

Perceptions of wetland ecosystem services in a region of climatic  
variability



UNIVERSITY *of the*  
WESTERN CAPE



Samantha Williams

UNIVERSITY *of the*  
WESTERN CAPE

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Supervisor: Dr. Suzanne Grenfell  
Co-Supervisor: Mrs. Mandy Carolissen

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## **Keywords**

Perceptions

Ecosystem services

Climatic variability

Climate change

Nuwejaars Catchment

WET-EcoServices



## Declaration

I Samantha Williams declare that *Perceptions of wetland ecosystem services in a region of climatic variability* is my own work, that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Full name: Samantha Williams

Date: 28/05/18

Signed.....



## Abstract

Wetlands provide various ecosystem services such as provisioning, regulating, supporting, and cultural services which may be directly or indirectly beneficial to humans. The manner in which such wetlands are managed is partly determined by human perceptions of their value. However, climatic variability and climate change put the continued provision of such ecosystems under stress. The result is that certain ecosystem services may be provided to differing extents during anomalously wet or dry years. There is thus uncertainty as to the values ascribed to wetlands by people during varying climatic phases. This thesis focuses on understanding how people perceive the functioning of wetlands within our current climate against a background of climatic variability and climate change.

This study explores people's perceptions regarding the functioning of wetlands and ecosystem services provided during dry and wet years, as an indication of how climatic variability and climate change impact peoples' perceptions. The data was collected in the wetlands of the Agulhas Plain in the Nuwejaars Catchment. Five wetlands classified and scored using the WET-EcoServices tool. In addition, five semi-structured interviews and three participatory mapping exercises with landowners were also undertaken. The study reports on the landowners' awareness of wetland ecosystems, ecosystem services and climatic variability and climate change. Provisioning, supporting, and cultural ecosystem services are frequently used by landowners, which can be impacted by climatic variability and climate change. The WET-EcoService benefits and landowners perceptions of ecosystem services varies, as the WET-EcoService direct and indirect ecosystem services are either effective or ineffective in dry and wet years. In contrast to landowners perceptions emphasising the importance of ecosystem services directly beneficial to them. The study recommends that the ecosystem services landowners perceive as important is linked to their interest to guarantee their participation in catchment management. WET-EcoService benefits can inform landowners and managers about ecosystem services degradation and whether their conservation methods are either positively or negatively impacting wetlands.

**Key words:** perceptions, ecosystem services, climatic variability, climate change, Nuwejaars Catchment, WET-EcoServices

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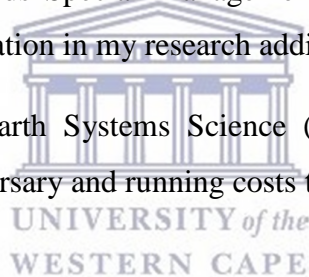
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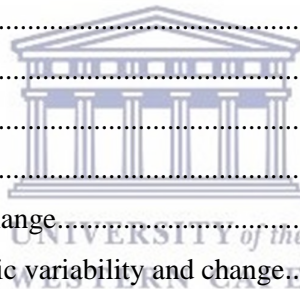
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## **Chapter 1 Introduction**

### **1.1 Background**

Wetlands provide a diverse range of functions such as flood control, water quality enhancement, and habitat for fauna and flora. Although wetlands provide a range of functions they are one of the most threatened habitats globally due to human activities (Turpie et al., 2010). Climatic variability and climate change provide an additional stress to wetland biodiversity. People dependent on wetland ecosystems will be affected by the degradation of ecosystem integrity as it will result in a decline in service provision (Finlayson et al., 2006).

According to Turpie et al. (2010), ecosystem services were previously divided into goods (products), services (ecosystem functions) and attributes (structure, diversity, and rarity). In contrast, the Millennium Ecosystem Assessment (2005) classifies ecosystem services into 4 type's namely provisioning, regulating, supporting, and cultural services. Provisioning services refer to the products obtained from the ecosystem such as food, water, fibre, medicines and raw materials. Regulating services are the benefits obtained from the regulation of ecosystem processes such as flow regulation, sediment trapping, erosion control and water purification, obtained from the natural control of the ecosystem processes. As well as, contributing to economic production or saving costs. Cultural services relate to ecosystem attributes as educational, cultural, recreational, and aesthetic beauty of the natural environment. Supporting services are the biophysical processes that produce conditions for the previously mentioned services.

There is uncertainty regarding how and what people value and appreciate about wetlands and their associated ecosystem services, despite the apparent economic benefit of wetlands to society. It is difficult to place a monetary value on wetland ecosystem services. As people are responsible for the on-going conservation and management of wetlands, it is important to understand how people perceive wetlands and the ecosystem services they provide (Kaplowitz and Kerr, 2003). The study aims to understand how people perceive the functioning of wetlands against a background of climatic variability and climate change. The study will focus on the wetlands on the Agulhas Plain on the south Western Cape coast of South Africa.

## 1.2 Study Area

The Agulhas Plain is found at the southernmost tip of Africa, in the Western Cape province of South Africa. The Plain is a low-lying coastal area of around 27 000 hectares. The area stretches from Stanford to the Breede River and down to the southern tip of Africa (Nuwejaars Wetlands Special Management Area, 2011). The region has a Mediterranean climate, with hot dry summers and cold wet winters. The majority of the rainfall occurs in the winter months from May to October, with a mean annual rainfall of 445 mm in the east to 540 mm in the west and 650 mm along the northern boundary of the plain (Kraaij et al., 2009). The winter rainfall is derived primarily from the passage of temperate mid latitude cyclones.

The Plain is located within a biodiversity hotspot and is recognised as a vulnerable and irreplaceable region in terms of biodiversity. This area is the only floral kingdom found entirely within a single country which falls within a threatened biodiversity hotspot, the Cape Floristic Region (Pauw, 2012). According to the Nuwejaars Wetlands Special Management Area (2011), this region is one of the largest remaining patches of lowland fynbos and the endangered Renosterveld. The lowland fynbos is biologically rich and is a threatened vegetation type. Fynbos plant species primarily the *Protea pudens* and *Erica regia* are prevalent in the region and under threat. The Agulhas Plain has a variety of habitats, red data plant species, local endemics and wetlands (Van Breda, 2012).

The coastal plain is geologically a remnant of an ancient wave-cut platform predominantly covered by calcareous sands of the Tertiary age. The coastal mountains are Cape Fold Belt sandstone, covered in segments of limestone. Inland, the plains are primarily Bokkeveld shale, including Malmesbury Shales and Bredasdorp limestone (Kraaij et al., 2009). The Cape Floristic Region has low-gradient topography from the base of the Bredasdorp mountain range in the north-west to the Indian Ocean in the south-east. Therefore, the region is associated with a number of water bodies and wetlands (Gordon et al., 2011). The Agulhas wetlands form part of the Heuningnes and Nuwejaars River systems. The Nuwejaars River rises through several tributaries in the southern slopes of the Bredasdorp Mountains, the Koueberge, and the hills to the south of Elim and the northern slopes of the Soetanyberg. Flows into Soetendalsvei and then meets the Kars River combined with the Nuwejaars River forms the confluence known as the Heuningnes River (Heuningnes Estuary) (Pauw, 2012).

The south-eastern part of the plains landscape has a low gradient, resulting in a significant variety of wetlands. The selected wetlands presented (Figure 1) below for the study are Karsrivierlei, Soetendalsvlei, Wiesdrift, and Waskraalvlei (Waagschallvlei) which are managed by the NWSMA, and lastly Vöelvlei (Droërivier).

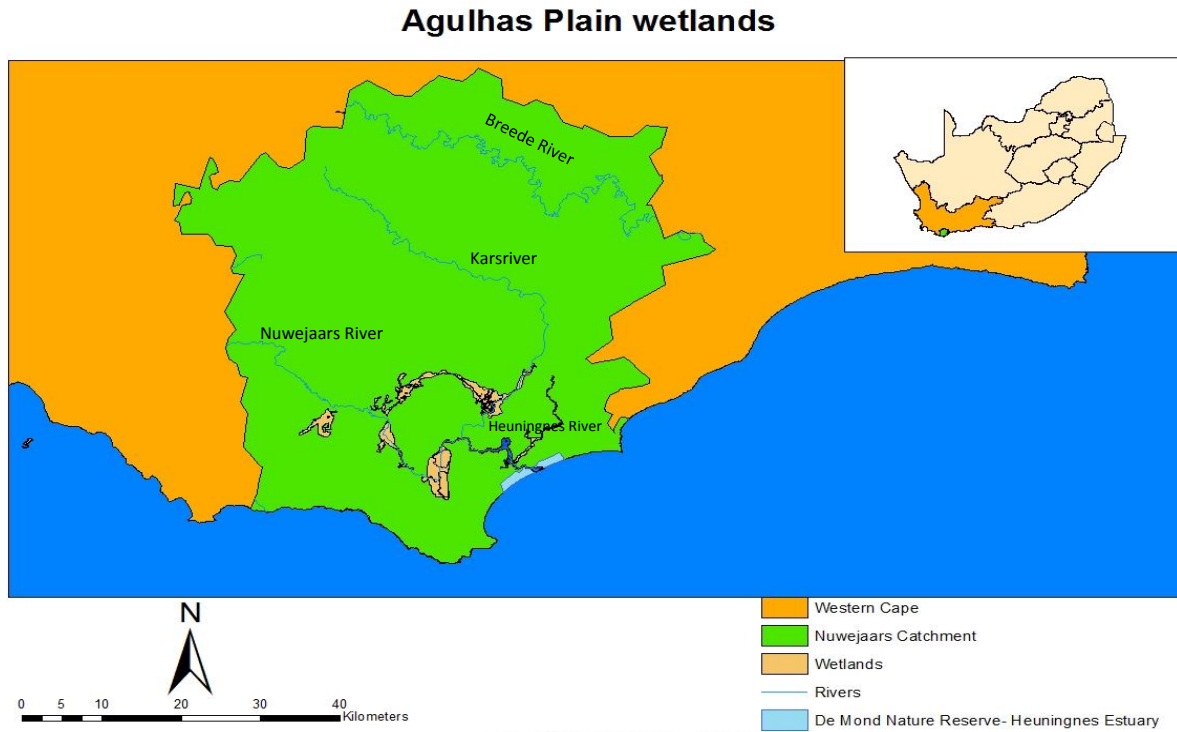


Figure 1 Agulhas Plain wetlands

The Nuwejaars Wetland Special Management Area (NWSMA) consists of a collaborative group of private landowners conserving the biodiversity-rich environment. The 25 private landowners work in partnership collectively by managing their land to ensure a relationship of environmental, social, economic sustainable development and preserving the rich biodiversity of the area (Nuwejaars Wetland Special Management Area, 2011).

### 1.3 Rationale

Greenland-Smith et al. (2016) state that landowners are important agents of ecosystem goods and services in terms of the area of land they manage and studies are progressively seeking to understand how farmers observe and influence ecosystem goods and services. The co-management of balancing the agriculture and conservation relationship is often positive, although it can be complex and service dependent. It can increase opportunities for both relationships, although there is a need to understand these relationships much better in order to use the benefits efficiently (Austin et al., 2016). According to Bernués et al. (2016), improved knowledge is required regarding the effects of particular agricultural practices and management systems on ecosystem services including, associated sustainability issues perceived by participants.

Research regarding ecosystem services emphasises the connection between ecosystems and society. While the fynbos biome is the only biogeographical region of South Africa where ecosystem services have been assessed at an appropriate scale, studies on crucial services are absent and values were based on assumptions and generalisations (Daily et al., 1997). As Le Maitre et al. (2007) states, previous studies focused mostly on specific services such as water as an ecosystem service as compared to regulatory services. When cultural services were considered, recreational opportunities were emphasised.

Against this backdrop, an investigation is needed regarding people's perceptions of wetland ecosystem services. This study will not attempt to provide monetary valuation of ecosystem services, but determine people's perceptions of the services as this has an impact on how landowners might manage them. People's perceptions, values, attitudes, and beliefs are important to take into consideration in order to, create more insight regarding ecosystem system services instead of focusing only on biophysical assessments (Plieninger et al., 2013). This can contribute to changing worldviews and approaches that are entrenched in various sciences when addressing ecosystem systems, ecosystem services, and human well-being. The wetlands of the Agulhas Plain, located on the South Western Cape coast, will be used as a case study area.

## 1.4 Aim and Objectives

### 1.4.1 Aim

To investigate farmer's perceptions of wetland ecosystem service provision against a background of climate change and climatic variability.

### 1.4.2 Objectives

1. Classify selected wetlands of the Agulhas coastal Plain and score their likely ecosystem services provision using the WET-EcoServices tool.
2. Investigate farmer's perceptions regarding the functioning of wetlands and ecosystem services provided.
3. Compare perceptions of wetland ecosystem services provision during dry and wet years, as an indication of how climate change and climatic variability impact wetland services.
4. Compare perceptions of wetland ecosystem service provision to the estimated formal assessment of ecosystem service provision.

The thesis comprises of the following six chapters: Chapter 1 the introduction comprises of the background to the research and the Agulhas Plain as the selected study area. Chapter 2, literature review covers previous studies on wetlands, people's perceptions particularly farmers about wetlands, ecosystem services, climatic variability, and climate change. Chapter 3 describes the mixed methods approach to the research, data collection tools, analysis of data and limitations experienced throughout the study. Chapter 4 synthesises the key findings of the WET-EcoServices assessments of provisioning, regulating, supporting, and cultural ecosystem services. Chapter 5 discusses the main findings of participatory mapping and interviews conducted with participants. Lastly, chapter 6 discusses the research by outlining the key issues that emerged throughout the study and recommendations that can improve the research.

## **Chapter 2 Literature Review**

### **2.1 Introduction**

The functioning and values wetlands provide are direct and indirect benefits that are important to ecosystems and humans. The ecosystem services are the functions, products, attributes and services, which have value to people in terms of quality or importance but have also been degraded or poorly managed. On the other hand, Collins (2005) states that in recent time the benefits (i.e. ecosystem services) of wetlands to society were often not acknowledged. Furthermore, this paper will specifically focus on people's perceptions of wetland ecosystem services and how climatic variability and climate change have impacted these services in dry and wet years. This section reviews the literature on wetlands, including the Agulhas Plain, people's perceptions of wetlands and how farmers perceive wetland ecosystems, ecosystem services and climatic variability, and how climate change impacts wetlands and their services.

### **2.2 Wetlands and the Agulhas Plain**

Wetlands are defined as a land which is in-between terrestrial and aquatic systems, where the water surface is usually at or near the surface or when the land is periodically inundated with shallow water. Typically, the land supports or would support the vegetation depending on the environment and the associated vegetation adapted to life in saturated soil (National Water Act; Act No. 36 1998 cited in Ollis et al., 2013). However, wetlands can be permanently and periodically inundated with water, as a result, they are considered an aquatic system. Wetlands are difficult to define specifically for legal purposes as a result of their varied hydrological conditions, size, location, and human influence. On the other hand, Mitsch and Gooselink (2015) define wetlands as lowlands covered with shallow and occasionally temporary or intermittent waters. They may be referred to as marshes, swamps, bogs, wet meadows, potholes, sloughs, and river overflow lands. Shallow lakes and ponds, typically with emergent vegetation as a conspicuous feature, are included but the permanent waters of streams, reservoirs, and deep lakes are excluded.

The provisioning, regulating, supporting, and cultural ecosystem services are the direct and indirect benefits provided by wetlands. Provisioning ecosystem services are products obtained from the ecosystems, regulating ecosystem services are climate regulation, water purification,



and pollination. Supporting ecosystem services are habitats and breeding areas for fauna and flora. Cultural ecosystem services are benefits obtained from the ecosystems generally recreation, spirituality, and cultural heritage. Wetlands are also referred to as the “kidneys of the landscape” and “nature’s supermarkets” as they provide important ecosystem services and habitats areas for fauna and flora (Mitsch and Gooselink, 2015). However, Collins (2005) states that although wetlands are beneficial and provide a range of ecosystem services they are still impacted by human activities, especially if economic benefits are involved which are not always sustainable. For example, livestock grazing in wetlands can result in regulating and supporting services being impacted due to erosion and decreasing habitats. Hunting and fishing unsustainably can exceed the capacity of the population to reproduce and replace the species that are removed reducing the resources in the wetland.

### **2.3 People’s perceptions of wetlands**

Wetlands provide an array of ecosystem services such as provisioning, regulating, supporting, and cultural services. People are often dependent on wetlands and the services they provide, and as such, these services can be valuable to society if used sustainably or scarce and may impact human well-being (Millennium Assessment, 2005). In order to prevent the destruction of wetlands and the limitation of these services, it is important to understand what matters to people regarding wetlands and the services provisioned (Kaplowitz and Kerr, 2003). The land use and ecological functioning in the area determines people’s usage of wetland ecosystem goods and services. The ecological functioning of wetlands and the succeeding use of ecosystem goods and services by people in society indicates the ecological importance and irreplaceability which makes wetlands a priority for conservation.

Kaplowitz and Kerr (2003) state there is often uncertainty regarding what people truly value and appreciate about wetlands and the services provided. Olarewaju et al. (2014) argue that the destruction of wetlands is commonly caused by people’s poor appreciation of wetlands and their perception of the benefits from wetlands should be assessed. It is essential to understand how people living near wetlands perceive the benefits of the wetlands in their region (Plieninger et al., 2013). If the study focuses on people who live in an environment, where the provisioning of ecosystem services are scarce then their participation can strongly influence the study. A similar study was done in Jimma Highlands, Southwestern Ethiopia which focused on the imbalance of

ecosystem services of wetlands and the perceptions of the local community towards the restoration and management of wetlands (Moges et al., 2016). However, Greenland-Smith et al. (2016) argues wetlands in low-lying areas are sometimes in conflict with agriculture and therefore it is important to emphasise farmer's perceptions of wetlands. Therefore, the manner in which farmers perceive and understand wetland ecosystem goods and services, including their costs and benefits should be assessed. This is different to farmers in the High Nature Value as farmers and non-farmers perceptions vary (Bernués et al., 2016), yet both views are important for public policies as to how they perceive or attach value to the ecosystem services. In this context, only landowner's part of the NWSM, have access to the wetlands, not people outside of their farm boundaries. The Special Management Area (SMA) model involves the first collaborative group of private landowners in South Africa to implement the SMA model, where landowners manage their land and conserve the environment. In June 2002, landowners realised that they were farming on a biodiversity hotspot, which formed the idea of conserving the farming area. By August 2003, the SMA statement of Intent was official; thereafter the development framework was accepted in March 2007 following the establishment of the Nuwejaars Wetland Owners Association in December 2008 (Nuwejaars Wetland Special Management Area, 2011). Although the SMA model includes people from Elim they are not entirely involved or allowed to enter or assist in managing the land (Van Breda, 2012).

The studies need to analytically assess people's perception of the benefits obtained from wetlands. Greenland-Smith et al. (2016) state that assessing farmers' perceptions is essential since wetlands are useful in an agricultural context as they regulate and decrease run-off water which is usually challenging in agricultural landscapes. The HNV is frequently used in European agri-environmental policy which is grounded on conservation, in comparison to farming and policy domains being less understood than the ecological domain (Bernués et al., 2016). This is similar to the Nuwejaars Wetland Special Management Area (SMA) established by landowners working in partnership and managing their land to ensure environmental, social, economic sustainability, whilst protecting the biodiversity-rich environment (Nuwejaars Wetland Special Management Area, 2011). According to Van der Merwe (2017), the key components and principals of the SMA model have been applied in larger-scale land-use projects such as the south of the Karoo National Park near Beaufort West. The SMA model has been applied as a

management strategy in the local biosphere reserve that has been established with the assistance of the Cape Winelands Biosphere Reserve and the Cape West Coast Biosphere Reserve.

There is limited research about understanding agricultural practices that facilitate agroecosystems and ecosystem services provision, including how ecosystem services and environmental attitudes influence farmer's behaviour. Therefore, understanding people's perceptions especially landowners between the relationships of agricultural practices whilst protecting wetland ecosystem services benefiting them is essential (Greenland-Smith et al., 2016). The perceived benefits people receive from wetlands determine the likeliness of their participation in activities which guarantees a continuous supply of their desired ecosystem services (Asah et al., 2014). This may improve how management issues regarding wetlands are addressed and documented. Moges (2016) argues it is important as developing countries generally lack data on wetland biodiversity and ecology. Olarewaju et al. (2014) agree that this information can assist in policy agreements to develop balancing strategies between food security and environmental sustainability.

Olarewaju et al. (2014) illustrate that the majority of the respondents valued the direct benefits, mostly provision of food, medicinal plants, and building materials. This is similar to the livelihoods of locals that are dominated by agriculture and livestock rearing, where provisioning and cultural services were found to exceed regulatory and supporting services of wetlands in agricultural and urban land uses linked to wetlands in the forest (Moges, 2016). In the same way that Asah et al. (2014) agree that the majority of the participants perceive, attain, and use provisioning and cultural ecosystem services. Similarly, Greenland-Smith et al. (2016) result revealed that provisioning ecosystem goods and services were frequently mentioned and received more positive than negative responses.

The provision of freshwater and wildlife habitat, received more positive feedback from farmers regarding fresh water, compared to negative feedback. The provision of freshwater to farmers is essential for crop irrigation and water sources for livestock, whereas the negativity of this service was for water contamination that was unsafe for livestock. The habitat for wildlife was positively seen for the presence of attractive animals primarily turtles and the negativity was less, due to concerns of the habitats attracting species that might harm crops. Cultural ecosystem services

were the second most frequently mentioned and the positives outweighed the negatives. The recreation and tourism were repeatedly mentioned by participants, in comparison to cultural heritage, social relations, and inspiration being second. Inspiration and cultural heritage values were highly context specific as farmers draw mostly on distinct past experiences.

Few respondents appreciated environmental services such as windbreak action, nutrient cycling, and microclimate stabilisation. Moges et al. (2016) argue that the majority of the people positively viewed regulating and supporting services of wetlands but 66% of the households were not interested in conserving wetlands because of small landholdings and the need to support their livelihoods. This is similar to Greenland-Smith et al. (2016) results illustrating that regulating services received positive responses about water regulation were twice as common as negative responses that were influenced by floodwater accumulation in wetlands. Farmers discussed flood mitigation but often perceived wetlands as the root of floods which causes ecosystem disservices. In comparison, participants rarely mention supporting or regulating services (Asah et al. (2014). Greenland-Smith et al. (2016) find that supporting ecosystem services like primary reproduction and nutrient cycling were rarely mentioned by farmers. The opinions of farmers is first-hand information indicating ecosystem services important to them, which can assist in improving the valuation of ecosystem services, management, and policy directives (Asah et al., 2014). The wetlands and ponds are not equally valued and farmers consider farm ponds are most valuable in terms of ecosystem goods and services.

In Greenland-Smith et al. (2016) the study revealed that farmers' perceptions vary in different seasons yet participants were not familiar or knew of ecosystem services. They referred to ecosystem services as the economic benefits of wetlands or an obligation people have to preserve the environment. However, the farmers knew more about ecosystem services especially regulating services and grazing management, in comparison to non-farmers that knew less and were unable to relate agricultural practices and ecosystem services. The provisioning of quality food products was of high concern for non-farmers and certain cultural ecosystems services.

## **2.4 Ecosystem services**

According to the Millennium Ecosystem Assessment (2005), ecosystem services are the benefits that people obtain from ecosystems. However, 15 of the 24 ecosystem services are globally

declining, which is likely to have a negative effect on the future well-being of humans (Fisher et al., 2009). These ecosystem services are beneficial to people but the manner in which humans have used these services have changed (Millennium Ecosystem Assessment, 2005).

The provisioning services are unsustainably used, for example, the world's population increased from 3 billion to 6 billion people, meaning that food production, water usage, wood harvesting, and timber production increased (Millennium Ecosystem Assessment, 2005). The sustainable use of provisioning services varies in different locations. Austin et al. (2016) agree that it is required to produce more provisioning services mainly timber, fibre, and the food, but understanding the management of wetlands producing ecosystem services is important as well. On the contrary, Greenland-Smith et al. (2016) state it depends on the ecosystem services supplied at wetlands since all wetlands are not used in the same manner subject to the benefits people most often use. In addition, the value of ecosystem services varies by different sections of society (Pan et al., 2016).

The regulating services have changed particularly erosion and climate regulation. Erosion regulation has been degraded due to land use, crop, and soil management practices that exacerbate soil degradation and erosion. Climate regulation is altered by land use changes that add to an increase in the amount of carbon dioxide and other greenhouse gases in the atmosphere (Millennium Ecosystem Assessment, 2005). There is an increase in the use of ecosystems that provide cultural benefits generally aesthetic, recreation and ecotourism, spiritual and religious values. Aesthetic services have been degraded due to the great demand for natural landscapes for urbanisation due to a decline in the quantity and quality of regions to meet this demand. Recreation and ecotourism are degraded by the demand for landscapes with naturally occurring features such as coral reefs, which are increasingly being managed to cater for recreational practices. In addition, spiritual and religious values have been degraded due to the loss of sacred species or ecosystems (Millennium Ecosystem Assessment, 2005).

