of Forte Hare, as well as a senior statistician from the department of statistics at the University of the Free State (UFS).

9.3.5 Data analysis and presentation of results

9.3.5.1 Data analysis

The fact that the same questionnaire was completed by private commercial farmers and wetland managers in protected areas (only three respondents) permitted the analysis to be broadly grouped into communal and private wetland users. However, where specific information was required, data from wetlands in protected areas were analysed differently from that from private commercial farms.

To change the collected data into information, Excel and SPSS were used to analyse all quantitative data including data on climate from SAWS (see Chapter 10), while thematic analysis was adopted to transform qualitative data into emerging themes from the interviews and open-ended questions in the questionnaire. Where possible, the primary data were cross-checked with secondary data and information as a form of triangulation (Burns and Grove, 2005; Rakotsoane and Rakotsoane, 2006). The researcher solicited the services of two senior statisticians from the Department of Mathematics and Statistics and another from the

Department of Agricultural Economics at the UFS. The services of a Geographical Information System (GIS) specialist was solicited for handling the various shaped files.

Both descriptive and inferential statistics were used in analyzing the data. Firstly, descriptive statistics such as minimum, maximum, mean and standard deviations were used to identify the age and the approximate surface area of this wetland in square meters owned by respondents. Also, descriptive statistics using frequencies and percentages were used to identify wetland types, land ownerships, major land use activities and the proportion of wetlands on the total land area of wetland owners and the results were presented in bar charts and pie charts. A comparison was made between the present and the past physical elements of wetlands using mean scores and contingent rating. The mean scores were estimated from the frequencies obtained from respondents' ratings of vegetation, water, and soil to determine the wetland ecological status). In terms of legislation and institutional arrangements, perception index was used to analyze how wetlands are managed as well as the level of cooperation between wetland stakeholders. The perception statements were measured on a 5-point Likert scale starting from strongly disagree (-1) to strongly agree (1). In terms of suggestions that could help in the better management of wetlands in the FS the responses were analysed using qualitative descriptions. Descriptive statistics such as frequency and percentages were used to examine whether wetlands help to reduce the impacts of flood, droughts, and fire as well as ascertaining whether the respondents receive any education and training on how to manage wetland for DRR and CCA). Furthermore, contingent ratings using mean scores were used to examine wetland ecological services such as provisioning, regulating, cultural and supports. The items under each of the services were rated using the estimated mean scores. In terms of wetland threats and vulnerabilities, the communal wetland threats were analysed using descriptive statistics such as frequencies and percentages as well as qualitative description. Private wetland threats were analysed using Kendall's coefficient of concordance. The Kendall's test ranks the identified threats in order of severity as indicated by the sampled farmers or wetland users

9.3.5.2 Presentation of results

The analysed data were presented in the form of tables, figures, graphs, maps and photographs.

9.3.6 Validity and reliability of the data

9.3.6.1 Validity

Validity is concerned with the soundness and effectiveness of the measuring instrument, and refers to the ability of the instrument to measure only what it is intended to measure, given the context in which it is applied (Babbie and Mouton, 2001; Maree, 2007). In this study, much attention was paid to face, content and construct validity.

Face validity means that an instrument empirically appears to measure what is needed, given the construct that is supposed to be measured (Brink, 1996; Polit and Hungler, 1999; Saunders, 2000). Content validity refers to how representative or adequate the compiled questions are for the construct being measured (De Vos *et al*., 2005), while construct validity involves determining the degree to which an instrument successfully measures a theoretical construct (De Vos *et al*., 2005). In other words, it checks whether the tool does measure what it was supposed to measure. These three sub-constructs of validity are linked. They are also related to the reliability of the data. The same tools were used to check both as presented in the next sub-section.

9.3.6.2 Reliability

Reliability is concerned with the consistency, accuracy, dependability and comparability of a measuring technique and refers to how consistent or stable the data-collection instrument is (Bertram and Christiansen, 2014). On the other hand, Polit and Hungler (1999) describe reliability as the consistency with which a tool measures the attribute it is supposed to measure. According to De Vos *et al.* (2005), reliability indicates the accuracy or precision of an instrument and refers in general to the extent to which independent administration of the same instrument (or highly similar instruments) consistently yields the same or similar results under comparable conditions.

The use of structured questions in the questionnaires ensured a degree of reliability of the data. The questionnaires were the main source of data collection and they were scrutinised by both the researcher's supervisor who is a wetland specialist and co-supervisor who is a disaster management specialist. Other specialist inputs were sort from the department of statistics at the UFS, as well as from three senior researchers, two from UFS and one from the University of Forte Hare. The use of these specialists, triangulation and pilot study added credence to the validity and reliability of the collected data.

9.4 ETHICAL CONSIDERATIONS

Like any profession, researchers adhere to a code of conduct that guides the research process. As important as they are, ethical issues are often neglected, especially by novice researchers, and this could delay the research process or disrupt the whole study (Belle, 2010). Some of these ethical issues are considered in this subsection.

The ethical clearance certificate was obtained from the ethical committee at the UFS's and is attached as Appendix 1. The consent of the respondents was verbally requested and obtained before any questionnaire was completed, or the wetland observed and photographs taken by the researcher. The official application procedure was followed to obtain secondary data from the SAWS on past rainfall and temperature data in the eFS. Full acknowledgement was made in terms of embedded referencing and the final list of references to acknowledge other authors' ideas that were used in this research. Other forms of plagiarism were also avoided.

There was full disclosure of the nature and purpose of the research and how the study could benefit the respondents in terms of harnessing their experiences in managing wetlands and putting it into a scientific document that could be used by the future generation who could include their children and grandchildren. In support of Kumar (2011), confidentiality was strictly adhered to where no information about the respondents or their opinion was shared for reasons other than that for the study. Unanimity was maintained in that the identity of the respondents were not required and though farm names or wetland names were captured, this information was used only to make sure that the wetland actually existed and to indicate the geographical spread of the data.

9.5 DELIMITATION AND LIMITATIONS OF THE RESEARCH

9.5.1 Delimitation of the study

Delimitation explains what was included and what was not in a research project (Hoftsee, 2006; Polit and Beck, 2004). This study was confined to an arbitrary demarcated eFS (Figure 1.2) but the area was large enough to contain a sufficient sample size and diversity of wetland types. Bearing in mind that the dominant economic activity in the FS Province is agriculture (both crop production and animal grazing), the 500 mm to 700 mm rainfall line which permits rain-fed agriculture to the east was added to demarcate the eFS. Not all types of wetlands in the study area were included in this study. However, valley-bottom wetlands are the dominant types in the study area (Collins, 2006; 2011) and were therefore the focus in this study. Also, one or two flood-plain and hillslope wetlands were sampled, but this did not change the focus on valley-bottom wetlands.

The management of the selected wetlands was studied from an environmental management point of view, the concepts of vulnerability and DRR was integrated into the study from a disaster management perspective, while elements of CCA also formed part of the study from international climate change discussions. Only the three most frequent hazards in the study area (veldfires, drought and floods) were considered. The study of climatic changes was limited to two main climatic factors (temperature and rainfall) and existing data from the SAWS was used. The study adopted a multidisciplinary approach and credence was put on literature and frameworks used in environmental management, disaster management and climate change disciplines. This holistic and systems thinking approach opened a new chapter on wetlands management in the eFS and in South Africa.

9.5.2 Limitations of the study

Limitations are obvious in any research because no one researcher can do everything and do it perfectly in one single research project (Hofstee, 2006). Simon and Goes (2013) explain research limitations as issues that may arise during the study that are beyond the researcher's control and that may have an impact on the progress and results of the study. The main limitation was access to the farmers on whose farms most of the earmarked wetlands were located. Many of these farmers were often not available to complete the questionnaire and they were geographically much dispersed. In a specific instance, the researcher had to travel from Bloemfontein to Reitz only to collect one completed questionnaire, and in another instance, after several attempts, a farmer called requesting a questionnaire to be hand-delivered at Swinburne. The agricultural extension officers who accepted to help distribute the questionnaires to the farmers, failed to return the questionnaires despite repeated reminders.

This study did not investigate at least a 10% representative sample of approximately 54 000 wetlands in the FS, nor a representative sample of valley-bottom wetlands (about 2 624 wetlands) in the eFS. The homogenous nature of the population offset this deficit. Besides, only three hazards (veldfires, droughts and floods) formed part of the study. However, the three are the commonest hazards. Since data was collected only from a sample of the wetlands, the conclusions that are made from this study can only be suggestive and not definitive. More research is recommended wherever an aspect of the study was not exhaustively investigated. Time and financial constraints had an influence on the depth and scope of the study, while difficulty to access vital data and information was clear, especially amongst the geographically dispersed and very busy farmers on whose private land most of the sampled wetlands are found. The phenomenon of climate change was difficult to prove in this research so only indicative evidence, secondary data and literature reviews, especially from the IPCC, were used. However, the IPCC is the core of the world's best scientists on climate change and the

SAWS is the core custodian of climate data in South Africa. The methodological loopholes of using random sampling for the study of the targeted wetland owners and users were obvious, but again the homogenous target population reduced this weakness. The possibilities of bias in completing the questionnaires were reduced by internally built-in checks-questions, as well as formulating mostly close-ended questions which also helped to check digression by respondents. The final integrated wetlands management framework from this research will not have the luxury of time to proof its credibility and applicability, given that this was not a longitudinal study and also because of the current turbulent environmental situation as evident by climate instability. However, like any academic research, there is enough room for further investigation that could possibly include aspects of systems analysis and mathematical modelling. This study has laid a foundation on which more research will ensue.

9.6 CHAPTER SUMMARY

A mixed research design was used, involving quantitative and qualitative approaches. The post-positivist and interpretivist philosophical thinking was adopted in the research. In total, 95 wetlands were sampled. Mostly sampled, were valley-bottom wetlands. Questionnaires (176), field observations (21) and interviews (30) were used to generate primary data. Secondary data (two weather stations) and a comprehensive literature review was used to supplement the primary data that was collected. Interviews were conducted with wetland specialists, climate change specialists, environmental and disaster management specialists in the FS province. The quantitative primary data were analysed using Excel spreadsheet and SPSS, while qualitative data were analysed into emerging themes. The collected data were presented in the form of graphs, tables, charts and photographs.

Chapter 10
DATA ANALYSIS AND PRESENTATION OF RESULTS

10.1 INTRODUCTION

This chapter explores how the data was analysed and the manner in which the results were presented in various graphic formats. The emerging patterns in the analysed data are then highlighted in preparation for the next and final chapter. Table 10.1 below shows the sectional grouping of the data analysis and the questions in the questionnaires and other data sources that addressed each section.

TABLE 10.1: SECTIONAL GUIDE IN PRIMARY DATA ANALYSIS

Section	Question in the questionnaire		Other data collection tools
	Private	Communal	
1. Demographics of the respondents	1−4	1−4	1. Interview with specialists 2. Secondary data from SAWS 3. Field observation
2. Wetlands Identification	5−10		
3. Legislation and institution	15–18, 29	17 and 18	
4. Wetlands management	11−14, 32	20	
5. Wetlands ecological services	27, 31	7,10, 1−13	
6. Wetlands, DRR and CCA	21−25, 32	15−17	
7. Wetlands threats, risks and vulnerability	19, 20, 28	9, 14	
8. Wetlands ecological status	26		

10.2 SOCIO-DEMOGRAPHICS OF THE QUESTIONNAIRE RESPONDENTS

Ninety-three (93) respondents from eight different communal wetlands in the study area completed the questionnaire while eighty-three (83) private wetland owners and managers completed the private questionnaire. This gave a total of 176 valid questionnaires administered to different respondents.

10.2.1 Communal wetland respondents

Table 10.2 summarises the socio-demographic background of communal wetland respondents.

TABLE 10.2: SUMMARY OF SOCIO-DEMOGRAPHIC BACKGROUND OF COMMUNAL WETLANDS RESPONDENTS

Parameter	Number	Percentage
Gender		
Female	35	37.6
Male	58	62.4
Modal age	30–39	51.6
Employment status		
Unemployed	39	41.9
Self-employed	20	21.5
Employed	34	36.6
Number of years using the wetland – More than 5 years	84	92.3
Owner of the wetland		
Government	38	40.9
Communally-owned	34	36.6
Don't know	17	18.3

From the 93 respondents who completed the communal wetlands questionnaire, 35 (37.6%) were females and 58 (62.4%) males. Field observation confirms this split since most often men were seen herding cattle in the communal wetlands. The modal age range of these respondents was 30–39 years and the majority of the respondents were either unemployed or self-employed (63.4%). A sizeable number, 36.6% reported to be employed, meaning even those with gainful employment still use these communal wetlands for some activities. The majority of respondents had long historical experience in the wetlands as 84 respondents (92.3%) reported to have been using the wetlands for more than five years. Though these were communal wetlands, there was a split on who the respondents thought was the owner of the wetland; 40.9% thought government owned the wetland, while only 36.6% rightfully said they were communally owned and 18.3% did not know the owner of these communal wetlands. About 5% did not answer the question. In sum about 60% of the respondents did not know the communal ownership of the wetland they were using. Almost all the communal respondents could not complete the questionnaire on their own. Ignorance about wetland ownership and low level of literacy was shown by the respondents.

10.2.2 Private wetlands respondents

Table 10.3 summarises the socio-demographic background of privately-owned wetlands.

TABLE 10.3: SUMMARY OF SOCIO-DEMOGRAPHIC BACKGROUND OF PRIVATE WETLANDS OWNERS

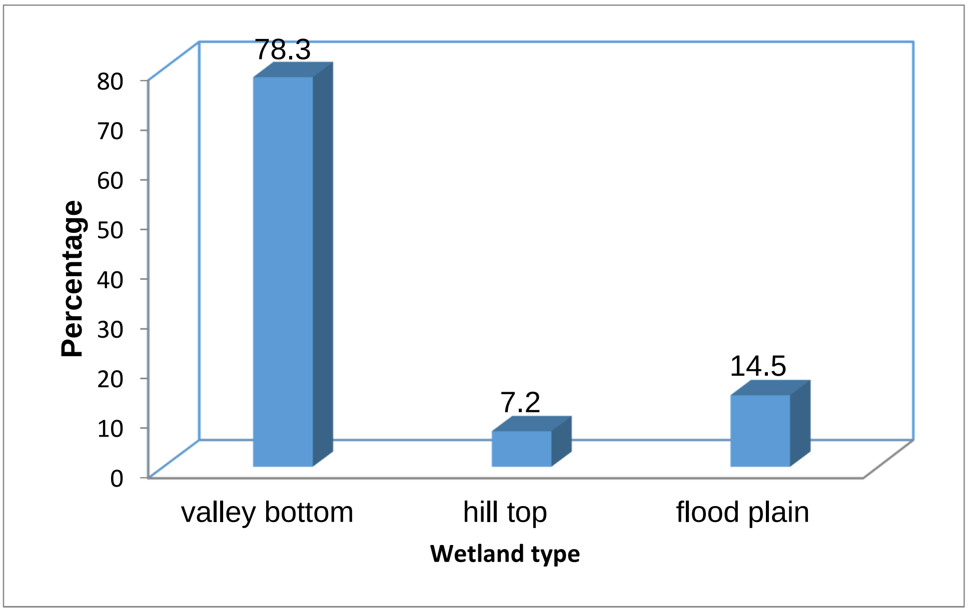
Parameter	Number	Percentage
Gender		
Female	16	19.28
Male	67	80.72
Median age	45–54 years	54.2
Mean age	51.98 years	
Modal age	55–64 years	31.3
Education		
Primary	7	8.4
Matrix	17	20.5
Undergraduate	30	36.1
Postgraduate	29	34.9
Number of years in using the wetland		
More than 5 years	64	77.1
More than 10 years	42	50.6

Most of the private wetland owners were male (67 respondents or 80%), while 16 respondents (19.3%) were female. The majority of the respondents (67 or 80.7%) were between the ages of 55−64, with a median age falling between 45−54 years. These private wetland owners were mostly commercial white farmers, were mature in terms of age with a lot of experience on wetland issues, as 64 (77.1%) reported to have been using the wetland for more than five years, and 42 (60%) have more than 10 years' experience on wetland issues. Another favourable factor was that 59 (71%) of these farmers have either an undergraduate or a postgraduate academic qualification, with only 17 (20.5%) having matric and 7 (8.4%) with a primary qualification. The long experience and better academic qualification reflected on the management and the ecological status of private wetlands compared to communal owned wetlands (see 10.7.2).

10.3 WETLANDS IDENTIFICATION

10.3.1 Type of wetlands sampled

All the communal wetlands that were sampled and the majority of private wetlands (78.3%) were valley-bottom wetlands (see section 5.3 on types of wetlands and Table 5.2 on the hydrogeomorphic wetland classification system). It was observed that many respondents did not know the type of wetland they have, though the field observation showed that most of them were valley-bottom wetlands. The Seekoeivlei (floodplain) wetland was purposefully sampled as the only Ramsar listed wetland in the study area. Almost all the valley-bottom wetlands that were sampled were channelled valley-bottom wetlands (Figure 10.1).



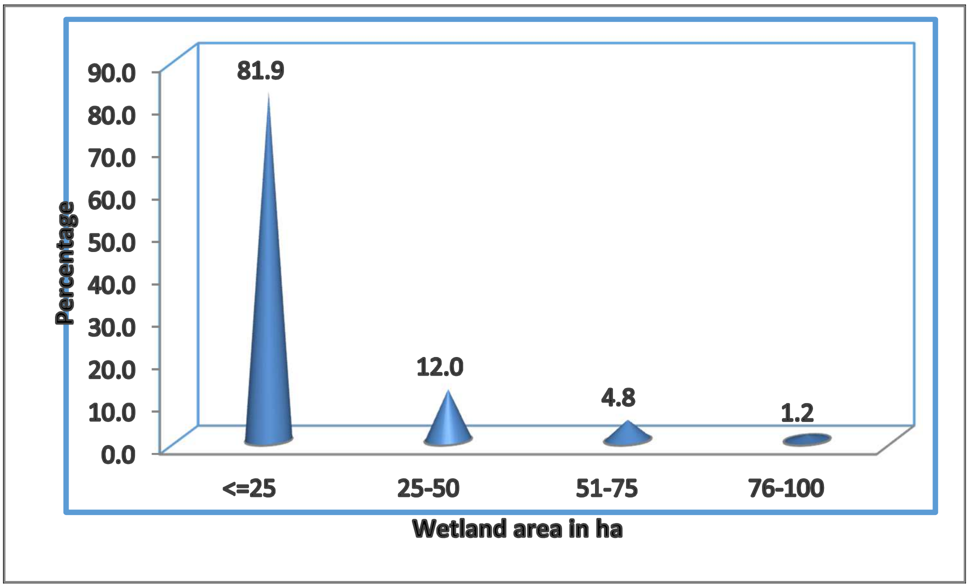
Source: Author's own (2016)

Figure 10.1 Type of private wetlands sampled

10.3.2 The sizes of the private wetlands

One important consideration that influence the ability of a wetland to perform various ecological functions is the size of the wetland. It was difficult to get the actual sizes of the wetlands as many of the famers did not indicate the size of the wetland in their responses. Besides, it was observed that in some cases many farmers shared the same wetland system. However, the smallest wetland that was observed in the field was estimated to be about 4 ha, while the largest was Seekoeivlei and is documented to cover about 3 000 ha (Collins, 2006; RSA DEA, 2014b).

