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Managing Wetlands for Climate Change Adaptation: A Case Study of the Eastern Free State; South Africa

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ABSTRACT

Ecosystems such as wetlands mitigate disaster risks and assist in adaptation to climate change impacts when well-managed, but when poorly managed, wetlands could be a major source of greenhouse gas emissions. Meanwhile, poor rural communities often lack adaptive and coping capacities to withstand the negative impacts of climate change. This article examines the management of wetlands to adapt to climate change by drawing examples from the rural and agriculturally-dominated Eastern Free State Province in South Africa. A mixed method was used to collect primary data, which included a questionnaire, interviews, observation and secondary climate data. The study showed that knowledge of managing wetlands for climate change adaptation was low in the area. Communal wetlands, which were much degraded could not effectively reduce and withstand the recurrent climate related risk of drought, flood and veld fires. Wetlands in protected areas and in private commercial farms were in good ecological state and effective in reducing recurrent climate related risks of drought, floods and veld fires. Better wetland management practices support sustainable agriculture and cushion food insecurity in the area even during extreme weather events like droughts. Effective education, training and awareness on wetland values and functions would be good instruments to assist the local communities to maintain well-functioning wetlands and thus build resilience to climate change and its related impacts.

1. INTRODUCTION

There is ample evidence that anthropogenic climate change is caused by increasing emission of Green House Gasses (GHGs) (IPCC, 2007; IPCC, 2012; IPCC, 2014, UNISDR, 2015). The United Nations Framework Convention on Climate Change (UNFCCC) is the main multilateral forum with universal participation, which focuses on addressing climate change issues. The main landmark of the UNFCC was the Kyoto Protocol, which bench-marked carbon emission targets to mitigate climate change. The COP21 and the Paris Agreement of 2015, (a follow-up of the Durban platform for enhanced action in 2011) looks promising with binding agreements, emission targets and monitoring instruments agreed upon by the contracting parties (UNFCCC, 2015).

Africa and South Africa are very vulnerable to the negative impacts of climate change due to, amongst others, their heavy dependence on the agricultural sector (IPCC, 2007; Jordaan, 2012; IPCC, 2014; UNFCCC, 2015; UNDP, 2015; UNISDR, 2015). Climate change mitigation and adaptation could be addressed using structural (grey) or natural (green) infrastructure (Talberth *et al.,* 2013; Renaud *et al.*, 2013). While structural measures could be very expensive and sometimes illusive to the poor's in rural Africa, nature offers a cheaper alternative with a win-win, community driven solutions to adapt to the impacts of climate change. It is in this context that this paper examines the role of good wetland management in climate change adaptation. The rural and agriculturally dominated eastern Free State, South Africa, is used as a case study.

2. Literature review

2.1 A wetland

According to the Ramsar Convention Secretariat (RCS) (2010: np):

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 meters.

The Ramsar Convention on wetlands was the first global convention on environmental issues held in Iran in 1971 (WI, 2015). The South Africa definition of a wetland differs slightly from that postulated by the RCS. According the South Africa National Water Act (NWA) 36 of 1998, wetlands are defined as:

A transitional land 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, 1998:9).

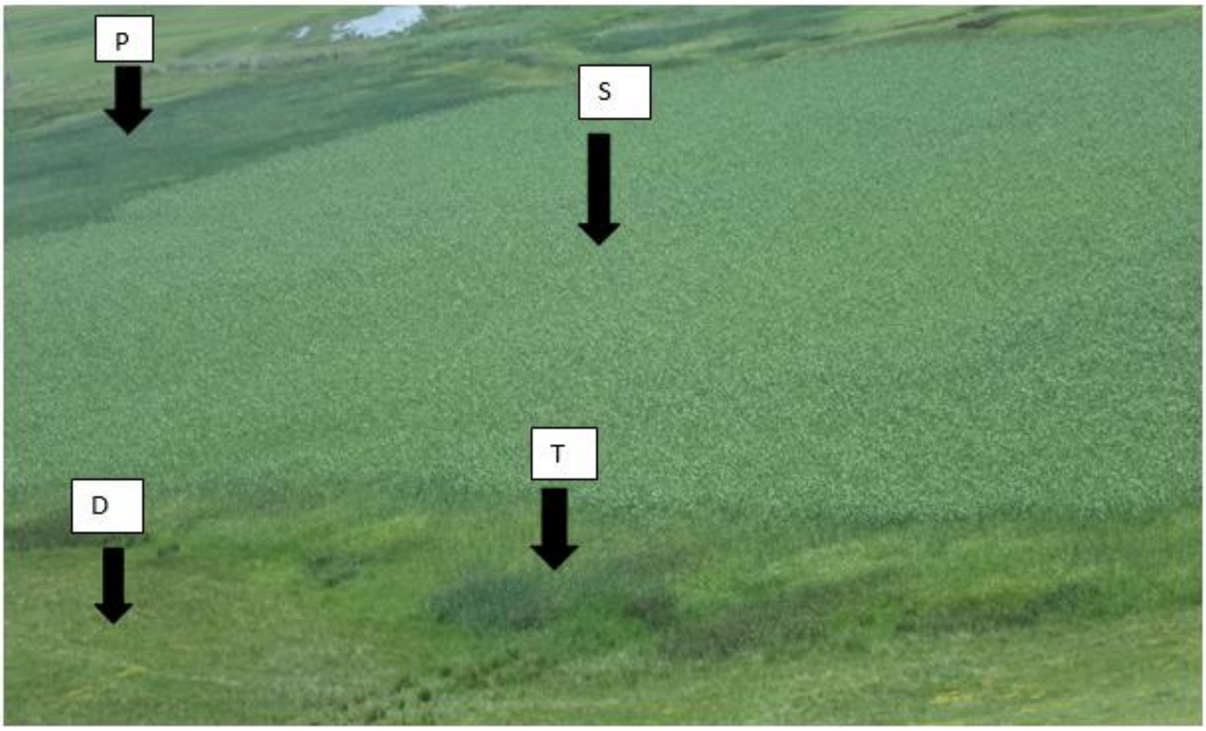
The South Africa definition, therefore, does not consider dams, rivers and certain marine areas as a wetland. South Africa adopted a more descriptive definition, which uses hydrology, soil and vegetation to define wetlands. Hydrology and geomorphology are the most influential factors in inland aquatic systems (Ollis *et al*., 2013) so the hydrogeomorphic (HGM) classification of wetlands is the main approach in identifying types of wetlands in South Africa. The HGM classification of wetlands encompasses three elements:

- Geomorphic setting which deals with the landform, its position in the landscape and how it evolved, for example through the deposition of river-borne sediments).