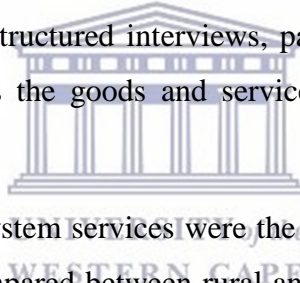
According to Daily et al. (1997), many people are aware of the role natural ecosystems services play in generating those ecosystem goods, which are traded in the marketplace, resulting in natural ecosystems being undervalued by people. When humans disrupt these systems by causing extinctions of native species and alterations of gaseous composition of the atmosphere through

fossil fuel burning, it then becomes difficult or impossible to undo what has been done already. If this current trend continues, humans will significantly alter the remaining ecosystems within a few decades (Daily et al., 1997). This is similar to the farmers in the Nuwejaars Catchment before protecting wetland ecosystems was not a priority until traditional agricultural practices were under stress (Nuwejaars Wetland Special Management Area, 2011). As a result, the natural habitat was damaged due to agricultural usage. However, the positive outcome was the establishment of the Special Management Area (SMA) initiative by balancing agriculture and conservation, whereby landowners sustainably used their land, wetlands ecosystems, and benefits (Nuwejaars Wetland Special Management Area Report, 2011).

The previously mentioned studies focused on the degradation of ecosystem services by human activities. However, what is also of significance is how people perceive the importance of certain ecosystem services. This is associated with the opinions of stakeholders, who can be defined as groups or individuals that affect or are affected by ecosystem services (Pan et al., 2016). Therefore, first-hand information is absent but informal knowledge from stakeholders and other experts is used in management interventions implemented as part of conservation programs (Austin et al., 2016). Plieninger et al. (2013) argue that studies which focus on peoples' perceptions, values, attitudes, and beliefs, generating more meaningful insights into the contributions of ecosystem services to human well-being are limited. Delgado and Marin (2016) agree that studies regarding ecosystem services are necessary and should take an interdisciplinary manner and analyse the relationship between human well-being and ecosystem services.

Austin et al. (2016) argue that there is limited data about the effectiveness of using diverse interventions in merging biodiversity conservation and ecosystem services. Including data of how the benefits of both may offer opportunities for conservation management and providing a wide range of ecosystem services. Although Austin et al. (2016) suggest that the relationship between biodiversity and ecosystem service provision is positive, it can be complex depending on the service. This relates to the area of study located within a biodiversity-rich area on the Agulhas Plain where agricultural practices and conservation are viewed as contradictory practices.

The contingent valuation method is used to estimate economic values for the ecosystem and environmental services. It can be used to estimate both use and non-use values and although it is mostly used for estimating non-use values (Pan et al., 2016). This method has only been used by a few ecological studies since integrating public opinions with environmental decision-making has only been promoted recently. The contingent valuation method has frequently been used in developed countries but is less frequently applied in developing countries (Pan et al., 2016). This method was applied in a study by Pan et al. (2016) used to assess the use and prioritisation of ecosystem services by people in rural and urban areas in China. The analyses of different stakeholders' perceptions regarding ecosystem services could provide essential information for setting environmental protection goals and assist in linking scientific research and policy (Pan et al., 2016). The majority of the studies previously mentioned used focus groups and interviews as data collection tools whereas Plieninger et al. (2013) used participatory mapping for a spatial perspective of how participants perceive ecosystem services. This study is using similar data collection techniques such as semi-structured interviews, participatory mapping and the WET-EcoServices tool designed to assess the goods and services provided by palustrine wetlands (Kotze et al., 2009).



In Pan et al. (2016) freshwater ecosystem services were the main focus and the perceived value of these ecosystem services was compared between rural and urban communities in China. The results of the study revealed that rural and urban participants used and prioritized different ecosystem services. This is similar to the study of Bernués et al. (2016) which revealed that farmers and non-farmers knowledge about ecosystem services were different. The most frequently used freshwater ecosystem services by rural participants provided by the local river are recreation (walking), water (washing), microclimate regulation and views of the river. Freshwater ecosystem services predominately recreation for walking, fishing, and the view of the river were less frequently used by participants in urban areas. Participants in rural areas prioritised ecosystem services such as recreation (walking), water (washing), and the view of the local river. Urban participants mainly prioritised recreation (walking and fishing), view of the river, sense of place, flood prevention and wildlife (Pan et al., 2016). This showed that participants in urban areas prioritised direct and indirect ecosystem services, compared to participants in rural areas who mostly prioritised direct ecosystem services. The farmers

frequently mentioned direct services particularly grazing management and regulation, especially the connection the two have regarding agriculture. Whereas, the non-farmers seldom mentioned regulating services and were concerned about the provisioning of quality food (Bernués et al., 2016).

The study by Kaplowitz (2000) showed similar results illustrating that the majority of the people mentioned direct ecosystem services especially provisioning services compared to recreational services. However, the participants also mentioned the beauty of the mangrove often during focus group sessions, compared to interviews resulting in participants significantly declaring diverse ecosystem services (Kaplowitz, 2000). Plieninger et al. (2013) argue that aesthetic values are repeatedly mentioned ecosystem services, followed by recreational practices like walking, cycling, and educational values. Spatial patterns in terms of cultural services, sense of place were frequently ascribed to settlement areas and disservices to loud unpleasant places like a campground and Kleinsaubernitz settlement. Likewise, to Asah et al. (2014) study participants disclosed in-depth information and frequently mentioned provisioning and cultural ecosystem services compared to them rarely mentioning regulating or supporting ecosystem services. The common provisioning services were fishing, game and assorted plants and the cultural services comprised of spiritual benefits, aesthetics, tranquillity and the attractiveness of the area. The forest areas were ascribed as fearful in comparison to grassland and croplands that were barely linked to perceiving cultural services (Plieninger et al., 2013). This is an illustration of people expressing their thoughts about ecosystem services being beneficial in terms of ecosystem services valuation and compliance with ecosystem management and policy directives. Furthermore, this encourages people to use the services by enhancing their experiences, improving their attitude and behaviour towards the environment (Asah et al., 2014).

## **2.5 Climatic variability and climate change**

Climate variability is conceptualised as variations in the climate system over a short time scale in terms of months, years, or decades. On the other hand, climate change is conceptualised as a long-term change in the earth's climate, especially a change due to an increase in the average atmospheric temperature (Finlayson et al., 2006). The studies by Finlayson et al. (2006) and Mubaya et al. (2012) similarly highlight the differences in climatic variability and climate



change according to the variations in time-scales. The view of Dang et al. (2014) on climate change emphasises the direct and indirect human activities causing the changes in climate.

#### 2.5.1 Farmers perceptions of climatic variability and change

Ayal and Filho (2017) defines perception as a procedure by which information or stimulus is received and converted to form psychological awareness. Therefore, according to West et al. (2001) stakeholder's perceptions regarding the climate changing are formed by events occurring instead of observations of metrological trends (West et al. 2001). Furthermore, farmer's perceptions of drought were driven by their direct experience, which may constrain their anticipation about environmental changes in future (Dang et al., 2014). The farmers perceive the same stimulus of climate change or climatic variability differently based on their previous experiences, usually being formed due to prolonged experiences (Ayal and Filho, 2017).

The perceptions farmers form result from their long experiences of events caused by climatic variability and change generally flooding, and changes in rainfall periods instead of metrological trends (West et al., 2001). On the contrary, farmers do observe meteorological trends and their perceptions can be linked to metrological records and scientific understandings of regional climate vulnerability vis-à-vis El Nino–Southern Oscillation and Pacific Decadal Oscillation (West et al., 2001). Vedwan and Rhoades (2001), states that understanding farmers perceptions of climatic variability and change are important, instead of just the consequences caused by changes in the weather and climate impacting farmer's socially and economically (Vedwan & Rhoades, 2001).

Previous studies regarding climate vulnerability focused on the potential use of seasonal forecast by stakeholder groups, which is likely grounded on the notion of predicting the direction of climate variability in future (West et al. 2001). In contrast, the study by West et al. (2001) highlights the importance of understanding how people perceive past variability, which is an essential first step of the forecasting process. Dang et al. (2014) shed light on farmer's perceptions of climate variability in the Mekong Delta and their adaptive responses. The studies by Ayal and Filho (2017) and Mubaya et al. (2012) focus on farmer's perceptions about global change and the various indicators of climatic variability and its effects on farmer's livelihoods. This similar to smallholder farmers perceptions of climatic variability and change in Nigeria and

how it impacts their adaptation strategies (Babatolu and Akinnubi, 2016). Similar to farmers livelihoods impacted by climatic stressors caused by climatic variability and change in Zimbabwe and Zambia. The study by Vedwan and Rhoades (2001) also aims towards understanding people's perceptions and relative direction and impact are to apprehend patterns in human responses.

The impacts of the changes caused by climatic variability and climate change such as droughts and flood hazards can lead to production losses to farmers, which is prominent in developing countries, especially in areas depending on agriculture or forms part of a source of income (Babatolu and Akinnubi, 2016). Mubaya et al. (2012) mention that southern Africa is generally expected to experience increased droughts and floods. According to Elum et al. (2017) people in Africa may be exposed to extreme water stress and South Africa has been identified as highly vulnerable to climate change impacts. This is relevant to the current study; the Agulhas Plain where agriculture forms part of landowners business and in general consists of grain, dairy and wine farmers, which have experienced large flood occurrences in 1978 and 2005 during which farmers were stranded and lost their livestock (Bailey, 2005).

Therefore, understanding farmer's perceptions of climatic variability and change are important before educating or creating awareness programs, it also helps to understand the reasons in the manner they respond to different situations or impacts. This will result in understanding perceptions or misconceptions of farmers regarding climatic variability and change, before addressing or implementing strategies to assist with drought or floods. Likewise, farmer's perceptions and knowledge can be integrated with scientific knowledge in order to design or improve adaptive strategies in order for farmers to respond effectively to climatic variability and climate change (Ayal and Filho, 2017).

Mubaya et al. (2012) state that the majority of the farmers in Africa have identified that there is an increase in temperature and a decrease in rainfall levels and duration. However, Haitayezu et al. (2017) disagree by mentioning that a substantial number of farmers hardly identify climate change, which is more noticeable in farmers in South Africa. According to Haitayezu et al. (2017), the public in South Africa is aware of climate change but the farmers in Limpopo,

Mpumalanga, North-West, Eastern Cape, and Gauteng who practice small-scale farming have noticed changes in the weather distribution.

There is still a need for research regarding farmers' perceptions of climatic variability and climate change effects on crop and livestock production, as well as studies about exploring how farmers perceive climatic variability and change linking to adaptive responses (Dang et al., 2014). According to Babatolu and Akinnubi (2016), the awareness and knowledge of climate change by smallholder farmers in Nigeria are to some degree limited, including their understanding, management, and perceptions of climate change. Likewise, Haitayezu et al. (2017) mentions the importance of investigating the low levels of awareness and misconceptions of climate change in small-scale farmers in Africa, limiting the success of climate change policies.

The study by West et al. (2001) revealed perceptions of increased drought occurrences, aridity, and fluctuations in summer and winter precipitation. The area has previously experienced drought occurrences and monsoonal precipitation (West et al., 2001). The perceptions of increasing aridity (73.7%) and fluctuations in summer and winter precipitation (57.9%) had the highest rates compared to the other perceptions that were expressed. There is a strong correlation between the perception that precipitation is becoming more winter dominant and rainfall data, which is valid on time-scales of at least decades (West et al., 2001).

The results of the study by Dang et al. (2014) were similar to the previous study about farmers' perceptions. The study discovered that farmers noticed an unusual temperature increase and fluctuation in various ways. Firstly, increases in the annual mean temperature and the temperature in the dry season. Secondly, a shift in the temperature distribution and the dry season days were perceived to be warmer. This is relevant to the current study that will focus on landowners and how climatic variability and climate change has impacted wetland ecosystem services. The farmers in this region are able to identify climate variability on periods of at least a decade. The highest correlation is shown with perceptions concerning seasonal precipitation and climatological explanations of climate variability (West et al., 2001).

The study by Ayal and Filho (2017) showed that the majority of the farmers perceive that the increasing temperature is caused by climatic variability. In addition to, their perceptions about the increased temperature correspond with meteorological records, together with consistent scientific claims regarding temperature increase in Ethiopia. Farmers also observed occurrences of early rainfall and drought consequently being a problem for agriculture. Elum et al. (2017) results are similar to the previous study by Ayal and Filho (2017) shows that farmers experience of the changing climates can be substantiated with weather data illustrating that climatic parameters have significantly changed over time. For example the weather in South Africa has significantly changed; Gauteng has the least variability in minimum temperature compared to Limpopo with the highest maximum temperature. Mpumalanga received the highest amount of rainfall, even though the precipitation has reduced and Limpopo's maximum temperature has decreased. The provinces (i.e. Gauteng, Limpopo, and Mpumalanga) average rainfall has decreased but there mean temperatures increased during sub-periods 1985-1999 and 200-2014 (Ayal and Filho, 2017).

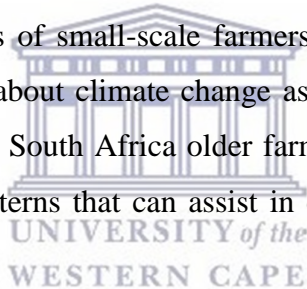
The metrological data analysis indicates that the increase in rainfall intensity corresponds with farmers' remarks. However, there was a difference between farmer's perceptions and the meteorological data regarding the seasonal and annual rainfall patterns. The meteorological data explains the changes in climate through temperature and rainfall statistical averages and absolute terms. In comparison, farmers explained changes in climate according to previous experiences of extreme events (Ayal and Filho, 2017). Furthermore, the results of Elum et al. (2017) show that the farmers' perceptions and knowledge about climate change issues could be attained through media (normally the news), although most of them indicated that they have noticed an increase in temperature.

The age, sex, income, and education level of farmers contributed to their perceptions about the effects of climatic variability on crop and livestock production. These social demographic factors can significantly predict the tendency of farmers perceiving seasonal climate change (Haitayezu et al., 2017). This is an indication that farmer's personal experience and analytical information processing of climate change information results in them identifying changes in KwaZulu-Natal (KZN), South Africa climate. Farmers' worldviews are associated with their climatic risks

observations, those farmers believing that all people are equal and deserve equivalent rights and opportunities highly believe in climate change. This illustrates those farmers values can determine the amount of attention given to climate change information.

According to Haitayezu et al. (2017) educated farmers in KZN have opportunities outside of agriculture, which are less climate change sensitive. Compared to, uneducated farmers that are dependent on agriculture and will often take climate change into consideration than educated farmers. The farmers of KZN are different compared to farmers in the Nuwejaars catchment understanding the importance of the wetland ecosystems and the biodiversity in the area. Therefore, the farmer's in the Nuwejaars Catchment practice sustainable agricultural methods and takes climate change into consideration (Nuwejaars Special Management Area, 2011).

According to Haitayezu et al. (2017) these studies are mostly conducted in developed countries, whereas this is the first study conducted about valuable past experiences and description-based perceptions of climate change issues of small-scale farmers in South Africa. In Europe, older people ought to have sceptic views about climate change as a result of politically conservative and traditional standards, whereas in South Africa older farmers have knowledge and access to previous explanations of climate patterns that can assist in current climate change information (Haitayezu et al., 2017).



The results of the study by Haitayezu et al. (2017) show the contrast between the decreasing rainfall trend and the insignificant increase in the annual minimum temperature. However, this covers the huge differences in the normal distribution of rainfall and the temperature across several seasons. The increasing temperature causes a decrease in rainfall patterns, throughout mid-summer to autumn, which impacts the spring being the early growing season. In addition to, the early winter rainfall and slightly warming patters are caused by increasing temperatures which impact the winter period.

The results of the study by Babatolu and Akinnubi (2016) were similar to previous studies; the findings revealed that there is a high level of climate change awareness in the Upper and Lower Niger basin. According to Mubaya et al. (2012), 70% of the farmer's in Zambia and Zimbabwe have been aware of the changes in the weather patterns for 5 years. The farmers in Zambia have

experienced an increase in floods and excessive rain. In comparison to, farmers in Zimbabwe that has received the lowest floods, since farmers have observed excessive rainfall periods and not floods per se. There were a substantial number of farmers that have confirmed that there have been changes in the temperature of the climate, including irregular, heavy, and increasing rainfall. The long-term impacts of climatic variability and change have led to regular floods; drought and changes in the rainfall period, which previously occurred in the planting season but now results in heavy cloudburst causing floods and little infiltration. The majority (50%) of the farmers mentioned they have observed an increase in rainfall but 30% disagree and stated they have observed no changes in the annual rainfall period, although it has varied yearly. The traditional knowledge and indigenous technologies farmers use minimize crop failure and increase harvest stability, and reduces the vulnerability to climatic variability and change (Babatolu and Akinnubi, 2016).

The farmers in Zambia and Zimbabwe believe that climatic variability is a natural phenomenon without any human intervention causing this phenomenon; this belief is more frequent among farmers in Zambia than Zimbabwe. The natural causes that lead to a change in the climate are believed to just occur as expected in winter, high and low temperatures, changes in wind movements (Mubaya et al., 2012). This indicates that farmers consider the anthropogenic activities increasing the contribution to climatic variability and change. However, farmers in Lupane and Lower Gweru, Zimbabwe proclaim that climate change is a result of a wrath between cultural spirits and God who has allocated punishment to Zimbabwe. The punishment is allocated since people have failed to appease their spirits and conduct traditional rites, especially the rain making ceremony (mukwerra) by asking God for rain and showing appreciation for the previous season's rain. This is an indication that socio-cultural and spiritual factors dictate farmer's perceptions about the causes of climatic variability and should be considered as this could result in environmental management issues as farmers may not notice the importance environmental management activities.

The study by Ayal and Filho (2017), recommends that farmers in Ethiopia should understand that the issues in the area are not the gradual amount of rainfall but the irregular duration and supply of rainfall. There should be less emphasises placed on farmer's life experiences and more

emphasises placed on determining the likelihood of extreme events such as drought, flooding and dry spells caused by climatic variability that will be more beneficial for agriculture. On the contrary, Elum et al. (2017) state that South African farmers are experiencing these issues regarding climate change and are adapting to the conditions but an integrated approach should be used to address multiple problems and experiences. Therefore, indigenous knowledge and scientific information is essential to begin an approach to address multiple issues about climate change. Likewise, to Hitayezu et al. (2017) recommends that positive encouragement and communication should be used since it promotes a sense of empowerment, personal control, and support. Communication about climate change should be well aligned with individual's local beliefs, values, and norms but not offend any religious views, cultural, and socio-political differences. The study by Mubaya et al. (2012) suggests that educational programs should be implemented for farmers and other stakeholders about climate change and variability, including their potential impacts on farmer's livelihoods. This will strengthen their capacity and institutions for noticing and assessing climate variability.

#### 2.5.2 Climatic variability and climate change on wetlands

Wetlands are highly dependent on water levels and provide a range of direct and indirect goods and services to the surrounding environment and people. Therefore, changes in climatic conditions primarily dry and wet seasons, the severity of extreme events floods and droughts, in particular, will impact the structure and functioning of wetlands (Lloréns, 2008). Although, wetlands are usually considered as resilient and may have the ability to function, despite the changes in the environment the rapid changes in climate may lead to over-imposing of new environmental systems that will outdo the resilience of thresholds of wetlands (Millennium Ecosystem Assessment, 2005).

The study by Lloréns (2008) focuses on the impacts of climate change on inland, low-lying, and coastal wetland ecosystems. Inland wetland ecosystem services depend on the rate and magnitude of temperature and water obtainability from precipitation and runoff compared to sea level and storm surges in coastal and low-lying wetlands. This will cause a change in regulating and supporting ecosystem services providing suitable habitats for fauna species, hydrological systems, sediment inputs, and nutrient loadings. Similar to Finlayson et al. (2006) study highlighting the impacts of climatic variability and climate change on wetlands but specifically

at how water birds adapt. However, Knapp et al. (2014) focuses on the differences in precipitation systems in wet and dry years.

The study by Finlayson et al. (2006) shows it is important to develop an understanding on how climate change, climatic variability, and human activities affect wetland ecosystems. This is important as the impacts of climate change can affect the ecosystem services provided by the wetland ecosystems and the water bird populations, habitats and migration patterns.

The study by Finlayson et al. (2006) results revealed that lakes will be influenced by climate change through warmer temperatures, extensive ice-free seasons, and variations in the hydrological cycle. The surface area, depth, exposure to wind and the location of the lake will determine how climate change would impact the lake. The water supply and level will be differently impacted by climate change. In the case, of water supply, it depends on the source of the water supply like glaciers, snowmelts, rain or aquifers and the water levels in higher altitudes will increase since climate models predict an increase in precipitation, whereas water levels between mid and low latitudes are likely to decline (Lloréns, 2008). This is an illustration that the changes in climate will impact regulating and supporting ecosystem services which provide habitats for fauna and flora. For instance, it will modify the habitat for fish that are suitable for cool or warm water temperatures. The endorheic lakes and temporary water bodies are vulnerable to climate change due to changes in the balance of inflows and evaporation. The lake levels might vary as well cause of the increase of evaporation and precipitation but the water turnover rate would likely accelerate (Lloréns, 2008).

The precipitation changes generally in rainfall patterns and the intensity is a result of climate change. Therefore, some areas experience rainfall later than usual and intense rainfall on fewer rain days. Likewise, in Finlayson et al. (2006) revealed that fluctuations in the global circulation patterns will result in alterations in rainfall patterns, causing regions to experience increasing or decreasing the rainfall amount. This will result in enhanced flooding events which lead to an increase in silt, pollutants, and organic matter entering streams and rivers, degrading the water quality which can impact the species in the river. Finlayson et al. (2006) mentioned that certain regions in Asia and Africa will be vulnerable to droughts as El Nino events have become more frequent and regions in Europe will experience an increase in sea-level rise, which is caused by



increasing temperature resulting in the thermal expansion of seawater and extensive loss of land ice. For example, this can relate to the Agulhas Plain flood occurrences in July 1978 and April 2005 impacting landowners, communities, livestock, businesses, and wetlands in the region (Fourie, 2005 and Bailey, 2005). Furthermore, arid and semiarid regions become drier causing decrease flows that result in reduced connectivity of the river, including floodplain and riparian zones because of reduced streamflow and aquatic diversity. In arid and semiarid regions long periods of low flows are common, but rewetting is critical for maintaining the ecosystem structure and functioning.

The study by Finlayson et al. (2006) discovered that there will be more adverse impacts than beneficial impacts on wetlands. Inland and coastal wetlands will experience large and early impacts of climate change and variability. Increased levels of inundation, storm flooding, augmented coastal erosion, seawater intrusion into fresh groundwater, encroachment of tidal waters into estuaries and rivers. The sea surface and ground temperatures will increase and have an impact on aquatic and terrestrial fauna and flora (Cleber and Silva, 2012). The bird species specifically migratory and nomadic bird populations that depend on coastal habitats will be adversely impacted by climate change. The decrease in wetlands and the duration of flooding in arid and semi-arid areas result in changes and loss of habitats. The rainfall fluctuations can cause changes in wetlands, water bird habitats, and populations, due to the reduced water flow and habitat loss as a result of agriculture (Finlayson et al. 2006).

In conclusion, this review has strongly emphasised the importance of peoples more specifically landowners' perceptions regarding wetlands, ecosystem services and climatic variability and climate change. There is a need to understand how people value wetlands and ecosystem services provided how people in close or far proximity to wetlands perceive and use ecosystem services. In relation to the study it is important to understand landowner's perceptions about wetland ecosystem services and their agricultural practices since it is perceived as incompatible (Greenland-Smith et al., 2016).

## **Chapter 3 Research Methods: Mixed Methods Approach**

### **3.1 Introduction**

This chapter includes a more in-depth framework of the mixed methods approach applied to the study. The research approach comprises of qualitative and quantitative data collection tools used together to collect data. The establishment of the mixed methods approach is pragmatism. The three data collecting techniques used in the research are also discussed. The data was analysed using content analysis and ArcGIS 10.3.1. Ethical considerations, research limitations, or problems encountered throughout the study will also be discussed.

### **3.2 Research Approach**

The mixed methods approach was used to collect, analyse, and integrate both quantitative and qualitative data for this particular study (Creswell, 2003). The approach integrates numeric and text information to enrich the understanding of the research problem. The purpose of combining both quantitative and qualitative research methods within the study was to explain or elaborate on the numeric results derived from the WET-EcoServices assessments with subsequent text information resulting from interviews and participatory mapping. Comparing quantitative and qualitative data sets to produce authentic conclusions can enhance the study with a complementary data set (Maree, 2010).