The private wetland users were asked to approximate the percentage cover of the wetland to the total land surface of the individual land they own (Figure 10.2). From the responses, it was realised that most of the wetlands sampled occupied less than 25% of the total land area of the individual farmers. This means that there is a great need to manage these wetlands well so that they can provide the identified ecological functions effectively. The current extreme weather events such as the floods of 2011, the runaway fires of 2014 and the drought of 2015/2016 highlights the need to manage wetlands effectively in the eFS to mitigate the impacts of these disaster risks.

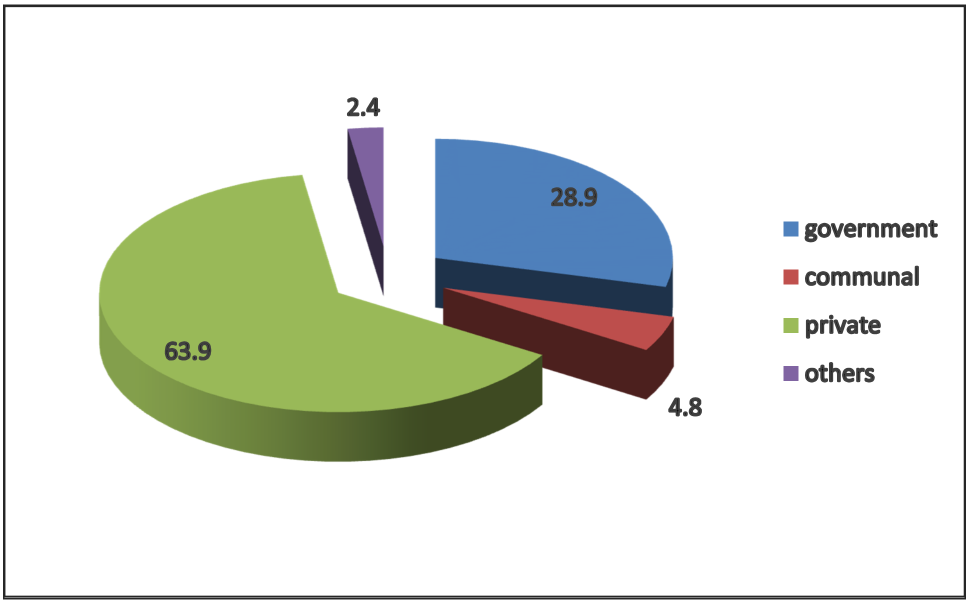


Source: Author's own (2016)

Figure 10.2 Percentage of wetland area to the total surface area of the land owned

10.3.3 Land owner of the wetlands sampled

Most of the wetlands sampled in this study were privately owned (Figure 10.3).



Source: Author's own (2016)

Figure 10.3 Wetland ownership

Other forms of wetland ownership in the area include those which are communally owned and those owned by the government like Seekoeivlei, wetlands at Golden Gate and Braamhoek (Ingula).

10.4 LEGISLATION AND INSTITUTIONS

10.4.1 Wetlands laws and policies

The respondents were asked to indicate whether there were any laws in the study area that regulate the use of wetlands (Figure 10.4). The majority (87 or 93.5%) of the communal wetlands users responded that there were no laws, while 57 (68.7%) of the private wetlands owners reported there were no clear laws. Also 61 (73.5%) of the communal wetland respondents attested that if there were any laws on wetlands in the area then these laws were poorly implemented.

TABLE 10.4: KNOWLEDGE OF LAWS THAT REGULATE THE USE OF WETLANDS BY COMMUNAL USERS

Valid	Frequency	Percentage	Valid percentage	Cumulative percentage
No	87	93.5	93.5	93.5
Yes	6	6.5	6.5	100.0
Total	93	100.0	100.0	

These responses were in line with the review of literature on legal and institutional arrangement for wetlands management (see 3.3) which indicated that there was no national wetland policy in South Africa, though there is a FS provincial wetland policy, but it has not been endorsed and therefore not known by most respondents. The legal status of wetlands in South Africa is different from that of a country like Uganda which, besides having wetlands related legislations, do also have a specific national policy on wetlands (see 3.2.3.2).

10.4.2 Opinions of environmental law experts

The two environmental law specialists (ELS) who participated in the survey, cited the challenges about environmental law (that cover wetlands) in South Africa in general and in the eFS in particular (see Figure 10.5).

Most of these arguments were also supported in the review of related literature (see 3.3) as well as field observations. A classic example of lack of effective wetland laws in the study area is the building of the Frontier Casino and the Dihlabeng Mall on a wetland in Bethlehem, a project which even went into litigation. The environmental law experts made some suggestions to alleviate the challenges explained above.

TABLE 10.5: RESPONSES FROM THE TWO ENVIRONMENTAL LAW SPECIALISTS

Questions	Responses
1. Do you know of a wetland policy is South Africa	ELS1 − No ELS2 − No
2. Which other general environmental law or policy relate to wetlands in South Africa	ELS1 − NEMA, NWA ELS2 − NEMA, NWA, NEMA: Biodiversity
3. Are environmental laws effectively implemented in South Africa	ELS1 − No ELS2 − No
4. State reasons to support Question 3 above	ELS1 − Lack of adequate capacity and resources − Priority considerations from national government on issues like economic growth, job creation over conservation of wetlands − Poorly defined environmental power and functions − Definition of wetlands in NWA is complicated − Lack of understanding of wetlands and general environmental laws − Corruption from those enforcing environmental law ELS2 − Reactive nature of environmental law − Lack of trained enforcers of the law − Lengthy litigation process − Lack of resources
5. Suggestions for better solutions	ELS1 − Capacity-building and education on wetlands − Allocation of more resources both human and financial − Involvement of courts to clarify roles and functions related to wetlands ELS2 − Train more environmental law enforcers − Speed up litigation process − Avoid duplication of functions

10.4.3 Wetlands stakeholders' cooperation and coordination

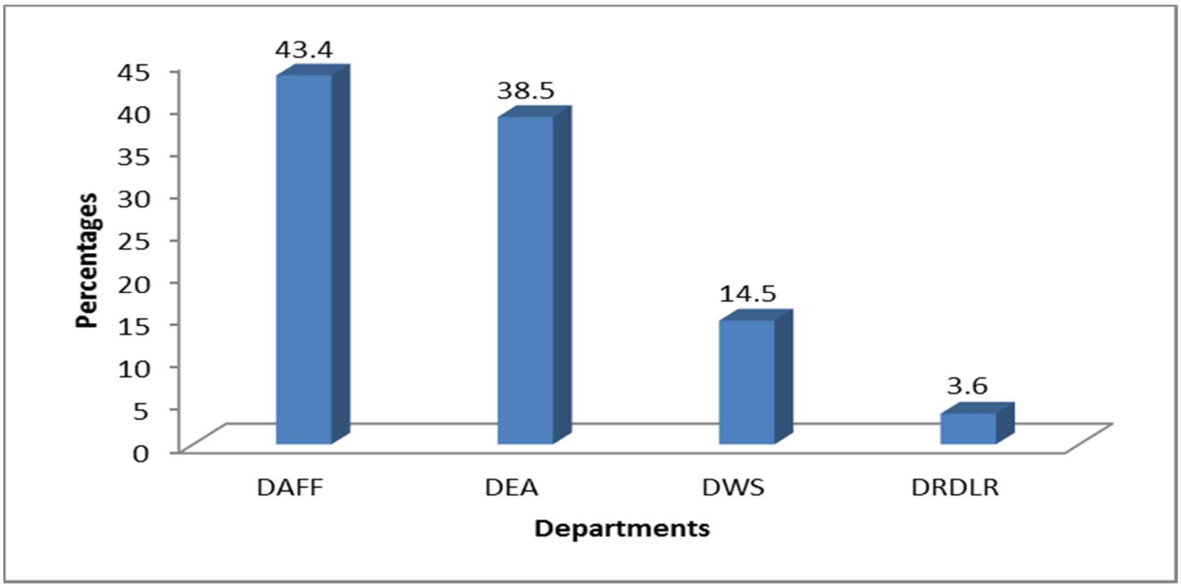
In terms of cooperation between major wetlands stakeholders such as the private land owners, the local community, the government and NGOs like the MWP and the EWT, the general impression amongst the respondents was that the cooperation was poor as indicated by a mean score of less than two, with wetlands in private ownership (Table 10.6). In the same vein, 77.1% of the communal wetland users indicated that wetland issues were not well-coordinated in the province. The Perception Index was calculated for the private wetlands owners (with a value range of −1 for negative and +1 for positive, with 0 being neutral) and with a value of −0.94 (Table 10.6), it was clear that the legal and institutional arrangement for wetlands management in the study area was poor. This assertion can be further supported by the fact that the combined Free State/Northern Cape Wetland Advisory Forum which could have been acting as the focal platform on wetland issues in the two provinces, collapsed and for the past two years, the forum has never met for any deliberations.

TABLE 10.6: PERCEPTION INDEX ON WETLAND LEGAL AND INSTITUTIONAL ISSUES (PRIVATE)

Perception statement	Strongly disagree (−1)	Disagree (−0.5)	Neutral (0)	Agree (0.5)	Strongly agree (1)	Mean score
Wetland issues are well-coordinated in the FS province	15 (18.1)	49 (59.0)	1 (1.2)	17 (20.5)	1 (1.2)	−0.36
There are clear laws with regards to wetlands management in FS province	18 (21.7)	39 (47.0)	3 (3.6)	21 (25.3)	2 (2.4)	−0.28
Laws regarding wetlands managements are properly implemented by wetland managers	12 (14.5)	49 (59.0)	2 (2.4)	17 (20.5)	3 (3.6)	−0.30
Wetland perception index						**−0.94**

10.4.4 Placement of the wetland function

When asked to indicate which government department should directly be responsible to handle wetland management issues in the FS province, responses from the respondents indicated that the current *status quo* under the DEA scored lower than the DAFF (Figure 10.4). Two possible reasons for this split could be that most of the respondents were farmers and therefore preferred their line department, or that many were not satisfied with the services from the current department. Some indication of lack of trust between some private land owners and the WfWetlands on issues of rehabilitation was picked up by the researcher during the field study. The lack of trust may be partially due to political debates around land redistribution in South Africa. This lack of trust was also reported by two out of five wetland specialists that were interviewed, which may add to support the reason to change the placement of the wetland function to the DAFF. The placement of wetland issues may not necessarily be the problem but rather the lack of education, awareness and inadequate resources for better management of wetlands in the study area.



Source: Author's own (2016)

Figure 10.4 Suggested placement of wetland functions by private respondents

10.4.5 Education and training

When asked to indicate whether they have ever received any form of education or training on wetland issues, 77 (82.3%) of the communal wetland users reported that they have never received any form of education. Meanwhile, the few who said they have received wetland education or training cited about ten different providers of such education.

TABLE 10.7: EDUCATION AND TRAINING ON HOW TO MANAGE WETLANDS BY COMMUNAL USERS

Valid	Frequency	Percent	Valid percentage	Cumulative percentage
No	77	82.8	82.8	82.8
Yes	16	17.2	17.2	100.0
Total	93	100.0	100.0	

Source: Author's own (2016)

Unfortunately, the same question was not included in the private wetland questionnaire, but from the discussion between the researcher and many of these private wetland users, it became clear that they had not received any formal education or training on wetlands management. During a meeting of agricultural extension officers in Bethlehem on 21 July 2014 attended by the researcher, it became clear that many of these extension officers did not know what a wetland was. This fact was quite worrying to the researcher, given the role these extension officers play in advising farmers on how to manage their farms, including those with wetlands, and also considering the role wetlands play during frequent conditions of drought and dry spells in the study area. A proposal by the researcher to organise a free short training course on the basics of wetlands fell on deaf ears as no invitation was extended to the researcher during the subsequent extension officer meetings as promised. This action could indicate a lack of interest or ignorance by these extension officers on wetland use and its value.

10.5 WETLANDS THREATS, RISKS AND VULNERABILITY

10.5.1 Communal wetland risks and vulnerability

Users of communal wetlands indicated that they were more vulnerable to floods than droughts and veldfires (Table 10.8). This can be explained by many factors. Firstly, all the communal wetlands that were sampled were valley-bottom wetlands which easily collect and channel rainfall in the catchment. Secondly, unlike floodplain wetlands, valley-bottom wetlands are less efficient in attenuating flood waters and thus mitigating the risk of flood (Collins, 2006, Kotze, 2008, RCS, 2010c). Thirdly, there are a lot of informal settlements within and around the communal wetlands with the attendant high risk of flood even with the slightest bank over flow. Lastly, concreting, draining of the wetlands for various reasons and road construction all increase the risk of floods around communal wetlands. These wetlands, however, play a better mitigation role against the risk of fires and droughts, given the presence of water. The presence of water or moisture in wetlands, even during dry spells and droughts, could be used as a better drum card for wetland conservation, given the fact that wetlands are also heavily used for grazing in the study area. The risk of climate change, overgrazing and uncontrolled fires were also reported.

TABLE 10.8: COMMON RISKS IN COMMUNAL WETLANDS

Hazard	Responses	Frequency	Percentage
Floods	No	31	33.3
	Yes	62	66.7
Droughts	No	79	84.9
	Yes	14	15.1
Fires	No	66	71.0
	Yes	27	29.0

10.5.2 Private wetland risks and vulnerability

In privately owned wetlands, 19 respondents (22.9%) disagreed that floods were becoming more frequent in the study area, while 63 (75.6%) respondents agreed that flood episodes are becoming more frequent. However, compared to floods, a higher percentage (56.6%) disagreed that droughts were becoming more frequent in the eFS with 43.4% agreeing. It should be noted, however, that data was collected before the worst drought in the past 50 years that hit the study area in late 2015 and beginning 2016. Perhaps the same question repeated today could yield different responses.

The Kendall’s W Test was performed to explore what the private wetlands owners perceive as current and major future threats to their wetlands (Table 10.9). Top in the ranking was the threat as a result of lack of awareness on wetland benefits, followed by uncontrolled fires, and then overgrazing was in the third position. The test statistic for the ranking of the threats revealed that about 93% of the private wetland owners agreed to the ranking order as indicated in Table 10.9. The Chi-square statistic of 92.91 was highly significant at 1% level, suggesting that the ranking is valid and efficiently estimated. This further shows that the individual threats identified in the study jointly and significantly explain the actual threats to the eFS wetlands.

TABLE 10.9: PERCEIVED WETLANDS THREATS BY PRIVATE WETLAND USERS

Kendall's W Test	
Threat	**Mean rank**
Lack of awareness on wetland benefits	8.94[1st]
Uncontrolled fire	8.81[2nd]
Overgrazing	7.64[3rd]
Upper catchment management activities	7.28[4th]
Sedimentation	7.23
Lack of material resources to manage	7.14
Soil erosion	6.96
Lack of human management capacity	6.70
Change in water regime	6.45
Invasive alien species	6.19
Pollution	6.12
Conversion to other uses	5.87
Climate variability	5.65

Test Statistics	
N	83
Kendall's W[a]	0.93
Chi-Square	92.91
df	12
Asymp. Sig.	.000

10.5.3 Bad practices that lead to wetland degradation

The private wetland respondents were also asked to list some of the bad practices they think could lead to the degradation of their wetlands. A Kendall's W Test was performed for the suggested activities and is presented in Table 10.10.

TABLE 10.10: SUGGESTED BAD ACTIVITIES THAT RESULT IN WETLAND DEGRADATION

Kendall's W Test	
Ranks	**Mean rank**
Overgrazing	6.34
Bad or poor fire management	5.80
Pollution	5.31
Drainage wetlands	4.87
Bad wetland management practices	4.77
Invasive and alien species	4.71
Construction within wetlands	4.60
Uncontrolled harvesting of wetland plants	4.44
Poor enforcement of wetland law	4.17

Test Statistics	
N	83
Kendall's W[a]	.158
Chi-Square	104.786
df	8
Asymp. Sig.	.000

10.5.4 Good practices that support healthy wetlands

The private wetland respondents were asked to suggest some of the practices that they think could support better management of wetlands in the area. Again, a Kendall's W Test was performed for the suggested activities and is presented in Table 10.11 below.

TABLE 10.11: SUGGESTED ACTIVITIES THAT WILL LEAD TO BETTER WETLAND MANAGEMENT IN THE AREA

Kendall's W Test	
Ranks	**Mean rank**
Education and training on wetlands	6.99
Awareness creation on wetland functions and values	6.22
Good coordination amongst wetland stakeholders	6.08
Fencing of wetlands	6.08
Effective law enforcement	5.87
Avoid settlement within wetlands	5.87
Avoid overgrazing	5.80
Avoid wetland pollution	5.73
Rehabilitation of degraded wetlands	5.73
Better management with management plans	5.94
Control veld fires	5.66

Test Statistics	
N	79
Kendall's W[a]	.064
Chi-Square	50.954
df	10
Asymp. Sig.	.000

Education, training and awareness on wetlands and their values was very prominent amongst the suggestions.

10.6 WETLANDS VALUES AND ECOLOGICAL SERVICES

10.6.1 The values and ecological services provided by communal wetlands

Communal wetlands are used for a variety of activities that range from recreation to provisioning services. Table 10.12 illustrates the various activities that the sampled communal wetlands users undertake within or near the wetlands. From the table, the use of these wetlands for waste disposal topped the list at 40.9%, followed by sand collection for buildings at 29%, crop production at 28%, grazing at 26.9%, just to mention the top four activities. It was not surprising that waste disposal topped the list, because and as observed in the field, most of the communal wetlands are either within or near informal settlements and are often used for domestic waste disposal. This also points to the fact that the local community still regards these wetlands as waste land, hence the pollution and degradation of these wetlands. This misconception can be rectified through proper wetland education and proper land redistribution and land-use zoning or by the municipalities providing an efficient and effective waste collection service.

TABLE 10.12: VARIOUS WETLAND USES SUGGESTED BY COMMUNAL WETLANDS USERS

Activity	Frequency	Percentage	Ranking
Waste disposal	38	40.9	1
Sand excavation for building	27	29.0	2
Agriculture (crops)	26	28.0	3
Grazing	25	26.9	4
Residential buildings	22	23.7	5
Water collection for domestic use	10	10.8	6
Medicinal plants	10	10.8	7
Commercial buildings (for example restaurant)	8	8.6	8
Education and research	6	6.5	9
Car wash	5	5.4	10
Recreation	3	3.2	11
Fishing	2	2.2	12

10.6.2 The perceived importance of communal wetlands to individual users and the community

When asked to indicate the importance of communal wetlands to the individual users and the local community as a whole, there was a split where 53.8% indicated that the wetlands were either very important or important to them, and 42% reported that the wetlands were also important to the local community as a whole. On the other side, 36.6% said the wetlands were not important to them, another 28% indicated that these wetlands were not important to the local community. Some respondents (10%), did not know whether the wetlands were important to them while 30.1% could not tell if these wetlands were important to the whole local community (Table 10.13).