- Water source which concerns the source of water that maintains the wetland such as precipitation, groundwater flow and stream flow, but their relative contributions will vary amongst wetlands.

- Hydrodynamics which refers to how water moves through the wetland (Kotze *et al.*, 2009).

Following the HGM classification, four broad types of wetlands can be identified in South Africa and they include slope wetlands, valley-bottom wetlands, depression wetlands and floodplains (Collins, 2006; Kotze, 2008; Kotze *et al.*, 2009; Ollis *et al*., 2013). The dominant type of wetlands in the eastern Free State province are the valley-bottom wetlands (Figure 1).



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

Source: Author's own (2016)

Figure 1:* *A cross section of a valley-bottom wetland showing different water regimes

2.2 The potential effects of wetlands on climate change

Wetlands make an important contribution to climate change mitigation, climate change adaptation and disaster risk reduction, but wetlands can also trigger climate change (de Souza Dias, 2015; WI, 2015). Wetlands occupy 1280 million hectares or just three percent of the global surface (Spray & McGlothlin, 2004; Dudley *et al*., 2010; RCS, 2010; Grundling, 2012). However, wetlands store 33% of soil organic matter making them the largest global soil carbon reservoir with a carbon storage rate ranging from 23 to 50 grams of carbon per square meter per year (Eswaran *et al*., 1993 and Schlesinger, 1997 in Spray & McGlothlin, 2004). Wetlands, especially peatland are the largest store of carbon estimated at 1300t of carbon/hectare or 550 GT of carbon globally. Most of these peats are located in the tropical forest of south east Asia especially in Indonesia as well as the tundra permafrost of far north Russia, Canada, Alaska and Scandinavia (Dudley *et al*., 2010; Grundling, 2012; MWP, 2012). Peatland stores twice the amount of carbon than all global forest biomass combined and globally, peatlands are destroyed at a rate of 4000 km^2 per year, with 50% attributed to agriculture, 30% to forestry and 10% to peat extraction (Opio, 2008). The current climate changes are putting much of this carbon stock at risk (Dudley *et al*., 2010).

Carbon dioxide and methane account for 80% of global warming potential of all GHGs (IPCC, 2007) and this has a significant impact on global climate change (Spray & McGlothlin, 2004). The draining of wetlands especially peats for agricultural (including palm plantation in places like Indonesia), burning and other activities changes wetlands from carbon sinks to carbon sources as the soil conditions change from anaerobic to aerobic (Spray & McGlothlin, 2004; Dudley *et al.* 2010;). Wetlands release methane as an end product of methanogenesis, which accounts for 20% to 40% of the annual global atmospheric methane flux. It is well documented that methane has 20 times more warming potential than carbon dioxide although peatlands absorb and store atmospheric carbon for thousands of years (Grundling, 2012). Tropical wetlands with higher temperature and microbial activities produce 51% of the yearly global wetlands atmospheric methane flux (Spray & McGlothlin, 2004)

In South Africa, 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 African wetlands have been degraded including 25% of peatland. The degradation of peatland leads to the release of CO_2 into the atmosphere. For example, 300,000 tons of CO_2 was released from peatland in 2008 alone (Grundling, 2012). About 194 million tons of CO_2 still lie in peat wetlands while 2200 million tons of CO_2 are stored in other wetlands types in South Africa (Grundling, 2012). All these carbon stores in wetlands will be release if present healthy wetlands are degraded. 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/methane sink and carbon/methane sources and the cause and effects of climate change on wetlands needs grounded research and careful planning.

2.3 The potential effects of climate change on wetlands

Wetlands are sensitive to the amount and seasonality of water they receive and rely on a positive water balance for at least part of the year for their existence. Climate is one of the most important external drivers, which determines the quantity and timing of rainfall and streamflow into wetlands. All this affects wetland structure and functioning and by and large, the goods and services that wetlands provide to people (MWP & WESSA, 2012; Collins, 2006; Grundling, 2012).

Climate change will mostly affect the hydrological regime or hydro-period of the wetlands (the periodic presence of saturated conditions or inundation that differentiates wetlands from terrestrial and fully aquatic habitats) (Erwin, 2009; Acreman *et al*., 2011; Gitay *et al.*, 2011; WI, 2015). The type and magnitude of climate change impact on wetlands vary and depend on local natural conditions, human activities, current state and type of wetland, environmental requirements and species tolerances of the wetland, sea level rise and the changes in the depth of inundation of the wetland, severity of extreme events, and the biochemical changes within the wetland as a result of elevated temperatures (Erwin, 2009; MWP, 2012; Akumu, 2011). 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 i.e. the magnitude of hydrological change required to cause an ecological impact (Acreman *et al.* 2011).

Climate change 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 it (Acreman *et al*., 2011).

In Korea, climate change will affect about 10% of wetland functions (Kim *et al.* 2012). Withey and Van Kooten (2011, in Kim *et al.* 2012) maintain that climate change affects the water balance in a wetland causing changes in the habitat and in the diversity of species. Rise in temperature and precipitation leads to change in the surface area of wetlands resulting in change of the number of water birds in the wetland (Withey & Van Kooten, 2011 in Kim *et al.* 2012). Rising temperature may also lead to biodiversity loss within wetlands and at worst lead to the drying up and even the disappearance of some wetlands (ACC, 2011). Furthermore, climate change reduces the functions of wetlands as it affects the average depth of inundation, tree density, tree basal area and canopy gap with a reduction in the number of water birds (Kim *et al*., 2012).

2.4 Effects of climate change on wetlands in South Africa

South Africa is vulnerable to climate change. Water, disease, food security and environmental migration are identified as key areas where climate change will exacerbate existing developmental challenges (AfDB & WWF, 2012). Drier subtropical regions like South Africa experiences warming more than the moist tropics. Rainfall in South Africa is likely to become more variable with a decrease in rainfall predicted for much of the winter rainfall region (Western and Northern Cape and parts of the Eastern Cape) and western margins of the country while greater rainfall is predicted on the eastern margins, but the general trend is a decrease in net rainfall (MWP, 2012, IPCC, 2014).