According to Creswell (2003), the mixed methods approach is established on pragmatic knowledge claims. Pragmatic knowledge considers the consequences of actions, is problem-centered and pluralistic. This is considered the best philosophical foundation to justify the integration of both methods in a single study (Maree, 2010). Maree (2010) states a study's research questions are more important than the methods used to answer them or the fundamental philosophical views of individual methods. Hence, pragmatism is not devoted to one particular philosophy and reality but allows researchers to make use of quantitative and qualitative standards (Creswell, 2003).

The structure of the research approach is sequential, concurrent and transformative and only one formed part of the study. Sequential is when a researcher expands the outcomes of one method with another method. Concurrent comprises joining both forms of data to providing an inclusive analysis of the research problem. Transformative is when a theoretical lens is used as a central

perspective within a design comprising of qualitative and quantitative data (Creswell, 2003). The data collection strategy was sequential, comprising of data being collected in two separate phases. Firstly, the WET-EcoService assessments were completed followed by the interviews and participatory mapping to best comprehend the research problem. The assessments gave an overall understanding of the different ecosystem services provided by the wetlands, in addition to the interviews and participatory mapping results providing an in-depth view of this from participants. This method complemented the aim and objectives of the study.

### **3.3 Data collection techniques**

Data collection was conducted using three techniques:

- Four in-depth interviews with 3 landowners and one local resident from Elim
- Participatory mapping exercises with 3 landowners (including those already interviewed)
- Formal ecosystem services assessments at 5 wetlands using the WET-EcoServices tool (Kotze et al., 2009).

The data collection commenced in November 2016 and concluded May 2017. The data collection in November included the completion of the WET-EcoService assessments at five wetland locations, comprising of classifying wetlands according to their hydrogeomorphic units (HGM units) and scoring selected ecosystem services at five wetlands. The interviews and participatory mapping took place in May and at landowner's homes, the Nuwejaars Wetland Special Management Office and at the Department of Agriculture's boardroom. The interviews and participatory mapping sessions were recorded using a voice recorder in addition to notes being taken.

#### **3.3.1 Interviews**

The Nuwejaars Wetland Special Management Area (NWSMA) consists of 25 landowners, three landowners were interviewed and one interview with a local from Elim. All interview material was provided in English as well as in Afrikaans given the location of the study area (Appendix A). Interviewees were selected through snowball sampling and previous participants were referred by another researcher in the field. The interviews were semi-structured and consisted of open and close-ended questions covering the main themes like perceptions of wetlands,

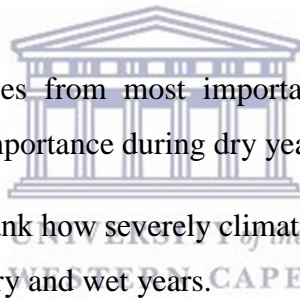
ecosystem services, and climatic variability. The full interview, including the participatory mapping exercise described below, was 45 minutes to 1½ hours.

### **3.3.2 Participatory mapping**

Participatory mapping is a set of approaches and techniques that combine tools of contemporary cartography with participatory methods to represent the spatial knowledge of local communities. The duration of each mapping exercise was 15 to 20 minutes. The participatory mapping exercises commenced with an introduction to the study and the purpose of the mapping exercise (Appendix B). Thereafter the participant and researcher addressed the information and consent form together; making sure the participant understood and agreed to what has been stated in the information and consent form.

The participants were shown a map of the Agulhas coastal Plain wetlands and asked to:

- Draw on the map to indicate wetlands in the landscape that they perceive as providing ecosystem services.
- Rank the listed ecosystem services from most important (5) to least important (1). The participants ranked the services by importance during dry years and wet years.
- Lastly, participants were asked to rank how severely climatic variability and climate change has impacted the ecosystem services in dry and wet years.



### **3.3.3 WET-EcoServices**

The WET-EcoServices tool may be used to evaluate the goods and services each wetland provides, in order to support informed planning and decision making (Kotze et al., 2009). The tool is designed specifically for palustrine wetlands (i.e. marshes, vleis, floodplains, and seeps). The WET-EcoServices tool provides a procedure for scoring the importance of a wetland in providing each of the 15 various ecosystem services. Firstly, wetlands were characterised according to their hydro-geomorphic setting. Ecosystem service delivery was assessed on level 2, which was grounded on a field assessment of the key descriptors. Vöelvlei, Karsrivierlei, Soetendalsvlei, Wiesdrift, and Waskraalvlei (figure 2) were classified and assessed using the WET-EcoServices tool.

The following ecosystem services were assessed:

- Water quality enhancements (i.e. sediment trapping, phosphate, nitrate and toxicant assimilation)
- Flood attenuation
- Tourism and recreation
- Provision of water for human use
- Provision of harvestable resources
- Education and research.

### Wetlands of the Nuwejaars Catchment



Figure 2 Wetlands classified and assessed using the WET-EcoServices tool

### 3.4 Data Analysis

The interviews were recorded using a voice recorder and were then transcribed and typed within 24 hours. The content analysis technique was used to systematically categorise texts that were mentioned frequently by participants into themes, in addition to identifying differences and similarities in textual information derived from the interview transcriptions. The maps from the

participatory mapping exercise were scanned and digitized displaying a visual map with all the ecosystem services participants drew on the maps using ArcInfo 10.3.

### **3.5 Ethics**

In January 2017 the researcher received ethical clearance from the Humanities and Social Sciences Research Ethics Committee at the University of the Western Cape. The researcher received the research permit from Cape Nature as De Mond Nature Reserve (Heuninges Estuary) is managed by CapeNature and form part of the study. Participants were informed about the study and the researcher provided all participants for interviews and participatory mapping exercises with an informed consent form. Consent forms and information sheets were provided in English and Afrikaans (Appendix A and B).

In order to protect participants their original names were not mentioned instead pseudonyms was used. Research records were kept safe in a locked file and electronic information was coded with a secured password. They will all be deleted 5 years after the research has been completed. Audio records were used and only the researcher and supervisor have access to them. The audio information and transcripts are secured with a password and will be destroyed in 5 years.

### **3.6 Limitations/ Problems encountered**

The researcher had no prior knowledge on how to use the WET-EcoService tool before the fieldwork commenced. Therefore, it was sometimes challenging or confusing with the technical requirements but the researcher became more confident using the tool with the assistance and support from the mentor. It was challenging at times to get in contact with the landowners since there was no contact information available of landowners on the NWSMA website. However, the researcher knew a few landowners from previous encounters and was introduced to them by researchers whom they previously interviewed. Although, the researcher emailed the chairperson of the committee no reply was received, in addition to the researcher being unable to attend NWSMA meetings. The scheduling of meetings or interviews were an issue at times, landowners were either out of town or busy when the researcher arrived at their homes. There were two occurrences that the participants suggested the researcher should draw on the map, where they indicate on the map during the participatory mapping.

In conclusion, the mixed method research approach complemented the aims and objectives of the study, allowing qualitative and quantitative methods to be used in order accomplish the aim of the study. The data collection methods revealed in-depth data from the interviews, participatory mapping and the WET-EcoServices illustrating effectiveness and opportunity of the ecosystem services at the wetlands.



## Chapter 4 Agulhas Plain wetlands WET-EcoServices Assessments

### 4.1 Introduction

This chapter presents the hydrogeomorphic (HGM) units and the scoring of five wetlands of the Agulhas coastal Plain using the WET-EcoServices tool. The hydrology and geomorphology influences wetlands landform characteristics, processes and functions, regardless of the climate, soils and vegetation (Ollis et al., 2013). In other words, the HGM unit provides an indication of the wetlands features and how it functions. The wetlands were classified according to their hydrogeomorphic (HGM) type and the relevant ecosystem services of each wetland were assessed using the WET-Ecoservices tool (Kotze et al., 2009).

### 4.2 Selected wetlands in the Nuwejaars Catchment

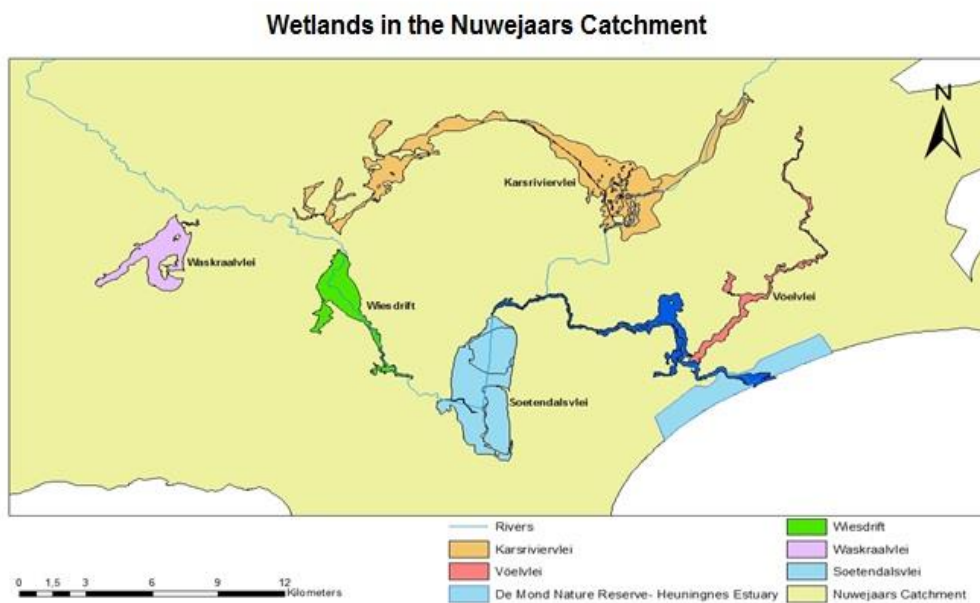


Figure 3 Wetlands in the Nuwejaars Catchment

The wetlands were classified according to their hydrogeomorphic characteristics (Figure 3). Hydrology is the presence or movement of water while geomorphology is the landform characteristics and processes (Ollis et al., 2013). The classification of HGM types take place because wetlands that fit into the same HGM type and parallel climate or geological setting are likely to have a similar structure and process (Kotze et al., 2009). The selected wetlands



(Appendix C) were mostly valley-bottoms (channelled) and two represent a depression/unchannelled valley-bottom or channelled valley-bottom setting (Table 1). This is a result of both wetlands presenting characteristics of two HGM unit types.

Table 1 HGM type of the Agulhas Plain wetlands

HGM Unit	Wetland	Hydrogeomorphic (HGM) type
1	Vöelvlei	Depression / Unchannelled valley-bottom
2	Karsriviervlei	Channelled valley-bottom
3	Soetendalsvlei	Depression / Channelled valley-bottom
4	Wiesdrift	Channelled valley-bottom
5	Waskraalvlei (also known as Waagschaalvlei)	Channelled valley-bottom



#### 4.2.1 HGM unit 1- Vöelvlei

#### HGM Unit 1- Vöelvlei



Figure 4 Vöelvlei Source: National Geospatial Information (NGI), Department of Rural Development and Land Reform (DRDLR)

The wetland shows no distinct river channel but there is an abandoned river course (i.e. Droërivier) that flows into the Heuningnes River north-east of De Mond (Pauw, 2012). There are micro-depressions within the wetland that are filled with water during winter and grass throughout summer which is used for livestock to graze. The surrounding catchment of Vöelvlei is used for agricultural activities. Vöelvlei vegetation consists mostly of grasses, restioids while reeds (*Phragmites australis*) are found in certain parts of the wetland. The HGM unit's slope is 1.2%. Charismatic species such as the blue crane and flamingos are present.

#### 4.2.2 HGM unit 2- Karsriviervlei

##### HGM Unit 2- Karsriviervlei



Figure 5 Karsriviervlei Source: National Geospatial Information (NGI), Department of Rural Development and Land Reform (DRDLR)

The Karsrivier flows into the top of the wetland as a distinct channel, but then floods out into multiple distributaries, before reforming toward the wetland to. In addition to the river channel, water is derived from adjacent slopes and the Poortrivier. A number of furrows have been used to drain portions of the wetland. The slope of the HGM unit is 1.1 %. The adjacent catchment land is used for cultivation for crops and grazing for livestock. The upper Karsriviervlei

vegetation mostly comprises of short grasses, and reeds, whilst the lower section of the wetland is moderately covered with restioids and sedges.

#### 4.2.3 HGM unit 3- Soetendalsvlei

##### HGM Unit 3- Soetendalsvlei



Figure 6 Soetendalsvlei Source: National Geospatial Information (NGI), Department of Rural Development and Land Reform (DRDLR)

The wetland is mainly fed by the Nuwejaarsriver and during time of high flow the excess flows into the channel that joins the Kars River forming the Heuningnes. The Heuningnes Estuary is located within the De Mond Nature Reserve. The northern and western shores of Soetendalsvlei are dominated by dense reeds (*Phragmites australis*). The slope of the HGM unit is 1.5%. The surrounding catchment area is used for reed harvesting, livestock grazing and cultivation of canola and wheat (Gordon et al., 2011). The wetland and catchment are home to a variety of birds making it a good place for recreational activities like bird watching. The wetland is unusual in that it resembles a depression, but it has an inlet and outlet. While large portions are permanently flooded and lacustrine in character, the upper portions resemble a channelled valley bottom wetland.

#### 4.2.4 HGM unit 4- Wiesdrift

### HGM Unit 4- Wiesdrift

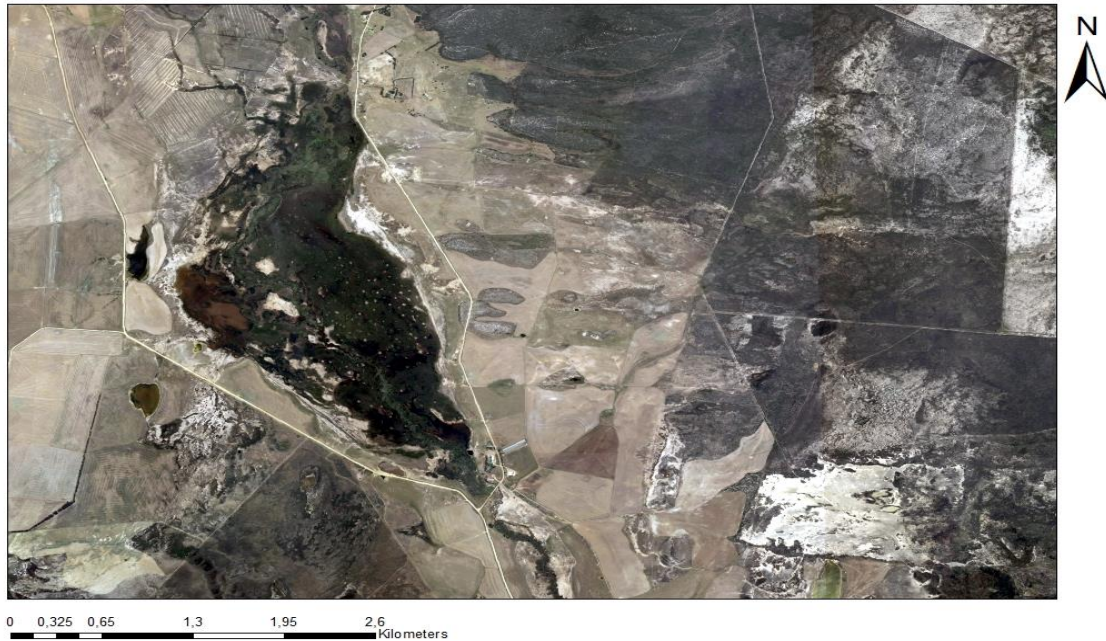
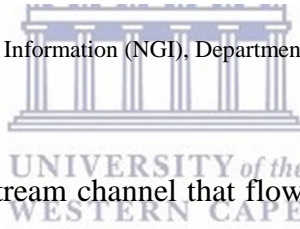


Figure 7 Wiesdrift Source: National Geospatial Information (NGI), Department of Rural Development and Land Reform (DRDLR)



The Nuwejaarsrivier is the distinct stream channel that flows throughout the wetland. Wiesdrift vegetation comprises of sedges (*Cyperaceae*) and restioids (*Restionaceae*) while the valley slope is 2%. Cultivated land, grazing for livestock and dairy farming are part of the land usage. The catchment area comprises of cultivation of land practices such as grazing for livestock and dairy farming.

#### 4.2.5 HGM unit 5- Waskraalvlei (Waagschaalvlei)

##### HGM Unit 5- Waskraalvlei



Figure 8 Waskraalvlei Source: National Geospatial Information (NGI), Department of Rural Development and Land Reform (DRDLR)

The wetland is dominated by reeds (*Phragmites australis*) and sedges (*Schoenoplecthus sp.*). The channel flowing through the wetland is the Nuwejaarsriver. The HGM unit slope is at 1.1%. Waskraalvlei is home to a variety of wildlife buffalo, hippotami, bontebok, and quagga which are a great tourism attraction. The hippopotami assist with wetland management by walking through the wetland and unclogging channels (Pauw, 2012).

### 4.3 Results of effectiveness and opportunity scores

The comparison of wetland ecosystem service scores (Appendix D) are provided in Table 2. The wetlands ecosystem services are compared according to effectiveness of the services delivered and opportunity it provides the services (Kotze et al., 2009). The likely extent to which a benefit is supplied are rated as low (<0.5), moderately low (0.5-1.2), intermediate (1.3-2.0), moderately high (2.1-2.8) and high (>2.8).

The WET-EcoServices tool designed for palustrine wetlands indirect ecosystem services were scored using the tool, excluding Soetendalsvlei as a lacustrine wetland (Gordon et al, 2011). This refers to non-tidal wetlands dominated by reeds, shrubs, or trees; however, Soetendalsvlei is a lake and has an extensive bed of reeds on the northern and southern shores too. Therefore, Soetendalsvlei and previously mentioned wetlands direct ecosystem services were all scored using the WET-EcoServices tool.

Table 2 Overall WET-EcoServices effectiveness and opportunity scores

WET-EcoServices Effectiveness and Opportunity Scores									
Ecosystem Services	Vöelvlei		Karsriviervlei		Soetendalsvlei	Wiesdrift		Waskraalvlei	
	E	O	E	O		E	O	E	O
Flood attenuation	1,4	0,9	1,4	0,9		1,7	2	1,6	1,1
Sediment trapping	1,2	3	2,6	3		1,8	3,3	1,3	3,7
Phosphate removal	3,1	2,7	2,7	2,7		2	3,3	2,1	3
Nitrate removal	3,8	3,5	2,6	3		2,3	3,5	2	3
Toxicant removal	3,2	2	2,9	2,7		2,4	3,3	2,1	2,7
Overall score rating for direct ecosystem services									
Water Supply for human use	1,3		1,9		2,3	1,9		2,1	
Harvestable natural resources	1,4		0,8		1,4	1,2		1	
Tourism and recreation	1,6		1,3		1,4	2		3,1	
Education and research	3,3		2		3	2,3		2,8	
Legend :	Low	Moderately low	Intermediate	Moderately High	High				

#### 4.3.1. Flood attenuation

The effectiveness of flood attenuation provided as a service is moderately low in Vöelvlei, Karsriviervlei, Wiesdrift, and Waskraalvlei. However, there is less opportunity for flood attenuation supplied as a benefit to Vöelvlei, Karsriviervlei, and Waskraalvlei. In comparison to,

Wiesdrift having a moderately low chance of flood attenuation in future due to low contribution of inherent soils in the catchment. Flood attenuation in Karsrivierlei, Wiesdrift, and Waskraalvlei is less effective due to the HGM unit type. In contrast, Vöelvlei (unchannelled valley-bottom) share characteristics of depressions which have limited opportunity for reducing floods (Kotze et al., 2009). The wetlands are unable to reduce the flow of water and the severity of floods primarily because the surface roughness of the wetlands are moderately low offering only a slight resistance to water flow. The upper reaches of Karsrivierlei has more robust vegetation offering a higher resistance to water flow compared to the lower reaches being moderate. Another contributing factor to the low flood attenuation scores is the sinuosity of the channel, which is low in Vöelvlei, moderately low in Karsrivierlei and Soetendalsvlei and intermediate in Wiesdrift and Waskraavlei.

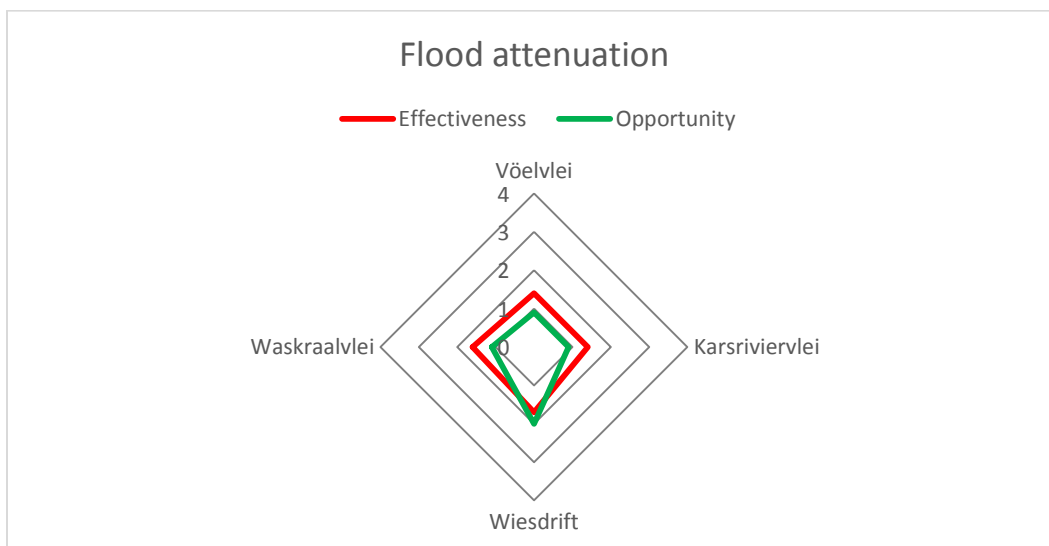


Figure 9 Flood attenuation effectiveness and opportunity scores

#### 4.3.2 Sediment trapping

The effectiveness of trapping sediment is moderately low for Vöelvlei, Wiesdrift, and Waskraalvlei. The ineffectiveness is due to the weak extent of the wetlands attenuating floods and low sediment trapping in the HGM unit's due to less direct indication of sediment deposition on plants. As a result of channelled valley-bottoms (Wiesdrift and Waskraalvlei) indicate a low effective score as they add less to sediment trapping but supplies it to a certain degree. On the other hand, Vöelvlei is different as it has some depression and unchannelled valley-bottom

characteristics executing no effective sediment trapping but provides a high opportunity for sediment trapping as well (Kotze et al., 2009). Karsriviervlei, scores highest compared to the other wetlands as it traps most of the sediment because the channel loses confinement. In addition, opportunity scores indicate that sediment trapping will be highly effective in future as a result of no dams in the HGM unit's catchments that would withhold sediment reaching the wetlands. Cultivated lands and gravel roads increase the sediment supply. The HGM units are surrounded by major sediment sources like cultivated land and gravel roads.