TABLE 10.13: PERCEIVED IMPORTANCE OF COMMUNAL WETLANDS

Importance	To individuals		To the local community	
	Frequency	Percentage	Frequency	Percentage
Very important	14	15.1	13	14.0
Important	36	38.7	26	28.0
Not important	34	36.1	26	28.0
Do not know	9	9.7	28	30.0
Total	93	100.0	93	100

From the responses, it can be deduced that communal wetlands are still important to the individual users, as well as the whole local community, as a natural capital. However, there is still a big problem of ignorance on the importance of communal wetlands as indicated by a combined high percentage of about 40% who did not know the importance of these wetlands to the individual users and to the local community as a collective.

10.6.3 The perceived future value of communal wetlands

It was important to find out what the sampled population think about the future value of communal wetlands, to give an indication of the possible conservation and preservation of these wetlands. The majority of the respondents (66.7%) indicated that communal wetlands will still play an important role in the next ten years. The 33.3% who indicated that these wetlands will not be important, backed their arguments on the grounds that these wetlands were always flooded or full of water, they were always heavily polluted, there was the acute problem of poor management, there was lack of concern from the local municipalities. Some cited political interference, while others said they do not receive any benefits from these wetlands at the moment and therefore do not foresee any future importance of these wetlands.

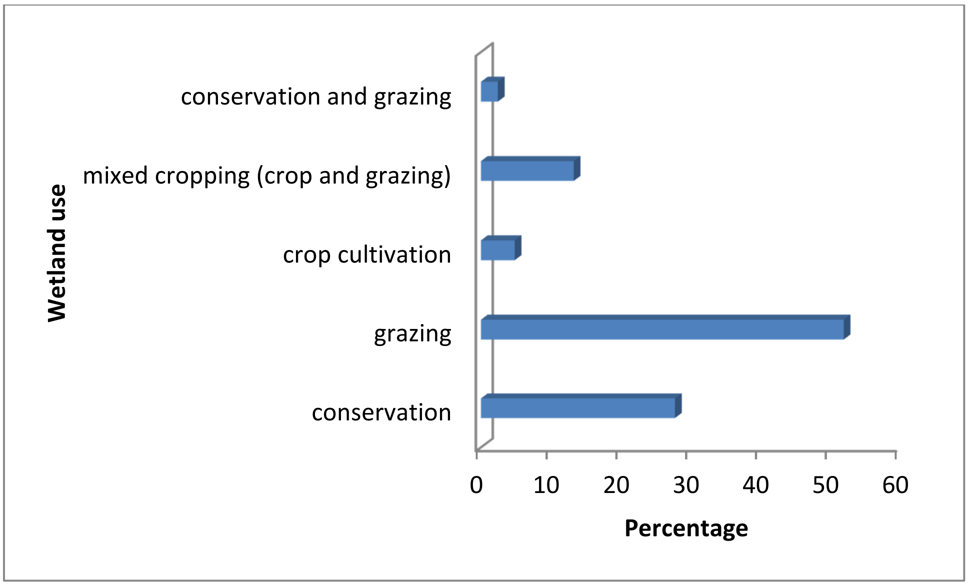
10.6.4 The value and ecological services provided by private wetlands

The MA (2005) grouped wetland ecological services into four broad categories that include provisioning, regulating, cultural and supporting services. From data collected from the sampled respondents using questionnaires, and supported by field observation, it was discovered that grazing and food production dominated the provisioning services, erosion and natural hazard regulations were dominant in the regulatory category, educational and aesthetic services dominated the cultural category, while soil formation and nutrient cycling completed the supporting services (Table 10.14).

TABLE 10.14: REPORTED MAJOR BENEFITS FROM WETLANDS IN PRIVATELY OWNED LAND

Services	No benefit	Little benefit	Important benefit	Very important benefit	Ratings
Provisioning					
Food	46	19	9	9	1.77 3rd
Grazing	10	15	27	31	2.95 1st
Fresh water	18	11	19	35	2.86 2nd
Fibre and fuel	48	22	7	6	1.65 4th
Biochemical	52	18	6	7	1.61 5th
Genetic materials	58	13	6	6	1.52 6th
Regulating					
Climate regulation	27	20	18	18	2.33 6th
Water regulation	10	11	25	37	3.07 3rd
Water purification and waste treatment retention	10	15	25	33	2.98 4th
Erosion regulation	10	10	23	40	3.12 1st
Natural hazard regulation	8	14	24	37	3.08 2nd
Pollination	8	22	25	28	2.88 5th
Cultural					
Spiritual and inspirational	39	22	17	5	1.86 5th
Recreational	35	16	19	13	2.12 3rd
Aesthetic	19	25	18	21	2.49 2nd
Educational	21	13	18	31	2.71 1st
Supporting					
Soil formation	13	14	22	34	2.93 1st
Nutrients cycling	15	14	24	30	2.83 2nd

The field observation supports the fact that most of the wetlands in the study area were used for grazing, with a few cultivated mainly for maize, beans and sunflower (Figure 10.5).



Source: Author's own (2016)

Figure 10.5 Dominant use of private wetlands in the eastern Free State

10.7 WETLANDS ECOLOGICAL STATUS

10.7.1 Information from questionnaire

Question 26 in the private wetland questionnaire required the respondents to score the current state of their wetlands compared to the past, against the key wetland indicators that include the vegetation, water and soil of the wetland (Table 10.15). The results show that 67.5% of private wetlands owners reported that their wetland vegetation was either in a good or very good ecological state, 63.9% said the hydrology in their wetland was either good or very good, while 60.3% reported that the soil was either good or very good. This information supported what was observed in the field (10.7.2) that these private wetlands may be in a good but not excellent ecological state.

TABLE 10.15: ECOLOGICAL STATUS OF PRIVATE WETLANDS

Ecological status	Poor (1)	Fair (2)	Good (3)	Very good (4)	Mean score
Vegetation	6 (7.2)	21 (25.3)	43 (51.8)	13 (15.7)	2.76
Water	13 (15.7)	17 (20.5)	35 (42.2)	18 (21.7)	2.70
Soil	9 (10.8)	24 (28.9)	35 (42.2)	15 (18.1)	2.67

10.7.2 Information from field observation

Ten indicators were used to assess the ecological status of 21 randomly sampled wetlands (see section 9.3.3.3). From field observations, six out of seven communal wetlands were in a poor state, with only one in an average ecological state. All wetlands in protected areas were in an excellent ecological state with one of them (Seekoeivlei) being a Ramsar site. The Braamhoek (Ingula) wetland, which is also a protected wetland under Eskom, could eventually qualify for a Ramsar site designation given its present status and ecological role. Wetlands found in private commercial farms were clustered around good ecological status; only one of them was in an excellent ecological health and this wetland is a heritage site.

The greatest wetlands management problem that needs tactful planning lies with wetlands in communal land which were mostly in a poor ecological state as indicated in Table 10.16 below.

TABLE 10.16: ASSESSMENT OF THE ECOLOGICAL STATUS OF WETLANDS USING A FIELD OBSERVATION SCORING SHEET

Wetland group	No.	Wetland ID	Score/50	Score percentage	Ecological status
Communal	1	Monontsha	20	40	Poor
	2	Bethlehem	18	36	Poor
	3	Heilbron	24	48	Poor
	4	Frankfort	23	46	Poor
	5	Petrus Steyn	24	48	Poor
	6	Edenville	22	44	Poor
	7	Clarens	27	54	Average
Private:					
Protected Areas	8	Seekoeivlei	45	90	Excellent
	9	Braamhoek	40	80	Excellent
	10	Golden Gate	39	78	Excellent
Commercial farms	11	SB1	36	72	Good
	12	SB2	36	72	Good
	13	SB3	34	68	Good
	14	SB4	34	68	Good
	15	VR1	35	70	Good
	16	VR2	36	62	Good
	17	VR3	33	66	Good
	18	VR4	34	68	Good
	19	FB1	41	82	Good
	20	RT1	33	66	Good
	21	QQ1	31	62	Average

10.7.3 Interview with wetlands specialists

The results from the field observation (10.2.2) tally with the interview results from five wetland specialists. All five interviewed wetland specialists reported that protected wetlands at Golden Gate, Seekoeivlei and Braamhoek were in very good conditions, apart from a few head-cut erosions here and there. They also reported that most wetlands in private commercial farms were in a good state and those identified to have problems were being rehabilitated by WfWetlands, Wetlands in communal wetlands were generally in a poor state in most parts, despite efforts to rehabilitate some of these wetlands. The main problem that was reported in communal wetlands were open, uncontrolled grazing and other activities within the wetlands. The conversion of the Dihlabeng wetland in Bethlehem into a mall was regrettably also cited.

10.8 WETLAND MANAGEMENT

10.8.1 Management of communal wetlands

Table 10.17 summarises the results of communal respondents when asked to suggest ways that communal wetlands can be well-used and better maintained.

TABLE 10.17: SUGGESTIONS ON HOW TO BETTER MANAGE COMMUNAL WETLANDS

Suggestions	Frequency	Rank
Provide education and training on wetlands	12	1
Effective wetland laws and policies	7	2
Provide dumping site, rubbish cans and control pollution	5	3
Relocate the settlers and provide better land	5	3
Build bridges and other forms of flood control	4	4
Provide fodder, especially in winter	3	5
Create jobs for the local people	3	5
Provide water-saving devices	3	5
Fence around the wetlands	2	6

On top on the list of suggestions was the need to provide education and training on the importance of wetlands, their conservation, protection and wise use. This was followed by formulating stringent laws on wetlands and implementing them effectively through the joint efforts of the government and the local municipalities. Third on the list was the plea that dumping sites, rubbish cans and other forms of pollution control should be put in place. This is important since communal wetlands were observed to be heavily polluted, especially from domestic waste since all the communal wetlands sampled were surrounded by informal settlements. There were suggestions that the government should relocate the people and provide better land. The land issue in the study area and the rest of South Africa is imbalanced and a complicated issue dating back to the apartheid era. It is still a heated political issue between the ruling African National Congress (ANC) and the radical Economic Freedom Fighters (EFF) youth-dominated party on the approach to use in land redistribution in South Africa. Resettlement in dryland could form part of flood safety measures, since cases of drowning in flooded wetlands were also reported. The provision of fodder, especially in winter, was also mentioned as was job creation and provision of water-saving devices like Jojo tanks that could ease pressure on wetlands that were used for water harvesting. Fencing the wetlands can be very expensive and was the least on the list of suggestions.

There were no management plans, written or unwritten, for communal wetlands and there was no observed control of illegal activities such as pollution by the users. For example, at the Monontsha wetland, a channel was constructed to direct waste from a pigsty into the wetland. This example indicates that the very users who complained about pollution are themselves the polluters.

10.8.2 Management of private wetlands

In privately-owned wetlands, 69.9% indicated that they had no wetlands management plans (written or unwritten), while 12% indicated they had plans that were seldom used and revised. These privately-owned wetlands were reported to have no protection status though literature review show that the NWA, the NEMA and CARA provide legal protection on wetlands (See section 3.3.2). Meanwhile, 75.9% reported that they either did not know the threats facing their wetlands, therefore could not address them or insufficiently addressed these threats. Another 85.5% either had no mechanisms in place to control inappropriate land use activities or the mechanisms were ineffectively implemented.

In contrast to communal and privately-owned wetlands, government-owned wetlands were in protected areas and had written management plans that were constantly revised. They also had in place mechanisms to control illegal activities within the wetlands.

10.8.3 Examples of good wetlands management from the study area

10.8.3.1 Selective use of wetlands

Selective use of a wetland is one good management practice that was observed in the field (Figure 10.6). This is a practice where the land user divides the wetland into sections and either use rotational grazing or use the various parts for different activities. In one wetland in Swinburne, in summer, the owner used the upper temporary wet area for grazing, then the seasonally wet area for the cultivation of beans and the permanently wet area was left fallowed, probably to be grazed in winter when the water table drops since most wetlands in the eFS are seasonal wetlands animated by summer rainfall. The poplar trees in this wetland, though alien, were used as shelter for the cattle during summer, the farmer explained.

A. Grazing section

B. Cultivation of beans Source: Author's own (2016)

Figure 10.6 Selective use of some wetlands

10.8.3.2 Moolmanshoek Wetland

> *We need to get the valley back to its ultimate glory in order to give back to our children the wonder of perfect nature that was experienced by our forefathers. This is a magnificent story yet to be told* (Mr Willie Nel, owner of Moolmanshoek farm; interviewed on 16 August 2015).

Mr Willie Nel, owner of the Moolmanshoek farm/wetland that is also a natural heritage site, combines natural, social and biblical science to rehabilitate and manage a well-maintained and ecologically intact valley-bottom wetland which lies about 39 km from Ficksburg and about 10 km from Rosendal in the eFS. He is inspired by the book of Genesis in the Bible to emulate the beauty with which God created the world. *"And God saw everything that He has made, and, behold it was very good"* (Genesis 1:31). From a natural science perspective, Mr Nel explained that those living at the foothills export top soil down-stream through irrational cultivation of slopes, deforestation and improper burning that generates a lot of soil erosion. On the contrary *"Instead of exporting the top soil, I export clean water to down-steam users"*, declared Mr Nel. In fact, pictures can paint a thousand words, so the three sets of photos below tell the whole story (see Figures 10.7, 10.8, and 10.9). The concept of payment for ecosystem services (Renaud *et al*., 2013; TEEB, 2010) can easily be applied here where downstream users could compensate for the purification role played by this well-maintained wetland. This private commercial farmer also realised that natural science alone was not enough for wetlands rehabilitation, conservation and wise-use, but there was a need to add social sciences into the equation in the form of "rehabilitating peoples' minds and thinking". He achieved this by providing education and workshops to other farmers, not only on wise and sustainable wetlands management, but also on organic and climate-smart farm management.

Source: Courtesy of Willie Nel (2015)

Figure 10.7 Poor land use leads to exportation of top soil through erosion at Moolmanshoek wetland

Source: Courtesy of Willie Nel (2015)

Figure 10.8 Wetland rehabilitation work in progress at Moolmanshoek wetland

Source: Courtesy of Willie Nel (2015)

Figure 10.9 The rehabilitated Moolmanshoek wetland in good ecological state and exporting clean water to downstream users

The Moolmanshoek wetland is in a very good ecological state, wet with green vegetation even during the heart of a severe drought like the one experienced in 2015/2016 in the FS. Activities within the wetland include cattle rearing, game, pisciculture, site-seeing and horse-racing. Due to the good ecological status of this wetland, the average cost of business in the wetland is also very low. For example, the cost per litre of milk was estimated at less than a cent as the cattle graze freely in a well-maintained natural pasture and remained healthy year-round as reported by Mr. Willie Nel. Other spinoffs include the use of the wetland for recreation such as natural swimming pools, medicinal plants and rich biodiversity wherein some very rare and endangered plant species are found, hence a national heritage site.

The main problem, however, in this wetland as reported by the owner relate to the fight against alien and invasive plants such as river pumpkin and wild rhubarb (*Gunnera Perpensa*) and cattail (*Typhaceae Typha Litifolia*) which WfW could assist in clearing (see 11.2.1).

10.9 WETLANDS, DISASTER RISK REDUCTION AND CLIMATE CHANGE ADAPTATION

10.9.1 Managing wetlands for disaster risk reduction

There is extensive literature that support the fact that wetlands can be managed to reduce the impact of disaster risks, as well as to adapt to climate change. This is currently referred to as the Eco-DRR/CCA approach (see Chapters 7 and 8 for details). Asked whether they (communal wetland users) manage their wetlands with the possibility to reduce the three common hazards in the area (veldfires, droughts and floods) or whether the wetlands help them to reduce these risks, the responses are presented in Figure 10.18).

TABLE 10.18: WETLANDS HELP TO REDUCE THE IMPACTS OF FLOODS, DROUGHTS AND FIRES IN COMMUNAL WETLANDS

Valid		Frequency	Percentage	Valid percentage	Cumulative percentage
Droughts	No	64	68.8	68.8	68.8
	Yes	29	31.2	31.2	100.0
	Total	93	100.0	100.0	
Fires	No	65	69.9	69.9	69.9
	Yes	28	30.1	30.1	100.0
	Total	93	100	100	
Floods	No	74	79.6	79.6	79.6
	Yes	19	20.4	20.4	100.0
	Total	93	100.0	100.0	

Most of the communal wetland users do not perceive the wetlands as having any mitigation effects on the common hazards in the area. They would therefore not manage these wetlands for possible DRR.

However, the picture in the private wetlands was quite different.

TABLE 10.19: MANAGEMENT OF WETLANDS TO REDUCE DISASTER RISKS IN PRIVATE WETLANDS

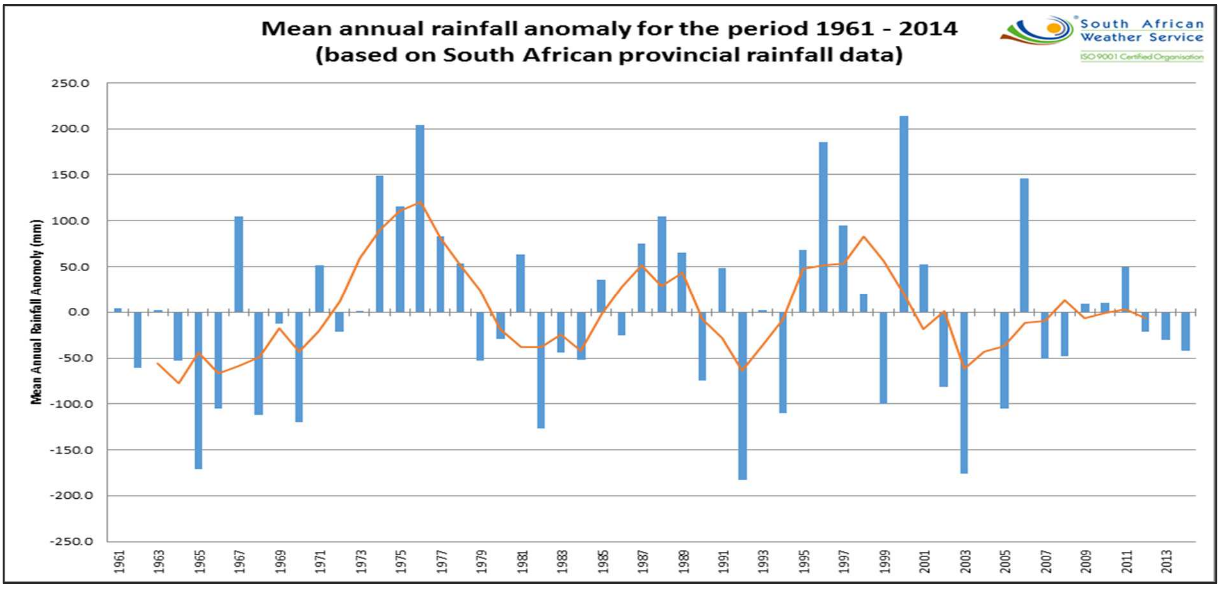
Valid		Frequency	Percentage	Valid percentage	Cumulative percentage
Drought	Agree	58	69.9	69.9	69.9
	Disagree	23	27.7	27.7	97.6
	Undecided	2	2.4	2.4	100.0
Fires	Agree	54	65.1	65.1	65.1
	Disagree	27	32.5	32.5	97.6
	Undecided	2	2.4	2.4	100.0
Floods	Agree	50	60.3	60.3	60.3
	Disagree	31	37.3	37.3	97.6
	Undecided	2	2.4	2.4	100.0
Climate change	Agree	38	45.8	45.8	45.8
	Disagree	42	50.6	50.6	96.4
	Undecided	3	3.6	3.6	100.0

The private wetlands owners agreed that they manage their wetlands in order to reduce the common disaster risks of drought, fire and flood as indicated in Table 10.19 above. This was quite contrary to what was reported by the communal wetland users (Table 10.18).