Many wetlands in South Africa and especially those in the Eastern Free State are seasonal in character, flooding only during the wet season (summer in the case of Eastern Free State) or for a short period when there is temporary abundance of water in the landscape. Many South African wetlands are connected to the aquifer that recharges them during periods of no rainfall. 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 (MWP & WESSA, 2012). Wetlands without water or with considerably less water may become dry-lands thereby losing many of their ecological attributes that make them valuable ecosystems (MWP, 2012).

Wetlands in drier regions of South Africa will receive less rain and 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 wetland management challenges at catchment level (Grundling, 2012).

Erratic rainfall pattern with prolonged drought will increase the vulnerability of wetlands to land use changes as wetlands 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 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).

In the face of climate change, some wetland services are becoming increasingly important and this mirrors the growing need to appreciate how society, wetlands and climate are closely connected directly and indirectly. While wetlands may be affected by human-induced climate change, at the same time they also provide a way of lessening the change itself and helping communities to adapt to climate change (MWP & WESSA, 2012). These interdependency with forwarding and feedback loops make wetland management a complex process requiring a system-thinking and a holistic-forward-planning approach.

3. MATERIALS AND METHODS

A multi-disciplinary and mixed method approach was used to collect primary data. To build a resilient and sustainable community, society or system to increasing climate-related risks requires the integration of knowledge from many spheres including the natural, engineering and social sciences, social–ecological systems analyses, the humanities, psychology and ethics (Birkmann *et al.*, 2013; IPCC, 2014; Takeuchi *et al.*, 2014). A single research method used to address complex multi-faceted and socio-ecological problems such as managing wetlands to reduce climate change related-risks may not be robust enough (Nagendra, 2006 in Takeuchi *et al.,* 2014). This study involved both natural (wetlands) and social sciences (people) and this interlink was recognized and applied in the methodology. The study used mixed method and multiple tools to generated both quantitative and qualitative data. A combination of the post-positivism and the interpretivism paradigms were followed as well as the application of the social-ecological framework (Kitchin & Tate, 2000; Creswell, 2014; De Vos *et al.*, 2005; Babbie et al., 2008; Gupta & Sreeia, 2012; Bertram & Christiansen, 2014; Fabinyi, *et al.*,2014; CDC, 2015; Okeke & Van Wyk, 2015; UCI, 2015; Van Wyk, 2016).

A total of 176 questionnaires were administered to farmers in private, communal and protected wetlands in the Eastern Free State. Face to face and telephonic interviews were conducted with three sets of specialists (five wetland specialists, eight environmental and disaster management specialists and 15 climate change specialists) in the Free State province. Field observations were done on 21 randomly selected wetlands comprising seven communal wetlands, 11 privately owned wetlands and three protected wetlands. Climate data on rainfall and temperature was obtained from the South Africa Weather Service (SAWS) for the study area. Three Master's and three Ph.D. students as well as three senior researchers were recruited to test the questions in the questionnaire after which a pilot study was conducted in six wetlands, two in protected area, two in communal and two in private land. All these measures were taken to ensure validity and reliability to the collected data (De Vos *et al.*, 2005; Maree, 2007; Bertram and Christiansen, 2014).

Ten indicators were designed and used (adapted from Oberholster *et al.*, 2014) to observe 21 wetlands in the study area to determine the ecological status of these wetlands. Each indicator was scored from the best value of 5 to the worst value of 1. The maximum score was on 50 which was later converted into percentage and grouped into four ecological status categories: excellent = more than 75%, good = 65-75%, average = 50-64% and poor = less than 50%. Three recurring climate related hazards in the area (flood, drought and veld fires) were used to assess the vulnerability of wetlands to climate change. The SPSS programme was used to analyze the quantitative data while qualitative data were inductively analyzed into emerging themes (Maree, 2007; Creswell, 2014). The Kendall's W Test was performed to explore what wetlands owners perceive as current and future major threats to their wetlands.

4. RESULTS

4.1 Communal wetland risks and vulnerability to climate related hazards

Users of communal wetlands indicated that they were more vulnerable to flood than drought and veld fire (table 1.).

Table 1 Common risks in communal wetlands

Hazard	Responses	Frequency	Percentage
Flood	No	31	33.3
	Yes	62	66.7
Drought	No	79	84.9
	Yes	14	15.1
Fire	No	66	71.0
	Yes	27	29.0

4.2 Private wetland risks and vulnerability to climate related hazards

Private wetlands owners perceived lack of awareness and fire as the most threatening to their wetlands (Table 2).

Table 2 Perceived wetlands threats: Kendall's W Test (Ranks)

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

4.3 Private wetland's ecological status

The ecological status of wetland can be used as a proxy to assess its level of vulnerability to eminent climate related hazards and on the other hand to assess its ability to mitigate those hazards and adapt to changes. Respondents were requested to score the current state of their wetlands against the key wetland parameters of the vegetation, water and soil (table 3). The results show that 67.5% of private wetland 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. Field observations supported this information.

Table 3 The 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

4.4 Field observations

It is often said that a picture paints more than a thousand words. Field observations of the ecological status of wetlands are given in photos below:

Source: Author's own (2016)

A communal wetland showing trampling, head cut erosion, settlement and other poor usage leading to degradation (Monontsha in QwaQwa)

Source: Courtesy of Willie Nel (2015)

A Private wetland in good ecological state and exporting clean water to downstream users (Moolmanshoek). The principle of "Payment for ecosystem services (PES) can easily be applied here for downstream water users.

A wetland in a protected area displaying excellent ecological condition (Memel) used mostly for conservation and providing much economic and socio-cultural services

Field observation data could be summarized in that the governmentally protected wetlands were generally in excellent ecological conditions, those in private land were generally in good conditions but the majority of wetlands in communal land were degraded and therefore generally in poor ecological conditions. This statement was supported by other data collection tools such as the questionnaires and interviews

4.5 Respondents' suggestions on wetland management

When asked to suggest ways that wetlands can be well used and better maintained, the respondents suggested education and training as the best management practice (table 5).