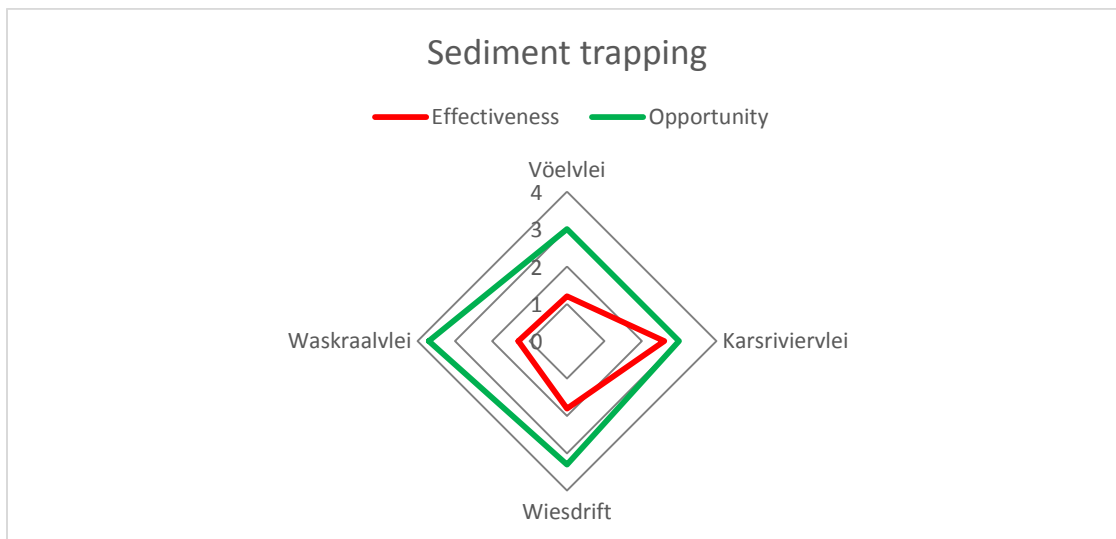


Figure 10 Sediment trapping effectiveness and opportunity scores

#### 4.3.3 Phosphate removal

The effectiveness of phosphate removal is higher in Vöelvlei and moderately high in Karsriviervlei, Wiesdrift, and Waskraalvlei. Vöelvlei and Karsriviervlei are effectively supplying the service and both wetlands have the same opportunity score for phosphate removal (moderately high). Wiesdrift and Waskraalvlei have a high opportunity to provide the service due to many sources in the catchment. Vöelvlei and Karsriviervlei's high effectiveness for phosphate removal is due to the wetland being well covered with permanent vegetation which allows for the removal of phosphates by direct assimilation of plants. The high extent of sediment trapping results in the pollutants such as phosphates being removed from wetlands (Kotze et al., 2009). Sediment trapping in Wiesdrift and Waskraalvlei scored moderately low, which results in the wetland not trapping sediment associated with phosphates. In addition the



pattern of low flows is confined to the channel, allowing less contact between water and the wetland resulting in less chance to assimilate pollutants. The opportunity scores are influenced by phosphate sources such as point and non-point sources (feedlots and animal droppings) at Soetendalsvlei, Wiesdrift, and Waskraalvlei.

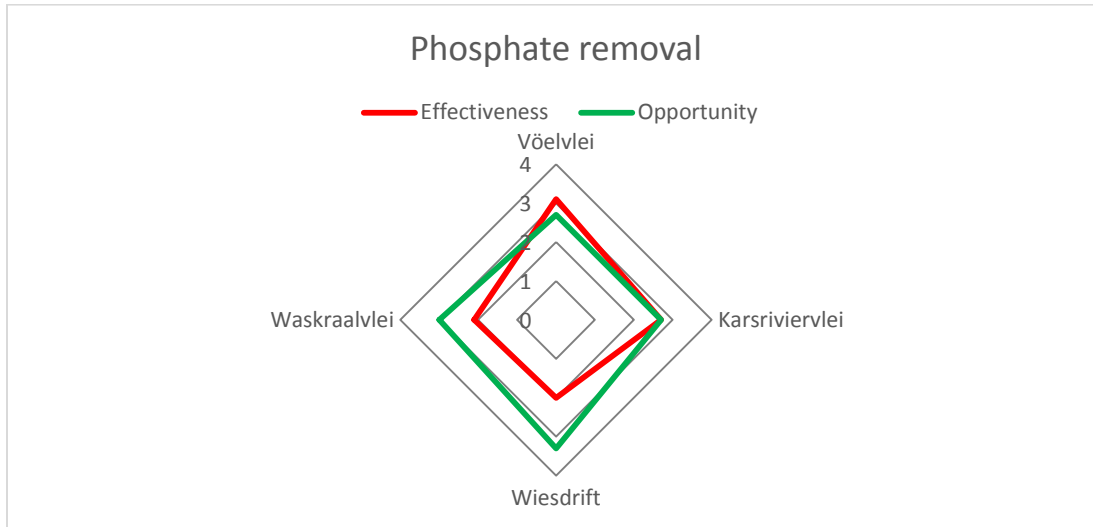


Figure 11 Phosphate removal effectiveness and opportunity scores

#### 4.3.4 Nitrate removal

Vöelvlei's nitrate removal is provided to its full potential since both the effectiveness and opportunity scores are high. This is a result of both seasonal and permanent hydrological zone present and collectively more than 60% and the intermediate extent of vegetation cover (Kotze et al., 2009). The effectiveness of the benefit provided is moderately high in Karsriviervlei, Soetendalsvlei, Wiesdrift, and Waskraalvlei. The high opportunity scores in all wetlands indicate that nitrate removal is currently and will be in future a high potential benefit. The high proportion of seasonal and permanent hydrological zones has a positive impact on water quality downstream of these wetlands as this feature enhances nitrate removal. The dispersed nature of water flow in an unchannelled valley bottom wetland explains the high score achieved by Vöelvlei. In contrast, channelled valley-bottom wetlands provide nitrate removal to a lower degree in Wiesdrift and Waskraalvlei.

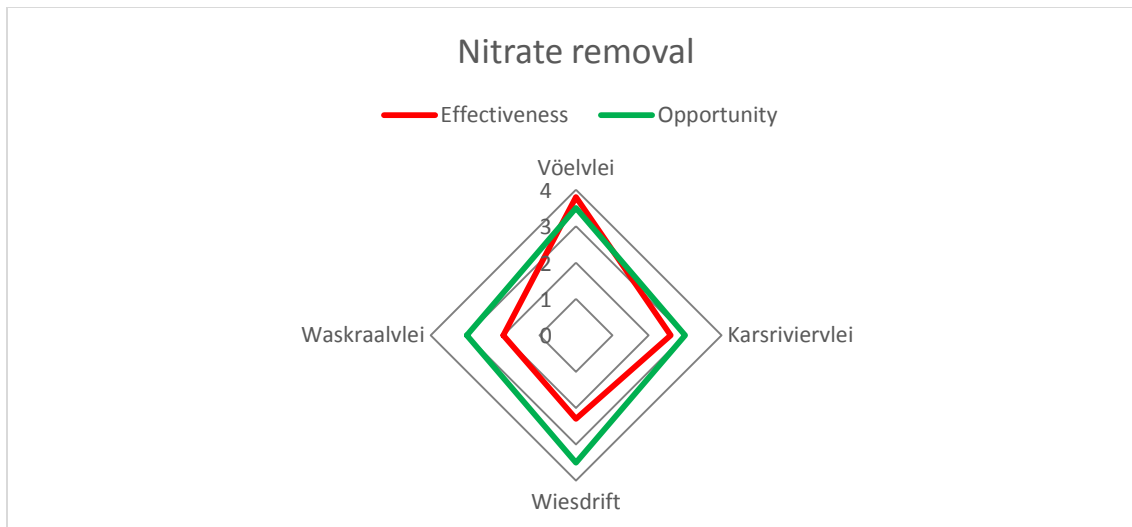


Figure 12 Nitrate removal effectiveness and opportunity scores

#### 4.3.5 Toxicant removal

The benefit is highly effective to its full potential in Vöelvlei, Karsrivervlei in comparison to Wiesdrift and Waskraalvlei which show moderately high effectiveness for toxicant removal. The opportunity score indicates that currently toxicant removal is high and will excel in future as a potential benefit in wetlands. The hydrological zone (i.e. seasonal and permanent) of all the wetlands enhances the capacity of the wetland to effectively assimilate a diversity of toxicants. However, the scale of vegetation cover (moderately high to high) in Vöelvlei and Karsrivierlei compared to Wiesdrift and Waskraalvlei vegetation presence (intermediate to high) illustrates, that hydrological zones and the extent of vegetation cover contribute to the effectiveness of toxicant removal in wetlands (Kotze et al., 2009). Toxicant removal is high in unchannelled valley-bottom wetlands and is provided to some degree in channelled valley-bottom wetlands. This results from runoff waters in Vöelvlei, opposed to low runoff potential of soils in the catchment. High vegetation cover and the presence of seasonally and permanent hydrological zones contributes to the high effectiveness scores of the benefit. Wiesdrift scores for the current and future benefit are higher than for Vöelvlei, Karsrivervlei, and Waskraalvlei illustrating toxicant removal as a moderate current and future benefit. The toxicant sources in the HGM unit's catchment add to the effectiveness of the benefit, whereby the wetland removes toxicants received from feedlots and biocides entering the wetland.

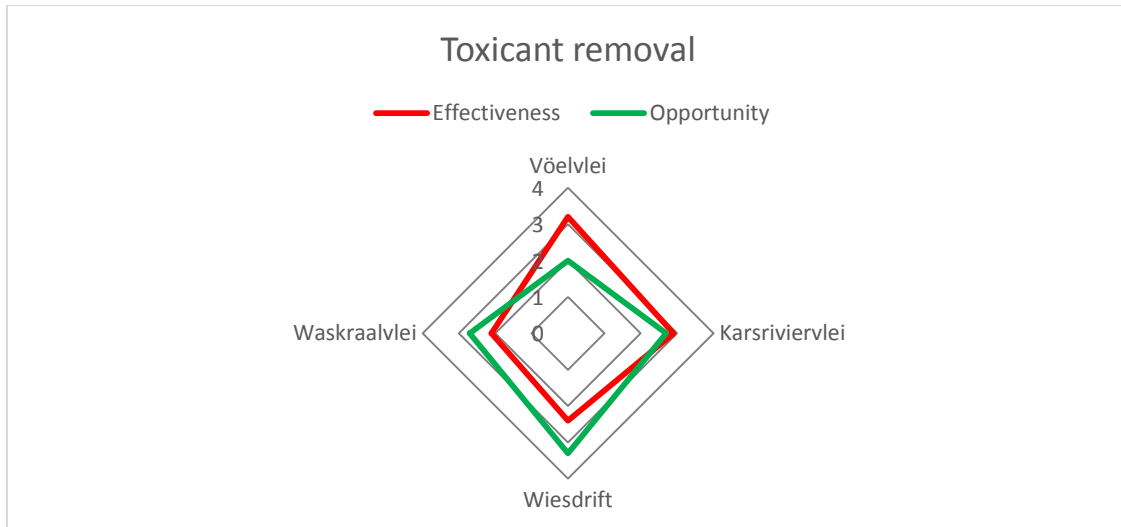


Figure 13 Toxicant removal effectiveness and opportunity scores

#### 4.3.6 Water supply for human use

Wetlands are seasonally or permanently waterlogged and may be a reliable source of water which differs between wetlands. The direct supply of water for human use is supplied at an intermediate amount in Vöelvlei, Karsriviervlei, and Wiesdrift, but moderately high in Soetendalsvlei and Waskraalvlei. At Vöelvlei and Karsriviervlei water is not utilised for domestic or agricultural purposes compared to being used for both purposes at Soetendalsvlei, Wiesdrift, and Waskraalvlei. Water supplied at Soetendalsvlei is used for gardening (domestic) and irrigation (agriculture), while wildlife consumes water from Waskraalvlei.

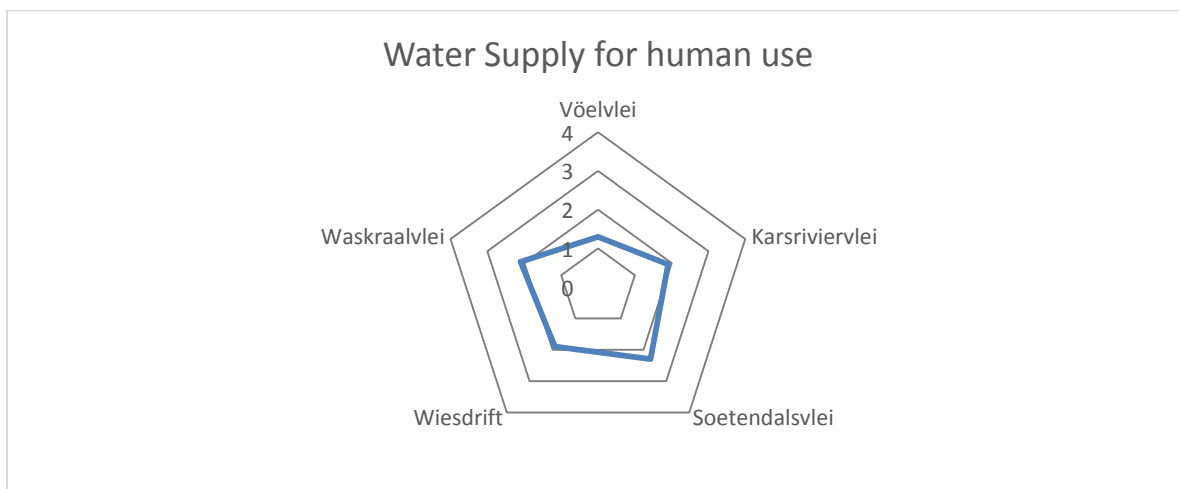


Figure 14 Water Supply for human use

#### 4.3.7 Harvestable natural resources

The provision of harvestable natural resources in general is at an intermediate level for Vöelvlei and Soetendalsvlei, which is reasonable compared to it being moderately low in Wiesdrift and Waskraalvlei and low in Karsriviervlei. This is probably a result of wetlands not being located within a rural communal area where people depend and use natural resources, while landowners are not directly dependent on the resources. The majority of the wetlands are used for livestock grazing since the area is seasonally and permanently water logged, providing good land for grazing (Collins, 2005). The harvesting of reeds for construction occurs at both Soetendalsvlei and Karsriviervlei. Fishing is provisioned at Soetendalsvlei and Waskraalvlei, while waterblommetjies are collected at Karsriviervlei. Vöelvlei provisions land for the cultivation of crops.

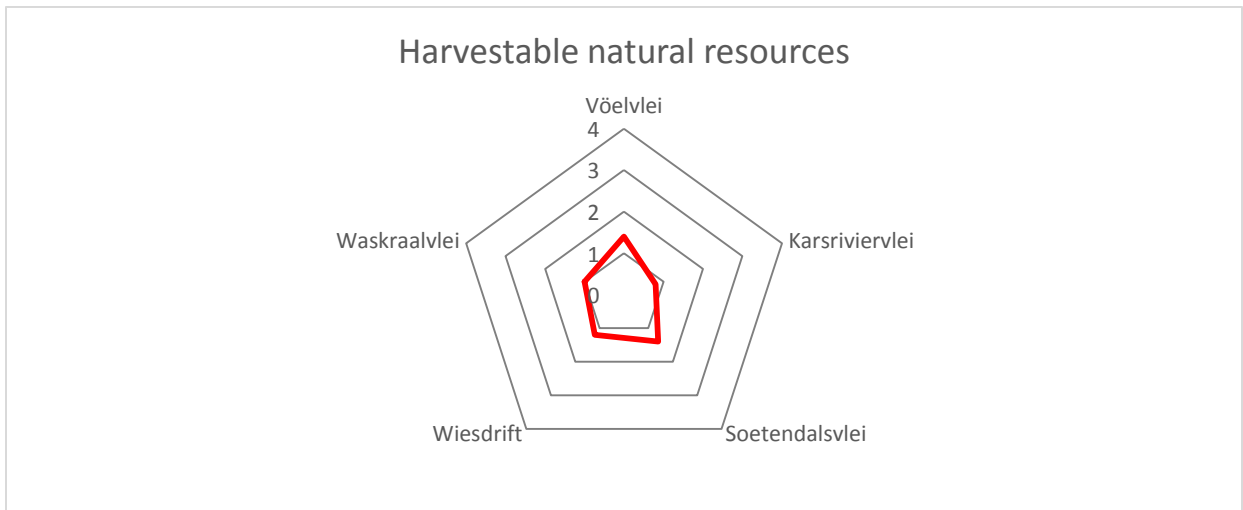


Figure 15 Harvestable natural resources

#### 4.3.8 Tourism and recreation

Vöelvlei, Karsriviervlei, and Soetendalsvlei moderately supply the service but Vöelvlei's score is slightly higher. Wiesdrift and Waskraalvlei indicate high scores of tourism and recreational value. Karsriviervlei and Soetendalsvlei scenic beauty consists of open water. Wiesdrift, Vöelvlei and Waskraalvlei have similar scenic characteristics like vegetation in different lengths, textures, colours and tones making it visual interesting. There are generally a variety of birds present at most wetlands at Vöelvlei, including the enigmatic blue crane (*Anthropoides*

*paradiseus*) and the lesser and greater flamingos (*Phoeniconaias minor* and *Phoenicopterus roseus*). Waskraalvlei is home to hippopotami, birds, buffalo, and the quagga. Tourism or recreation opportunities are inaccessible at most wetlands, except Soetendalsvlei and Waskraalvlei. Soetendalsvlei has accommodation facilities available in proximity to the wetland and Waskraalvlei has eco-tourism activities like guided tours to the buffalo boma. The recreation and tourism opportunities are present but limited to the public since the wetlands are located on private land. Vöelvlei is the only wetland located within an existing tourism route which contributes to its high score.

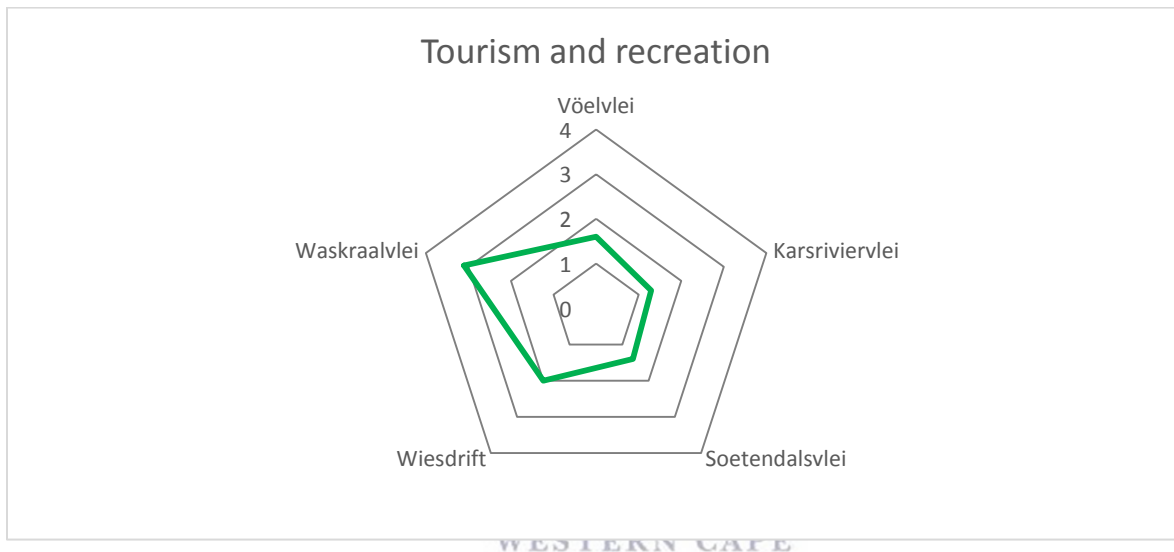


Figure 16 Tourism and recreation

#### 4.3.9 Education and research

The education and research benefit is highly supplied at Vöelvlei, Soetendalsvlei, and Waskraalvlei and reasonably well too at Karsriviervlei and Wiesdrift. This is a result of the wetlands in the area being used for research and to a certain extent, for education. The wetlands are not located in close proximity to schools or universities; yet tertiary institutions conduct research in the catchment and awareness is created for learners on World Wetlands day. There is existing data and research available for these wetlands and one landowner has rainfall data from previous years. Landowners have a good relationship with Universities, and allow researchers access.

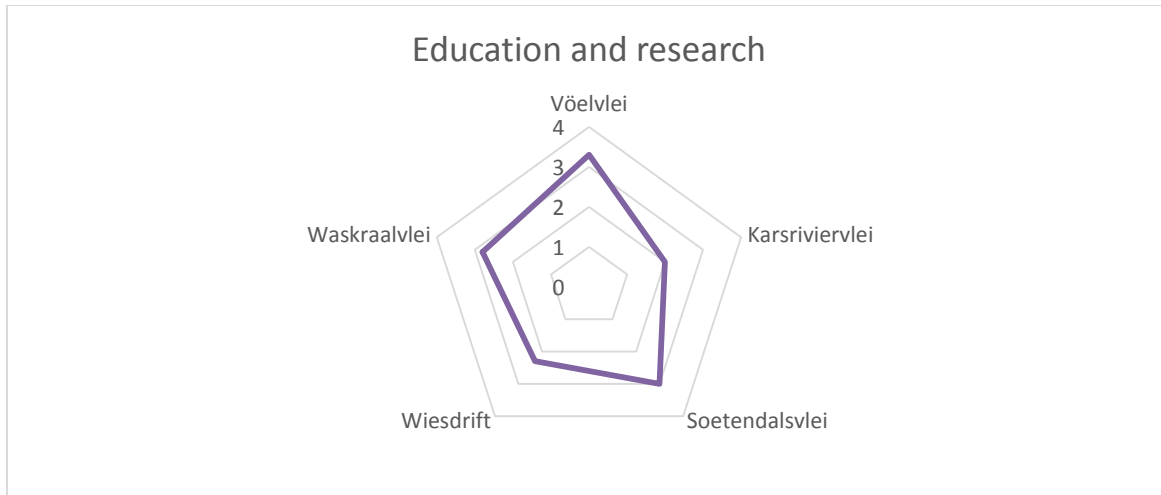


Figure 17 Education and research

#### 4.4 Indirect and direct ecosystem services

Indirect and direct ecosystem services were present in all wetlands but not all benefits were effectively provisioned or had the opportunity to be supplied. The common services with high effectiveness and opportunity scores were phosphate removal, nitrate removal and toxicant removal. In comparison, flood attenuation and sediment trapping were not provided to a high degree although the catchment offers opportunity. The factors that contributed to this are surface roughness which is low in certain wetlands and sinuosity of the stream channel results in the wetlands not attenuating floods. The sediment trapping is impacted by the ineffectiveness of flood attenuation in wetlands to trap sediment from runoff waters (Kotze et al., 2009). The large proportions of seasonal and permanent hydrological zones increases the wetland's ability to remove toxicants, while high vegetation cover contributes to the wetland eliminating phosphates through the direct absorption of plants (Kotze et al., 2009). The wetlands play a major role in improving water quality for the downstream estuary at De Mond Nature reserve.

According to Ellery et al. (2009) a wetland's landform setting influences hydrological components and the 1-5 year frequency of stormflow spread across the wetland. The surface roughness of Vöelvlei, Karsriviervlei, and Wiesdrift is low to moderately low. This results in patches of bare ground, restioids, and rare appearances of reeds (*Phragmites australis*) in Vöelvlei. Karsriviervlei's upper section is robust in vegetation (grasses and reeds), compared to

the lower section having patches of bare ground and restioids. Wiesdrift has a section of restioids, sedges and the other half has patches of bare ground. Therefore, the ineffectiveness of surface roughness causes less frictional resistance to slow down the water flow in the wetlands. Vöelvlei's depression characteristics contribute to its inability to attenuate floods (Kotze et al., 2009). However, Waskraavlei surface roughness was moderately high, allowing the wetland to reduce the flow of water cause of the high frictional resistance to the open flow of water. The ineffectiveness of flood attenuation influenced the efficiency of sediment trapping in wetlands.

The direct ecosystem services that are currently provisioned by wetlands are water supply, harvestable resources, tourism and recreation, and education and research. The majority of the wetlands are on private land and household's livelihoods do not directly depend on the HGM units benefits. The substitutability of the wetlands natural resources might be low since landowners' livelihoods are not directly dependent on the ecosystem services. The greater the importance of the wetlands for providing these ecosystem services (Kotze et al., 2009).

The benefits derived from Soetendalsvlei and Waskraalvlei are mostly water supply for gardening, agriculture, and livestock. The other wetlands supply the service moderately, although water is not used for human use as a result of the water being saline (Overberg District Municipality Wetland Report, 2017). The common harvestable resource in most wetlands was grazing for livestock. There is an array of tourism and recreation present at all wetlands but more frequent at specific wetlands. For example, Waskraalvlei natural beauty and abundance of wildlife is currently used for tourism and recreation. Education and research is valued at the wetlands with regards to existing data and research completed and currently being used for research by institutions, although accessibility can be a problem. Although, these wetlands provide or share similar benefits, outsiders are not allowed to make use of them since the wetlands are located on private land. It was common that most of the wetlands have an extent of open water but it is limited for recreational activities due to dense reeds. The water supply, tourism and recreation and education and research benefits are more in abundance compared to the other direct ecosystem services.

## 4.5 Comparison of dry and wet years ecosystem services

Wet-EcoService assessments were reconsidered for each wetland in order to compare likely effectiveness and opportunity in very wet or very dry years. Throughout the dry and wet years (Table 3) the wetlands various indirect and direct benefits may change either positively or negatively, impacting upon estimated ecosystem services scores. The ecosystem services scores can increase, decrease, show no change or there may be uncertainty.