10.9.2 Managing wetlands for climate change adaptation

Less than half of the total number of privately-owned wetland respondents (38 or 45.8%) agreed that they manage their wetlands to adapt to climate change. More than half of the respondents (42 or 50.6%) reported that they do not manage their wetlands with climate change impacts in mind. Only 3 (3.6%) respondents were undecided on this issue. The communal wetland respondents had no knowledge about what climate change was. The responses here highlight the difficulty of pinpointing climate change impacts in the study area.

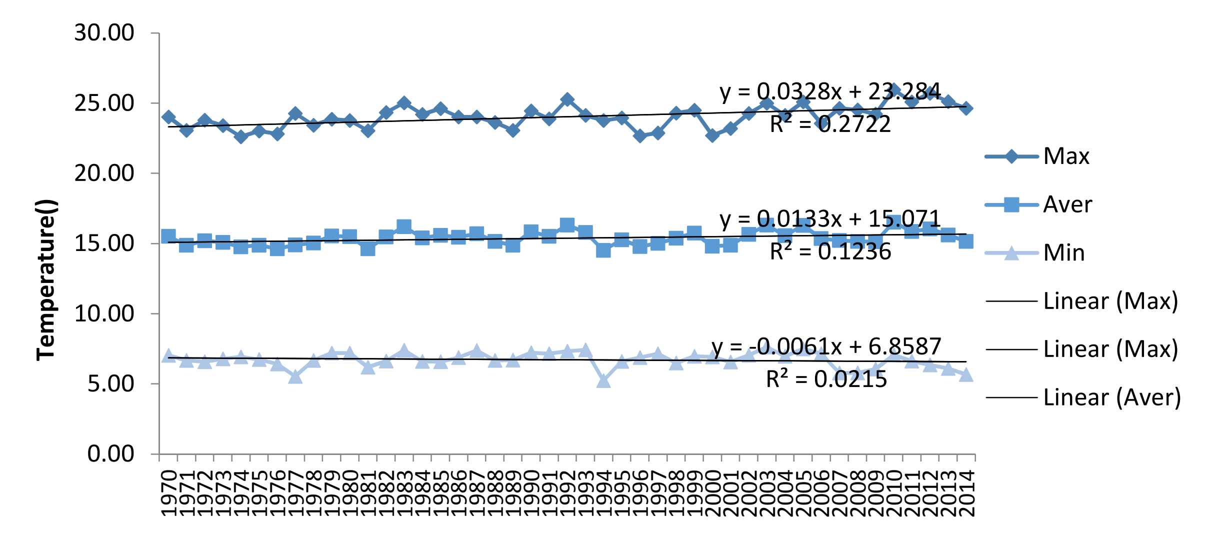
Analysis of secondary data on two key climate parameters are presented in Figure 10.10 below:



Source: SAWS (n.d.)

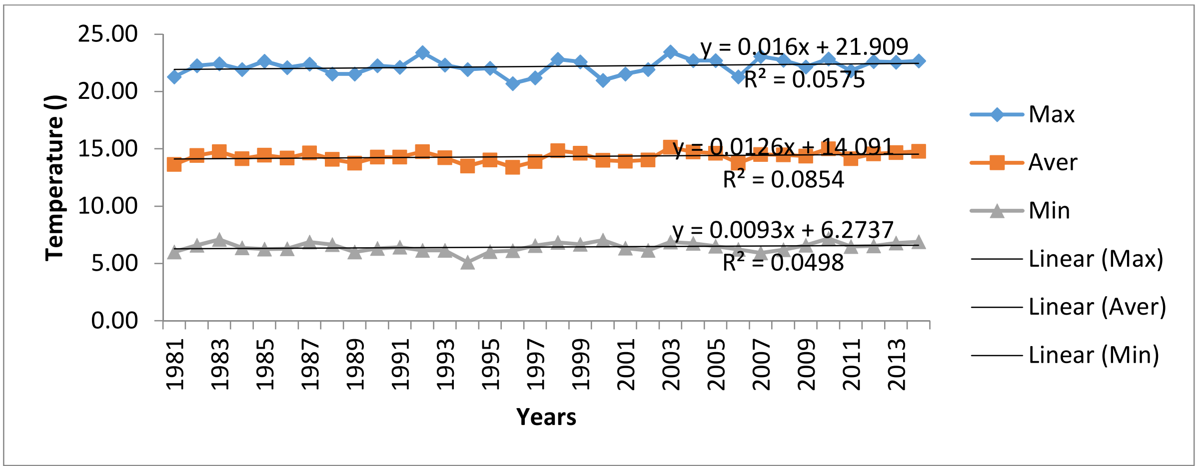
Figure 10.10 Average annual rainfall anomaly for the Free State

Rainfall and temperature data was also obtained from six weather stations within the eFS. The purpose was to analyse that data to see if any noticeable trend could be identified. Out of the six weather stations, five fell within the arbitrary demarcated eFS. The researcher also wanted to have consistently recorded rainfall and temperature data for at least thirty years. Following these criteria, only data from the Frankfort weather station in the north and Bethlehem in the south of the study area were used (Figure 10.11).



Source: Adapted from SAWS (n.d.)

Figure 10.11 Annual temperature distribution for the Frankfort weather station (1970 to 2014)

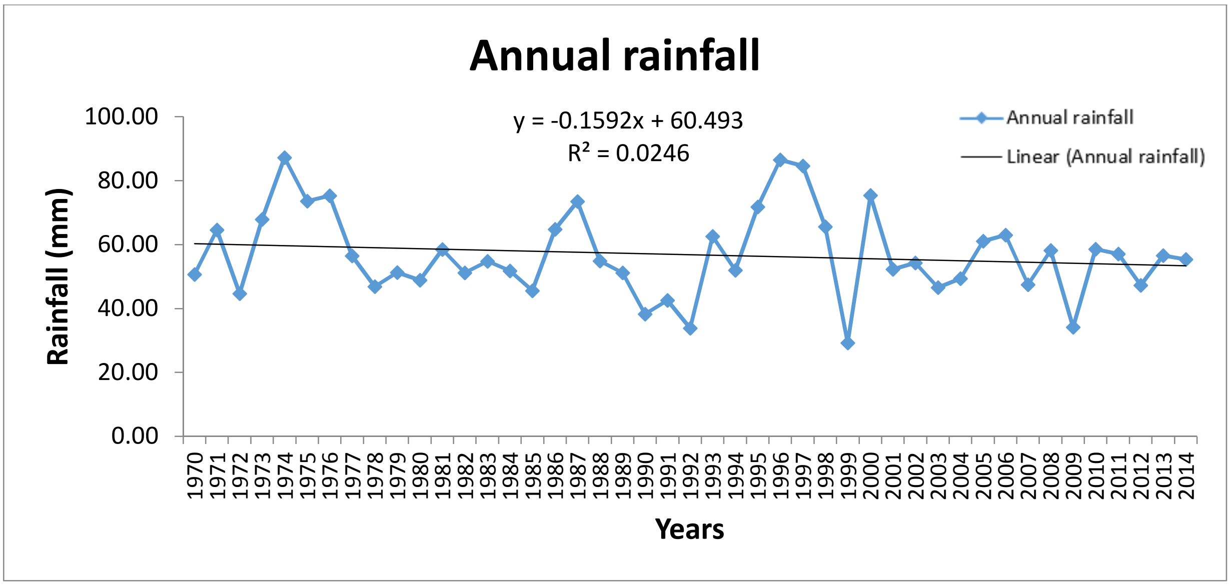


Source: Adapted from SAWS (n.d.)

Figure 10.12 Annual temperature distribution for Bethlehem weather station (1981 to 2014)

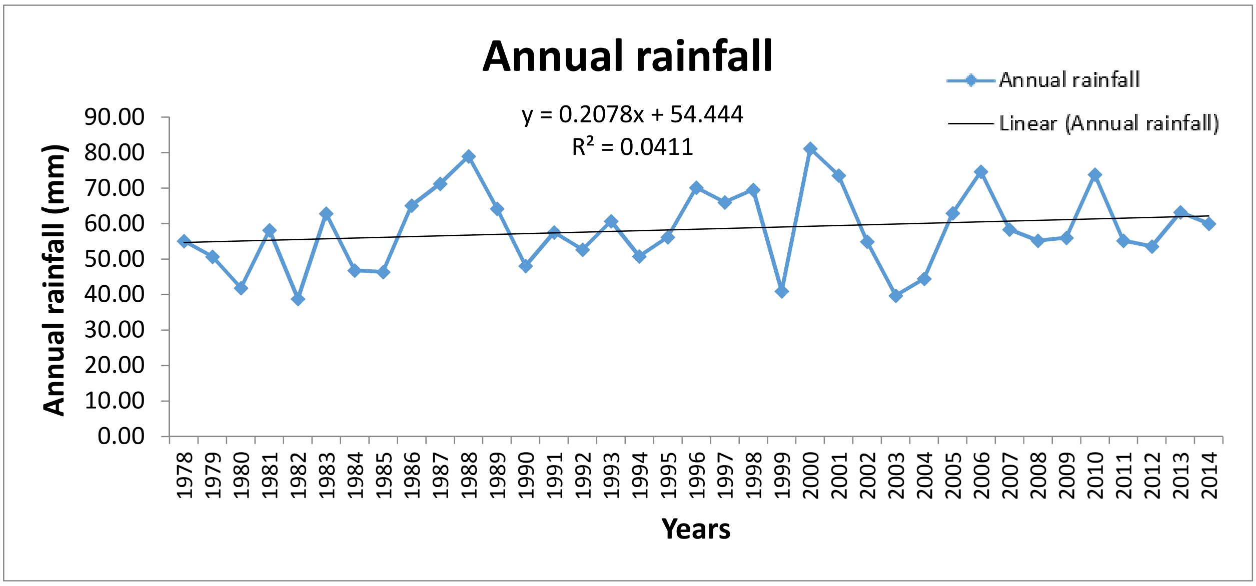
Like the general FS rainfall anomaly (Figure 10.10), the only visible trend in the temperature distribution for more than 30 years was the variability indicated by an average R^2 of less than 0.1 showing variability in the average annual temperature data. This average could mask the daily and monthly variability which could be higher with more consequences to people, animals and plants.

The rainfall distribution for the two weather stations reveals a similar and even higher variability as shown in Figure 10.13 and 10.14 below.



Source: Adapted from SAWS (n.d.)

Figure 10.13 Annual rainfall for the Frankfort weather station (1970 to 2014)



Source: Adapted from SAWS (n.d)

Figure 10.14 Annual rainfall for the Bethlehem weather station (1978 to 2014)

10.9.3 Expert opinion on climate change

Fifteen climate experts were interviewed at different times in the course of the research project. The last interview was held during the Post COP21 Provincial Climate Change Dialogue on 07 June 2016 at Ilanga Estate in Bloemfontein. Table 10.20 to 10.22 summarise of the responses:

TABLE 10.20: INTERVIEWED EXPERTS' OPINION ON CLIMATE CHANGE AND WETLANDS

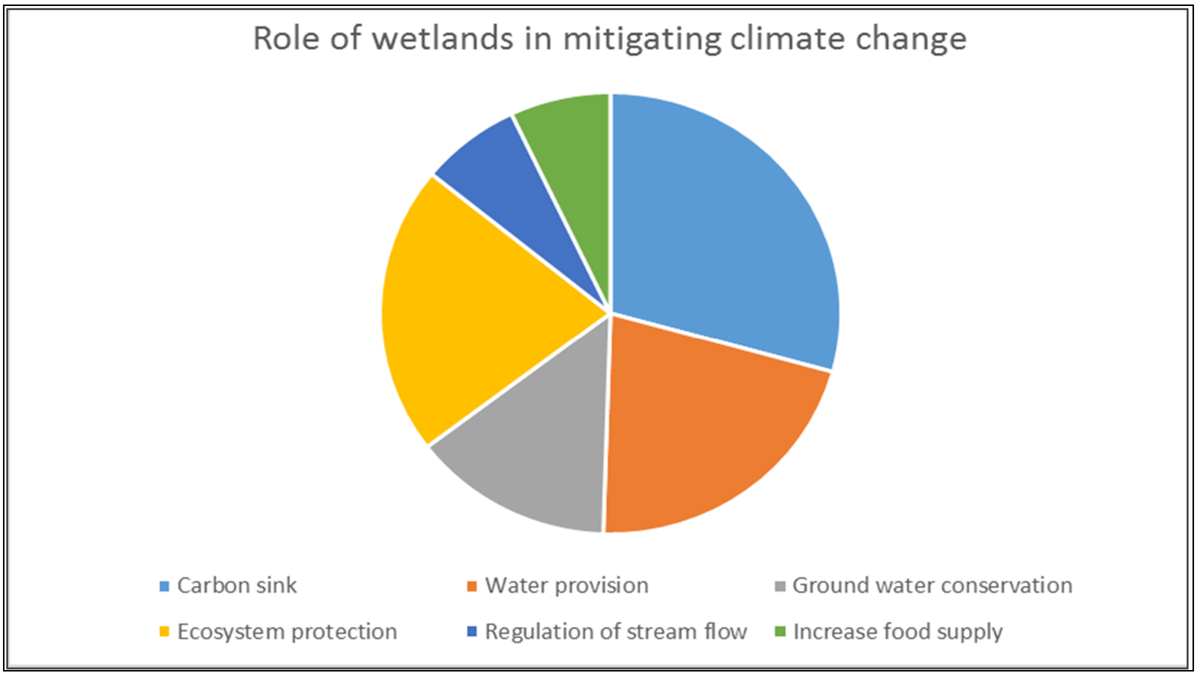
Question	Response	Percentage
Do you think the climate in the FS has changed?	N = 15 Yes = 15 No = 0 Not sure = 0	100% agreed
Do you think good management of wetlands can reduce the impacts of climate change?	N =15 YES = 14 No = 1 Not sure =0	93.3% agreed and 6.7% disagree
Do the local communities in the FS understand the value of wetlands?	N =15 No = 14 Yes = 0 Not sure =1	93.3% disagreed while 6.7% agreed

All the climate experts agreed that the climate has changed in the FS, and 14 out of 15 agreed that good management of wetlands would help to reduce the impact of climate change. However, 93.3% disagreed on the fact that the local community understand the value of wetlands (Table 10.20) and most of them (80%) suggested that education, training and awareness could help alleviate the problem (Table 10.22).

TABLE 10.21: REASONS INDICATED BY CLIMATE EXPERTS TO SUPPORT CLIMATE CHANGE

Number	Reason	Frequency
1	More frequent droughts episodes	6
2	Warmer and shorter winters	3
3	Changes in rainfall patterns	3
4	Changes in weather patterns	2
5	Increase in temperature	2
6	Drier summer and reduced rainfall	2
7	Fall in crop yield, especially maize	2
8	Weather extremes	1
9	Political discussions	1
10	Lower dam levels	1
11	Heatwaves	1
12	Cold spells	1
13	Floods	1

The climate change experts gave various reasons to support climate change in the FS, and popular among the reasons was the frequent episodes of drought in the area (Table 10.20). They also gave various ways that wetlands could mitigate climate change; top of which was wetlands acting as good carbon sink (Figure 10.15)



Source: Author's own (2016)

Figure 10.15 Suggested roles that wetlands can play in mitigating climate change by interviewed experts on climate in the Free State

TABLE 10.22: SUGGESTION BY CLIMATE EXPERTS ON HOW TO IMPROVE UNDERSTANDING OF WETLAND FUNCTIONS AND VALUES

Number	Suggestion	Frequency
1	Education, training and awareness on wetland values and functions to local communities and in schools	12
2	Dedicated government personnel to better manage wetlands	2
3	Promotion of community involvement and ownership	1
4	Better budget	1
5	More information	1

10.10 DISASTER AND ENVIRONMENTAL MANAGEMENT

This research has a very strong link between two well-established disciplines (disaster management and environmental management) at the UFS which is the largest tertiary institution in the province. It was therefore of interest to find out what link exists between the two disciplines in terms of building synergy and promoting knowledge and skills transfer. A short survey with eight disaster management and environmental management specialists was carried out in an attempt to establish the relationship between disaster management and environmental management which are the two pillar disciplines in this study. The premise here is that climate is part of the natural environment.

From the thematic analysis of the responses all eight specialists agreed to the fact that there is a strong relationship between disaster management and environmental management. It was stated that all disasters occur within the ambient of the natural environment and will most often affect the environment negatively. They also stated that a well-managed natural environment help to mitigate disaster risks, while a degraded environment will act as a catalyst to many disaster risks. The third theme mentioned was the fact that many disasters nowadays are climate-related such as floods, droughts, heatwaves and that the climate is part of the natural environment. Lastly, it was pointed out that the natural environment in pristine or excellent conditions are good tools to build local resilience to many hazards, including climate change. The arguments from these specialists were strongly supported in other related literature reviewed (Chapters 4, 7 and 8) and support the Eco-DRR/CCA approach which guided the conceptual framework for the operationalisation of this research.

Asked whether knowledge of disaster management will benefit environmental managers in their operations, seven out of the eight specialists were in strong agreement. Some of the justifications were that knowledge of disaster management supports better planning in environmental management. It was pointed out that the linkage between hazards, vulnerability and resilience are well-covered in disaster management and that such knowledge will benefit environmental managers to tackle environmental planning such as the EIA from a proactive and holistic perspective. The only specialist who did not agree, argued that better environmental management will automatically reduce disaster risk. Even in the latter argument, one could still identify a link between disaster management and environmental management. On the other hand, all eight specialists agreed that knowledge of environmental management would benefit disaster managers, citing for example the planting of shelter trees which reduce the impact of storms on infrastructures such as schools and houses. Knowledge of environmental management will also assist disaster managers to identify areas which are vulnerable to certain hazards and therefore plan for DRR measures accordingly. All these arguments are again in support to the Eco-DRR/CCA approach.

The largest tertiary institution in the FS province is the UFS with two renowned centres that specialise in disaster management and environmental management at Master's degree level. These are the Disaster Management Training and Education Centre for Africa (UFS-DiMTEC) and the Centre for Environmental Management (UFS-CEM). Asked if there was enough content of disaster management in environmental management, and *vice versa*, as a way of building skills and transferring specialist knowledge, the result was a 50% split.

10.11 CHAPTER SUMMARY

This chapter analysed and presented the data that was collected from both primary and secondary sources to bring out information that address the research questions and objectives. The primary data was based on two sets of almost identical questionnaires that were administered to private and communal wetland owners and users. Three government-owned wetlands in protected areas were also sampled to act as benchmarks for better management of wetlands in the study area, and their managers also completed the questionnaire for privately-owned wetlands. Besides data from the questionnaires, a field observation was carried out using a field data sheet involving 21 randomly selected wetlands. Short surveys were also carried out with wetland specialists, disaster and environmental specialists as well as climate change specialists. Secondary data on temperature and rainfall in the study area was sourced from the SAWS. The varied sources of information were good for triangulation. The next chapter focuses on a general discussion before concluding and making recommendations.