Table 5 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 round the wetlands	2	6

4.6 Climate change specialists

The specialists were asked whether climate change has changed in the study area and if so how that has affected wetlands and suggested solutions. All 15 specialists agreed that the climate had changed in the Free State, 93% thought that good management of wetlands could reduce impacts of climate change, and 93% disagreed that local communities understood the value of wetlands. Specialists' perceptions on evidence of climate change, how wetlands could play a role in mitigating climate change and how to improve understanding of wetland functions and values is given in table 6.

Table 6 Specialists' perception of climate change and wetlands

FS: Free State

	Reason	Frequency
Evidence to support climate change	More frequent droughts episodes	6
	Warmer and shorter winters	3
	Changes in rainfall patterns	3
	Changes in weather patterns	2
	Increase in temperature	2
	Drier summer and reduced rainfall	2
	Fall in crop yield especially maize	2
	Weather extremes	1
	Political discussions	1
	Lower dam levels	1
	Heat waves	1
	Cold spells	1
	Floods	1
Role of wetlands in mitigating climate change	Carbon sink	12
	Water provision	6
	Groundwater conservation	4
	Ecosystem protection	3
	Regulate stream flow	3
	Increase food supply	2
How to improve understanding of wetland functions and values	Education, Training and awareness on wetland values and functions to local communities and in schools	12
	Dedicated government personnel to better manage wetlands	2
	Promotion of community involvement and ownership	1
	Better budget	1
	More information	1

4.7 Secondary data on climate patterns in the Free State

Secondary data on annual rainfall for the Free State (1961-2014), temperature for the Frankfort station (1970-2014) situated north of the study area, temperature for the Bethlehem station (1981-2014) situated south of the study area, annual rainfall for the Frankfort station (1970-2014) and annual rainfall for the Bethlehem station (1978 – 2014) is given in Figures 2 – 6, respectively.

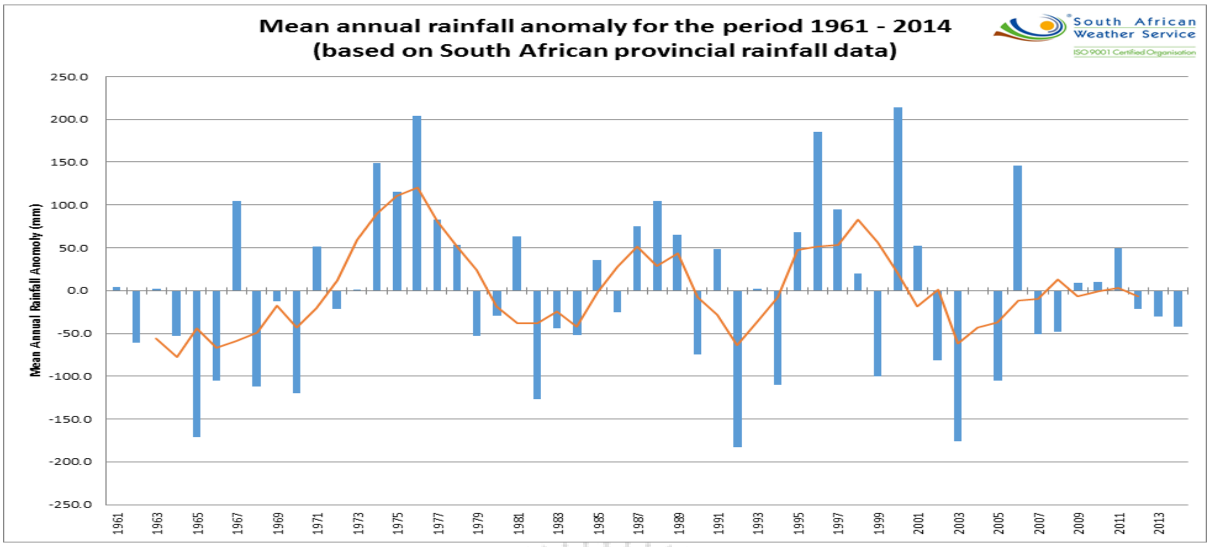


Figure 2 Average Annual rainfall anomaly for the whole Free State province (1961 – 2014)

Source: SAWS

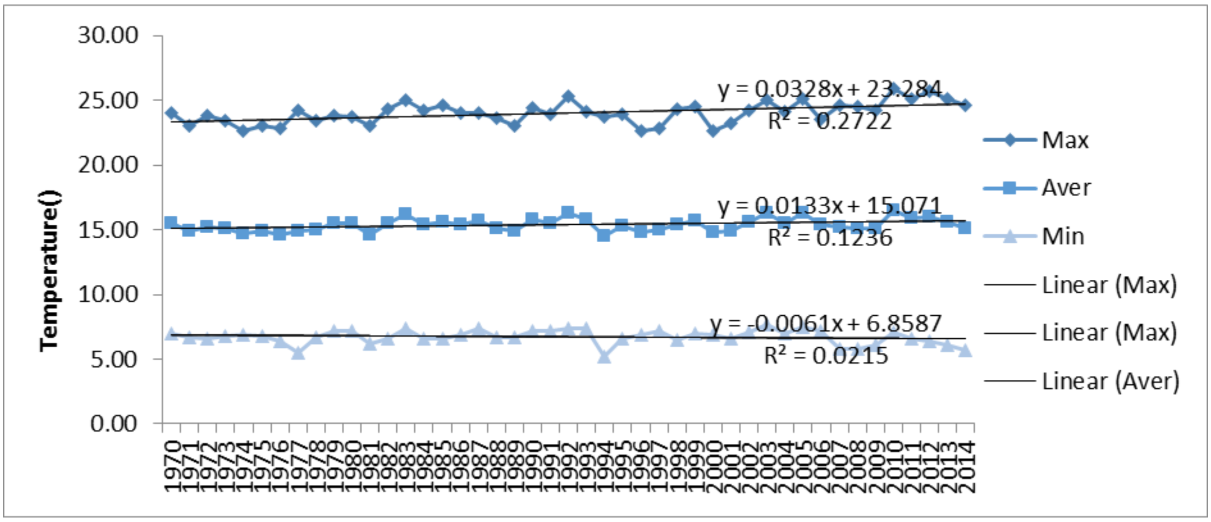


Figure 3 Annual temperature distribution for the Frankfort station (1970 – 2014) situated north of the study area