Table 3 Ecosystem services in dry and wet years

WET-EcoServices in Dry and Wet Years										
Ecosystem Services	Vöelvlei		Karsrivierlei		Soetendalsvlei		Wiesdrift		Waskraalvlei	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Flood attenuation	+/-	-	-	+			-	+/-	-	+/-
Sediment trapping	+/-	-	-	+			-	+/-	-	+/-
Phosphate removal	-	-	-	+			-	-	-	+/-
Nitrate removal	-	+	-	+			-	+	-	+
Toxicant removal	-	-	-	+			-	-	-	+/-
Water Supply for human use	0	0	0	0	+	+/-	+	0	0	0
Harvestable natural resources	0	-	+/-	+/-	0	+	+/-	+	+	0
Tourism and recreation	-	+	+/-	0	+/-	+	+/-	+	0	+
Education and research	0	0	0	0	0	0	0	0	0	0
Legend	<span style="background-color: #004a87; color: white; padding: 2px;">+ increase</span> <span style="background-color: #4a86e8; color: white; padding: 2px;">- decrease</span> <span style="background-color: #cccccc; color: black; padding: 2px;">0 no change</span> <span style="background-color: #cfe2f3; color: black; padding: 2px;">+/- uncertainty</span>									

### 4.5.1 Dry year

#### 4.5.1.1 Flood attenuation

The flood attenuation in Vöelvlei shows uncertainty as the benefit provided by the wetland can either increase or decrease. Flood attenuation decreases in Vöelvlei, Karsrivierlei, Wiesdrift,



and Waskraalvlei. The wetlands capacity to reduce floods increases as the wetland is in a dry state and has not been previously flooded. The chances are greater to detain flows and reduce the floodpeak in a dry year compared to the wetland in a wet state (Kotze et al., 2009). During a wet year the wetland has less capacity to attenuate, capture, and slow down floods as a result of the wetland being inundated. The moderately high surface roughness will cause poor friction resistance to slow down the flow of water in a dry year as a result of a decrease in vegetation cover.

#### 4.5.1.2 Sediment trapping

Sediment trapping can either increase or decrease in Vöelvlei and possible decrease in Karsriviervlei, Wiesdrift and Waskraalvlei. The sediment trapping will increase in Vöelvlei as of the sediment sources such as cultivated lands and gravel roads supplying sediment to the HGM unit's catchment. The sediment supplied to the wetland is not limited by dams in the HGM unit catchment allowing for a greater opportunity of sediment trapping. Vöelvlei, Karsriviervlei, Wiesdrift, and Waskraalvlei ability to effectively provide sediment trapping is reduced by the ineffectiveness of attenuating floods. This is a result of low rainfall and the drought impacting the vegetation (i.e. high surface roughness). In addition, there is less chance in attenuating floods and trapping sediment. Throughout the dry year the vegetation cover in the wetlands will be reduced but more sediment is available as of the permanent vegetation cover with noticeable bear areas which lack vegetation.

#### 4.5.1.3 Phosphate removal

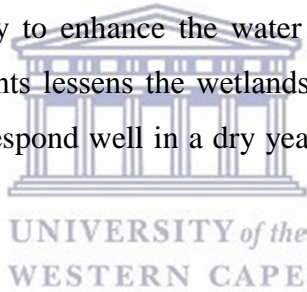
The removal of phosphates from runoff water decreases in Vöelvlei, Karsriviervlei, Wiesdrift, and Waskraalvlei. The decrease in phosphate removal is caused by the low sediment trapping levels in Vöelvlei, Wiesdrift, Waskraalvlei, and the moderately low levels in Karsriviervlei. The low levels of flood attenuation and sediment input during the dry year results in a decreased level of sediment input from the HGM unit's catchments and the opportunity to improve water quality. This will result in phosphates remaining in the wetlands as a result of a low opportunity for sediment trapping to absorb and remove phosphates during a dry year (Kotze et al., 2009). The low flow pattern causes the water to reside longer by assimilating the phosphates in shallow water.

#### 4.5.1.4 Nitrate removal

Nitrate removal will decrease in Vöelvlei, Karsriviervlei, Wiesdrift, and Waskraalvlei. The decrease in the ecosystem service is caused by the prolonged drought and the wetlands level of saturation is likely to be greatly diminished. This results in the wetlands unable to remove nitrates from runoff waters through denitrification. The moderately high vegetation cover will be reduced and the sparse vegetation will affect the wetland's ability to assimilate pollutants and remove nitrates as the organic matter of the soil is required by the microbiota in order to assimilate nutrients and toxicants (Kotze et al., 2009).

#### 4.5.1.5 Toxicant removal

Toxicant removal decreases in Vöelvlei, Karsriviervlei, Wiesdrift, and Waskraalvlei as a result of low levels of sediment input and trapping in wetlands, and the vegetation cover impacting the ecosystem service provided. The decrease in sediment trapping results in a decrease in toxicant trapping given that many toxicants are absorbed by sediment. The low sediment input causes a decrease in the wetlands opportunity to enhance the water quality. The low level of toxicant sources in the HGM unit's catchments lessens the wetlands opportunity to trap toxicants. The aquatic plants in wetlands will not respond well in a dry year as the wetlands are unable to trap toxicants (Cleber et al., 2012).



#### 4.5.1.6 Water supply for human use

The water supply for human use in Vöelvlei, Karsriviervlei, and Waskraalvlei indicate no change. The water supply for human use will not change and is mostly used as stock water for livestock at Karsriviervlei and Waskraalvlei. Vöelvlei's water supply is not used for domestic and agricultural purposes. Soetendalsvlei and Wiesdrift show an increase in the usage of the water supply. The water supply at Soetendalsvlei is used for irrigation purposes (i.e. gardening) and used for agricultural and domestic purposes at Wiesdrift. Although, irregular rainfall occurs the wetlands (i.e. Soetendalsvlei and Wiesdrift) are still most likely saturated than the surrounding landscapes as the most of the wetlands have permanent and seasonally hydrological zones (Kotze et al., 2009).

#### 4.5.1.7 Provision of harvestable resources

Provision of harvestable natural resources shows no change in Vöelvlei and Soetendalsvlei. The provision of harvestable resources increases in Waskraalvlei but shows uncertainty in

Karsriviervlei and Wiesdrift. Vöelvlei's vegetation cover will be moderately high and provide grazing for livestock (i.e. cattle and sheep) in the dry year. The ecosystem service will remain the same (i.e. no change) as result of landowners not being directly dependent on the resource provided. The provision of edible plants (i.e. waterblommetjies) and grazing for livestock can decrease in Karsriviervlei as the drought may reduce the edible plants growing season. Wiesdrift provides the provisioning of fish which may decrease. The prolonged drought can impact or lead to changes in fish populations. The use of thatching in Soetendalsvlei can either increase or show no change. Although, harvestable resources such as grazing will decrease as the vegetation cover in wetlands may change.

#### 4.5.1.8 Tourism and recreation

Tourism and recreation may decrease in Vöelvlei compared to Karsriviervlei, Soetendalsvlei, and Wiesdrift having a chance of either increasing or decreasing (uncertainty). Waskraalvlei shows no indication of change in the ecosystem service. The decrease in the ecosystem service will impact are the aesthetics, nature, and the bird populations at Vöelvlei, Karsriviervlei, Soetendalsvlei and Wiesdrift. The prolonged drought will impact these bird species, as the low water levels will negatively impact the ecology of the birds breeding period, which can also be associated with water availability (Cleber et al., 2012). Karsriviervlei may possibly provide the benefit as charismatic bird species are generally present at the wetland. Soetendalsvlei's tourism and recreation services may increase as the wetland occasionally provides birding opportunities. Wiesdrift also provides an opportunity for fishing activities. Tourism and recreation at Waskraalvlei will not change as the wetland is available for tourist and has a large presence of wildlife.

#### 4.5.1.9 Education and research

The education and research in Vöelvlei, Karsriviervlei, Soetendalsvlei, Wiesdrift, and Waskraalvlei will not be impacted by the dry year. The wetlands are currently used for research purposes, there is data available about the wetlands, and they are moderately accessible.

### **4.5.2 Wet year**

#### 4.5.2.1 Flood attenuation

Flood attenuation will decrease in Vöelvlei and increase in Karsriviervlei. The ecosystem service shows uncertainty as the benefit can either increase or decrease in Wiesdrift and Waskraalvlei.

The decrease in Vöelvlei, Wiesdrift, and Waskraalvlei capacity to attenuate floods are caused by the several wetlands permanent and seasonal hydrological zones, which remain wet throughout the wet season. The 1-5 year frequency with which stormflows are contained within a channel passing through the wetland will decrease the effectiveness of flood attenuation in wetlands. The presence of furrows in certain wetlands contributes to reducing the frequency of flooding, in turn, reduces the effectiveness of attenuating floods.

In a wet year, the flood attenuation will increase in Karsriviervlei, Wiesdrift and Waskraalvlei. The moderately high surface roughness (i.e. permanent vegetation and bare areas lacking vegetation) of the wetlands will result in greater frictional resistance to reduce the flow of water. This indicates that the wetlands are able to attenuate floods although it was previously a dry year.

#### 4.5.2.2 Sediment trapping

The benefit will increase in Karsriviervlei, decrease in Vöelvlei, and shows uncertainty (either increase or decrease) in Wiesdrift and Waskraalvlei. The increase of the benefit in Karsriviervlei, Wiesdrift, and Waskraalvlei as of no dams in the HGM unit's catchments to reduce sediment input. Channelled valley-bottom wetlands provide sediment trapping to a certain extent compared to unchannelled valley-bottom wetlands (Kotze, 2009). Sediment trapping will increase as of the high vegetation cover in the wetlands resulting in effective trapping and retaining of sediment carried by runoff waters (Kotze et al., 2009).

The ecosystem service can decrease in Vöelvlei, Wiesdrift and Waskraalvlei resulting in the wetlands not being able to reduce floods as the wetland is saturated with water and the low sinuosity of the stream channel in Vöelvlei, moderately low in Wiesdrift and intermediate in Waskraalvlei. This is the cause of the wetlands inability to trap sediments due to the ineffectiveness of attenuating floods.

#### 4.5.2.3 Phosphate removal

Phosphate removal will increase in Karsriviervlei and decrease in Vöelvlei and Wiesdrift. Waskraalvlei shows that the benefit can either increase or decrease. The effectiveness of sediment trapping is high resulting in Karsriviervlei and Waskraalvlei to trap new sediment and have a greater chance of removing phosphates and associated pollutants (Kotze et al., 2009). The high vegetation cover in Karsriviervlei and Waskraalvlei allows the plants to directly remove the

phosphates. The wet year will increase the rainfall and runoff waters entering the wetland, which will increase the opportunity to remove phosphates in wetlands. The decrease in phosphate removal is caused by the low flood attenuation, sediment input and trapping in Vöelvlei, Wiesdrift, and Waskraalvlei in a wet year. This explains that phosphates may be a problem in the wetlands, as the potential for phosphate sources (point and non-point sources) are moderately high in Vöelvlei, Wiesdrift, and Waskraalvlei and are not absorbed by sediments.

#### 4.5.2.4 Nitrate removal

The ecosystem service increases in Vöelvlei, Karsrivierlei, Wiesdrift, and Waskraalvlei. Nitrate removal increases as the permanent and seasonal hydrological zones are waterlogged allowing the wetlands to remove nitrates from runoff waters through denitrification. The denitrification process requires saturated soil leading to anaerobic conditions, occurring extensively as the wetlands (i.e. Vöelvlei, Karsrivierlei, Wiesdrift, and Waskraalvlei) are seasonally waterlogged as well. The moderately high vegetation cover in wetlands contributes towards the removal of nitrates providing a significant supply of soil organic matter, which is essential for microbiota to assimilate nutrients. Therefore, the nitrate removal in wetlands increases as the vegetation cover contributes to assimilate pollutants (Kotze et al., 2009). The extent of nitrate sources present in the HGM unit's catchments is moderately high, increasing the possibility of the ecosystem service being a problem but also a greater opportunity for the wetlands to trap nitrates enhancing the water quality.

#### 4.5.2.5 Toxicant removal

The ecosystem service increases in Karsrivierlei compared to the decrease in Vöelvlei and Wiesdrift. Toxicant removal in Waskraalvlei indicates uncertainty there is either a chance that the benefit can increase or decrease. The waterlogged seasonally and permanent hydrological zones will contribute to the capacity of Karsrivierlei effectively assimilating a variety of toxicants. The increase in runoff waters entering the wetlands will increase the opportunity to remove toxicants as of the level of sediment input and trapping in Karsrivierlei stimulating the water quality and plant growth in wetlands (Kotze et al., 2009). The ecosystem service in Vöelvlei, Wiesdrift, and Waskraalvlei will decrease due to the moderately low amount of sediment input and trapping, including the wetlands ineffectiveness to attenuate floods. The amount of fertilizers/biocides and toxicant sources entering Vöelvlei's catchment is low resulting

in fewer toxicants to be removed and entering the river system. Wiesdrift is reasonably well covered with vegetation with some sparse areas of plant cover contributing less to the wetland ability to assimilate pollutants (Kotze et al., 2009). Waskraalvlei toxicant removal can increase as a result of the wetlands high vegetation cover, flood attenuation, and sediment trapping.

#### 4.5.2.6 Water supply for human use

Water supply for human use in Vöelvlei, Karsriviervlei, Wiesdrift, and Waskraalvlei shows no change, while Soetendalsvlei displays a chance of either increasing or decreasing (i.e. uncertainty) the supply of water for human use. The water supply used for agriculture or domestic purposes in Karsriviervlei and Waskraalvlei are normally used in dry years. Whereas, the water supply for Vöelvlei and Wiesdrift is not utilised either for agriculture or domestic purposes. The frequent rainfall and waterlogged hydrological zones can increase the water supply but the water supply can decrease as the usage water is used for stock water and irrigation purposes.

#### 4.5.2.7 Provision of harvestable resources

The ecosystem service shows a decrease in Vöelvlei in comparison to Soetendalsvlei and Wiesdrift showing an increase in the benefit provisioned. Karsriviervlei may have an increase or decrease (uncertainty) in the grazing for livestock and edible plants. Waskraalvlei ecosystem service shows no change. The provision of grazing for livestock is used at a greater extent in Vöelvlei throughout a dry year than a wet year. The growth of reeds (i.e. *Phragmites australis*) in Soetendalsvlei is used for the thatching of roofs and will increase as the vegetation prefers saturated areas. The provision of fishing in Wiesdrift will increase as various fish species are available. Waskraalvlei resources supplied will not change as the wildlife are present in dry and wet years and will continue to graze the vegetation. Karsriviervlei's resources provided may increase as a result of the availability of waterblommetjies in the wetland but resources such as grazing may decrease as it is most beneficial in a dry year.

#### 4.5.2.8 Tourism and recreation

Tourism and recreation will increase in Vöelvlei, Soetendalsvlei, Wiesdrift, and Waskraalvlei. On the other hand, Karsriviervlei tourism and recreation benefit will not change. The outcome of the wet year will result in the increase of the benefit provisioned in terms of the scenic beauty of the HGM units, their charismatic fauna (i.e. blue crane and flamingo) present at Vöelvlei in

connection with the water availability (Cleber et al., 2012). Soetendalsvlei will effectively provide recreational birding prospects and Wiedrift fishing. Waskraalvlei is currently used for tourism and recreational purposes in terms of having wildlife present, birding opportunities and is available for tourists to visit. Karsriviervlei tourism and recreation prospects and activities are low.

#### 4.5.2.9 Education and research

The education and research services in Vöelvlei, Karsriviervlei, Soetendalsvlei, Wiedrift, and Waskraalvlei will not be impacted. The wetlands are currently used for research purposes, there are data available on these wetlands, and they are moderately accessible.

The climate whether it is short or long term can cause changes over seasons and years impacting wetland ecosystem service provision. The dry years result in low or late rainfall patterns, whilst the opposite occurs in wet years over a number of seasons or year's resulting in floods (Knapp et al., 2015).

Indirect ecosystem services decreased and uncertainty occurred more in the dry year compared to wet year. Throughout a wet year there were more ecosystem services increasing and showing possible uncertainty, and fewer decreases in services shown. The majority of the indirect services in a dry year decreased in Karsriviervlei, Wiedrift, and Waskraalvlei compared to Vöelvlei showing possible uncertainty in flood attenuation and sediment trapping and a decrease in the rest of the services. In comparison, indirect ecosystem services increased in Karsriviervlei during a wet year, compared to frequent decreases in Vöelvlei and possible uncertainty in Wiedrift and Waskraalvlei.

There were certain direct ecosystem services that frequently showed no change in all wetlands during dry and wet years. There was an increase in ecosystem services provided in most wetlands than a decrease in both dry and wet years. Uncertainty of certain ecosystem services were indicated more frequent in Karsriviervlei, Soetendalsvlei, and Wiedrift throughout a dry year than in a wet year only in Karsriviervlei and Soetendalsvlei.

## **Chapter 5 Landowners perceptions and usage of ecosystem services**

### **5.1 Introduction**

This chapter presents the outcome of the participatory mapping and interviews with landowners. The participatory mapping was a broad visual representation of the wetlands identified and the perceived importance of the ecosystem service benefits derived. Interviews with the Nuwejaars Wetland Special Management Area (NWSMA) landowners focused on their perceptions of wetlands, ecosystem services, climatic variability, and climate change in dry and wet years. The participants are conscious about the functioning of wetlands, benefits provided and the impacts of climatic variability and climate change.

### **5.2 Background of participants and wetlands**

The participants of the interviews and participatory mapping included 3 landowners that are members of the NWSMA, a farm manager, an additional NWSMA committee member, and a resident from Elim. The participants have all lived in the area for long periods, and in certain cases, the land has been passed on by previous generations.

The two types of wetlands that were assessed are palustrine and lacustrine wetlands. Palustrine wetlands (i.e. vleis, floodplains, and seeps) are ecosystems situated between terrestrial and aquatic systems. They are non-tidal wetlands influenced by an excess of water and are usually linked to a drainage network. Even where groundwater is present, they may be seasonal (van Gikel et al., 2011). Vöelvlei (Droërvier), Karsrivier, Wiesdrift, Soutpan, Vöelvlei and Waskraalvlei are palustrine wetlands. Lacustrine wetlands (i.e. lakes) have permanent wet conditions and open standing or slow-moving water (Pauw, 2012). Soetendalsvlei has characteristics of both palustrine and lacustrine wetlands.

### **5.3 Participatory Mapping**

The map (Figure 18) spatially displays the ecosystem services at various wetlands on the Agulhas Plain. The most prevalent benefits provided by wetlands illustrated on maps by landowners were direct benefits such as provisioning and cultural ecosystem services. According to Pan et al. (2016) people in rural areas frequently use and prioritise provisioning and cultural ecosystem services compared to urban areas. This is similar to the Agulhas Plain wetlands whereby landowners make use of provisioning and cultural benefits more frequently. The figure



below is an indication of the frequent usage of wetland ecosystem services by landowners. Landowners identified provisioning and cultural ecosystem services more frequently compared to regulating and supporting ecosystem services. This is similar to the study of Plieninger et al. (2013) that discovered the most highly valued ecosystem services were recreation and tourism and provision of fresh food and water. For example, provisioning ecosystem services were identified at Vöelvlei (Droërivier), Karsriviervlei, Soetendalsvlei, Wiesdrift, Waskraalvlei, and Vöelvlei. Cultural ecosystem services were pointed out at Vöelvlei (Droërivier), Soutpan, Vöelvlei, Soetendalsvlei, Waskraalvlei, Varkvlei, and the Heuningnes Estuary. Soetendalsvlei, Waskraalvlei, Vöelvlei, and Wiesdrift were repeatedly mentioned wetlands providing ecosystem services to landowners.

### Ecosystem Services

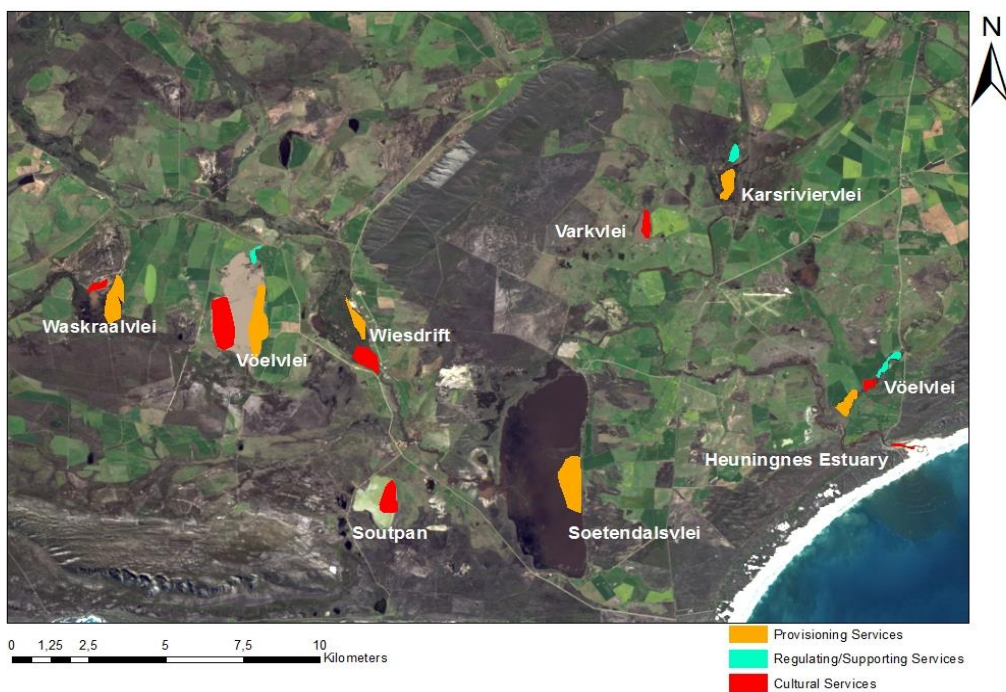


Figure 18 Participatory mapping exercise displaying ecosystem services

#### 5.3.1 Provisioning Services

The provisioning benefits obtained from the wetlands are grazing, water supply, edible plants, reeds for construction and gardening. The wetland vegetation particularly short grasses are usually in the seasonal section (i.e. especially in the dry year) of the wetland and are beneficial for livestock grazing (i.e. cattle and sheep) at Vöelvlei (Droërivier), Wiesdrift, Karsriviervlei,

and Vöelvlei. The livestock at Soetendalsvlei graze on the edges of the wetland. There are different animals grazing on vegetation at specific wetlands, for example, cattle and sheep at most wetlands except for Waskraalvlei which also has hippopotami, bontebok, and buffalo. In addition water from Waskraalvlei, Vöelvlei, and Karsriviervlei is used for stock water in dry years. Water is also used for domestic purposes such as gardening, while Soetendalsvlei crops are irrigated with water from the adjacent lake. Waterblommetjie (*Aponogeton distichos*), an edible plant that grows in vleis or ponds is found and collected in the lower section of the Karsriviervlei. The reeds used for construction or thatching are restiods, these are mostly collected from Soetendalsvlei and not from the other wetlands in the area.

### 5.3.2 Regulating/Supporting Services

The regulating and supporting benefits identified by landowners obtained from the wetlands are flood attenuation, maintaining biodiversity, toxicant assimilation removing toxicants from water, and erosion control. The benefits provided were pointed out on the map at Vöelvlei (Droërivier), Karsriviervlei and Vöelvlei. Toxicant assimilation removes pesticides or chemicals entering the river water flowing through Vöelvlei (Droërivier), as a result of farmers ploughing close too wetlands in the upper reaches. According to Kraaij et al. (2009) there is also an extensive use of herbicides, pesticides, and fertilizers on agricultural lands on the Agulhas Plain. Therefore, the wetland removes chemicals to improve the water quality. Vöelvlei, located west of Soetendalsvlei reduces the flow of water by its output channel, which flows into the Nuwejaars River. In the event of a flood in the Nuwejaars River, Vöelvlei then receives a reserve flow through the outlet channel during a flood event (Gorden et al., 2011). Erosion control was only pointed out at Karsriviervlei and not at other wetlands. Vöelvlei (Droërivier), Waskraalvlei, Wiesdrift, and Vöelvlei maintains the biodiversity by providing fauna especially birds, fish, insects, and antelope with a habitat and breeding area.

### 5.3.3 Cultural Services

The cultural benefits provided by wetlands are aesthetics, tourism and recreation and education and research. The aesthetics involve individuals enjoying the presence and scenic beauty of all the wetlands, especially Waskraalvlei that is home to a variety of wildlife. The wetlands in the area attract a variety of birds such as the blue crane and flamingo, hence birding is a dominant recreational activity. Vöelvlei (Droërivier), Soetendalsvlei, Soutpan, Waskraalvlei, Vöelvlei and

the Heuningnes Estuary all support bird species, depending on the depth of inundation. Including, fishing activities present at Vöelvlei, Wiesdrift, Waskraalvlei, and the Heuningnes Estuary. Galjoen and Kob are some of the fish species found at the Heuningnes Estuary and the Red Minnow at Waskraalvlei. Varkvlei is also used for waterskiing.