Chapter 11

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

11.1 INTRODUCTION

This chapter starts by discussing the trends and patterns in the collected and analysed data with reference to the stated research questions and objectives. The primary data and secondary data were blended with facts from the review of literature in order to add credence to the information that was used in drawing conclusions, proposing recommendations and in drafting the final holistic framework for wetlands management in the eFS. The chapter is organised into three broad interlinked sections: discussion, conclusions and recommendations.

11.2 DISCUSSION

11.2.1 The legal and institutional arrangement for wetlands management

Evidence from primary data collection (10.4.1 and 10.4.2) is supported by literature (3.3.2) on the fact that there is no specific wetland policy both at national and provincial level in South Africa. Although the FS province developed a wetland policy in 2015, this policy has not been endorsed and popularised amongst the various wetland stakeholders in the province. The lack of a directive policy on wetlands makes wetland issues mentioned in a myriad of national legislations, especially the NWA, NEMA and CARA (see 3.3.2). Evidence from literature studies show that wetlands are well-managed in Uganda, partly because there is a specific national wetland policy in the country and partly because there are well-established and good bottom-up institutional arrangements for effective wetlands management (see 3.2.3.2).

The institutional arrangement for wetlands management in South Africa and therefore in the study area, is also not streamlined. Three government departments, DWS, DAFF and DEA (including DESTEA-FS), all have a direct role in wetland issues (see 3.3). Each of these departments have their core issues to tackle to which wetlands are annexed. There are also seven EPWPs with direct or indirect roles on wetlands and all placed under the DEA. This researcher is of the opinion that the DEA is overloaded with national responsibilities, especially given the fact that the DEA already handles many broad environmental issues in the country, including climate change issues, with limited resources both financial and human. Sometimes the roles of the different EPWPs overlap. For example, the primary role of WfWetlands is to rehabilitate and restore wetlands, while at the same time it is charged to create jobs to reduce unemployment in the study area. On the other hand, the primary role of WfW is the clearing of alien and invasive species, to compare only these two EPWPs. There will be an overlap of functions in the case where WfWetland clears alien and invasive species found in a wetland and may be without adequate budget and personnel. The functions of some of the EPWPs that overlap need proper coordination which seems lacking or not effective in the study area. For example, many private wetland owners complained of, and the field observation showed that invasive species were a problem in the study area (see 6.7.3.2 and 10.5.2). One farmer mentioned that he has reported the problem of alien species in his wetland to WfW on many occasions, but the problem has not been addressed. Though the reason for not responding was not given, it is possible that WfW is relying on WfWetland to attend to the problem and *vice versa*, hence highlighting the problem of overlapping mandate. Besides, balancing the twin responsibilities of rehabilitating wetlands and creating local jobs was reported by some wetland managers as a challenge in the study area with the attendance risk of prioritising one over the over given the limited financial resources. Political interference was also reported in the operational activities of these EPWPs (see 10.6.3). The lack of a clear process of selecting wetlands for rehabilitation was also picked up in the review of literature (Kotze *et al.*, 2009).

Proper management of wetlands involves many stakeholders. A stakeholder in wetlands management means any individual, group or community living within the influence of the site, and any individual, group or community likely to influence the management of the site. This will obviously include all those who are dependent on the site for their livelihood (Kotze *et al*., 2009).

From field observation and review of related literature (Wang *et al*., 2008), it was realised that there are many stakeholders involved in wetlands management. These stakeholders have varying degrees of influence and interest or stake in wetlands affairs. Table 11.1 attempts a classification of 17 of these stakeholders and divides them into four groups to which letters A, B, C or D were assigned. Though the classification is not scientifically based, it gives an indication of which stakeholders have high influence and can be lobbied for wetland issues or those with a very high stake who may champion effective management of wetlands in the eFS.

The classification was based on the RSC (2010a) identification of wetland stakeholders to which the ability of the identified stakeholder to influence wetland policies and/or management, as well as whether the stakeholder gets direct or indirect benefits from wetlands, was considered. The involvement and coordination of these stakeholders are poor (see 10.4.3) and is a big challenge in the study area.

Table 11.1: Preliminary discussion of identified wetlands stakeholders

	Low influence	High influence
High stake	Important stakeholder group perhaps in need of empowerment **C**	Most critical stakeholder group **A**
Low stake	Stakeholder group with least priority **D**	Useful for decision and opinion formulation, brokering **B**

Key:

DEAT–B; DWA–B; DAFF–B; WfWetlands (SANBI)–A; WfWater–B; Landcare–D; Land owners–A; Land users–B; Farmers–C; Local Community–C; Catchment Management Agencies–B; Mondi wetland project–A; Provincial Wetland Forums–C; Crane Foundation–A, SANParks–B; Developers–B, Town planners–B

To highlight the problem of wetland stakeholders' coordination one can cite the non-functioning of the Free State/Northern Cape Province Wetland Advisory Forum. This forum was established to act as a platform that brings wetland stakeholders together. Membership of this forum was never representative of all the wetland stakeholders as indicated in table 11.1 and for the past two years, the forum has never had any meetings. The wetland forum was a voluntary group and membership was not a line function of any designated person. Members were unwilling to chair the forum after the last chairperson served his terms in line with the constitution of the forum.

Effective wetlands management must understand the past and present human usage of the wetland, the current and future impacts, as well as ways that sustainable wetland usage can be achieved (Chatterjee *et al*., 2008; Kotze *et al.,* 2009). The best way to achieve this is through integrated wetlands management. Integrated wetlands management brings various wetlands stakeholders together, who then develop a vision, agree on shared values and behaviours, make informed decisions and act together to manage the wetlands. The success hinges on the willingness of sectoral stakeholders to work together since effective management of wetlands requires a multidisciplinary approach that integrates technical, economic, environmental, social and legal aspects of water management at catchment scale (Wageningen International, 2009). Such a well-coordinated approach is key for the wise and sustainable management of wetlands in the eFS.

11.2.2 Risk and vulnerability of wetlands in the study area

The type of wetland ownership plays a critical role in the degradation of wetlands in the eFS. Communal wetlands with common ownership were the most degraded wetlands in the study area. This observation is also supported by Sparks (2012). As observed in the field, the seemingly weak traditional authorities as custodians of communal land may have contributed to the degradation of many wetlands on communal tenure in the eFS, since activities with negative impacts in these wetlands were not well-reported and handled by the community themselves. In Ghana, strong traditional authorities and traditional beliefs about the deity powers of wetlands has helped in the conservation of many wetlands (Republic of Ghana, 1999). Protected wetlands owned by the government or government agencies were in an excellent ecological state while, most private wetlands were in a good state (see Table 10.16).

Many communal wetlands in the eFS are occupied by informal settlements, some are used as cemeteries (Figure 11.1), pigsties, small poorly managed gardens, playgrounds for children, power utilities, schools and even as a source of drinking water. There is almost every wrong or unsustainable form of land use in communal wetlands in the study area. Poor land use systems and land use changes may negatively affect many ecosystems including wetlands and greatly influence the intensity and frequency of disaster risks (Chen and Huang, 2012; IPCC, 2014; UNISDR, 2015).

Source: Author's own (2016)

Figure 11.1 Wetland at Heilbron in the eastern Free State used as a cemetery

Poor land management and lack of vegetation cover can increase the occurrence and intensity of droughts and even floods (Jordaan, 2012). Droughts, veldfires and floods are the common identified hazards in the study area and good wetlands management can mitigate the impacts of these hazards. Many informal settlements observed in communal wetlands were mostly inhabited by black South Africans with a few coloured South Africans. This may point back to the effects of apartheid when blacks were denied the opportunity to occupy proper dryland for settlement. The towns near these wetlands have developed during the apartheid regime and after 1994 with the introduction of modern democracy in South Africa, there was no land left around the towns for black people to settle, hence the occupation of wetlands around these towns. A shocking situation was observed in Heilbron where the RDP houses were built in a wetland and inhabitants of these houses (mostly coloured) complained bitterly about the frequent flooding of their houses. Many lost their valuable property, but still live in these houses with no alternative places to go. One will therefore question if proper EIA was done before such a development was carried out and who actually approved the building of RDP houses on a wetland. This example indicates a lack of proper implementation of existing legislations related to wetlands (see 10.4.1 and 10.4.2). It is also a perfect example where inappropriate development planning generates new vulnerabilities to the local community (UNISDR, 2015).

One of the threats to wetlands observed in the field was the impact of road and bridge construction across wetlands (Figure 11.2). This affects the hydrology of the wetlands, especially in the downstream section where channelling of the water through the bridges and converts increases the water energy and results in erosion. The proposed diversion of the N3 around the Harrismith area is under serious contestation with one of the main arguments being that it will pass through and impact on many wetlands and conservancies. This will then result in many wetlands and other endangered species in the area being affected. This proposed project is closely monitored by conservationists in the study area. Dam constructions that were observed in the field, for example the Ingula Hydro Project may also have detrimental effects on the downstream hydrology of wetlands.

Source: Author's own (2016)

Figure 11.2 Road construction across wetlands affects wetland hydrology

Closely related to the effects of roads, bridges and dam construction in wetlands is oil and gas exploitation. An application for environmental authorisation for an exploration right to exploit petroleum on many farms in the eFS especially around the Frankfort area, by Rhino Oil and Gas Exploration South Africa (Pty) Ltd could have serious negative impacts on wetlands if one looks at the case of the Niger Delta in Nigeria (WI, 2014). The researcher attended two of the consultation meetings as an interested and affected party and gave a presentation on the possible effects of oil exploitation on wetlands. Drawing experience from the Niger Delta in Nigeria, it was realised that most oil and gas reserves are in wetlands for obvious bio-chemical reasons (WI, 2014). Therefore, oil exploitation using whatever method, including the most contested method of fracking, will have detrimental effects on wetlands. Besides, the Niger Delta case also highlighted serious problems of oil pollution (WI, 2014) which may also be the case in the study area should the Rhino project be approved. The loss in biodiversity is another possible effect of the proposed oil exploitation. The Rhino Oil and Gas project is still in the exploration phase and consultations are still going on with the interested and affected parties. The Department of Mineral Resources is the most competent authority in this case for the EIA, compared to the DEA, but the chances of the project being approved without proper EIA and cost-benefits analysis are high, given other projects in the study area like the Dihlabeng Mall in Bethlehem.

Overgrazing is a threat to wetlands in the study area and can be attributed to poor management of wetlands. The type of grass in the wetland can also be a contributing factor. The area has mainly seasonal wetlands that receive summer rainfall and dominated by soar grass, which is less palatable and nutritious to the livestock, especially the large stock units and therefore would hold a lower carrying capacity compared to sweetveld (Kotze *et al.*, 2009). These factors are important for the farmers to bear in mind when stocking the animals in the wetlands. Furthermore, episodes of flood and drought impact negatively on the carrying capacity of these wetlands. Floods lead to trampling and clotting, while during dry spells and droughts there is concentrated grazing in the wetlands, especially in the seasonal and temporary sections of the wetlands (see Figure 11.3). Lastly, improper burning regimes and veldfires also help to reduce the carrying capacity of the wetlands and may result in overgrazing.

Source: Author's own (2016)

Figure 11.3 An example of an overgrazed wetland in the study area, showing spaces with no grass cover

Overgrazing of wetlands is an example of a biocapacity deficit at micro-level. Biocapacity deficit is when the footprint of a population exceeds the biocapacity of the area available to that population (Africa Development Bank and WWF, 2012). This means the number of grazing animals and their rate of footprint intensity exceed the ability or the rate of the wetland to regenerate itself, thus producing bare patches as observed in Figure 11.3 above. It is therefore important to balance the number of animals in the wetland, control their grazing intensity and allow the wetland to regenerate itself through wise and sustainable management (Kotze *et al.*, 2009).

In the US, one of the common wetland quality indices is the duck energy-days (DEDs) or duck-use days which estimate the energy carrying capacity of foraging habitats for dabbling ducks as calculated with the equation below (Gray *et al.,* 2013:149):

$$\text{DED} = \frac{\text{Seed Production (kg[dry]/ha)} \times \text{TME (kcal/kg[dry])}}{\text{Daily Energy Requirement (kcal/day)}}$$

DED = Duck energy-days
kcal = kilocalories per gram
TME = True metabolisable energy of the food

The DED estimates the number of ducks that a wetland can sustain for a certain period given the amount of available food and daily energetic requirements (Reinecke *et al*., 1989 in Gray *et al.,* 2013). This same calculation can be applied for wetlands in the eFS to calculate their carrying capacity by replacing the ducks with livestock since most of the wetlands are used for grazing. However, the DED formula will need to be modified since livestock mainly feed on grass and not seeds.

11.2.3 Ecological status of wetlands

The various threats to wetlands and the way they are managed determine the ecological status of the wetland which in turn determine the way the wetland is able to perform its ecological functions (Collins, 2006; Kotze, 2004; MA, 2005). There are many ways to determine the ecological status of a wetland (see 6.5.2), but all the indicators look at the hydrology, vegetation, soil and the quality of ecological services provided by the wetland which themselves are influenced by many factors, both human and natural.

In this study, the field observation data sheet that was used to assess the ecological status of 21 randomly selected wetlands (Appendix 6) included 10 indicators adapted from the assessment of wetlands in South Africa, by Oberholster *et al.* (2014). The aggregated field results showed that wetlands in protected areas were in an excellent ecological status, those on private farms were in a good status, while those in communal land were in a poor ecological status (see section 10.7.2). This *status quo* can be linked to many factors, ranging from poor management, ignorance of wetland functions and values, land title and private interest, non-existence or weak implementation of wetland related laws, as revealed in the review of existing literature in section 3.3.

11.2.4 The main functions of wetlands in the eastern Free State

There was a fair balance of the provisioning, regulating, cultural and supporting services (MA, 2005) derived from the sampled wetlands by private wetland owners (see 10.6.4). On the other hand, waste disposal, collection of building materials like sand, agriculture and grazing topped the dominant functions of communal wetland (Table 10.10). Though grazing for both livestock and wildlife and crop production dominate wetland use in the study area, it is important to note the different ways these activities are managed within communal and private wetlands. This different land use systems partly explain the differences in the ecological status of these two main types of wetlands ownership and use. Kotze *et al.* (2009) support the fact that the dominant wetland use in South Africa include grazing, cultivation and to an extent the harvesting of wetland plants for craft and thatching.

11.2.5 Wetlands management planning and plans

Communal wetlands were very poorly managed with no management plans and this was closely associated with the poor ecological status of these wetlands. The wetlands in protected areas like Seekoeivlei and the wetlands at Golden Gate were well-managed with management plans and thus were in an excellent ecological state. On the other hand, private wetlands in privately owned farms had no written management plans, but most owners had enough management experience that they applied on their wetlands. The private wetlands were thus in a good state but head cuts, invasive species and overgrazing were noticed in some of these wetlands. However, one privately owned wetland (Moolmanshoek Wetland) with a management plan was in an excellent condition. This wetland is a heritage site. The case of the Moolmanshoek Wetland (see 10.7.3.2) illustrates that better management, notwithstanding the type of ownership, can greatly improve the ecological status of most wetlands in the study area.

The success of a wetlands management plan depends on building partnerships with the local communities, adopting a participatory approach in wetlands management planning, building trust among wetlands stakeholders, building awareness among wetlands stakeholders, especially the local communities, using incentives to gain support and building capacity to ensure continuous involvement and management continuity (Chatterjee *et al*., 2008). One may add that a wetland plan also requires continuous monitoring, evaluation and updating to accommodate changing circumstances such as the impacts of climate change, new research findings and technological advances.

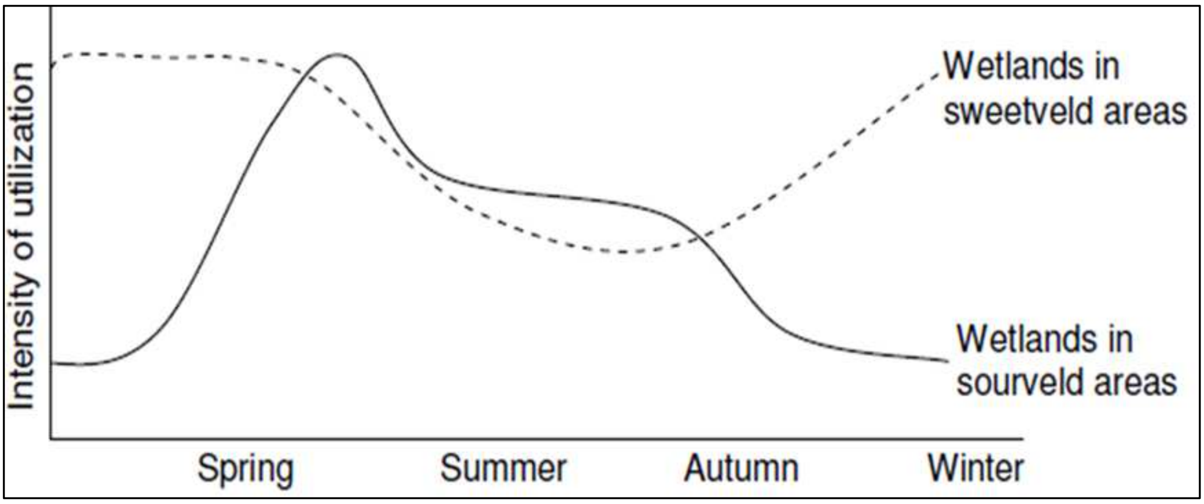
Managing wetlands effectively requires knowledge of wetland processes, plants and animals, as well as habitat management techniques (Gray *et al*., 2013). Good wetland management also involves the manipulation of the ecosystem processes using prescribed techniques (for example, disking, burning, herbicide application, and providing food plots), as well as wetland conservation practices to create a high-quality habitat to meet the target wetland use (Gray *et al*., 2013). The application of these management techniques will improve wetland quality in the study area.

11.2.6 Seasonal management of wetlands

Wetlands are used for different activities that may vary with season and with varying impacts on the wetland. There is limited research on the effects of livestock grazing on southern African wetlands (Kotze *et al.*, 2009). However, wetland grazing is affected by the seasons, the conditions in that particular year, variability between years, as well as whether the grazing animals use the wetland for a short duration, but at a very high or low intensity for that period (Kotze *et al.*, 2009). Also to note, is the fact that grazing has the potential to affect all the components of wetland condition, but particularly erosion and vegetation composition (Kotze *et al.*, 2009).

The quality of forage provided by a specific type of veld is generally not the same throughout the year, and declines during the non-growing season (Kotze *et al.*, 2009). In sweetveld, this decline is small, but in sourveld it is great, as the plants withdraw much of the nutrients from their leaves down into their roots for storage during the non-growing season (Kotze *et al.*, 2009).

The frequency, duration, timing, depth of flooding as well as the soil and topography affect the type, density and richness of plant species in a wetland. If undisturbed, the wetland plant succession will eventually culminate to the climatic climax vegetation through the normal plant succession processes (Collins, 2011; Gray *et al*., 2013; Kotze *et al.*, 2009; Strahler and Strahler, 2005). This idea is important in the seasonal management of wetlands in the eFS.