Source Adapted from SAWS

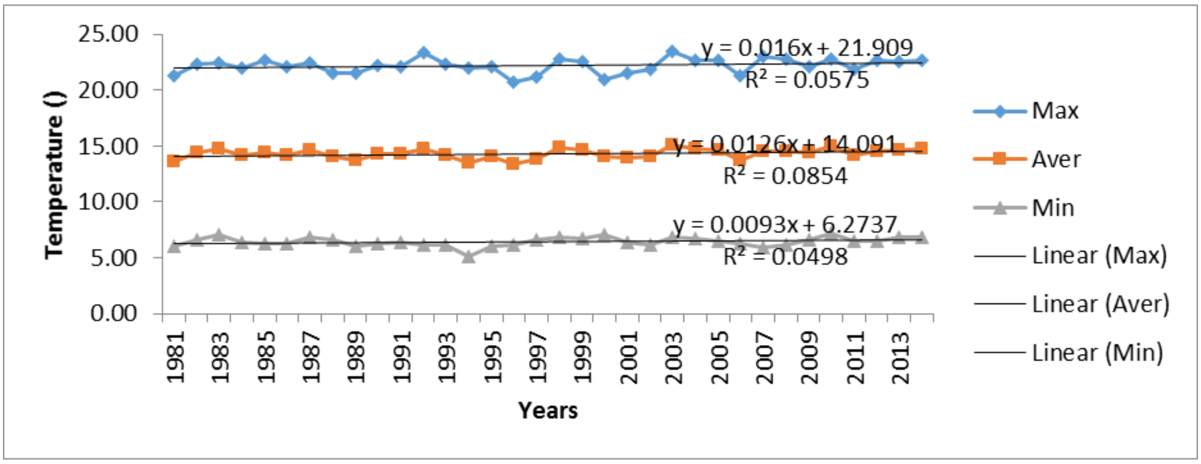


Figure 4 Annual temperature distribution for Bethlehem Station (1981 – 2014) situated south of the study area

Source: Adapted from SAWS

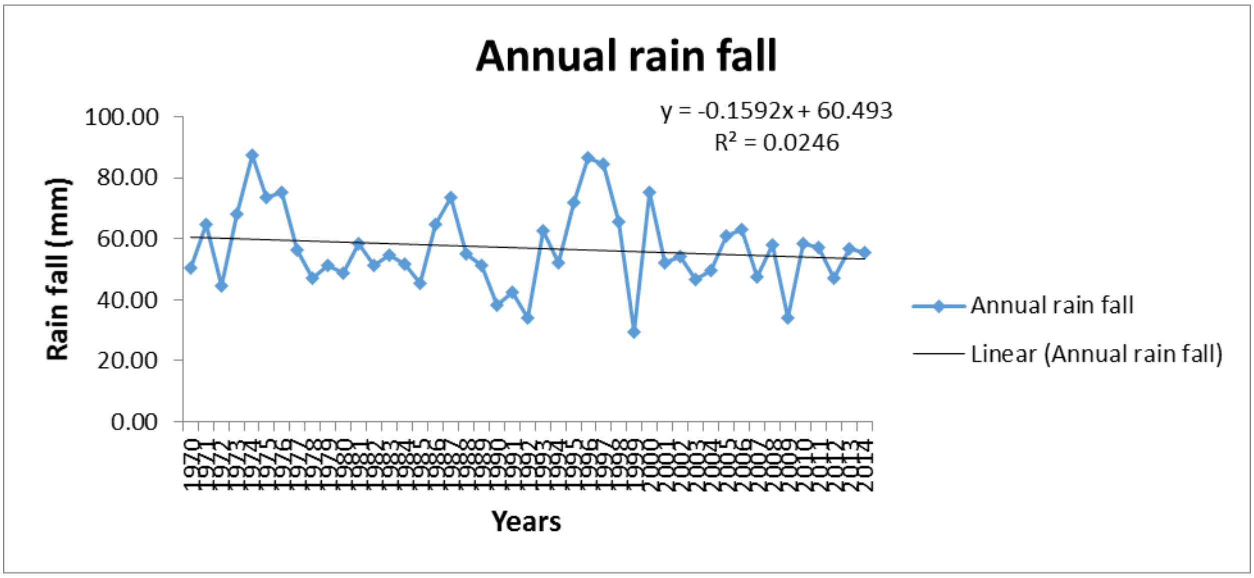


Figure 5 Annual rainfall for the Frankfort Station (1970 – 2014) situated north of the study area

Source: Adapted from SAWS

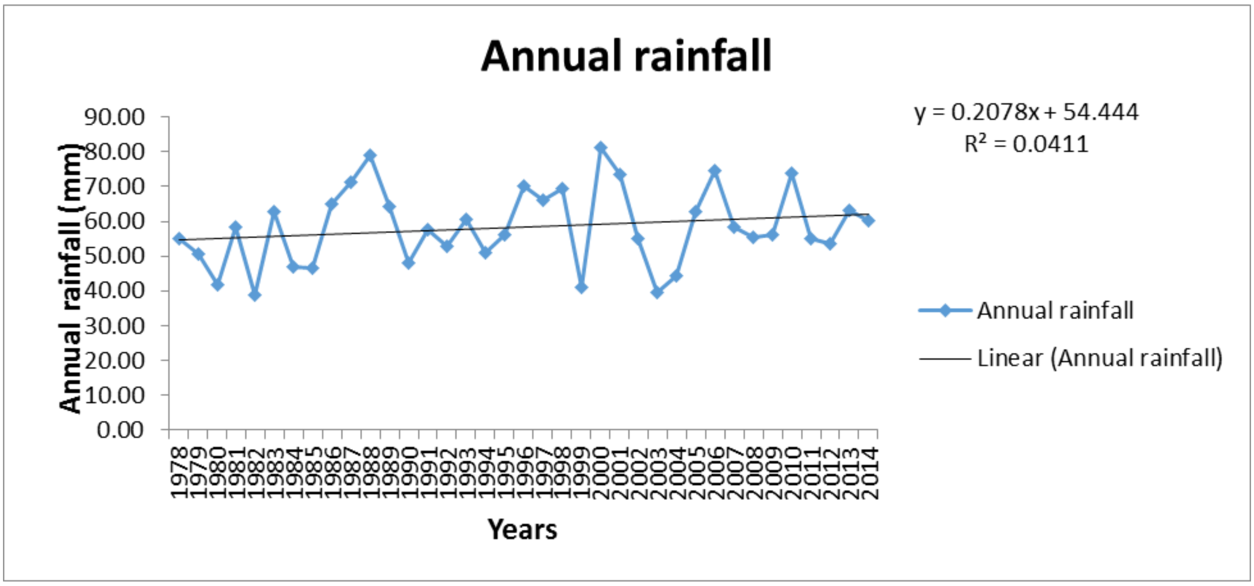


Figure 6 Annual rainfall for the Bethlehem Station (1978 – 2014) situated south of the study area

Source: SAWS

Several lessons could be drawn from these figures and tables, and they are discussed below.