Waskraalvlei and the Heuningnes Estuary both have recreational and tourism activities present, compared to the other wetlands having one activity present. Waskraalvlei has an incredible array of wildlife and the Heuningnes Estuary is a pristine wetland with international importance (RAMSAR status), both are available for people to utilise their benefits. Compared to the other wetlands tourism and recreational benefits are available only to landowners. The majority of the wetlands in the area are also used for education and research purposes.

#### **5.4 Importance of ecosystem services in dry and wet years**

The ecosystem services (i.e. water quality enhancement benefits, flood attenuation, tourism and recreation, water usage, harvestable resources, education and research) were ranked from 1 (being the least important) to 5 (extremely important), landowners were asked to rank both in dry and wet years for comparison. Throughout the dry year, 5 of the ecosystem services like water quality, flood attenuation, water usage, and harvestable resources were ranked as not important by participant A (Table 4). Previously mentioned services were also ranked as not important by participant C, excluding water quality and flood attenuation which were ranked as moderately important. Tourism and recreation, harvestable resources, education and research were ranked as very important by both participants. For participant B, important ecosystem services varied compared to participants A and C. Participant B ranked water usage and harvestable resources as very important but ranked flood attenuation, water quality, tourism and recreation and education and research as not important.

Table 4 Importance of ecosystem services in a dry year rated by three participants

Importance of ecosystem services rated by three participants (Dry year)						
Participant	Flood attenuation	Water quality	Water usage	Harvestable resources	Tourism and recreation	Education and research
A						
B						
C						
Legend: not important slightly important moderately important very important extremely important						

During wet years, participant C indicated that harvestable resources are not important, compared to participant A ranking harvestable resources as slightly important (table 5). Participant A and B ranked water quality as very important and participant C ranked the ecosystem service being moderately important. Participants A and C have similar ranking to education and research and tourism and recreation as very important. There is a difference in the water quality ranking. Participant A and B ranked water quality as very important compared to participant C, ranking it as moderately important. All the participants ranked flood attenuation as extremely important. Throughout the wet year water quality and flood attenuation are extremely important to some landowners.

Table 5 Importance of ecosystem services in a wet year rated by three participants

Importance of ecosystem services rated by three participants (Wet year)						
Participant	Flood attenuation	Water quality	Water usage	Harvestable resources	Tourism and recreation	Education and research
A	not important	slightly important	not important	very important	very important	very important
B	not important	slightly important	not important	not important	not important	not important
C	not important	slightly important	not important	not important	very important	very important
Legend: not important slightly important moderately important very important extremely important						



#### 5.4.1 Comparison of perceptions in dry and wet years

There are differences and similarities as to what ecosystem services are important to landowners in dry and wet years. Provisioning services in terms of water usage for domestic or stock water purposes was considered important by one landowner and harvestable resources were considered very important by all landowners in the dry year. The regulating services such as water quality enhancing benefits (i.e. sediment trapping, phosphate, nitrate, and toxicant assimilation), and flood attenuation were considered as slightly important by one landowner.

However, during the wet year, water quality enhancing benefits and flood attenuation were considered important to landowners. During the course of the wet year the rainfall increases the water supply and water usage generally used for domestic and stock water is not important to landowners. The harvestable resources (waterblommetjie) supplied was considered important to some extent in the wet year.

The benefits showing a similar pattern in dry and wet years are tourism and recreation and education and research that were considered as very important ecosystem services by landowners. Throughout the dry and wet years the area attracts a variety of birds that are

breeding or roosting and fish species in the wetlands. Education and research especially research is done in the area by various tertiary institutions.

During the course of the dry year landowners suggested that flood attenuation, water quality enhancing benefits, tourism, and recreation are impacted by climatic variability and climate change. This results in fewer bird species at wetlands, impacting tourism and recreational activities and associated business. Infrequent rains could result in less water quality enhancing benefits as a result of a reduction in opportunity. Landowners also pointed out that flood attenuation, water quality enhancing benefits, tourism, and recreation are also impacted by climatic variability and climate change during wet years.

The ecosystem services landowners consider being impacted by climatic variability and climate change are similar in dry and wet years. Flood attenuation was considered to be impacted in a dry year but with infrequent rains and drought the ecosystem service will be ineffective compared to a wet year. Therefore the ecosystem service will be less important to landowners in the dry year but more important in a wet year, potentially as the opportunity for the effectiveness of the ecosystem service will be much greater at spreading out and slowing down water flows (Kotze et al., 2009). However wetlands with depression characteristics would be filled with water resulting in a less great chance of the benefit being offered. The landowners consider flood attenuation to be impacted by climatic variability and climate change based on previous flood events that caused damage downstream. Instead of considering how beneficial the benefit will actually be to them in different periods. Their perceptions of flood attenuation being impacted are driven by the direct experience of floods in 1940, 1986, and 2005 (Fourie, 2005). This is a result of their previous experience constraining their thoughts about the effectiveness or beneficial the ecosystem service will be in a dry or wet year (Dang et al., 2014).

The water used for stock water purposes during the dry years are considered to be important to landowners which results from the water quality enhancing benefits. Therefore sediment trapping, nitrate and phosphate removal is important. However the ecosystem services will be affected by the drought in dry years as of infrequent rains and runoff waters. There will be more sediment available and reduced vegetation cover. The wetlands are able to attenuate floods which results in an ineffectiveness of trapping and retaining sediment. Nitrate removal will be

less effective as the primary process to remove nitrates is through denitrification but this requires soil saturation. The ecosystem services will be more important in the wet year as it frequently rains and the opportunity for the ecosystem services to take place is greater. Flood attenuation will most likely be effective which can result in sediment trapping and retaining. The outcome of the previous ecosystem service effectiveness will ensure that phosphate, nitrate, and toxicant removal taking place in wetlands. This illustrates that the water quality used for stock water may not be of great quality in the dry year compared to the wet year where the water quality may be improved as the water quality enhancing benefits are effective.

Tourism and recreation benefits may change in a dry year as drought may influence aquatic fauna and flora in the wetlands. The most frequent activity landowners partake in is birding; this may increase different bird species in the area or change the migratory patterns of birds. The vegetation cover in wetlands is for breeding and roosting. The breeding of birds is associated with the inundation of wetlands. The dry year can also impact fish and invertebrates (Cleber and Silva, 2012). However the ecosystem service will increase in the wet year as the vegetation cover used for birds to breed, roost and malt will increase the variety of bird species and their populations. The ecosystem service was believed to be important since landowners directly benefit from tourism and recreational opportunities for their leisure and financially benefit, for example Waskraalvlei.

### **5.5 Semi- Structured interviews**

Participant A is a farm manager, participant B and C are landowners, and participant D is a local from Elim. The participants identified wetlands in the Nuwejaars catchment and discussed the usage and importance of ecosystem services provided by wetlands. Understanding landowners' perceptions of wetlands is essential as wetlands are beneficial for agriculture which is sometimes perceived as conflicting (Greenland-Smith et al., 2016). The interviewees are attentive and observant of any changes in ecosystem services caused by climatic variability and climate change (Hitayezu et al., 2017). The interviews will be discussed within three categories; landowners' perception and use of wetlands, wetlands benefiting landowners, climatic variability, and change impacting people.

### 5.5.1 Landowners perceptions and use of wetlands

The landowners are conscious regarding other wetlands in the Nuwejaars catchment besides ones on their own land and were able to identify Karsriviervlei, Soetendalsvlei, and Vöelvlei (Droërivier), including the Poortrivier, Heuningnes, and Nuwejaars rivers. One interviewee, participant A was unable to identify other wetlands. In comparison, participants B and C, who are associated to the NWSMA, were able to identify many wetlands. There are differences and similarities regarding how landowners perceive and use the wetlands on their land. Their understanding of a wetland was defined differently according to their perceptions, experience, and its physical features. For example Participant A: suggested *“A wetland is a thing with its own ecosystem, plant life, animals and insects and very often its own climate if it’s a big wetland. It’s a thing that affects the winter and summer conditions of an area.”* Participant B: *“Areas that get periodic flooding, marsh lands and that gets periodic flooding from time to time.”* Participant C: *“My perception of a wetland is an area that either has annual or perennial water enters steadily flowing slowly not in a specific channel in a wider area. Other than a lake which is obviously a wetland. I would call a river water flowing from a channel a wetland will be more spread out.”*

Their perceptions varied as a result of the surrounding wetlands on their farms and the functioning of wetlands. Whereas, participant B mentioned “marsh lands” as a result of wetlands in the area and specifically to the wetlands lower Karsriviervlei (i.e. downstream half of Karsriviervlei) and Varkvlei on his farm. The participants used descriptive terms such as ‘periodic flooding’ and ‘marsh lands’ to define a wetland. The constant use of the term flooding is based on previous experiences of flood events (Fourie, 2005). Participant C referred to a wetland as an area where the flow of water is more spread out. In comparison, participant A mentioned more physical characteristics of the wetland but also described the wetland as being the cause of seasonal conditions in the area. Yet, these seasonal conditions may be beneficial to the area and landowners, the summer season provides grazing for livestock and the winter season may provide flood attenuation and tourism and recreational benefits.

The outcome of landowner’s general perspective of wetlands was based mostly on their experiences such as the major flood in 2005 and physical characteristics of wetlands. This indicates that landowners are conscious regarding the ecological functioning of wetlands



including their ecosystems and benefits (Greenland-Smith et al., 2016). However, their perspective on wetlands focused exclusively on wetlands located on their farms and did not include wetlands in the catchment.

Throughout, summer the wetland vegetation is used for cattle and sheep to graze compared to the winter months when the wetlands are not suitable for grazing. Previously drained wetlands are more arable and suitable for crops to grow than wetlands that are not drained. The wetlands water supply is at times used for stock water purposes, for example, participant C mentioned that the river on his farm previously had an abundance of Palmiet (*Prionium serratum*) peat, and deep holes that stored water after it rained. Therefore, prior to the 2005 flood the river would flow in winter and during summer the deep holes filled with water were used as stock water for cattle and game.

### **5.5.2 Wetlands benefiting landowners**

The landowners used and prioritised different ecosystem services received from wetlands in the area (Table 6). The residents in Elim previously used the reeds for ornamental resources particularly for baskets with a candle inside, which was placed on their porches at night and as a bait basket for fishermen. This resulted in localised over-harvesting and resource degradation in Elim, subsequently, a benefit derived by people was lost (Collins, 2005). Currently, the harvesting of reeds and purchasing predominately occurs at Soetendalsvlei and is used for construction practices such as rooftop thatching for houses. The provision of waterblommetjies (*Aponogeton distchyos*) occurs along the Nuwejaars River in close proximity to Elim and the lower sections of Karsriviervlei. The water supply is either used for stock water at Karsriviervlei and domestic practices (i.e. gardening and spraying crops) at Soetendalsvlei. In comparison, Vöelvlei's (Droërivier) water supply was not suitable for domestic or stock water due to high salinity levels (Kraaji et al., 2009).

Table 6 Frequency of ecosystem services mentions in interviews

Frequently mentioned wetland ecosystem services			
Provisioning Ecosystem Services	Regulating Ecosystem Services	Supporting Ecosystem Services	Cultural Ecosystem Services
<b>Harvestable resources</b>	Erosion control	<b>Biodiversity (Habitat for fauna)</b>	Spiritual connection
Water for human use	Water quality enhancing benefits		<b>Tourism and recreation</b>
Legend: Rarely <span style="background-color: #f4a460; padding: 2px;">Occasionally</span> <span style="background-color: #d9534f; color: white; padding: 2px;">Frequently</span>			

The water quality enhancing benefits for water entering the wetlands is an important ecosystem service to landowners, especially for trapping and removing pollutants to improve water quality for downstream ecosystems (Kotze et al., 2009). The benefits of experiencing and enjoying the natural ecosystems especially bird watching occurs at all wetlands. Certain ecosystem services were available at specific wetlands in the case of fishing at Wiesdrift and water skiing at Varkvlei. However, Waskraalvlei has a variety of wildlife mainly bontebok, buffalo, quagga, and eland (Appendix C). The employee at the NWSMA mentioned that there are 3 Rooi Hartebeest, 36 Bontebok, 100 Eland, and 7 Hippo. Participant C had developed a sense of attachment with Waskraalvlei “*Waskraal is obviously just an incredible nucleus of nature. If it wasn’t there then it would have been a disaster to me. It’s got to be there if it wasn’t I would move.*” This illustrates that the participant values, appreciates, and has a connection to the wetland as the participant directly obtains the benefits of the cultural ecosystem service (Asah et al., 2014). This is contrasting to ecosystem services that were rarely or occasionally mentioned indicating how landowners value or appreciate ecosystem services (Kaplowitz and Kerr, 2003).

The provisioning of harvestable resources such as grazing for livestock and wildlife and biodiversity providing a habitat for birds were repeatedly mentioned by participants. The birds in the area provide sites of value for recreational or tourism activities. The occasionally mentioned

ecosystem services were water for human use (i.e. stock water) and water quality enhancing benefits (i.e. sediment trapping, phosphate, nitrate, and toxicant assimilation). The rarely mentioned ecosystem services were erosion control and a spiritual connection. The results in the table above shows that ecosystem services provide multiple benefits and not all landowners might perceive or use the given services provided by wetlands in the area (Asah et al., 2014). This highlights that landowners consider direct benefits such as grazing for livestock and wildlife and a habitat and breeding space for birds more important. On the other hand, indirect ecosystem services are not viewed as important although these services are essential as well.

#### 5.5.2.1 Livestock and wildlife grazing

The provisioning ecosystem service provided by wetlands that were repeatedly mentioned by landowners was the provision of valuable grazing lands for livestock animals such as cattle, sheep, and wildlife mainly buffalo, eland, and bontebok. Seasonal and permanent hydrological zones present in wetlands are beneficial to landowners as the service is essential in the dry year for livestock to graze (Collins, 2005). Therefore, livestock, and wildlife are able to graze in these wetlands for the duration of the dry year when water levels have receded. For example participant C mentioned in 1970, he started farming in partnership by working together with another farmer, during the summer period the cattle and bontebok would graze at Moddervlei and in winter be transferred to another wetland. This illustrates that the majority of the landowners perceive, attain, and utilise provisioning ecosystem services mainly grazing for livestock. Therefore, landowners understand the importance of the ecosystem service during the dry years, including the cost and benefits of the ecosystem service provided (Greenland-Smith et al., 2016). The outcomes of understanding the importance of provisioning ecosystem services for agriculture will improve agricultural businesses and result in producing quality food (Burnués et al., 2016).

#### 5.5.2.2 Habitat and breeding space for birds

The landowners perceive the biodiversity (i.e. habitat and nursery) for birds and fish within the wetlands as an important supporting ecosystem service. The wetland habitat preserves the lifecycle and gene pool protection of animals, which also sustains the vital ecosystems services such as such as a nursery for fish, breeding and, roosting areas for birds. The landowners repeatedly mentioned the variety of birds like the flamingo, blue crane and waterfowl (i.e.

Egyptian geese) at Vöelvlei (Droërivier), Soutpan, Langpan, and Vöelvlei. These wetlands are important habitats for birds, for example, the blue crane (*Anthropoides paradiseus*). The wetlands protect birds when escaping predators by entering the water, swimming, or hiding between the reeds. The Heuningnes Estuary is a nursery for juvenile fish species to mature and a breeding habitat for birds such as the Damara tern (*Sterna balenarum*) (Kraaji et al., 2004).

The supporting benefit (i.e. habitat) is important and provides a habitat attracting different bird species in dry and wet years. However, participant C mentioned waterfowl (i.e. Egyptian geese) are increasing in the area. Egyptian Geese cause a financial strain to landowners who farm wheat, specifically at Sotendalsvlei, Vöelvlei, Moddervlei, and Zeekoevlei. The Egyptian geese cause damage through three main growing phases; surface seeds (soon after sowing), developing plants (growing plants) and cut plants stacked in windrows (long, linear piles) to dry (Mangall, 2001). They also preferably feed on seeds than growing plants, damaging young barley and wheat plants shorter than 25cm. Fields in close proximity to roosting sites suffered the greatest yield lost. In 1997 and 1998 about 300 geese grazed on approximately 2 hectares of land for two months (Mangall, 2001). The estimated annual revenue reduction of >2.5% and 7% for barley and wheat in 1997 and 1998 is the outcome of damages caused by geese (Mangall, 2001). In 1997 landowners potentially suffered a financial loss of R 180 000 for damage to wheat and barley crop plants, an additional R205 000 to surface seeds and windrows and R420 000 loss in 1998 incurred by damage to growing plants only.

In the same way, these wetlands are important in terms of safety for waterfowls (Egyptian Geese) to roost, breed, and malt (Mangall, 2001). According to Mangall (2001) Egyptian geese prefer feeding on fields in close proximity to their roosting sites because of the availability and abundance of wheat (*Triticum sp.*) and barley (*Hordeum sp.*). This results in the waterfowl (i.e. Egyptian geese) impacting farmer's crops and causing them financial losses. The presence of the Egyptian geese is only beneficial for recreation in terms of hunting since there are plenty of the geese (Mitsch and Gosselink, 2015). Therefore, bird shooting was introduced by landowners in the Nuwejaars Catchment to manage the Egyptian geese problem and afterwards became a recreational enterprise. Landowners created a wing shooting business to financially compensate

for the damaged crops caused by the geese (Mangall, 2001). In contrast, participant A mentioned that bird shooting does not take place at Vöelvlei (Droërivier), while participant C participated within the bird shooting at Moddervlei and Zeekoevlei which explains that the waterfowl were not impacting all landowner's crops.

The damage to crops is caused by the Egyptian geese and has financially strained landowners in the region. This highlights that the interviewees considered the Egyptian geese feeding on their crops as a financial strain as it directly impacts their agricultural business. Landowner's only perceive negativity of the Egyptian geese in the area and not the importance of geese benefiting from the wetlands ecosystem services. On the contrary, landowner's repeatedly mentioned the importance of supporting ecosystem services predominantly biodiversity in terms of providing a habitat for birds and cultural ecosystem services in the sense of recreational and tourism activities. However, wetlands are located on private land and tourists are unable to access wetlands without the landowners consent. Alternatively, tourists may visit the lodge which is in close proximity to Soetendalsvlei. De Mond Nature Reserve (Heuningnes Estuary) is managed by CapeNature, a government organisation and Waskraalvlei forming part of the Special Management Area (SMA) by private landowners. The NWSMA are both managed by organisations and are open for people to utilise for recreational and tourism services. This indicates that the positive benefits of having the birds in the area were accepted by landowners. However when the birds damaged landowner's crops and resulted in financial losses the geese was viewed as problematic. This shows that landowners consider their benefits (i.e. provisioning and cultural ecosystem services) and financial gain from wetland ecosystems as more important than Egyptian geese benefiting from wetlands. Therefore if landowner's benefits are impacted then it becomes an issue.

The occasionally mentioned services that are beneficial include providing stock water for livestock and wildlife to consume during dry years and water enhancing benefits which play a crucial part in improving water quality downstream. Erosion control is rarely mentioned which is essentially for assisting in reducing downstream flooding intensity, and to contribute in decreasing the level of erosion. Although, this is an essential ecosystem service landowners consider it as a less important benefit as it indirectly benefits them. This indicates that

landowners might not necessarily mention the importance of indirect ecosystem services but they do consider it as important which is influenced by biodiversity.

The landowners frequently make use of certain ecosystem services that are important to them mainly provisioning, regulating, supporting, and cultural ecosystem services. Provisioning ecosystem services predominately livestock grazing. Regulating/supporting services as biodiversity providing a habitat for fauna especially, birds. Cultural ecosystem services in terms of bird watching attracting tourist to this diverse landscape and the unique wildlife present at Waskraalvlei. In terms of the frequently used ecosystem services, provisioning, cultural, and supporting benefits exceed regulatory benefits provided by wetlands in this agricultural context (Moges, 2016).

### **5.5.3 Climatic variability and change impacting people**

The landowners are aware of climatic variability and climate change impacting the wetlands in the area. The previous flood events, changes in rainfall periods, and wind patterns, including the alien encroachment problem, experienced prevalent veld fires, changes in fynbos and agriculture were amongst the repeatedly mentioned impacts of climatic variability and climate change. Their perceptions regarding climatic variability and climate change were formed by previous events they have observed in the area (West et al., 2001).

#### **5.5.3.1 Flood events**

The landowners' perceptions about climatic variability and climate change and wetlands in the catchment are influenced by previous flood events which occurred in 1978 and 2005 (figure 7). Participant A declared that the flood event was a "*disruption*" as it impacted their daily routines, livestock, and crops. Consequently, it influenced the successfulness of their agricultural businesses. Therefore, certain landowners drain wetlands and create drainage furrows, which increase the speed of water flowing through the wetland. Participant B mentioned that the negative impacts on his agricultural practices are more serve for flooding than droughts. The flood event negatively impacted the well-being of livestock causing animals being immovable which resulted in them drowning. Livestock were also affected with a specific lung disease. Consequently, the farmers are unable to slaughter the livestock or sell. The participants believe that the flood events occur due to the intense rainfall periods experienced in a shorter period.



Figure 19 Soetendalsvlei farm before and during the in 2005 flood Source: Participant B

This (figure 19) shows how negatively flood events have an impact on agricultural practices in the Nuwejaars Catchment. Therefore it impacts the indirect benefits of the wetland (Collins, 2005). In addition, the area may experience flooding if the mouth of the Heuningnes Estuary is closed (figure 20).

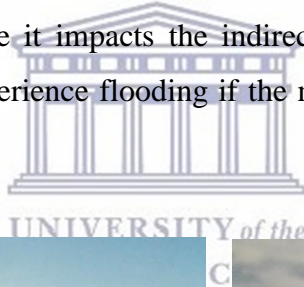


Figure 20 De Mond Nature Reserve (Heuningnes Estuary) when the mouth is closed (left), and an attempt by farmers to artificially open the mouth to the sea (right). Source: Participant B

The landowners share similar perceptions about the negativity of floods impacting their agricultural businesses, in terms of crops and livestock. Participant B mentioned that the flood

has more severe impact than drought. This is an illustration about how the impacts of climatic variability and climate change influence landowners perceptions that are normally driven by direct experiences and observations or meteorological trends (West et al. 2001). This can be connected to landowners' perceptions in order to understand scientific information about climatic variability and climate change (Vedwan and Rhoades, 2011). Therefore, understanding landowner's perceptions about climatic variability and climate change impacts are essential as it assists in understanding landowner's manners in response to different situations and their misconceptions (Ayal and Filho, 2017).

### 5.5.3.2 Annual rainfall period between 2007 and 2016

The Agulhas Plain region has a Mediterranean climate (i.e. dry summers and cold wet winters), therefore the majority of the rainfall occurs in the winter months between May to October (Kraaij et al., 2009). On the other hand, interviewees believe that climate change is the cause of the changes they have noticed in the rainfall periods, as they have experienced a dry or wet year (figure 21) and late rainfall periods, which occurs in summer instead of winter.

The figure below displays the rainfall over a 10 year period, illustrating changes in the rainfall over a decade. There were definitely variations in the annual amount of rainfall in the area received between 2007 and 2016. Figure 21 shows a difference in the amount of rainfall the area received compared to the mean monthly rainfall (figure 22).

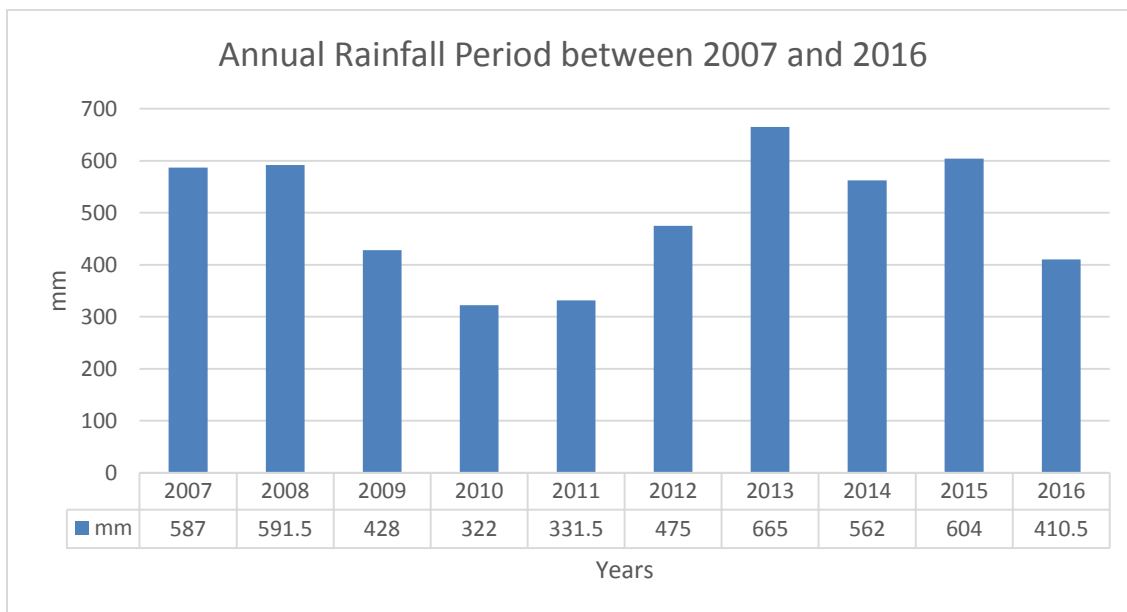


Figure 21 Annual rainfall period between 2007 and 2016

Source: Participant B



Rainfall was well below average in 2010 and 2011. It was above average in 2007, 2008, 2013, 2014, and 2015. Variability is exhibited by the fact that annual rainfall in a dry year (e.g. 2010) is often half that of wet years (e.g. 2013). However, participant D mentioned that the area previously received 600mm-800mm of rainfall, which has decreased to 400mm-600mm. The participant perception about the variations in rainfall highlights that people observe the changes in climate.