Source: Kotze et al. (2009)

Figure 11.4: Suggested intensity of seasonal grazing in sweetveld and sourveld areas for summer rainfall conditions such as in the eastern Free State

Given the seasonal nature of the wetlands in the eFS and that most of the wetlands are used for grazing (both livestock and wildlife), it will be important to suggest possible seasonal management plans for the area. Grazing management in wetlands is complex, often site-specific, depends on the type of wetland, its soils and its degree of wetness. Very wet wetlands may have a low grazing capacity in summer simply because they are inundated. Many animals in a very wet wetland may also cause poaching. On the other hand, the wetlands in the study area are particularly valuable as winter grazing because it is a sourveld area, i.e. the nutritional value of the vegetation is very low in the winter, especially the protein content – this is an adaptation of the vegetation to the high fire frequencies in the area where the plants therefore transport their nutrients and energy to the roots for regrowth in the spring. Wetlands, on the other hand, maintain higher nutrient and protein levels as compared to the dryland vegetation and are therefore valuable winter grazing. Farmers in the study area often have farms in Kwazulu-Natal where they take their cattle in the winter seasons as a coping strategy to the reduced winter grazing capacity. Also, during winter when the grazing capacity of the wetlands is reduced, it is important not to overstock animals in the wetlands, but to additionally carry out supplementary feeding of the animals from stored hay.

Seasonal management of wetlands would depend on the hydrogeomorphic wetland type, the land use type (grazing, cultivation, harvesting of wetland plants), as well as the management objective.

Grazing affects the aerial cover of the vegetation, the height of the vegetation (which also depends on the type of vegetation and the burning regime). The intensity impact of grazing also depends on the density of paths in the wetland, as well as poaching (Kotze *et al.*, 2009).

Poaching is the disruption of soil structure because of repeated penetration of livestock hooves into wet soil (Wilkins and Garwood, 1986 in Kotze *et al.*, 2009). For grazing, it is important to monitor the hydrology, vegetation, the soil conditions and the grazing process of the livestock in order to avoid overgrazing, poaching, erosion and invasion of alien species. The type of vegetation biomes, as well as seasonal changes in the vegetation in response to changes in the hydrological regime (for example sourveld and sweetveld), affect seasonal grazing in wetlands.

With regard to seasonal harvesting of wetlands plants, this also needs careful planning. Common reeds (*Phragmites australis*) may be harvested during their dormant period (autumn and winter), but this is not same with sedges and rushes which need to be harvested during their growth period in summer in order to provide good quality materials used for craft-making (Kotze *et al.*, 2009). However, the harvesting of sedges during their growth period has unintended consequences in that most wetlands have birds that depend on these wetlands and they breed during this period and would therefore be disturbed (Kotze *et al.*, 2009). This is where defined management objectives and systems thinking come into play. It is advisable to balance the proportion of the vegetation harvested, as well as to do selective harvesting in order to provide heterogeneity of the habitat for the various fauna preferences (Kotze *et al.*, 2009).

11.2.7 Fire as a wetlands management tool

Fire was identified as one of the major hazard in the study area but fire is a good wetlands management tool if properly planned. While it is recommended to burn the wetlands after three to five years to reduce the fuel load (moribund) in wetlands, it will be important to consider the type of burning and the seasonal timing of the burning. In the USA, marsh (a type of wetland) fires can be classified as peat burns, root burns, or cover burns. Peat burns consume marsh soil where peat is drained or dried. Peat burn is not a good management tool as it can easily release CO_2 into the atmosphere (Gray *et al*., 2013; IPCC, 2014). The peat content of wetlands in the eFS is still to be researched and quantified though there is increasing evidence of only a few wetlands with peat in the study area. Root burns kill roots without consuming soil and occur when there is little or no water over the soil surface, there is an abundant fuel load, and the fire is slow-moving (Gray *et al*., 2013). The root burns may not be good as it may reduce the richness of wetland plants in the study area. Cover burns remove above-ground biomass without killing roots or harming soils and occur when there is high soil moisture or when the soil surface is flooded a few centimetres deep (Gray *et al*., 2013). Parts of emergent plants are then burned, but the soil and roots remain intact. Plants can then quickly recover from cover burns if plant stubbles are not subsequently covered by flood water (Gray *et al*., 2013). Cover burns can be a good approach in the eFS. Properly planned, wetlands are also used to construct effective firebreaks in the study area.

11.2.8 Managing wetlands for disaster risk reduction and climate change adaptation

All 15 climate change experts who completed the survey on climate change agreed that the FS climate has changed over the years. Some of the cited evidence included the fact that there were more frequent droughts, rise in temperature, rainfall patterns have unprecedentedly changed, and the change in the timing of the seasons, decrease in crop yield and even political discussions on climate change (see 10.9.3).

As a predominantly agricultural province and with the eFS heavily dependent on rain-fed agriculture, the current climate change has and will continue to have dire consequences on agricultural outputs and undermine food security in the province. The 2015/2016 drought situation was such that South Africa needed to import between four and seven million tons of grains; besides the weakening exchange rate for the national currency (the Rand), raised questions on whether the country would be able to source the supply on time and has the financial, transport and storage capacity to handle such a massive import of grains. The situation could compromise food security in the whole country including the eFS. The FS, as well as the whole country, was likely to shift from a net food basket exporter to a net food basket importer. Hardest hit like in any disaster situations would be the poorest of the poor.

The climate change experts also pointed out that climate change will affect wetland hydrology in the study area, given the fact that rainfall has persistently fallen below normal, temperatures have been rising, accompanied by higher evaporation and therefore affecting the recharge of wetlands. They further commented that these climatic changes will put much stress on wetlands aquatic species. The afore-mentioned effects of climate change on wetlands were supported in the review of related literature (Chapter 7).

The IPCC and the UNFCCC support climate change and are the champions of climate change issues at international level (see 7.2.1). The analysed secondary data from SAWS on two key climate factors of temperature and rainfall for over three decades in the study area, showed high variability trends in both temperature and rainfall, but failed to show a clear shift in these climate parameters (see 10.9.2 and Figures 10.8 to 10.12). While it is not the focus of this research to establish if there is climate change in the study area or not, evidence from the research point to the fact that wetlands should be managed to cater for high climate variability and increased frequency and intensity of climate related hazards (IPCC, 2014; UNDP, 2015; UNFCCC, 2015; UNISDR, 2015).

The management of wetlands for DRR and CCA is gaining global attention as supported in various literature reviewed (Chapters 7 and 8) and well-encapsulated in the new approach of Eco-DRR/CCA (CNRD/PEDRR, 2013; PEDRR, 2013; Renaud *et al*., 2013). Managing wetlands under the principles of Eco-DRR/CCA is often a community-driven bottom-up approach. Research shows that community-based natural resource management contributes to enhancing resilience by conferring social and ecological benefits to individuals, their community and to the environment, and to reducing vulnerability (Svendsen, 2013 in Takeuchi *et al*., 2014; Tidball and Krasny, 2014). This is a 'win-win and no regret approach'. Despite these established benefits, managing wetlands for DRR and CCA is not well-understood and is not being formally applied in the eFS. Whatever was observed in terms of DRR and CCA applications in private wetlands was a matter of chance and learning by doing. Most respondents in private wetlands knew they could rely on wetlands for fodder as a coping strategy in times of drought and dry spells. A few also indicated that wetlands could be good areas to establish effective firebreaks, but the whole idea of Eco-DRR/CCA linked to wetlands is still in its infancy and needs to be popularised and implemented as an integrated wetlands management strategy (see 11.4.3).

The study found that the sampled community, especially those using communal wetlands, have little or no knowledge about climate change and the role that wetlands could play to mitigate and adapt to the impacts of climate change. There is a lot of overlaps between DRR and CCA strategies. The two are separated only at policy and strategic planning level, but there is very little or no difference at operational level. This is strongly supported by literature review, both at international and national levels (see 8.12).

11.2.9 Building wetlands resilience

Resilience, vulnerability, DRR, and adaptation are inter-related concepts though their mutual relationships are still not well-documented (Lei *et al*., 2014). These concepts are common in environmental management, climate change, social−ecological and disaster risk sciences (Lei *et al*., 2014). Reducing vulnerability, building resilience and putting in place sustainable strategic adaptive strategies help to reduce the vulnerability of social−ecological systems (wetlands in this study), improve their resilience and foster adaptive capacities of these systems to withstand future shocks (Lei *et al*., 2014). A resilient system such as a wetland should be able to absorb disturbance without undergoing structural and functional change (Fabinyi *et al*., 2014). Building sustainable relationships between human and ecosystems or social-ecological resilience increases general security and contributes to enhancing the quality of life for the present and future generations (Takeuchi *et al*., 2014; UN, 1987). However, while advocating for the promotion of wetlands resilience in the study area, care should be taken not to compromise the resilience of the local community as these are often trade-offs (Fabinyi *et al*., 2014). The proposed IWMF (see 11.4.3) is all about building wetlands resilience.

11.2.10 Disaster and Environmental Management

DRR, CCA, environmental management and poverty reduction communities have been working in isolation and this has led to a situation where the vulnerability to hazards of many communities has been increasing, resulting to more damages because of disasters (IPCC, 2014; Thomalla *et al*., 2006; UNISDR, 2014). There is a great need for these communities of practices to work together and build synergy because natural hazards and climate change impacts affect numerous natural, economic, political and social activities and processes. This research was conducted in recognition of this important gap that needs to be filled amongst local communities in the eFS with regard to wetlands management.

In order to fully operationalise the Eco-DRR/CCA approach, disaster management and environmental management must talk to one another. The understanding here is that climate is part of our natural environment. Unfortunately, there is lack of cross-pollination between disaster management and environmental management at provincial level. The two functions are championed by two different government departments and both run separate provincial advisory forums that sometimes are convened on the same day. The DESTEA, which is the champion of environmental issues in the FS hardly attend the quarterly Provincial Disaster Management Advisory Forum which is under CoGTA. Meanwhile the Free State Provincial Disaster Management Centre was not represented in the now non-functional Free State/Northern Cape Wetlands Advisory Forum. The key role of the environment in DRR and the impacts of disasters on the environment cannot be over emphasised. The opportunities and synergy between the two as strongly advocated under Eco-DRR/CCA can thus be compromised if there is a lack of cross-pollination (see section 8.8). In terms of skills building and knowledge transfer, the two main centres in the FS on disaster (UFS-DiMTEC) and environmental issues (UFS-CEM) have very limited content of both aspects in their programmes and there is no full-fledged course on wetlands in the UFS-CEM programme (see 10.10). This lacuna may have a negative impact on effective wetlands management in the study area in terms of skills acquisition, advocacy, wetlands awareness and the building of synergy.

11.3 CONCLUSIONS

The focus of this study is encapsulated in the statement by the executive secretary of the CBD as:

> *Ecosystem-based approaches to climate change adaptation and disaster risk reduction use biodiversity and ecosystem services in an overall adaptation strategy and aim to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change* (De Souza Dias, 2015).

Informed by evidence from both empirical research and review of related literature, the following conclusions are made:

11.3.1 Legal and institutional issues

There is no national wetland policy like the case in Uganda though there is a FS provincial wetland policy that has not yet been endorsed. Wetlands in South Africa are covered by many sectoral legislations which are poorly coordinated and not effectively enforced.

There are so many public work programmes in South Africa with direct implications on wetlands management. These programmes are not effectively coordinated, often have the challenge of balancing job creation and other responsibilities related to wetlands like rehabilitation or clearing invasive and alien plants. These EPWPs lack enough resources.

There is weak and poor coordination of wetlands stakeholders in the FS and therefore in the study area. This is illustrated by the collapse of the Free State/Northern Cape Wetland Advisory Forum and also by the lack of building synergy between DESTEA and the Free State Provincial Disaster Management Centre programmes and activities.

The adopted definition of a wetland in the South African context could be a weakness. While most countries follow the Ramsar definition of wetlands that include rivers and dams, this is not the case in South Africa. If the Ramsar definition was adopted in South Africa, then maybe wetlands management could have fallen under the direct leadership of DWS instead of the DEA as the lead department. The DEA represents South Africa at the Ramsar Convention. With such changes, wetlands could then be managed holistically as part of the catchment management under CMAs of the DWS. There is no doubt that water resources receive more political and administrative attention in South Africa than wetland resources under the DEA though wetlands are considered as part of the water course in the NWA.

11.3.2 Wetlands risk and vulnerability

It can be concluded from the data and field observation that most communal wetland users are black and self-employed or unemployed, younger and less experienced on wetland issues, while private wetland owners in the study area are mostly white commercial farmers with better education and rich experience on wetland issues (see 10.2). This partly supports the reason why most wetlands in private land in the area are in a good ecological state (Table 10.13). Education is the strongest weapon for empowerment. Therefore, these educated and experienced commercial farmers should be encouraged to mentor the emerging farmers and communal wetland users on better wetlands management techniques.

Communal wetlands are the most degraded and therefore the most vulnerable wetlands in the study area. These wetlands are often flanked by informal settlements. The association with informal settlements could be linked to the apartheid system on discrimination about land ownership. Ignorance on wetland functions and values and lack of control over the use of these communal wetlands could be blamed for their heavy degradation. Meanwhile, wetlands in protected areas are in an excellent ecological state, while most in private commercial farms are in a very good ecological state.

The dominant wetland use in the study area is grazing. Unfortunately, overgrazing is one of the wetland threads in the area which portrays a problem of biocapacity deficit in the area. Overgrazing is most acute during dry spells, droughts and in late winter or early spring. It should be noted that most of the sampled wetlands are seasonally wet wetlands in a summer rainfall region. Sour grass in the wetlands also have a bearing on the carrying capacity of the wetlands as the nutritious content of the biomass is reduced especially in winter and therefore logically cannot support the same number of grazing animals compared to sweetveld (Kotze *et al.*, 2009).

Invasive and alien species are another wetland stressor which also could possibly reduce the carrying capacity of the wetlands and can contribute to overgrazing if the same stock is maintained in the affected wetland. When a wetland is overgrazed, it creates a condition for invasive species to colonise the area and, if not cleared, these invasive species reduce the grazing area for the animals. Without proper interventions, this may create a vicious cycle. These problems are linked to poor wetlands management in the area but prolonged shocks like drought exacerbate the situation.

Wetlands are a major source of water supply in the study area, both for domestic and agricultural purposes. However, the construction of dams affects the natural hydrological role of wetlands in the catchment. The downstream users are often affected. This is the case of the

Ingula Power Station in the water shed and border between the FS and the KwaZulu-Natal Province.

Lack of comprehensive knowledge of the functions and values of wetlands should be a concern in the study area. For example, many agricultural extension officers who work with farmers (in whose land most of these wetlands are located) do not know what a wetland is. Some even reported to the researcher that there were no wetlands in their agricultural region which was not true as field observation proved. Efforts by the researcher and his supervisor (an ecologist and wetland specialist) to present a workshop on wetlands to the agricultural extension officers during their meetings failed due to poorly coordinated schedules of their meetings. An opportunity to acquire free basic knowledge on wetlands was thus missed.

Though not the focus of this study, field observation of a few wetlands with peat deposits in an area such as the Monontsha wetland, could be a potential source of CO_2 if the peat is disturbed by activities such as draining. A lot of grazing in the study area could also be a potential source of methane emission from the grazing animals. All these could negatively affect the climate through greenhouse gas emissions.

11.3.3 Wetlands uses

The main uses of wetlands in the study area are grazing and crop production. However, these wetlands are also used for other activities such as harvesting reeds for craft-making and there are informal settlements in communal wetlands. The various types of wetland uses affect the ecological status of these wetlands as shown in the difference in the ecological status between private and communal wetlands.

The way the community uses natural environmental resources, depends on the nature of entitlements on the property rights of the resources. When property rights are exclusive, transferable and enforceable, then users have a great incentive to use that resource efficiently since failure to do so will result in great personal loss (Tietenberg and Lewis, 2012). This is not the case with communal usage. For example, communal wetlands can be regarded as a public good (Spray and McGlothlin, 2004). As public goods, they have both consumption indivisibility and non-excludability (Tietenberg and Lewis, 2012). Non-excludability means even those who abuse the wetland or fail to pay for its upkeep may not be excluded from its usage, while consumption indivisibility poses the problem of who uses what quantity of the wetland, like in the case of communal grazing. These two reasons partly explain why most communal wetlands in the eFS are seriously degraded. The solution lies in massive and aggressive wetlands education, training and awareness campaigns.

It is often difficult to decide between preservation or conservation and development. Environmental policies are often in conflict when development is earmarked on an ecologically significant piece of land (Tietenberg and Lewis, 2012). This was the case of developing a mall on a wetland in Bethlehem, despite the specifications of the NWA (RSA, 1998b). Conservationists should not be seen as being anti-developmental, but choices to transform wetlands should be made based on correct decision-making tools such as a proper and scientific cost-benefit analysis, EIA, DRR and SEA (Tietenberg and Lewis, 2012)

11.3.4 Wetlands management

There are three broad types of wetland ownership in the study area such as government-owned wetlands in protected areas, communal-owned wetlands and privately-owned wetlands mostly in commercial farms. While government-owned wetlands are properly managed with a written management plan, those in private land are taken good care of through experience, but with hardly any written management plan. The communal wetlands are poorly managed with no management plans.

Well-managed wetlands in the study area reduce the risk of flood, droughts and veldfires which are the three most common risks in the area.

11.3.5 Managing wetlands for disaster risk reduction and climate change adaptation

There are much similarities and almost no difference at operational level between DRR and CCA measures, though at strategic, national and international level the two have parallel structures (see 8.12). Well-managed wetlands in the study area reduce disaster risks (flood, drought and veldfires) and support adaptation to climate change. Information from the review of literature, primary and secondary data point to the fact that building wetland resilience through a holistic management approach that incorporate DRR and CCA, would lead to improvement on biodiversity as the wetland becomes ecologically intact to support a diversity of species, improves rural livelihoods and brings about sustainable development through the supply of better ecological services. This is an example of integrated management and system thinking approach with a win-win and no regrets outcomes.

11.4 RECOMMENDATIONS

11.4.1 General recommendations

11.4.1.1 On legal and institutional matters

The government, through the DEA, should come up with a national wetland policy or a wetland act such as the National Forest Act, Act 84 of 1998*,* that can be applicable to all spheres of government. Such a wetland act or policy will deal specifically with wetland issues in South Africa. There is currently no national policy or act on wetlands, while related acts such as the NEMA and the NWA are not effectively implemented for inherent and contingent reasons (see sections 3.3.2 and 3.4). In South Africa, we have acts that address specific environmental issues besides the general NEMA, such as the National Forest Act, Act 84 of 1998*,* and the National Veld and Forest Fire Act, Act 101 of 1998, so in the same logic there should be a specific wetland act.

The DESTEA should fast track the endorsement of the FS provincial wetland policy and use various means to popularise the endorsed policy in the province. Meanwhile other provinces should emulate the FS in drafting provincial wetland policies and appoint dedicated wetland ecologists to better handle wetland issues.