5. DISCUSSION

5.1 Wetlands risks

Respondents from communal wetlands indicated that they were more vulnerable to the climate related risk of flood than fire and drought (table 1). This can be explained by many factors. Firstly all the communal wetlands that were sampled were valley bottom wetlands, which easily collected and channeled 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, 2010). Thirdly, there were many informal settlements within and around the communal wetlands with a high risk of flooding even with the slightest over-flow. Lastly concreting, draining of the wetlands for various reasons and road construction increased the risk of flood around communal wetlands. These wetlands, however, could have played a better mitigation role against the risk of fire and drought, given the presence of water. The presence of water or moisture in wetlands even during dry spells and droughts could be used for wetland conservation, given the fact that wetlands were also used for grazing in the study area. The risk of climate change, overgrazing and uncontrolled fires were also reported.

For the private wetlands, top in the ranking of perceived threats was the lack of awareness on wetland benefits, followed by uncontrolled fire and then overgrazing was in the third position (Table 2). The Kendall's W Test confirmed the urgent need for education and training on wetland management. The test statistic for the ranking of the threats revealed that about 93% of the private wetland owners agreed to ranking order as provided in Table 2. The Chi-square statistic of 92.91 was highly significant at 1% level, suggesting that the ranking was valid and efficiently estimated. This further showed that the individual threats identified in the study jointly and significantly explained the actual threats to the Eastern Free State wetlands.

From the field observations using prepared field data scoring indicators, six out of seven communal wetlands were in a poor state. All wetlands in protected areas were in an excellent ecological state with one of them (Seekoevlei) being a Ramsar site. Another wetland in the area (the Braamshoek or Ingula wetland) 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. One of them was in an excellent ecological health and this wetland is also a heritage site. This state of affairs could be linked to many factors ranging from ignorance, land title and private interest, management style to non-existence or weak implementation of wetland laws or environmental laws.

5.2 Respondents' suggestions to better manage wetlands

Top on the list of suggestion was the need to provide education and training on wetlands importance, their conservation, protection and wise use of the resource (table 5). This was followed by formulating and implementing stringent laws on wetlands. 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 of surrounding informal settlements. There were suggestions that the government should relocate the people living in informal settlements located within wetlands and provide better dry land for them. The land issue in the study area and the rest of South Africa is contentious and complicated dating back to the apartheid area with deprivation, discrimination and segregation. Resettlement in dry land 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 in the list of suggestions.

The 15 climate change experts who were interviewed all agreed that the climate was changing and they advanced 13 different but interrelated reasons to support climate change in the Free State. Most (93.3%) agreed that better management of wetlands would help reduce the impact of climate change in the province. The only one who did not feel that better management of wetlands could reduce the negative impacts of climate change defended the argument by saying that wetlands occupied a small portion of the earth compared to the sea to make any meaningful contribution to climate change. While this statement may be true in that wetlands as an ecosystem occupying only about 3-6% of the earth surface, they play a key role in especially carbon sequestration. Besides, the Free State is land-locked and therefore dams, rivers and wetlands are the major water bodies in the province.

The various reasons advanced by respondents on the role that wetlands play to reduce the impact of climate change closely related to the various ecosystem services provided by wetlands (MA, 2005). These ecosystem services provided by wetlands, therefore, helped in mitigating the impact of climate change in areas such as carbon sequestration or adapting to climate change by providing food for humans and animals during droughts. Though the reasons mentioned above are not exhaustive, they paint a clear picture of the role of wetlands in climate change mitigation, climate change adaptation and even reducing the risk of disasters especially those related to extreme climate or weather events such as drought. This approach is popularly referred to as Eco-DRR/CCA (Sudmeier-Rieux and Ash, 2009; UNEP, 2010; Estrella and Saalisma, 2011; PEDRR & CNRD, 2013; Renauld *et al.*, 2013; 2016; Talberth *et al.* 2013; Takeuchi *et al.*, 2014)

Despites these important values of wetlands, climate change specialists in this study perceived that local communities in the Free State did not understand the full value of wetlands. With such an overwhelming support of lack of awareness in wetland values and functions in the province, wetlands were therefore exposed to a high vulnerability of being erroneously degraded and damaged. This view is shared and supported in this research from the review of related literature and personal experience of the researchers.

5.3 Secondary data

The use of average weather parameters to determine climate change, for example, average annual temperature and rainfall smoothed over a long period of time, mask the extreme realities of climate change. Though Figures 2-6 showed extreme variability in the temperature and rainfall in the study area over 30 years, the law of averages masked the reality such as extreme temperatures and heat waves that hit the area and changes in seasons, which affected crop production and therefore food security in the area. The year 2015/2016 has gone into record in the area as not only the hottest years but was accompanied by the worst drought on record in the area

CONCLUSION AND RECOMMENDATIONS

The common ownership with no control over communal wetlands made their management very poor in the study area. 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 pigsties into the wetland.

While monitoring is required to maintain the excellent ecological state of protected wetlands, it will be a good management idea to improve the status of wetlands in private commercial farms from good to excellent. The greatest wetlands management problem that needs tactful planning lies with wetlands in communal land which are in red (table 4). These wetlands are the main grazing areas for communal grazing especially during recurrent dry spells and droughts.