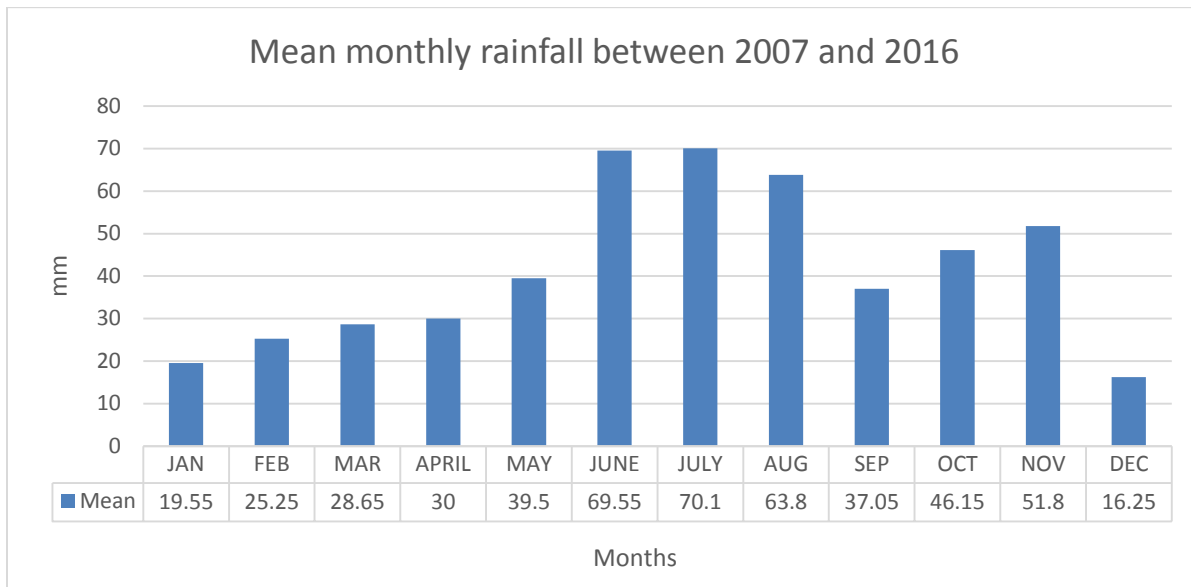


Figure 22 Mean monthly rainfall between 2007 and 2016 Source: Participant B

Participants believe that rainfall causes an encroachment of alien vegetation (*Acacia sp.*) which poses a significant risk to the fynbos, provisioning services and the biodiversity diversity of the area (Pauw, 2012). Although alien vegetation clearing occurs, the removal of the woody plants for agricultural activities increases its chances of being more susceptible to alien vegetation invasion (Kraaji et al., 2004). The participants believe that the encroachment of alien vegetation is an issue and caused by climatic variability. According to De la Fontaine (2013) Agulhas Plain landowners mentioned that alien vegetation which is considered a problem in the area is beneficial for fuel wood, construction, fodder, and shade for livestock. The invasive alien vegetation is also used as a buffer to mitigate the impact of baboons on fruit orchards. The invasive alien vegetation such as pine (*Pinus spp.*) has economic value as well “*Pine is an asset, because you get money for it. We use to cut it off and let it lay there in the hope that it would rot away. Or we would burn it. Now you don’t do it anymore. Pine is really worth money. I don’t*

*regard Pine as a problem*” (De la Fontaine, 2013: 101). However, this is an indication that the presence and increase of alien vegetation is considered as a problem to landowners to the point where it benefits them financially. Their opinion strongly emphasises that climatic variability and the changing rainfall periods cause an increase in alien vegetation and not agricultural activities such as land mismanagement through ploughing too close to the river banks, livestock grazing, chemical pollution, or loss of arable land.

The participants also observed an increase in alien vegetation due to rainfall occurring in the summer months. In 2007, 2008, 2013, and 2015 the region received late rainfall in November. In 2007 the highest rainfall was recorded for that month. The area sometimes receives rainfall later (Table 7), resulting in changes in the invasive alien vegetation growth cycle generally from winter to summer for suitable conditions. The participants observed changes in rainfall patterns and apprehended the difficulty in managing the spread of invasive alien vegetation and its effect on the fynbos vegetation by not receiving the sufficient supply of rainfall.

Table 7 Annual monthly rainfall between 2007 and 2016 Source: Participant B

Seasonal Rainfall Period between 2007 and 2016												
Year	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
2007	7	37	22	45	60	65	<b>80</b>	57	21	55	<b>99</b>	39
2008	14	57	24	20	<b>100</b>	37,5	67	62	43	23	<b>100</b>	44
2009	27	10	14	12	48	<b>67</b>	59	30	47	<b>95</b>	16	3
2010	4,5	19	21	11	33	<b>63</b>	54	11,5	17	47	23	18
2011	4	13	3,5	36,5	59	46,5	<b>61</b>	42	11,5	18	22,5	14
2012	7	27	10	39	21	54	<b>81</b>	76	31	<b>110</b>	17	2
2013	13	19	43	44,5	30	<b>75,5</b>	49	184	45	51	<b>105</b>	6
2014	<b>84</b>	20	51	45	21	<b>123</b>	81	37	29	28	38	5
2015	15	13	65	29	10	<b>121</b>	65	95	73	14	<b>86,5</b>	17,5
2016	20	37,5	33	18	13	43	<b>104</b>	43,5	53	20,5	11	14
Legend Seasons: Summer and Winter												
Winter and Summer rainfall (mm) peaks are highlighted in bold for comparative purposes												

Landowners believe that variations in rainfall patterns are currently more frequent, for example receiving late arrival of the winter rainfall or in summer months. The outcome caused changes in the provision of wetlands ecosystem services to landowners. Participants B, C, and D mentioned that the changes in the rainfall periods impact how they benefit from wetlands. The changes in the rainfall period impacts soil and water availability to crops. This poses a risk to crop production, grazing availability for livestock, and flood events. In contrast, participant A disagrees by stating that he still benefits the same from Vöelvlei (Droërvier). Therefore, participants C and D agree that dry years and late winter rainfall is caused by climate change. According to Mubaya et al. (2012) farmers in Africa share similar views about the short duration of rainfall and the increase in temperature due to climate change (Mubaya et al., 2012).

Participant B stated that climatic variability causes the delayed rainfall period and prolonged drought. Landowners have previously experienced and observed changes to wetlands and ecosystem services provisioned influencing their perceptions of climatic variability and climate change causing changes in rainfall patterns (Mubaya et al., 2012). For example, participant C mentioned that the rainfall period was previously July/August, sometimes in October/November followed by a dry year again. The previous dry year mentioned by participant C changed agricultural practices and impacted provisioning ecosystem services mostly livestock grazing and croplands.

Participant D observed late rainfall periods and at times the region would receive rain twice per annum, causing flash floods. This has an impact on the small town of Elim's traditional celebrations. The Elim community is managed by the Moravian Church and has different traditions celebrated throughout the year. In August the Kinder fees (Children's festival) and in October/November Doode Sondae (Eternal Sunday) are celebrated. The people in the community usually plant and harvest their crops before August. In September, approximately 90-120 days is the duration for groenboontjies (green beans) to cultivate, which is part of a traditional meal served in October/November for Doode Sondae (Eternal Sunday).

The provisioning ecosystem services are significant to participants and changes in the rainfall period have impacted their land use activities predominately agricultural croplands due to landscape degradation and water scarcity (Mubaya et al., 2012). Participants C and D have similar experiences of delayed rainfall periods and drought impacting their provisioning

ecosystem services. Participant C mentioned that before the drought, the area experienced good rainfall periods, producing enough grazing for cows. On the other hand, it impacted the cow's health due to gaining weight quickly being problematic for cows. Furthermore, during the summer season cows gained less weight but had difficulty adapting to new conditions that could impact the cow's calving, as a result of an unstable grazing period and changes in the grazing season. Throughout this period, participant C had 40 cows, 70 Eiland, and 40 bonteboks. After the dry year the farmer had 15 Eiland, 15 bonteboks, had sold half of his cows and the rest had died. This indicates that the impacts of climatic variability and climate change can hinder the benefits participants make use of or depend on during a specific season. This has an impact on people's traditions in Elim and agricultural practices.

The changes in the rainfall period caused by climatic variability and climate change influence invasive alien vegetation, harvesting of crops and grazing, causing changes in traditional agricultural practices and small-town celebrations. However, invasive alien vegetation is a major problem in the area, causing water loss in wetland systems (Nuwejaars Wetland Special Management Area Report, 2011). The participants have observed the changes and had to adapt from farming for production to farming for survival. This indicates that participant's perceptions about climate change and climatic variability are formed by changes noticed in the ecosystem services they use. Participants C and D both value the provisioning services (i.e. grazing and harvesting), which are important to them in the dry year as it provides food for livestock and people. However, climatic variability and change influence the extent to which the benefit is provided. This results in the productivity of farming systems being impacted that is dependent on the wetlands ecosystem since it sustains the livestock and harvesting of crops (Christin et al., 2014). In addition, the wet year is impacted due to changes in the rainfall period, which influences Elim's traditions and farming practices.

#### 5.5.3.3 Changes in wind direction

The prevailing wind direction of the Agulhas Plain is westerly in winter and easterly in summer (Kraaij et al., 2009). On the other hand, participants have repeatedly mentioned that the wind direction in the area has changed. They have observed strong wind speeds compared to previous years. The wind direction also comes from different directions, firstly from a North-West

direction following a South-West direction. Therefore, farmers believe the changes in the wind direction causes prevalent veld fires in the area. The veld fires used to be at 5-8 years intervals but have become more prevalent, burning every 3 years. The appropriate time to burn the veld is usually late summer/autumn season (Kraaij et al., 2009). The Agulhas Plain is experiencing an increase in temperature and invasive alien plants (IAP's) (Nuwejaars Wetland Special Management Area, 2011). The outcome of this is a reduction of an abundance of fynbos elements.

In conclusion, this section highlighted NWSMA members perceptions of the functioning of wetlands, their use of ecosystem services and climatic variability and climate change they mainly believe are impacting wetlands in the area. Participant's perceptions about the Nuwejaars Catchments wetlands ecosystem services are important as it illustrates that landowners with agricultural businesses are cautious about farming sustainably and conserving the environment. This is an indication that landowners are mindful and observe changes in wetland ecosystems. However, the participants consider the changes in wetland ecosystems to be caused mainly by climatic variability or climate change.



## Chapter 6 Discussion

### 6.1 Comparison of WET-EcoServices benefits and Landowners perceptions of ecosystem services

There is a difference between the WET-EcoService benefits and the landowners' perceptions of wetland ecosystem services. The WET-EcoServices benefits consist of both direct and indirect ecosystem services as being effective or ineffective in dry and wet years. In comparison, the landowner's perceptions highlight the importance or the effectiveness of the ecosystem services that are directly beneficial to them. This illustrates the point that landowner's perceived benefits provided by wetlands define the likeliness of their participation in activities or measures taken for the continuous supply of their important ecosystem services (Asah et al., 2014).

The WET-EcoService shows the authenticity of the ecosystem services provided being effective or ineffective and the characteristics contributing to the performance of the benefits within a dry or wet year. Landowner's perceptions of certain ecosystem services can be either positively or negatively influenced by previous experiences. The WET-EcoService tool can create awareness and assist landowners into seeing the practicality in the ecosystem services they consider as important that will be impacted by climatic variability and climate change. Compared to their perceptions being based on changes they have observed and experienced in the environment. The ecosystem services landowners perceive as important and the results of the WET-EcoService benefits can assist them into making adaptive strategies in order to respond effectively to climatic variability and climate change impacts (Ayal and Filho, 2017).

The outcomes of the study substantiate the argument that it is important to understand people's perceptions of wetland ecosystem services, especially landowners in the Nuwejaars Catchment practicing sustainable agriculture and conserving wetlands. Kaplowitz and Kerr (2003) state the perceptions of people are important to understand as it shows which ecosystem services landowners consider as important. As well as whether the effects of climatic variability and climate change are the only impacts affecting ecosystem services. The landowners mostly considered provisioning, supporting, and cultural ecosystem services as important. Yet flood attenuation, phosphate, nitrate, toxicant removal, and water quality ecosystem services are also beneficial to wetland ecosystems and agriculture. Greenland-Smith et al. (2016) argues that provisioning services are frequently mentioned and received more positive than negative

feedback. This is similar to landowners in the Nuwejaars Catchment whereby provisioning ecosystem services were positively mentioned. In comparison to flood attenuation receiving negative feedback as of the previous flood events and wetlands are perceived to be the cause of floods (Asha et al., 2014). This shows that landowners consider these ecosystem services as important as it is directly visible and benefits them in terms of grazing for livestock, habitat for fauna and the presence of wildlife at Waskraalvlei.

The indirect benefits such as regulating ecosystem services (i.e. flood attenuation and water quality enhancing benefits) are rarely considered as important, except during a wet year. In contrast, the WET-EcoService benefits show that the water quality enhancing benefits (i.e. phosphate, nitrate, and toxicant assimilation) show high effectiveness and opportunity scores compared to sediment trapping and flood attenuation showing low effectiveness scores but high opportunity scores. However, throughout the dry and wet years, the direct and indirect ecosystem services are impacted by prolonged drought and floods, which can result in the benefits increasing, decreasing, showing signs of no change, or uncertainty. This indicates that there is a difference between landowners and possible WET-EcoService benefits.

The direct ecosystem services were considered important to landowners but scored low in the WET-EcoService assessment. In comparison, to the indirect ecosystem services which scored higher in the WET-EcoService assessment and were not considered as important to landowners. The ecosystem services considered as important by landowners and WET-EcoServices benefits was different in terms of importance and whether they were used in dry and wet years. Pan et al. (2016) state that people in urban areas prioritised direct and indirect ecosystem services and rural people mostly prioritised direct ecosystems services. This was verified when landowners frequently mentioned provisioning ecosystem services.

The WET-EcoService results illustrate that the functioning of wetlands is extremely important in connecting the effect of agriculture on downstream systems, which are ignored by landowners. Agricultural practices in the catchment can contribute to the effectiveness and opportunities of the ecosystem services provided. The agricultural factors such as the extent of sediment sources (cultivated lands and gravel roads), amount of biocides and fertilizers, point and non-point sources and land use practices in the catchment contribute to the effectiveness and opportunity

scores. However, landowners did not openly acknowledge that their agricultural practices may contribute to wetland ecosystems or downstream uses but often only pointed to climatic variability or climate change as causing changes in the benefits.

The landowners have observed changes in rainfall and wind direction in the catchment and their experiences can be substantiated with rainfall data provided by landowners illustrating that there have been changes in climate over time. Elum et al. (2017) argues that South Africa's weather has considerably changed as well as changes in rainfall. Although, landowners are aware of the changes in the region and believe that changes in the wetland ecosystems are only caused by climatic variability or climate change. Similarly to the IPCC (2007) definition of climate change being more empirically based compared to Dang et al. (2014) defining it to be the change in climate caused by direct and indirect human activities. However, this is an indication that landowners are oblivious that their farming activities are impacting important ecosystem services of wetland ecosystems and their considered important benefits.

The conclusion that landowner's of the Nuwejaars Catchment are aware of wetland ecosystems and the benefits provided is an indication that the landowners understand the importance of wetland ecosystem services and the benefits provided. However, they mostly consider provisioning, supporting, and cultural ecosystem services as important compared to regulating ecosystem services. The WET-EcoServices benefits show the reality of direct and indirect ecosystem services important to people, fauna and wetland ecosystems. Landowners have identified changes in rainfall, wind direction and have experienced flood events.

## **6.2 Recommendations**

Nuwejaars Wetland Special Management Area (2011) states that sustainable agricultural activities is a priority, previously this was not important to landowners until their traditional agriculture was under pressure. Therefore, the study recommends the following in order to manage wetlands and practice agriculture sustainably. Landowners have a connection to the landscape and their perceived important ecosystem services are more likeable to their interest in catchment management to guarantee their participation (Asha et al., 2014). The WET-EcoService tool is beneficial to wetland management as it evaluates the effectiveness and opportunity of ecosystem goods and services. The results can inform landowners and managers



on which ecosystem services are ineffective or degraded and provide landowners with information on how their conservation methods are either positively or negatively impacting wetlands. The outlet of the Heuningnes Estuary should be maintained to prevent floods during heavy rainfall periods. The extent of livestock grazing and removing of reeds should be reduced in dry years as the vegetation is beneficial for decreasing the speed of water in wet years.



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## Appendix A



UNIVERSITY of the  
WESTERN CAPE

### INFORMATION SHEET

**Thesis title:** Perceptions of wetland ecosystem services in a region of climatic variability

**Student name:** Samantha Williams

**Student no.:** 3263933

**Supervisor:** Dr. Suzanne Grenfell and Mrs. Mandy Carolissen

**Department:** Geography, Environmental Studies and Tourism

Wetlands provide humans with several benefits such as managing flood waters, purifying water, and providing a habitat for plants and animals. The ability of a wetland to provide such benefits is dependent on its health, as well as opportunity. For instance, a wetland can only manage flood waters during heavy rain or purify water that is dirty. This study looks at wetland benefits and how they are impacted upon by climate.

The aim of this study is to understand how people view wetlands and investigate how these views change when the climate is very wet (flood) or very dry (drought). For example, the grazing provided by wetlands may be much more important during dry years when there is little vegetation, as compared to during wet years, when there is plenty of grazing available. We have chosen to focus on 6 benefits that wetlands are known to provide to different extents.

The interview will take up to one hour, and will allow you to express your views on the benefits provided by wetlands and how these are impacted upon by climate. There is no right or wrong answer, the study is about how people view wetlands and all opinions are valid.

Please indicate on the attached consent form that you have granted me permission to make an audio recording of the interviews. You have the right to withdraw from the study at any time or reason. Participants will not receive any payment/reimbursement. Audio recordings and notes from interviews will be treated with confidentiality. Information will be kept safe in a locked file and electronic information will be coded with a secure password. All research records will be deleted 5 years after the study has been completed. Participants will be anonymous and pseudonyms or the role within an organization the participant is associated with will be used.

If you wish to contact me or my supervisor at any time, please do not hesitate to make use of the contact information as provided below.

Samantha Williams  
35 Ruimte Road  
Manenberg, 7764

Dr. Suzanne Grenfell  
Department of Geography Environmental Studies  
and Tourism

Tel. 021- 6336497    Cell. 072 688 1907  
Email: [williamssamantha13@gmail.com](mailto:williamssamantha13@gmail.com)

Tel. 021- 959 2668  
Email: [sgrenfell@uwc.ac.za](mailto:sgrenfell@uwc.ac.za)

**Consent Form**  
**Please initial box**

**Project:** Perceptions of wetland ecosystem services in a region of climatic variability

**Researcher:** Samantha Williams (3263933)

**Supervisor:** Dr. Suzanne Grenfell and Mrs. Mandy Carolissen

1. I confirm that I have read and that I understand the information sheet explaining the above research project and confirm that I have had the opportunity to ask questions about the project.
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason or negative consequences for me. In addition, should I not wish to answer any particular question or questions, I am free to decline.
3. I understand that the information given will be protected, e.g. by using pseudonyms for all the individuals interviewed and those mentioned in such interview.
4. I hereby give permission for an audio-recording of the interview.
5. I agree for the data collected from me to be used in this project and publications.
6. I agree to take part in the above research project.



I..... (Full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

\_\_\_\_\_  
Name of Participant  
(Or legal representative)

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Name of person taking consent  
(If different from lead researcher)

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Researcher  
(To be signed and dated in presence of the participants)

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature

*Copies: Each participant will receive a copy of the signed and dated version of the consent form and information sheet. A copy of these forms will be filled and kept in a secure location for research purposes only.*



## **Semi-Structured Interview**

**University of the Western Cape**

**Department of Geography, Environmental Studies and Tourism**

### **Perceptions of wetlands**

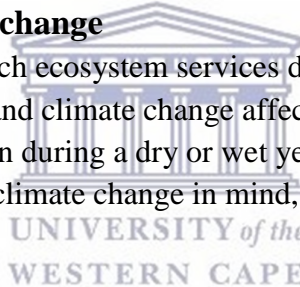
1. How would you define a wetland?
2. Do you have any wetlands on your land?
3. As a landowner how do you make use of the wetlands on your land?
4. Are you aware of any wetlands used in the surrounding area? (Or how they have been used?) If so, which wetland, and what is it used for?

### **Ecosystem services**

5. What benefits do you think wetlands provide to people?
6. Which of these benefits are important to you?
7. How do you make use of those benefits?
8. How beneficial are ecosystem services previously mentioned in dry and wet years?
9. Are there different ecosystem services provided in dry and wet years?

### **Climatic variability and climate change**

10. During dry and wet years which ecosystem services do you make use of?
11. How has climatic variability and climate change affected the benefits of wetland ecosystem services you rely on during a dry or wet year?
12. With climate variability and climate change in mind, has it changed the way you benefit from wetlands?



## Aanhangsel A



UNIVERSITY of the  
WESTERN CAPE

### INLIGTINGSBLAD

**Titel:** Persepsies van vleiland ekosisteedienste in 'n streek van klimaatsberanderlikheid

**Studente naam:** Samantha Williams

**Studente nommer:** 3263933

**Studieleier:** Dr. Suzanne Grenfell en Mev. Mandy Carolissen

**Departement:** Geografie, Omgewingstudie en Toerism

Vleilande voorsien mense met verskeie voordele soos die bestuur van vloedwater, suiwering van water en die voorsiening van 'n habitat vir plante en diere. Die vermoë van 'n vleiland om sulke voordele te bied is afhanklik van sy gesondheid, sowel as die geleentheid. Byvoorbeeld, 'n vleiland kan slegs vloedwater bestuur tydens swaar reën of suiwer water wat vuil is. Hierdie studie kyk na die voordele van vleilande en hoe dit deur klimaat beïnvloed word.

Die doel van hierdie studie is om te verstaan hoe mense vleilande besigtig en ondersoek hoe hierdie sienings verander wanneer die klimaat baie nat (vloed) of baie droog (droogte) is. Byvoorbeeld, die weiding wat deur vleilande voorsien word, kan tydens droë periodes baie belangriker wees as daar min plantegroei in vergelyking met nat tydperke wanneer daar genoeg weiding beskikbaar is. Ons het gekies om te fokus op 6 voordele wat vleilande op verskillende vlakke bekend stel.

Die onderhoud is een uur en sal jou toelaat om jou standpunte oor die voordele van vleilande uit te spreek en hoe dit deur klimaat beïnvloed word. Daar is geen regte of verkeerde antwoord nie, die studie gaan oor hoe mense die vleilande sien en alle menings is geldig.

Dui asseblief op die aangehegte toestemmingsvorm aan dat u my toestemming gegee het om 'n klankopname van die onderhoude te maak. U het die reg om eniger tyd uit die studie te onttrek. Deelnemers ontvang geen betaling / terugbetaling nie. Oudio-opnames en notas uit onderhoude sal met vertroulikheid hanteer word. Inligting sal veilig gehou word in 'n geslote lêer en elektroniese inligting sal met 'n veilige wagwoord gekodeer word. Alle navorsingsrekords sal in 5 jaar verwyder word nadat die studie voltooi is. Deelnemers sal anoniem wees en pseudonieme of die rol binne 'n organisasie waaraan die deelnemer geassosieer word, sal gebruik word.

As u my of my studieleier te eniger tyd wil kontak, moet asseblief nie huiwer om die kontakinligting soos hieronder uiteengesit, te gebruik nie.