If wetlands are managed as part of the water source and course (RSA, 1998b), then the definition of a wetland should include rivers and lakes just like that of the Ramsar Convention (1971). And if this becomes the case, then logically wetlands management issues should directly be handled by DWS to ensure a holistic catchment management approach than is the current *status quo* where wetlands issues though recognised by the DWS are handled by DEA at national level and FS DESTEA at provincial level. The official definition of a wetland in South Africa comes from the NWA and not the NEMA nor the NEMA: Protected Areas Act.

The government should also harmonise the functioning of the various 'Working for' programmes under a unified command structure like USEPA in the USA or the structure in Uganda (see section 3.2.2 and 3.2.3). Such a structure could be an independent para-public structure linked to the ministry of Water Affairs or the DEA. The SANBI could be elevated to such a structure to harmonise and coordinate the functioning of the EPWPs. These EPWPs should also be well-resourced to create more jobs and also accomplish their assigned environmental tasks. Overlap of functions in some cases, lack of enough resources, both financial and human, as well as political interference in the activities of WfWetlands, were some of the challenges reported by respondents. The researcher is of the opinion that the DEA has a lot of national and provincial responsibilities without enough resources to handle core environmental business together with issues on climate change and economic development.

It is important for the lead department to create a properly constituted wetland platform for the coordination of all wetland stakeholders in the province. These stakeholders could include representatives from the DEA, DWS, DAFF, private wetlands owners and users, local chiefs and traditional leaders, conservationists, environmentalists, Department of Education (DoE), academia and researchers and other identified role players. These stakeholders should have dedicated focal persons who will be evaluated in their performance appraisal by the supervisors on wetland issues, either as their line functions or community service. A good starting point will be to re-establish the dysfunctional provincial wetland advisory forums with an allocated budget from DEA or WfWetlands.

There is need for better international arrangement. The degradation of ecosystems such as wetlands necessitates better financial negotiations, policies implementation and better management (UNDP, 2012). At international level, there is a need to build synergy and find common approaches from conventions and conferences such as the Ramsar Convention of 1971 on wetlands, the CBD, the UNFCCC, the United Nations Conference on Environment and Development (Rio+20) of 2012, the United Nations World Conference on Disaster Reduction the latest held in Sendai Japan in March 2015, the MDGs and the new SDGs. Once such synergy is built at international level, it would cascade down to national level and this will enhance wetlands management in the eFS with multiple roleplayers. Systems thinking as encapsulated in the Eco-DRR/CCA paradigm and supported in this study, is a good approach to build synergy using different role players to solve interrelated problems as those related to wetland degradation.

The Swampbuster provision of the Food Security Act in the USA withholds certain federal farm programme benefits from farmers who convert or modify wetlands. Under this act, wetlands are considered to mitigate climate related risks and therefore reduce the cost of risk transfers in terms of insurance. Since most wetlands in the eFS are on private farms, a similar measure like the Swampbuster provision of the US Food Security Act can be valuable to motivate for lower farm insurance for farms with well-functioning wetlands and this will promote the conservation of private wetlands.

11.4.1.2 Wetlands management

It is important to manage wetlands as an ecosystem. The ecosystem approaches to wetlands management is important because ecosystems are part of a wider social−economic and political context which are in constant mutation and therefore ecosystems and wetlands management require broader thinking and collaboration (Finlayson and Pollard, 2009). Wetlands are social−ecological systems that are complex and dynamic and therefore require strategic adaptive management that involves learning by doing (Finlayson and Pollard, 2009).

Wetlands should be managed as part of the integrated water resources management at catchment level. This is a holistic natural resource management approach that takes into account social, economic and environmental interests and tries to balance them (GWP/INBO, 2009). The social−ecological approach (see 2.4.4) and the CHESM (see 2.3.4) are two related models that can fit very well in the management of wetlands at catchment level. The management of wetlands using these lenses is not evident in the eFS. Wetlands are clearly identified as systems by NFEPA (Ollis, 2013), but this is limited to the geo-ecological perspective and therefore lacks a holistic approach. The NWA (1998b) also identifies wetlands as water sources and water courses, but catchment management in the study area does not preserve wetlands, instead dams are constructed without taking into consideration their negative impact on downstream wetland. The Braamhoek (Ingula) wetlands are partly affected by dam constructions. A wetland in Bethlehem has been drained for the construction of the Dihlabeng Mall, even after a lengthy litigation process for proper EIA and CBA processes to be followed in order to probably conserve the wetland.

Proper grazing should be applied in wetlands that are overgrazed. The number of grazing animals in the wetland should match the carrying capacity of the wetland. The carrying capacity of the wetland is determined by the ecological state of the wetland, the type of animal grazed (whether small stock units or large stock units), the season of the year as well as whether the wetland has sweet- or sour grass. The latter is always not very nutritive and palatable to the animals.

Besides maintaining a good fit in the carrying capacity of the wetland, there is need for other good grazing practices such as paddocking and rotational grazing in the wetlands. For those farmers who cultivate, conservation agriculture with limited tillage of the wetland is ecologically good practice. However, conservation agriculture is labour intensive and it is unlikely to be accepted by most commercial farmers in the eFS who rely on large acreage of tillage and cropping to benefit from economies of scale. Conservation agriculture can make good sense to small-scale communal farmers in communal wetlands after proper education and training from the government through agricultural extension workers. It is also important to give comprehensive wetlands management training to agricultural extension workers who can then diffuse the skills down to the farmers who own and use most of the valley-bottom wetlands in the study area.

Cover burns are the recommended type of burning in the eFS so that the soil and the wetland plants are kept intact or improved upon after the burning. Late winter and spring can therefore be a suitable season for cover burning to prepare for early summer rainfall (Kotze, 2004; Kotze *et al.,* 2009). However, care should be taken to accommodate seasonal changes in rainfall patterns often attributed to climate change. Cool and patchy burning is also recommended when the relative humidity is high and temperature is low. Head-fires that burn with the wind and not back-fires that burn against the wind, is also recommended (Kotze, 2004).

11.4.2 On building wetlands resilience

Wetland management should be geared towards reducing vulnerabilities and building resilience. Ecological resilience and biocapacity of wetlands can be enhanced through measures such as good agricultural practice, restoration of degraded wetlands, careful use of limited water resources in the context of river basin management, and better ecosystem management principles (Africa Development Bank and WWF, 2012).

Reduce wetland stressors especially overgrazing, combat invasive and alien plants and plan for possible climatic change impacts through better wetlands management. Include the use of indigenous knowledge in the management of wetlands as was picked up in the case of Ghana (see 3.2.4).

Of paramount importance is to strengthen education, training and public awareness on the wetland values, functions, management and conservation. The DEA should spearhead this drive and partner with the DoE. The current wetland indaba should be more popularised to include other departments such as DoE, DAFF, DWS and the local community. Wetland issues should be included into school curriculums at all levels. The institutions of higher learning, and in relation to this study, the UFS-CEM which already presents various short course on wetlands, should develop a full-fledged and examinable course on wetlands management. This will help in knowledge and skills acquisition for better wetlands management, both in the province and in the country.

DRR, CCA and environmental management (ecosystem management) are found to be cross-cutting issues (IPCC, 2014; UNFCCC, 2015; UNISDR, 2015). It is therefore recommended that cross-discipline courses should be taught at UFS-DiMTEC and UFS-CEM. DRR courses should be taught at UFS-CEM, and environmental management courses should be taught at UFS-DiMTEC to encourage the cross-pollination of the two interrelated disciplines. Such cross-disciplinary teaching could be replicated in other institutions of learning in the province and in the country. Climate change and CCA should be part of this multidisciplinary approach as demonstrated in this study under the Eco-DRR/CCA paradigm. The integration of DRR tools such as RVA into environmental management tools such as EIA would foster cross-pollination of the two disciplines and build synergy.

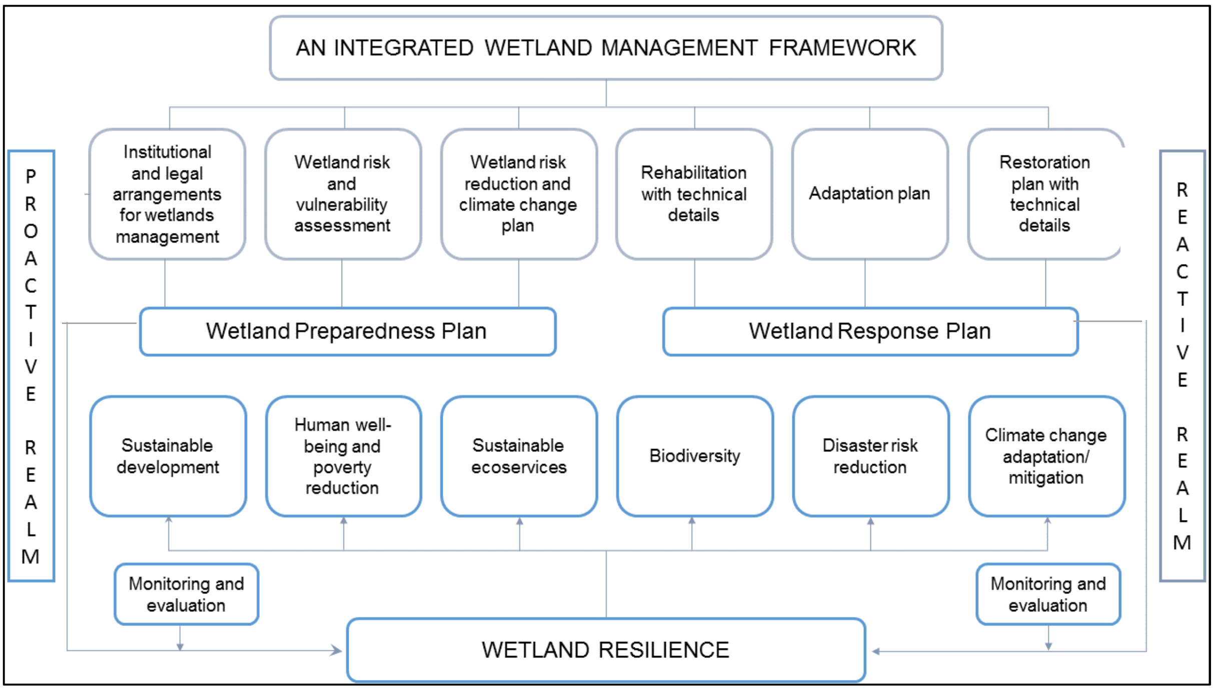
Incorporate DRR and CCA tools, processes and strategies into a holistic wetlands management approach to build wetland resilience. In this case, resilient wetlands will reduce disaster risk, adapt to climate change, improve on biodiversity and local community livelihoods through the continuous supply of wetland ecological services.

It is also recommended that DRR and CCA policies, strategies and institutions be integrated, or form strong cooperative linkages, as the two virtually address the same issues and use the same tools at operational level. The UNISDR and the UNFCCC should look for common ground to start working together at international level, while the DEA (which handles environment and climate change issues) and CoGTA (which handles DRR issues) should start working together and talking more to each other at national and provincial levels.

11.4.3 Proposed integrated wetland management framework for wetland resilience

The proposed wetland management framework integrates DRR and CCA into wetland management. Such a holistic approach improves wetland resilience to various stressors. Information from various models (see Chapter 2), literature review (Chapters 3 to 8) and primary data (Chapter 10) were brought together in the formulation of the proposed IWMF (Figure 11.5). The proposed IWMF involves two broad sub-plans. First is the preparedness sub-plan which is informed by proactive activities. This preparedness plan includes activities such as wetland risk and vulnerability assessment supported by related literature (Chapter 6), together with information from primary data (Chapter 10). The DRR framework (Figure 2.3) with related literature (Chapter 7), alongside related primary data (Chapter 10), forms the foundation of the DRR section of the sub plan, while the corresponding climate change model (Figure 2.4) together with related literature (Chapter 8), as well as climate data from SAWS fed into the CCA section of the framework.

The preparedness section of the framework highlights the fact that any meaningful DRR and CCA measures should be informed by a meticulous risk and vulnerability assessment of the wetland (see 6.6.2 for a proposed wetland risk and vulnerability assessment equation). From the assessment results, appropriate preventive and/or mitigation measures are then put in place which either reduce or prevent the stressors (for example effective legislations that prevent pollution of wetlands) or reduce the vulnerability of the wetlands to external stressors (for example better land use system that improves the ecological status of wetlands and therefore assist wetlands to cope and adapt to climate change).



Source: Author's own (2016)

Figure 11.5 Proposed Integrated Framework for Wetland Management for the eastern Free State Province, South Africa

The second part of the proposed framework is the response sub-plan which deals with technical issues related to rehabilitation and restoration of already degraded wetlands. The response plan is best handled by specialised agents like the Wfwetland programme and wetland specialists. The whole framework is encapsulated in the human and natural environment interface as captured in the social−ecological model (Figure 2.6) and CHESM models (Figure 2.5), backed by the Eco-DRR/CCA paradigm and informed by the systems thinking approach. The outcome of the implementation of the two sub plans is to have resilient wetlands. Resilient wetlands can provide better and sustainable ecological services. However, resilience is not static, therefore monitoring measures are included in the framework that may warrant the revisiting of both sub-plans of the IWMF. Meanwhile, the existing legislation and institutional arrangements of the country (Chapter 3) form the outer frame within which the IWMF is implemented.

This framework is the outcome of this study as was stated in the aim (see 1.6.1). The IWMF is an integrative and holistic framework that systematises the wise and sustainable management of wetlands in the eFS. The IWMF proposes the management of wetlands from both a preparedness (pro-active) and response (reactive) approach supported by effective monitoring measures and legislative framework. The framework is a simple management tool, is heuristic and draws from multiple disciplines. The framework incorporates a mixed method approach and borrows from many other models. The IWMF proposes multiple dimensions that need to be addressed and incorporated in order to build social−ecological resilience of wetlands under a changing global and local environment.

A resilient wetland will promote local sustainable development through a sustained supply of wetland provisioning services like sedges and reeds used for craft industry, food and medicinal plants that improve human wellbeing and reduce poverty. The same resilient wetland will also promote biodiversity in terms of wetland plants and animal species, which in turn will bring in more recreational, educational and research spinoffs. A resilient wetland will also better reduce the disaster risks such as those of flood, drought and fire in the study area; as well as cushion the negative effects of climate change such as providing grazing land for animals during drought or acting as carbon sequestration and mitigating the emission of methane in the area.

11.4.4 Recommendations for further research

i) It is recommended that a further study be conducted on the implementation of the proposed integrated wetlands management framework to test its robustness over time. Such a study should develop other quantifiable indicators for the sub- sections of the framework.

ii) It is also recommended that further studies be conducted for the whole province using a larger sample size and including all types of wetlands such as pans which are the dominant wetland type in the western Free State.

iii) There is a need for further research to quantify the carbon stock in the study area and to exploit potential carbon trading opportunities to reduce the emission of CO_2 and methane in the area. Quantifying and using carbon offsets through carbon trading, holds good potential for wetlands conservation, wise and sustainable management, but further research is needed in this domain.

11.5 CHAPTER SUMMARY

This chapter started with the discussion of the emerging patterns from the primary data sources that were collected and analysed and supported, where relevant, by reviewed literature. The analysed primary data, together with information from the literature review, then informed the main conclusions that were made in the study. Based on the conclusions and in line with the research questions, the necessary recommendations were made. The crux of these recommendations was the proposed IWMF which supported the aim of this study. As no researcher can do everything and do it properly in one research, follow up research gaps were identified and recommendations made for further research.

11.6 GENERAL CONCLUSION OF THE STUDY

This research examined the integration of DRR and CCA strategies into wetlands management in the eFS in South Africa. The main identified problem in the study area was the continuous degradation of wetlands under the current changing environmental conditions. This is happening despite the fact that wetlands ecological services could help in mitigating disaster risks and adapt to climate change impacts. The poor management of wetlands was seen as the main cause of wetland degradation in the eFS and the aim of the study was then to develop a holistic wetlands management framework that will help in building wetlands resilience so that these wetlands could better withstand the changing environmental conditions, while they continue to provide the much-needed ecological services for the local communities. This whole concept is well-articulated in the emerging paradigm of Eco-DRR/CCA and systems thinking.

To realise this aim and tackle the identified problem, a couple of frameworks guided the study. These included the social−ecological system framework, the CHESM, the DRR framework and the climate change framework. A single framework could not suffice given the multidisciplinary nature of the research which involved especially environmental management, disaster management and climate change science.

The post-positivist and the interpretivist orientation guided the philosophical thinking and the two blended well in this study which involved both social and natural science. Besides, a mixed method approach guided the ontological and epistemological orientation of the study. A combination of stratified random sampling and convenient sampling was used to select 95 mostly valley-bottom wetlands in the study area. Data was collected using four data collection tools which included questionnaires (176 wetland users), interviews (30 specialists), field observation (21 wetlands) and secondary data from SAWS (two weather stations). The data was analysed using the Microsoft Excel program and the SPSS for quantitative data, while qualitative data was analysed into emerging themes. These various forms of data collection supported the triangulation approach which, besides other measures, added credibility to the collected data. The analysed data was then presented and discussed using a simple statistical analysis and captured in the form of tables and figures (which included photographs and diagrams).

The main conclusions were that wetlands in the eFS, especially those on communal land, were vulnerable to degradation. This vulnerability was partly explained by a problematic legal and institutional arrangement for wetlands management in South Africa and therefore in the study area. There was no national policy on wetlands and the works of the various EPWPs were not properly coordinated. There were problems of managing wetlands in the area, especially with the communal wetlands with poor land use systems, uncontrolled grazing and no management plans. A comprehensive knowledge of wetland values and functions was also lacking among communal wetland users. Wetlands in protected areas were in excellent conditions, while those on private commercial farms were in a good ecological state, but need constant monitoring as cases of head cut erosion, overgrazing and invasive and alien species were still visible. Besides management problems, natural shocks like prolonged droughts often associated with climate change impacted negatively on wetlands.

The main recommendations were that the government of South Africa, through the DEA, formulate an effective and implementable national wetland policy and or modify the definition of a wetland so that wetland issues could better fit into the Catchment Management Agencies of the DWS; to unify the control of the EPWPs and improve the allocation of their resources both human and financial. There is also a need for proper coordination of wetland stakeholders. Education and awareness on wetland functions, values and management will be key to ensure the wise and sustainable management of wetlands as ignorance was a big issue in the area. To build wetland resilience in the area, an IWMF was proposed. The IWMF proposes the management of wetlands from both a pro-active and reactive perspective with strong monitoring measures and legislative framework. To stand the test of time, further research was recommended for the longitudinal testing of the proposed framework that will be aided by the development of other quantifiable indicators. With this framework, the aim of the study was achieved. Finally, it was also recommended that a study to quantify the peat content of wetlands in the study area be carried out and thereafter exploit the possibility for carbon trading as a way of reducing greenhouse gas emission and conserving wetlands. The main limitation of the study was the small sample size, but this was reduced by the homogenous nature of the sampled wetlands and not knowing the exact number of the total population, as well as the use of simple descriptive statistics. Another limitation was the quantification of some of the indicators for the IWMF and time to test it in the field, but recommendations for further studies on this has been included.