There was an overwhelming feeling amongst the respondents that the solution for better management, conservation and sustainable use of wetlands in the Free State lies in education, training and awareness of wetland values and functions. This should be a joint responsibility of the DESTEA as the government department assigned with the role of rehabilitating and conserving wetlands in the province (Working for Wetlands), the local municipalities whose community members degrade wetlands, the ministry of education and higher institutions of learning to build knowledge and skills on wetland management and inculcating the values and functions of wetlands in learners and other stakeholders. To bring all these stakeholders together requires proper coordination.

Formulating and implementing stringent laws on wetlands is highly recommended. This possibly should be the joint effort of the government and the local municipalities. The laws and policies should be complemented with proper education as indicated above.

Though secondary weather data did not show clear changes in climate, climate change experts acknowledge evidence of climate change in the area. It is therefore recommended that statistical records on weather parameters should be accompanied with field and observable evidence in the area to establish the phenomenon of climate change and understand its impacts for proper DRR and CCA interventions.

REFERENCES

1. Acreman, M.C., Blake, J.R., Mountford, O., Stratford, C., Prudhomme, C., Kay, A., Bell, V., Growing, D., Rothero, E., Thompson, J., Huges, A., Barkwith, A., and van de Noort, R. (2011). *Guidance on using wetland sensitivity to climate change tool-kit. A contribution to Wetland Vision Partnership*. Wallingford: Centre for Ecology and Hydrology.
2. Africa Conservation Centre (ACC). (2011). *Kenyan wetlands-An indicator of climate change and human disturbance.* Nairobi: ACC.
3. Africa Development Bank and World Wild Fund for Nature (AfDB & WWF). (2012). *Africa ecological footprint report: Green infrastructure for Africa's ecological security.* Available at http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/Africa%20Ecological%20Footprint%20Report%20-%20Green%20Infrastructure%20for%20Africa's%20Ecological% 20Security.pdf (Accessed 28/02/2014).
4. Akumu, C.E. (2011). *Assessing the potential impacts of climate change on coastal wetlands in north-east New South Wales using geoinformatics*. Ph.D. thesis, Southern Cross University. Lismore: SCU.
5. Babbie, E., Mouton, J., Vorster, P. and Prozesky, B. (2008).*The practice of social research*.South Africa edition. Cape Town: Oxford University Press South Africa.
6. Bertram, C., and Christiansen, I. (2014). *Understanding research: An introduction to reading research*. Pretoria: Van Schaik Publishers.
7. Birkmann, J., Cardona, O.D., Carreño, M.L., Barbat, A.H., Pelling, M., Schneiderbauer, S., Kienberger, S., Keiler, M., Alexanser, D., Zeil, P., Welle, T. (2013). Framing vulnerability, risk and societal responses: the MOVE Framework. *Natural Hazards*. Vol 67(2): pp 193-21.
8. Centre for Disease Control (CDC). (2015). *The Social-Ecological Model: A Framework for Prevention.* [Online]. Available at http://www.cdc.gov/violenceprevention/overview/social-ecologicalmodel.html. (Accessed 04/12/2015).
9. Collins, N.B. (Ed). (2006). *Wetlands: the basics and some more*. Bloemfontein: Department of Water and Forestry.
10. Creswell, J.W. (2003). *Research design: Qualitative and quantitative and mixed-method approaches*. Thousand Oaks, CA: Sage Publications.
11. Creswell, J.W. (2014). Research design: Qualitative, quantitative and mixed methods approaches. Fourth edition. Los Angeles: SAGE.
12. De Souza Dias, B.F. (2015). *Executive Secretary statement at the technical workshop on ecosystem-based approaches to climate change adaptation and disaster risk reduction; Sandton, Johannesburg from 28 September to 2 October 2015*. [Online]. Available at https://www.cbd.int/doc/speech/2015/sp-2015-09-28-cc-en.pdf. (Accessed 06/10/2015).
13. De Vos, A.S., Strydom, H., Fouche, C.B., Delport, C.S.L. (2005). *Research at Grass Roots for the Social Sciences and Human Service Profession*.3rd Edition. Pretoria: Van Schaik Publishers.