Samantha Williams  
35 Ruimteweg  
Manenberg, 7764  
Tel. 021- 6336497 Sel. 072 688 1907  
E-pos: [williamssamantha13@gmail.com](mailto:williamssamantha13@gmail.com)

Dr Suzanne Grenfell  
Departement Geografie Omgewingsstudie  
en Toerisme  
Tel. 021-959 2668  
E-pos: [sgrenfell@uwc.ac.za](mailto:sgrenfell@uwc.ac.za)

**Vrywarings vorm  
Asseblief aanvanklike boks**

**Projek:** Persepsies van vleiland ekosisteedienste in 'n streek van klimaatsveranderlikheid

**Navorsers:** Samantha Williams (3263933)

**Studieleier:** Dr. Suzanne Grenfell en Mev. Mandy Carolissen

1. Ek bevestig dat ek gelees het en dat ek die inligtingsblad verstaan wat die bogenoemde navorsingsprojek verduidelik en bevestig dat ek die geleentheid gehad het om vrae oor die projek te stel.

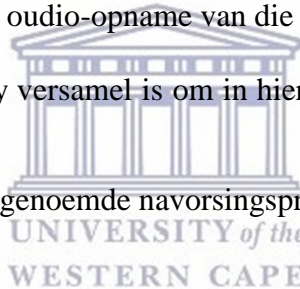
2. Ek verstaan dat my deelname vrywillig is en dat ek te eniger tyd vry kan wees sonder om enige rede of negatiewe gevolge vir my te gee. Verder, as ek nie 'n spesifieke vraag of vrae wil beantwoord nie, is ek vry om te weier.

3. Ek verstaan dat die gegewe inligting beskerm sal word, bv. deur gebruik te maak van pseudonieme vir al die individue wat ondervra is en diegene wat in so 'n onderhoud genoem word.

4. Hiermee gee ek toestemming vir 'n oudio-opname van die onderhoud.

5. Ek stem in vir die data wat van my versamel is om in hierdie projek en publikasies gebruik te word.

6. Ek stem in om deel te neem aan bogenoemde navorsingsprojek.



Ek ..... (Volle name van deelnemer) bevestig hiermee dat ek die inhoud van hierdie dokument en die aard van die navorsingsprojek verstaan en ek stem in om aan die navorsingsprojek deel te neem.

\_\_\_\_\_  
Naam van Deelnemer  
(Of wettige verteenwoordiger)

\_\_\_\_\_  
Datum Handtekening

\_\_\_\_\_  
Naam van persoon wat toestemming neem  
(Indien anders as hoofnavorsers)

\_\_\_\_\_  
Datum Handtekening

\_\_\_\_\_  
Navorsers  
(Om onderteken te word en gedateer in die teenwoordigheid van die deelnemers)

\_\_\_\_\_  
Datum Handtekening

*Afskrifte: Elke deelnemer sal 'n afskrif van die getekende en gedateerde weergawe van die toestemmingsvorm en inligtingsblad ontvang. 'N Afskrif van hierdie vorms sal slegs vir navorsingsdoeleindes op 'n veilige plek gevul word.*

## **Semi-gestruktureerde Onderhoud**

**Universiteit van Wes-Kaapland**

**Departement van Geografie, Omgewingstudie en Toerisme**

### **Persepsies van vleilande**

1. Hoe sal jy 'n vleiland definieer?
2. Het u enige vleilande op u grond?
3. As grondeienaar, hoe gebruik jy die vleilande op jou land?
4. Is jy bewus van enige vleilande wat in die omliggende gebied gebruik word? (Of hoe is hulle gebruik?) Indien wel, watter vleiland, en waarvoor word dit gebruik?

### **Ekosisteedienste**

5. Watter voordele dink jy bied vleilande aan mense?
6. Watter van hierdie voordele is belangrik vir jou?
7. Hoe maak jy van daardie voordele gebruik?
8. Hoe voordelig is ekosisteedienste wat vroeër in droë en nat tydperke genoem is?
9. Is daar verskillende ekostelseldienste wat in droë en nat tydperke voorsien word?

### **Klimaatverandering en klimaatsverandering**

10. Gedurende droë en nat tydperke watter ekostelseldienste gebruik jy?
11. Hoe het klimaatsveranderlikheid en klimaatsverandering die voordele van vleiland-ekosisteedienste beïnvloed wat u op 'n droë of nat tydperk gebruik?
12. Met klimaatsveranderlikheid en klimaatsverandering in gedagte, het dit verander hoe jy voordeel trek uit vleilande?



UNIVERSITY of the  
WESTERN CAPE

## Appendix B

### INFORMATION SHEET

**Thesis title:** Perceptions of wetland ecosystem services in a region of climatic variability

**Student name:** Samantha Williams

**Student no.:** 3263933

**Supervisor:** Dr. Suzanne Grenfell and Mrs. Mandy Carolissen

**Department:** Geography, Environmental Studies and Tourism

Wetlands provide humans with several benefits such as managing flood waters, purifying water, and providing a habitat for plants and animals. The ability of a wetland to provide such benefits is dependent on its health, as well as opportunity. For instance, a wetland can only manage flood waters during heavy rain or purify water that is dirty. This study looks at wetland benefits and how they are impacted upon by climate.

The aim of this study is to understand how people view wetlands and investigate how these views change when the climate is very wet (flood) or very dry (drought). For example, the grazing provided by wetlands may be much more important during dry years when there is little vegetation, as compared to during wet years, when there is plenty of grazing available. We have chosen to focus on 6 benefits that wetlands are known to provide to different extents.

The participatory mapping exercise will be 15 to 20 minutes.

The participants will be shown a map of the Agulhas coastal Plain wetlands and will be asked to:

- The participants will draw on the map to indicate wetlands in the landscape that they perceive as providing their important ecosystem services. The exercise will be repeated for dry and wet years.
- Rank the listed ecosystem services from most important to (5) to least important (1). The participants will rank the services by importance during dry years and wet years.
- Lastly participants will be asked to rank how severely climatic variability and climate change has impacted their important ecosystem services in dry and wet years.

Please indicate on the attached consent form that you have granted me permission to make an audio recording of the participatory mapping exercise. Remember you have the right to withdraw from the study at any time or reason and participants will not receive any payment/reimbursement. Audio recordings and notes from the participatory mapping exercise will be treated with confidentiality. Information will be kept safe in a locked file and electronic information will be coded with a secure password. All research records will be deleted 5 years after the study has been completed. Participant will be anonymous and pseudonyms or the role within an organization the participant is associated with will be used.

If you wish to contact me or my supervisor at any time, please do not hesitate to make use of the contact information as provided below.

Samantha Williams  
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Manenberg, 7764  
Tel. 021- 6336497 Cell. 072 688 1907  
Email: [williamssamantha13@gmail.com](mailto:williamssamantha13@gmail.com)

Dr. Suzanne Grenfell  
Department of Geography Environmental Studies  
and Tourism  
Tel. 021- 959 2668  
Email: [sgrenfell@uwc.ac.za](mailto:sgrenfell@uwc.ac.za)

**Consent Form**  
**Please initial box**

**Project:** Perceptions of wetland ecosystem services in a region of climatic variability

**Researcher:** Samantha Williams (3263933)

**Supervisor:** Dr. Suzanne Grenfell and Mrs. Mandy Carolissen

1. I confirm that I have read and that I understand the information sheet explaining the above research project and confirm that I have had the opportunity to ask questions about the project.

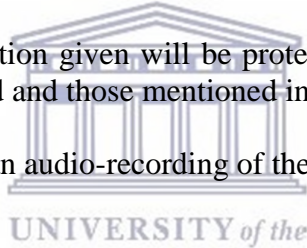
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason or negative consequences for me. In addition, should I not wish to answer any particular question or questions, I am free to decline.

3. I understand that the information given will be protected, e.g. by using pseudonyms for all the individuals interviewed and those mentioned in such interview.

4. I hereby give permission for an audio-recording of the participatory mapping exercise.

5. I agree for the data collected from me to be used in this project and publications.

6. I agree to take part in the above research project.



I..... (Full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

\_\_\_\_\_  
Name of Participant  
(Or legal representative)

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Name of person taking consent  
(If different from lead researcher)

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Researcher

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature

(To be signed and dated in presence of the participants)

*Copies: Each participant will receive a copy of the signed and dated version of the consent form and information sheet. A copy of these forms will be filled and kept in a secure location for research purposes only.*



**University of the Western Cape**  
**Department of Geography, Environmental Studies and Tourism**  
**Participatory Mapping Exercise**



Age: .....

Gender: Male       Female       Closest Wetland: .....

Please rank the importance of the following wetland benefits.

- |                         |                       |
|-------------------------|-----------------------|
| 1- Not at all important | 2- Slightly important |
| 3- Moderately important | 4- Very important     |
| 5- Extremely important  |                       |

<b>Wetland Benefits- Dry year</b>	
Ecosystem Services	Rank
Purify water	
Decrease floods	
Tourism and recreation	
Water usage	
Harvestable resources	
Education and research	

<b>Wetland Benefits- Wet year</b>	
Ecosystem Services	Rank
Purify water	
Decrease floods	
Tourism and recreation	
Water usage	
Harvestable resources	
Education and research	

Please state which wetland benefits you think are most severely impacted during a wet or dry year, stating the most affected services first.

Dry year: \_\_\_\_\_

Wet year: \_\_\_\_\_



## Aanhangsel B



### INLIGTINGSBLAD

**Titel:** Persepsies van vleiland ekosisteedienste in 'n streek van klimaatsberanderlikheid

**Studente naam:** Samantha Williams

**Studente nommer:** 3263933

**Studieleier:** Dr. Suzanne Grenfell en Mev. Mandy Carolissen

**Departement:** Geografie, Omgewingstudie en Toerism

Vleilande voorsien mense met verskeie voordele soos die bestuur van vloedwater, suiwering van water en die voorsiening van 'n habitat vir plante en diere. Die vermoë van 'n vleiland om sulke voordele te bied is afhanklik van sy gesondheid, sowel as die geleentheid. Byvoorbeeld, 'n vleiland kan slegs vloedwater bestuur tydens swaar reën of suiwer water wat vuil is. Hierdie studie kyk na die voordele van vleilande en hoe dit deur klimaat beïnvloed word.

Die doel van hierdie studie is om te verstaan hoe mense vleilande besigtig en ondersoek hoe hierdie sienings verander wanneer die klimaat baie nat (vloed) of baie droog (droogte) is. Byvoorbeeld, die weiding wat deur vleilande voorsien word, kan tydens droë periodes baie belangriker wees as daar min plantegroei is, in vergelyking met nat tydperke wanneer daar genoeg weiding beskikbaar is. Ons het gekies om te fokus op 6 voordele wat vleilande op verskillende vlakke bekend stel.

Die deelnemende kaart oefening sal 15 tot 20 minute wees.

Die deelnemers sal 'n kaart van die Agulhas kus Plain vleilande getoon word en sal gevra word om:

- Die deelnemers sal op die kaart teken om vleilande in die landskap aan te dui wat hulle beskou as hul belangrike ekosisteedienste. Die oefening sal herhaal word vir droë en nat periodes.
- Rangskik die gelyste ekosisteedienste van die belangrikste tot (5) tot die minste belangrike (1). Die deelnemers sal die dienste rangskik tydens droë en nat periodes.
- Laastens sal deelnemers gevra word om te bepaal hoe swaar klimaatsverandering en klimaatsverandering hul belangrike ekosisteedienste in droë en nat tydperke beïnvloed het.

Dui asseblief op die aangehegte toestemmingsvorm aan dat u my toestemming gegee het om 'n klankopname van die deelnemende karteringoefening te maak. Onthou jy het die reg om enige tyd of rede uit die studie te onttrek en deelnemers sal geen betaling / terugbetaling ontvang nie. Oudio-opnames en notas uit die deelnemende karteringoefening sal met vertroulikheid hanteer word. Inligting sal veilig gehou word in 'n geslote lêer en elektroniese inligting sal met 'n veilige wagwoord gekodeer word. Alle navorsingsrekords sal 5 jaar verwyder word nadat die studie voltooi is. Deelnemer sal anoniem wees en pseudonieme of die rol binne 'n organisasie waaraan die deelnemer geassosieer word, sal gebruik word.

As u my of my studieleier te eniger tyd wil kontak, moet asseblief nie huiwer om die kontakinligting soos hieronder uiteengesit, te gebruik nie.

Samantha Williams

35 Ruimteweg

Manenberg, 7764

Tel. 021- 6336497 Sel. 072 688 1907

E-pos: [williamssamantha13@gmail.com](mailto:williamssamantha13@gmail.com)

Dr Suzanne Grenfell

Departement Geografie Omgewingsstudie  
en Toerisme

Tel. 021-959 2668

E-pos: [sgrenfell@uwc.ac.za](mailto:sgrenfell@uwc.ac.za)



**Vrywarings vorm  
Asseblief aanvanklike boks**

**Projek:** Persepsies van vleiland-ekosisteedienste in 'n streek van klimaatsveranderlikheid

**Navorsers:** Samantha Williams (3263933)

**Studieleier:** Dr. Suzanne Grenfell en Mev. Mandy Carolissen

1. Ek bevestig dat ek gelees het en dat ek die inligtingsblad verstaan wat die bogenoemde navorsingsprojek verduidelik en bevestig dat ek die geleentheid gehad het om vrae oor die projek te stel.

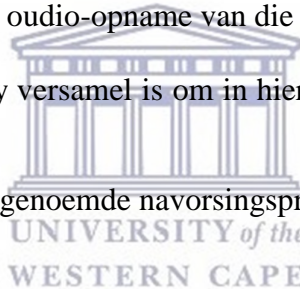
2. Ek verstaan dat my deelname vrywillig is en dat ek te eniger tyd vry kan wees sonder om enige rede of negatiewe gevolge vir my te gee. Verder, as ek nie 'n spesifieke vraag of vrae wil beantwoord nie, is ek vry om te weier.

3. Ek verstaan dat die gegewe inligting beskerm sal word, bv. deur gebruik te maak van pseudonieme vir al die individue wat ondervra is en diegene wat in so 'n onderhoud genoem word.

4. Hiermee gee ek toestemming vir 'n oudio-opname van die onderhoud.

5. Ek stem in vir die data wat van my versamel is om in hierdie projek en publikasies gebruik te word.

6. Ek stem in om deel te neem aan bogenoemde navorsingsprojek.



Ek ..... (Volle name van deelnemer) bevestig hiermee dat ek die inhoud van hierdie dokument en die aard van die navorsingsprojek verstaan en ek stem in om aan die navorsingsprojek deel te neem.

\_\_\_\_\_  
Naam van Deelnemer  
(Of wettige verteenwoordiger)

\_\_\_\_\_  
Datum Handtekening

\_\_\_\_\_  
Naam van persoon wat toestemming neem  
(Indien anders as hoofnavorsers)

\_\_\_\_\_  
Datum Handtekening

\_\_\_\_\_  
Navorsers  
(Om onderteken te word en gedateer in die teenwoordigheid van die deelnemers)

\_\_\_\_\_  
Datum Handtekening

*Afskrifte: Elke deelnemer sal 'n afskrif van die getekende en gedateerde weergawe van die toestemmingsvorm en inligtingsblad ontvang. 'N Afskrif van hierdie vorms sal slegs vir navorsingsdoeleindes op 'n veilige plek gevul word.*

Universiteit van Wes-Kaapland

Departement van Geografie, Omgewingstudie en Toerisme

Deelnemende Kaart Oefening



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Ouderdom: .....

Geslag: Manlik  Vroulik  Naaste vleiland: .....

Rangskik asseblief die belangrikheid van die volgende vleiland voordele.

- 1- Glad nie belangrik nie
- 2- Bietjie belangrik
- 3- Redelik belangrik
- 4- Baie belangrik
- 5- Uiters belangrik

Vleilandvoordele-Droë Periode	
Ekosisteem Dienste	Rang
Suiwering van water	
Verminder vloede	
Toerisme en ontspanning	
Waterverbruik	
Oesbare hulpbronne	
Onderwys en navorsing	

Vleilandvoordele- Nat Periode	
Ekosisteem Dienste	Rang
Suiwering van water	
Verminder vloede	
Toerisme en ontspanning	
Waterverbruik	
Oesbare hulpbronne	
Onderwys en navorsing	

Dui asseblief aan watter vleilandvoordele u dink die mees ingewikkelde impak het gedurende 'n droë of nat periode, met vermelding van die mees geraakde dienste.

Droë periode:

\_\_\_\_\_

Nat periode:

\_\_\_\_\_

## Appendix C



## Appendix D

Wetland name/reference number	Vöevlei (Droërivier)	Karsriviervlei	Soetendalsvlei	Wiesdrift	Waskraalvlei
	Score	Score	Score	Score	Score
<b>Flood attenuation</b>					
<b>Effectiveness of the wetland</b>					
Size of wetland relative to catchment	3	0	0	0	0
Slope of wetland	0	0	1	1	1
Surface roughness of wetland	1	2,5	1	2	3
Depressions	0	2	0	0	0
Frequency with which stormflows spread across the wetland	3	3	3	3	3
Sinuosity of the stream channel	0	2	1	1	2
Representation of different hydrological zones	0	0	0	0	0
<b>Score for effectiveness:</b>	<b>1,0</b>	<b>1,4</b>	<b>0,9</b>	<b>1,0</b>	<b>1,3</b>
<b>Opportunity for attenuating floods</b>					
Average slope of the wetland's catchment	0	0	1	1	1
Inherent runoff potential of soils in catchment	0,5	0,5	1	0	1
Contribution of catchment land-uses to changing runoff intensity from the natural condition	2	2	3	3	1,5
Rainfall intensity	1	1	1	3	1
Extent of floodable property downstream	0	1	3	3	1
<b>Score for opportunity:</b>	<b>0,7</b>	<b>0,9</b>	<b>1,8</b>	<b>2,0</b>	<b>1,1</b>
<b>Overall score/rating for flood attenuation</b>	<b>0,9</b>	<b>1,1</b>	<b>1,3</b>	<b>1,5</b>	<b>1,2</b>
<b>Streamflow regulation</b>					

Link to the stream network	4	4	4	4	4
Representation of different hydrological zones	4	4	4	4	4
Presence of fibrous peat or unconsolidated sediments below floating marsh	0	0	0	0	0
Reduction in evapotranspiration through frosting back of the wetland vegetation	0	0	0	0	0
HGM unit occurs on underlying geology with strong surface-groundwater linkages	4	4	4	4	4
Presence of any important wetlands or aquatic systems downstream	4	4	4	4	4
<b>Overall score/rating for streamflow augmentation</b>	<b>2,666666667</b>	<b>2,666666667</b>	<b>2,666666667</b>	<b>2,666666667</b>	<b>2,666666667</b>
<b>Sediment trapping</b>					
<b>Effectiveness of the wetland</b>					
Effectiveness in attenuating floods	1,0	1,4	0,9	1,0	1,3
Direct evidence of sediment deposition	1	4	1	2	1
<b>Score for effectiveness:</b>	<b>1</b>	<b>2,678571429</b>	<b>0,928571429</b>	<b>1,5</b>	<b>1,142857143</b>
<b>Opportunity</b>					
Extent to which dams are reducing the input of sediment	4	4	4	4	4
Extent of sediment sources delivering sediment to the HGM unit	1	1	2	2	3
Presence of any important wetlands or aquatic systems downstream	4	4	4	4	4
<b>Score for opportunity:</b>	<b>3</b>	<b>3</b>	<b>3,333333333</b>	<b>3,333333333</b>	<b>3,666666667</b>

<b>Overall score/rating for sediment trapping</b>	<b>2,0</b>	<b>2,8</b>	<b>2,1</b>	<b>2,4</b>	<b>2,4</b>
<b>Phosphate trapping</b>					
<b>Effectiveness of the wetland</b>					
Effectiveness of trapping sediment	1,0	2,7	0,9	1,5	1,1
Pattern of low flows within the wetland	4	1	2	1	1
Extent of vegetation cover	3	4	2	2	3
Application of fertilizer/biocides directly in the HGM unit	4	3	4	3	3
<b>Score for effectiveness:</b>	<b>3,0</b>	<b>2,7</b>	<b>2,2</b>	<b>1,9</b>	<b>2,0</b>
<b>Opportunity</b>					
Extent of sediment sources	1	2	2	3	2
Extent of other potential sources - point source	3	2	3	3	3
Presence of any important wetlands or aquatic systems downstream	4	4	4	4	4
<b>Score for opportunity:</b>	<b>2,666666667</b>	<b>2,666666667</b>	<b>3</b>	<b>3,333333333</b>	<b>3</b>
<b>Overall score/rating for phosphate trapping</b>	<b>2,8</b>	<b>2,7</b>	<b>2,6</b>	<b>2,6</b>	<b>2,5</b>
<b>Nitrate removal</b>					
<b>Effectiveness</b>					
Hydrological zonation	4	4	4	4	4
Pattern of low flows	4	1	2	1	1
Extent of vegetation cover	3	4	2	2	3
Contribution of sub-surface water inputs relative to surface water inputs	4	1	0	1,5	1
Application of fertilizer/biocides directly in the HGM unit	4	3	4	3	1
<b>Score for</b>	<b>3,8</b>	<b>2,6</b>	<b>2,4</b>	<b>2,3</b>	<b>2,0</b>



<b>effectiveness:</b>					
<b>Opportunity</b>					
Extent of nitrate sources in the HGM unit's catchment	3	2	3	3	2
Presence of any important wetlands or aquatic systems downstream	4	4	4	4	4
<b>Score for opportunity:</b>	<b>3,5</b>	<b>3</b>	<b>3,5</b>	<b>3,5</b>	<b>3</b>
<b>Overall score/rating for nitrate removal</b>	<b>3,7</b>	<b>2,8</b>	<b>3,0</b>	<b>2,9</b>	<b>2,5</b>
<b>Toxicant removal</b>					
<b>Effectiveness</b>					
Hydrological zonation	4	4	4	4	4
Pattern of low flows	4	1	2	1	1
Extent of vegetation cover	3	4	1	2	3
Effectiveness in trapping sediment	1,0	2,7	0,9	1,5	1,1
Application of fertilizer/biocides directly in the HGM unit	4	3	4	3	1
<b>Score for effectiveness:</b>	<b>3,2</b>	<b>2,9</b>	<b>2,4</b>	<b>2,3</b>	<b>2,0</b>
<b>Opportunity</b>					
Extent of sediment sources	1	2	2	3	2
Extent of toxicant sources	1	2	3	3	2
Presence of any important wetlands or aquatic systems downstream	4	4	4	4	4
<b>Score for effectiveness:</b>	<b>2</b>	<b>2,666666667</b>	<b>3</b>	<b>3,333333333</b>	<b>2,666666667</b>
<b>Overall score/rating for toxicant removal</b>	<b>2,6</b>	<b>2,8</b>	<b>2,7</b>	<b>2,8</b>	<b>2,3</b>
<b>Water supply</b>					
Hydrological zones	4	4	4	4	4
Importance for streamflow augmentation	2,7	2,7	2,7	2,7	2,7
Current use for agricultural purposes	0	2,5	2,5	2	4

Current use for domestic purposes	0	0	3	2	1
Number of households	1	0	1	1	0
Substitutability of wetland water source	2	2	2	3	3
<b>Overall score/rating for water supply</b>	<b>1,6</b>	<b>1,9</b>	<b>2,5</b>	<b>2,4</b>	<b>2,4</b>
<b>Provision of harvestable natural resources</b>					
Total number of resources	3	1	3	2	4
Location in rural communal area	0	0	3	1	0
Level of poverty	0	0	0	0	0
Number of households depending on wetland	2	0	0	1	0
Substitutability of the wetland resources	2	3	2	2	3
<b>Overall score/rating for source of goods /resources</b>	<b>1,4</b>	<b>0,8</b>	<b>1,6</b>	<b>1,2</b>	<b>1,4</b>
<b>Tourism and recreation</b>					
Scenic beauty of the HGM unit	3	2	2	3	4
Presence of "charismatic" species	3	3	2	2	4
Currently used	1	0	0,5	1	4
Suitable locations for facilities	0	0	0	3	2
Location within a tourism route	2	2	0	1	1
Recreational hunting and fishing and birding opportunities	1	1	2	2	4
Extent of open water	1	1	1	3	3
<b>Overall score/rating for tourism and recreation</b>	<b>1,6</b>	<b>1,3</b>	<b>1,1</b>	<b>2,1</b>	<b>3,1</b>
<b>Education and research</b>					
Currently used	4	2	3	2	3
Reference site suitability	4	2	2	3	4
Existing long term	2	2	4	2	3

research & data collected					
Accessibility	3	2	3	2	1
<b>Overall score/rating for education and research</b>	<b>3,3</b>	<b>2,0</b>	<b>3,0</b>	<b>2,3</b>	<b>2,8</b>



## Appendix E



Photography source: Erica Brink (Nuwejaars Wetland Special Management Area)



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