11.7 CONCLUDING REMARKS

It will be important to integrate wetlands management into national, provincial and local strategies for adapting and mitigating the negative impacts of climate change and disaster risks. This has a beneficial cyclical effect where ecosystem-based adaptation strategies help vulnerable communities to increase their local resilience to shock, while at the same time building the resilience of the ecosystems themselves such as wetlands, on which the local community strongly depend (UNDP, 2012). For example, rehabilitating wetlands and other ecosystems create local jobs, well-functioning wetlands act as buffers against disaster risks and the negative impacts of climate change. In addition, healthy wetlands function as effective carbon sinks and therefore mitigate climate change, but poorly managed wetlands could be a source of greenhouse gases. Many other local livelihoods are supported by these wetlands from their ecological services. Therefore, integrating DRR and CCA strategies into wetlands management help to build wetland resilience to external shocks, which include those from disaster risks and climate change. On the other side of the coin, resilient wetlands reduce disaster risks and improve adaptation to climate change, while still performing other beneficial ecological services as discussed in section 5.6. These cyclical win-win outcomes are the central message in this study.

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Appendix 1

ETHICS CLEARANCE FOR THE RESEARCH

Faculty of Natural and Agricultural Sciences

24-Oct-2014

Dear Mr Johannes Belle

Ethics Clearance: THE INTEGRATION OF DISASTER RISK REDUCTION AND CLIMATE CHANGE ADAPTATION STRATEGIES INTO WETLANDS MANAGEMENT IN THE EASTERN FREE STATE

Study Leader/Supervisor: Jordaan, Andries

Principal Investigator: Mr Johannes Belle

Department: DiMTEC (Bloemfontein Campus)

This letter confirms that a research proposal with tracking number: **UFS-HSD2014/0331** and title: **'THE INTEGRATION OF DISASTER RISK REDUCTION AND CLIMATE CHANGE ADAPTATION STRATEGIES INTO WETLANDS MANAGEMENT IN THE EASTERN FREE STATE'** was given ethics clearance by the Ethical Committee.

Please ensure that the Ethical Committee is notified should any substantive change(s) be made, for whatever reason, during the research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the Ethical Committee on completion of the research. The purpose of this report is to indicate whether or not the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the Ethical Committee should be aware of.

Note:
1. This clearance is valid from the date on this letter to the time of completion of data collection.
2. Progress reports should be submitted annually unless otherwise specified.

Yours Sincerely

Prof. Neil Heideman
Chairperson: Ethical Committee
Faculty of Natural and Agricultural Sciences

Appendix 2

QUESTIONNAIRE FOR PRIVATE WETANDS OWNERS/USERS

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS·UV
NATURAL AND AGRICULTURAL SCIENCES
NATUUR- EN LANDBOUWETENSKAPPE

My name is Johanes Belle. I am a PhD student at the University of the Free State, in the Centre for Environmental Management (UFS-CEM). I am carrying out a research project on THE INTEGRATION OF DISASTER RISK REDUCTION AND CLIMATE CHANGE ADAPTATION STRATEGIES INTO THE MANAGEMENT OF WETLANDS IN THE FREE STATE PROVINCE. The objective of this study is to identify wetland management problems in the province, and then to formulate a sustainable wetlands management framework applicable to the Free State Province and South Africa.

I kindly request you to complete the attached questionnaire as objectively as possible. Confidentiality of the information you provide will be strictly maintained, please do not write your name on the questionnaire. Of course, completion of the attached questionnaire is voluntary.

The questionnaire will take you about fifteen (15) minutes to complete. Select the best answer to each particular question and mark an X or briefly state your opinion where indicated. The findings, conclusions and recommendations from this study will be communicated to you as part of my contribution for effective management of wetlands in the province.

Thank you very much for your understanding, cooperation and valuable information!

JA Belle

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1. Gender:

Male		Female	

2. Age group:

Less than 20 years	
20-29 years	
30-39 years	
40-49 years	
50-59 years	
60-69 years	
70 or more years	

3. Employment status:

Employed	
self-employed	
unemployed	
Other (Specify)	

4. How long have you been involved in (lived or used) this wetland?

Less than five years	
5-10 years	
11-15 years	
16-20 years	
21-25 years	
More than 25 years	

5. Who is the owner of this wetland?

Government		Communal		Private		Mixed		Do not know	

6. Do you pay to acquire land in this wetland?

Yes		No		Not applicable	

7. List the benefits that you derive from this wetland?

....

....

....

....

....

....

8. Have these benefits changed over the last five years? YES ☐ NO ☐

2

9. If YES to question 8 give possible reasons for these changes?

....
....
....
....
....

10. Which of the following activities do you perform in this wetland (Tick as many as applicable)

Agriculture	
Grazing	
Collection of water for domestic use	
Collection of sand for building	
Collection of medicinal plants	
Residential building	
Commercial activity	
Car wash	
Education & Research	
Recreation	
Fishing	
Waste disposal	
Others(Specify)	

11. How would you rank the importance of this wetland to you and the local community?

Importance	**You**	**Local community**
Very important		
Important		
Not important		
Do not know		

12. Do you think this wetland will be important to you in the next ten years?

YES ☐ NO ☐

13. If No to question 12 state possible reasons

....
....
....
....

3

14. Do you sometimes experience the followings risks in this wetland?

Risk	**Yes**	**No**
Floods		
Drought		
Fire		
Others (Specify)		

15. Does this wetland help to reduce the impacts of these risks?

Risk	Yes	No
Floods		
Drought		
Fire		
Others (Specify)		

16. Do you receive any education or training on how to manage this wetland?

YES ☐ NO ☐

17.If YES to question 16 from whom do you receive this education or training?...

....

....

-

18. Are there any laws that guide you on how to use this wetland?

YES ☐ NO ☐

19. If YES to question 18, do you think this law or laws are respected by people using this wetland? Y ES ☐ NO ☐

20. What suggestions can you give so that this wetland is well used and better maintained?

....

....

....

....

Thank you very much for your time and valuable contribution!

4

Appendix 3

QUESTIONNAIRE FOR COMMUNICAL WETLANDS USERS

LETTER OF INTRODUCTION

My name is Johanes Belle. I am a PhD student at the University of the Free State, in the Centre for Environmental Management (UFS-CEM). I am carrying out a research project on THE INTEGRATION OF DISASTER RISK REDUCTION AND CLIMATE CHANGE ADAPTATION PRINCIPLES INTO THE MANAGEMENT OF WETLANDS IN THE FREE STATE PROVINCE. The objective of this study is to identify wetland management problems in the province, and then to formulate a sustainable wetlands management framework applicable to the Free State Province and South Africa.

I kindly request that you complete the attached questionnaire as objectively as possible. Confidentiality of the information you provide will be strictly maintained, please do not write your name on the questionnaire. Of course, completion of the attached questionnaire is voluntary.

The questionnaire will take you about thirty five (35) minutes to complete. Select the best answer to each particular question, and where indicated, briefly state your opinion. You could return the completed questionnaire to me in person, or post it to the address provided below.

The findings, conclusions and recommendations from this study will be communicated to you as part of my contribution for effective management of wetlands in the province.

Thank you very much for your understanding, cooperation and valuable information!

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QUESTIONNAIRE FOR EFFECTIVE WETLANDS MANAGEMENT

SECTION A: DEMOGRAPHIC PROFILE OF THE RESPONDENT (Wetland owners and/or users).*Tick the correct answer.*

1.Gender: Male ☐ Female ☐

2.Indicate your age group

Less than 25 ☐ 25 - 34 years ☐ 35 - 44 years ☐ 45 - 54 years ☐ 55 - 64 years ☐

More than 64 years ☐

3.**How long have you been involved with this wetland?**

Less than 5 years ☐ 5- 10 years ☐ 10-15 Years ☐ more than 15 years ☐

4.**What is your approximate highest level of education?**

Primary ☐ Matric ☐ Undergraduate degree ☐ Postgraduate degree ☐

SECTION B: WETLAND IDENTIFICATION

5. Wetland site name?...

6. Wetland type? Valley-bottom ☐ Hill slope ☐ Flood plain ☐ Pan ☐

Other ☐ (Please specify)…..

7. Land owner? Government ☐ Communal ☐ Private ☐ Other ☐

(Please specify)……………..……………

8. What is the approximate surface area of this wetland (in square meters)? ....

9. Indicate the approximate percentage (%) area of the wetland in relation to your total land surface

≤ 25% ☐ 25 – 50% ☐ 50 – 75% ☐ 75-100% ☐

10 What is the major land use activity taking place in this wetland?

Conservation ☐ Grazing ☐ Crop cultivation ☐

Mixed farming (Crop and grazing) ☐ Other Activities ☐ (please specify)……………….

SECTION C: WETLAND MANAGEMENT ***(for each question tick only one correct response in the column to the right.***

Variable	Explanation	Column
11.Protection Status What is the protection status of the wetland?	The whole wetland has no protection status	0
	The whole wetland has limited protection status but it is not legally binding	1
	Part of the wetland has partial protection status	2
	The entire wetland has been legally gazzetted as a protected area	3

2

12.Management Plan Is there a Management Plan for this wetland?	There is no management plan for the wetland	0
	A management plan exists but it is very seldom used	1
	A management plan exists and is occasionally used but is seldom, if ever revised	2
	A management plan exists and is being regularly used and periodically revised to incorporate new learning and altered circumstances	3
13. Awareness of Wetlandspressures orthreats Is the wetland managed for the threats or pressures it faces	The pressures and threats facing the wetland are not known	0
	The pressures and threats facing the wetland are known but are not being addressed	1
	The pressures and threats facing the wetland are being addressed but insufficiently to meet the management objectives of the wetland	2
	The pressures and threats facing the wetland are being well-addressed so as to meet the management needs of the wetland	3
14. Mechanisms forcontrolling inappropriateactivities Are inappropriate land-usesand activities (e.g. overgrazing)controlled?	There are no mechanisms for controlling inappropriate land-use and activities in the wetland	0
	Mechanisms for controlling inappropriate land-use and activities in the wetland exist but there are major problems in implementing them effectively	1
	Mechanisms for controlling inappropriate land-use and activities in the wetland exist but there are few problems in effectively implementing them	2
	Mechanisms for controlling inappropriate land-use and activities in the wetland exist and are being effectively implemented	3

15. Cooperation in Wetland Management. In terms of management of wetlands, how would you rate the level of cooperation between yourself and the following stakeholders?

	Poor	Fair	Good	Very good
a) Government				
b) Other private wetland owners				
c) Local communities				
d) Non-governmental Organizations				

For Questions 16-20 tick the option that best suits your impression

	Strongly disagree	Disagree	Agree	Strongly agree
16. Wetland issues are well coordinated in the Free State province				
17. There are clear laws with regard to wetlands management in the FS Province				
18. Laws regarding wetland management are properly implemented by wetland manager(s) in the FS				
19. In recent times, floods are becoming more frequent				

3

in the eastern FS				
20. In recent times, droughts are becoming more frequent in the eastern FS.				
21. I manage this wetland to reduce the possible impacts of drought				
23. I manage this wetland to reduce the possible impacts of floods				
24. I manage this wetland to reduce the possible impacts of climate change				
25. I manage this wetland to reduce the possible impacts of veld fires				

26 The ecological state of Wetland Physical features. Compared to the past, how would you score the present physical elements of this wetland?

	Poor	Fair	Good	Very good
a) Vegetation				
b) Water (hydrology)				
c) Soil				

27.Ecosystem Services Provided or Derived from Wetlands. Rate by ticking in the appropriate column the benefits that this wetland provides (NB=No Benefit, LB=Limited Benefit, IB=Important Benefit, VB=Very important Benefit)

a) Provisioning		N.B	L.B	I.B	V.B
Food	Production of fish, wild game, fruits and grains				
Grazing	Grazing land and production of fodder				
Fresh Water	Storage and retention of water for domestic, industrial, and agricultural use				
Fibre and fuel	Production of logs, fuelwood, poet, fodder				
Biochemical	Extraction of medicinal products and other materials from the biota				
Genetic Materials	Resistant genes to plant pathogens, ornamental species, and so on				
b) Regulating					
Climate regulation	Source of and sink for greenhouse gases, influence local and regional temperature, precipitation, and other climatic processes				
Water regulation (Hydrological Flows)	Groundwater recharge/discharge				
Water purification and waste treatment retention	Recovery and removal of excess nutrients and other pollutants				
Erosion regulation	Retention of soil and sediments				
Natural hazard regulation	Flood control, storm water, drought				
Pollination	Habitat for pollinators				
c)Cultural					
Spiritual and inspirational	Source of inspiration, spiritual and religious values to aspects of wetland ecosystem				

4

Recreational	Opportunities for recreational activities				
Aesthetic	Many people find beauty or aesthetic value in aspects of this wetland ecosystem				
Educational	Opportunities for formal and informal education and training				
d)Supporting					
Soil formation	Sediment retention and accumulation of organic matter				
Nutrients cycling	Storage, recycling, processing and acquisition of nutrients				
Source: Adapted from Millennium Ecosystem Assessment, 2005					

28. Threats to Wetlands. Rate the following threats that may be applicable to this wetland

Threat		No threat	Low	Moderate	High
i)	Invasive alien species				
ii)	Overgrazing				
iii)	Uncontrolled fire				
iv)	Lack of awareness on wetland benefits				
v)	Soil erosion				
vi)	Sedimentation				
vii)	Pollution				
viii)	Climate variability				
ix)	Change in water regime				
x)	Conversion to other uses				
xi)	Lack of human management capacity				
xii)	Lack of material resources to manage				
xiii)	Upper catchment management activities				
xiv)	Other threats (specify)				

29. Which government Department do you think should directly be responsible to handle wetland management issues in the FS province?

Dept of Agriculture ☐ Dept of Environment ☐

Dept of Water Affairs ☐ Dept of Rural Development and land Reforms ☐

Others (Please Specify) ☐ **……………………………………………………………..**

30. List some activities that you consider as good practices to maintain healthy wetlands

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31. List some of the bad activities that could cause damage on the wetland

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32. Any other suggestion(s) that you think can help to better manage wetlands in the FS Province?

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Thank you very much for your valuable contribution!!

Appendix 4

INTERVIEW QUESTIONS FOR WETLAND SPECIALLISTS

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS·UV
NATURAL AND AGRICULTURAL SCIENCES
NATUUR- EN LANDBOUWETENSKAPPE

INTERVIEW QUESTIONS FOR WETLAND SPECIALISTS

My name is Johanes Belle. I am a PhD student at the University of the Free State, in the Centre for Environmental Management (UFS-CEM). I am carrying out a research project on THE INTEGRATION OF DISASTER RISK REDUCTION AND CLIMATE CHANGE ADAPTATION STRATEGIES INTO THE MANAGEMENT OF WETLANDS IN THE FREE STATE PROVINCE. The objective of this study is to identify wetland management problems in the province, and then to formulate a sustainable wetlands management framework applicable to the Free State Province and South Africa.

I kindly request you to answer these questions as objectively as possible. Confidentiality of the information you provide will be strictly adhered to. You are free to leave out any question you are not comfortable to answer or withdraw from the interview.

The interview will take about ten (10) minutes. The findings, conclusions and recommendations from this study will be communicated to you as part of my contribution for effective management of wetlands in the province.

Thank you very much for your understanding, cooperation and valuable information!

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1. What are some of the major causes of wetlands degradation in the FS?

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2. What are some of the major challenges in managing wetlands in the FS?

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3. Which are the most degraded wetlands in the FS?

i) Government protected wetlands ☐

ii) Communal wetlands ☐

iii) Privately owned wetlands ☐

4. Name some of the laws and policies that guide the management of wetlands in the FS

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5. Are these laws properly implemented? YES ☐ NO ☐

6. If No to question 6, what are some of the reasons?

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7. Are there any problems in trying to meet the objectives of rehabilitating degraded wetlands and creating local jobs?

☐ ☐

YES **No**

8. If **YES** to question 7, what are some of the problems?

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9. Who are the key role players in wetlands management in the FS?

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10. Is there proper coordination of wetlands management activities in the FS?

YES ☐ **NO** ☐

11. If **No** to Question 10 state some suggestions for proper coordination

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Thank you very much for your invaluable information!

Appendix 5
INTERVIEW QUESTIONS FOR OTHER SPECIALISTS

Dear colleagues, I need to fill some information gap and I would appreciate your honest opinion on this few items for my PhD research. This may take you just about 3 minutes.

A) Environmental and disaster management specialists

i) Do you think there is any relationship between disasters and the environment? Explain your answer in some details

ii) Do you think knowledge of environmental management benefit disaster managers?

iii) Do you think knowledge of disaster management benefit environmental managers?

iv) Is there enough content of both in CEM and DiMTEC programmes? (comment based on the centre you belong to)

v) Any suggestions?

Thank you!

B) To climate change specialists

i) Do you think the FS state climate has changed or is changing?

ii) If yes, what are some of the evidence? (maximum 5)

iii) Can good management of wetlands reduce the impacts of climate change?

iv) Support your answer to question (iii) with examples (maximum 5)

v) Do you think the local community understand the value of wetlands?

vi) State any suggestions that could help improve the management of wetlands in the FS

Thank you!

C) Environmental law specialists

i) What are some of the main challenges of implementing environmental law in South Africa?

ii) Any particular challenges for the FS?

iii) Any particular challenges in relation to wetlands management?

iv) How can these challenges be addressed?

Thank you!

Appendix 6

FIELD OBSERVATION DATA SHEET

THE INTEGRATION OF DRR AND CCA STRATEGIES INTO WETLAND MANAGEMENT IN THE EASTERN FREE STATE BY J.A. BELLE

FIELD OBSERVATION DATA SHEET

WL ID	Size				Land use					Hydro period			Vegetation cover				Alien species				Pollution				Sedimen-tation			Grazing capacity			Within/On-site activities				Bank stability/ erosion			
	5	3	2	1	5	4	3	2	1	5	3	2	5	3	2	1	5	4	3	2	5	3	2	1	5	3	1	5	3	1	5	3	2	1	5	3	2	1

Parameters:

1) **Wetland Size**
   - Mega-scale = 5
   - Macro-scale = 3
   - Meso-scale = 2
   - Micro-scale = 1
2) **Land use system**
   - Protected area = 5
   - Grazing = 4
   - Agriculture = 3
   - Mixed farming = 2
   - Settlement = 1
3) **Hydroperiod**
   - Permanent = 5
   - Temporary = 3
   - Seasonal = 2
4) **Vegetation Cover** (Excellent = 5, Good = 3, Average = 2, poor= 1)
5) **Alien species** (None = 5, Few = 4, Moderate= 3, High = 1)
6) **Pollution** (Non = 5, Low = 3, moderate = 2, High = 1)
7) **Sedimentation** (Low = 5, Moderate = 3, High = 1)
8) **Grazing carrying capacity** (Number of livestock per meter square) (Low = 5, Moderate = 3, High = 1
9) **Activities within the wetland**
   - High impact such as dam and road construction = 1
   - Moderate impact such as mining and sand excavation = 2
   - Low negative impacts such as plant harvesting = 3
   - Activities with no impact = 5
10) **Bank Stability/erosion**
   - 5 = stable ie wetland banks are stable and well protected by vegetation cover
   - 3 = Good ie some minor spots of erosion occurring or areas of limited vegetation
   - 2 = Moderate ie some erosion occurring, spot erosion points are often interlinked and possibly minor structural and vegetation damages
   - 1 = Poor ie significant areas of erosion