14. Dudley, N., Stolton, S., Belokurov, A., Krueger, L., Lopoukhine, N., MacKinnon, K., Sandwith, T., and Sekhran, N. (eds). (2010). *Natural Solutions: Protected areas helping people cope with climate change*. Geneva: IUCNWCPA.
15. Erwin, K.L. (2009). Wetlands and the global climate change: the role of wetland restoration in a changing world. *Wetland Ecol Management*. Vol 17: pp 71-84.
16. Estrella, M., and Saalismaa, N. (Eds). (2011). *Demonstrating the Role of Ecosystems-based Management for Disaster Risk Reduction. UNISDR GAR Report.* Geneva: Partnership for Environment and Disaster Risk Reduction.
17. Fabinyi, M., Evans, L., and Foale, S.M. (2014). Social-ecological systems, social diversity, and power: insights from anthropology and political ecology. *Ecology and Society.* Vol 19(4): pp28.
18. Gitay, H., Finlayson, C.M. and Davidson, N. (2011). *A framework for assessing the vulnerability of wetlands to climate change*. Ramsar Technical Report No. 5, CBD Technical Series No. 57. Ramsar Convention Secretariat, Gland, Switzerland & Secretariat of the Convention on Biological Diversity, Montreal, Canada. Available at http://www.ramsar.org/sites/default/files/documents/pdf/lib/lib_rtr05.pdf (Accessed 23/06/2013).
19. Grundling, P.L. (2012). *An overview of expected impacts of climate change on wetlands of South Africa. COP 17 Side Event: Ecosystem-based Adaptation-South Africa case studies*. Durban: COP17.
20. Gupta, A. K. and Sreeja , N.S. (2012). *Ecosystem approach to disaster risk reduction*. New Delhi: National Institute of Disaster Management.
21. Intergovernmental Panel on Climate Change (IPCC). (2007). *Climate change. Synthese report of the IPCC Fourth Assessment Report 2007*.Geneva: IPCC.
22. Intergovernmental Panel on Climate Change (IPCC). (2012). *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. *A Special report of Working Groups I and II of the Intergovernmental Panel on Climate.* UK: Cambridge University Press.
23. Intergovernmental Panel on Climate Change (IPCC). (2014). *Firth Assessment Report, synthesis for policy makers.* Geneva: IPCC.
24. Jordaan, A.J. (2012). *Drought Risk Reduction in the Northern Cape.* Ph.D. Thesis. Bloemfontein: University of the Free State.
25. Kim, D.G., Noh, H.S., Kang, N.R., and Kim, H.S. (2012). *Impact of climate change on wetland functions. Hydrology Day*. Korea: Center for Hydrology and Ecology.
26. Kitchin, R., and Tate, J. (2000). *Conducting research in human geography: theory, methodology and practice.* Harlow: Prentice Hall.
27. Kotze, D. (2008). *How wet is a wetland? An introduction to understanding wetland hydrology, soils and land forms.* Wetland-Use Booklet 2.Howick: WESSA Share-Net Resources.
28. Kotze, D.C. (2012). *Wetlands and People: What values do wetlands have for us and how are these values affected by our land-use activities*. Wetland-Use Booklet 1.Howick: WESSA Share-Net Resources.
29. Kotze, D.C., Breen, C.M., Nxele, I.Z and Kareko, J. (2009). Wet-management review: The impact of natural resources management programmes on wetlands in South Africa. Pretoria: Water Research Commission. (WRC Report No.TT 335/09).
30. Leedy, P.D. and Ormrod, J.E. (2001). *Practical research planning and design*. International Edition.
31. Maree, K. (2007). *First steps in research*. Pretoria: Van Schaik.
32. Millennium Ecosystem Assessment (MA). (2005). *Ecosystems and Human Well-being: Wetlands and Water Synthesis*. Washington, DC: World Resources Institute.
33. Mondi Wetlands Programme (MWP). (2012). *What does climate change mean for our wetlands in South Africa?* [Online]. Available at www.wetland.org.za. (Accessed 24/04/2015).
34. Mondi Wetlands Programme and Wildlife & Environment Society of South Africa (MWP and WESSA). (2012). *What does climate change mean for our wetlands in South Africa?* [Online]. www.wetland.org.za. (Accessed 13/05/2015).
35. Oberholster, P.J., McMillan, K., Durgapersad, K., Botha, A.M., and De Klerk, A.R. (2014). The Development of a Wetland Classification and Risk Assessment Index (WCRAI) for non-wetland specialists for the management of natural freshwater wetland ecosystems. *Water Air Soil Pollution*, Vol 225, pp1833; Springer Science.
36. Okeke, C., and Van Wyk, M.M. (2015). *Educational research: An African approach*. Cape Town: OUP.

37. Ollis, D., Snaddon, K., Job, N., and Mbona, N. (2013). *Classification system for wetlands and other aquatic ecosystems in South Africa: User mannual: Inland systems*. Pretoria: SANBI.
38. Opio, M. (2008). *An institutional analysis of the management of wetlands resources: A comperative study of Floahreppur Municipality in South Iceland and Oyam District in Uganda*. [Online].Available at www.unulrt.is/static/fellows/document/moses-1-pdf. (Accessed on 28 March 2013).
39. Partnership on Environment and Disaster Risk Reduction and Centre for Natural Resources and Development (PEDRR & CNRD). (2013). *Disasters, Environment and Risk Reduction- Eco-DRR Master's Module, instructors' manual*. Geneva: CNDR-PEDRR.
40. Ramsar Convention Secretariat (RCS). (2010). *Managing wetlands: Frameworks for managing Wetlands of International Importance and other wetland sites. Ramsar Handbooks for the wise use of wetlands*, 4th edition, vol. 18. Gland: Ramsar Convention Secretariat.
41. Renaud, F.G., Sudmeier-Rieux, K. and Estrella, N.(eds). (2013). *The role of ecosystems for disaster risk reduction.* Tokyo: United Nations University Press.
42. RSA (Republic of South Africa). (1998). *National Water Act (NWA), Act 36 of 1998*. Cape Town: Government Gazette.
43. Spray, S.L. and McGlothlin, K.L. (2004). *Wetlands: Exploring environmental challenges; a multidisciplinary approach.* USA: Rowman and Littlefield Publisher Inc.
44. Sudmeier-Rieux, K. and Ash, N. (2009). Environmental guidance note for disaster risk reduction. *IUCN Commission for Ecosystem management series no. 8.* Gland, Switzerland: IUCN. Suter, W.N. (2006). *Introduction to educational research: A critical thinking approach*. California: SAGE Publications, Inc.
45. Takeuchi, T., Elmqvist, T., Hatakeyama, M., Kauffman, J., Turner, N., and Zhon, D. (2014). Using sustainable science to analyse social-ecological restoration in North East Japan after the great earthquake and tsunami of 2011. *Sustainable Science*. Vol 9(4) pp 513-526.
46. Talberth, J., Gray, E., Yonavjak, L. and Gartner, T. (2013). *Green versus Gray: Nature's solutions to infrastructure demands.* [Online]. Available at http://thesolutionsjournal.anu.edu.au/node/1241. (Accessed 27/10/2014).
47. United Nations Development Programme (UNDP). (2015). *A new sustainable development agenda: the SDGs*. [Online]. Available at http://www.undp.org/content/undp/en/home/sdgoverview.html. (Accessed 12/12/2015).
48. United Nations Environmental Programme (UNEP). (2010). The role of ecosystems in developing a sustainable "Green Economy". *Ecosystem Management Policy Brief 2*. Geneva: UNEP.
49. United Nations Framework Convention on Climate Change (UNFCCC). (2015). *Draft Paris outcome*. [Online]. Available at http://climateaction.unfccc.int. (Accessed 10/02/2016).
50. United Nations International Strategy for Disaster Reduction (UNISDR). (2015). *The Sendai Framework for Disaster Risk Reduction 2015-2030.* Geneva: UNISDR.
51. University of California, Irvine (UCI) School of Social Ecology. (2015). *What is social ecology?* [Online]. Available at https://socialecology.uci.edu/core/what-social-ecology. (Accessed 01/03/2016).
52. Van Wyk, M.M. (2016). *Philosophies of research for postgraduate students*. Powerpoint presentation at the postgraduate workshop on 07/03/2016. Bloemfontein: UFS.
53. WI (Wetlands International). (2015). *What are wetlands?* [Online]. Available at https://www.wetlands.org/the-problem/what-are-wetlands/ (Accessed 28/3/2015).