Exploring the ecological and social benefits of the Khayelitsha Wetlands Park

By

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Declaration

I know the meaning of plagiarism and declare that all of the work in the dissertation, save for that which is properly acknowledged, is my own.

Signature: Signed by candidate Date: _____

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Abstract

In a world confronted by rapid urbanization linked with dramatic population growth rates, there is a general consensus that quality urban green spaces are important components of urban landscapes. Urban green spaces are defined as open spaces in urban areas primarily covered with vegetation, which are available to users within the community. They have the ability to shape the image of cities and provide various important socioecological benefits, which can contribute to improving the quality of life within these urban communities. In Cape Town, the provision of readily accessible quality urban green spaces is often overridden by other conflicting demands, such as biodiversity conservation and infrastructure development demands. The literature suggests that Cape Town has ample available green spaces. However, the accessibility of this green space is linked to issues of poor management and maintenance, and as a result poor urban spaces are often associated with criminal activities, and are therefore unavailable to benefit urban communities. This is particularly evident in areas which have a low socioeconomic status. This study explores the ecosystem services offered by the Khayelitsha Wetlands Park in the Khayelitsha Township on the Cape Flats. A variety of methods were used to establish the condition of the Wetlands Park and assess the impacts of various uses (e.g. recreation, agriculture etc.) on the vegetation structure and water quality. Qualitative semi-structured interviews were also conducted to assess the local community's uses and perceptions of this green space. A Complex Adaptive Landscape (CAL) approach was adopted to derive the positive and negative social-ecological impacts of the Khayelitsha Wetlands Park. The vegetation structure assessment results showed a dominance of emergent and invasive vegetation, such as *Typha capensis* and *Acacia cyclops*, and indicates a high level of degradation and a lack of indigenous vegetation species. The water quality analysis reveals high concentrations of physiochemical and microbial pollutants, where a majority exceeded the Targeted Water Quality Ranges (TWQR) recommended by the Department of Water Affairs for livestock watering, irrigation and human use. Findings from the semi-structured interviews, revealed that a majority of users

visit the Park for multiple activities offered by the Park. These include relaxation, creating and maintaining social relations, sports and recreation and agricultural use. The CAL framework revealed negative and positive feedback mechanisms at play in this urban green space. The negative feedback effects are illustrated and confirmed by poor water quality and a predominantly alien infested vegetation structure. The poor ecological condition of the Wetland is linked to a number of anthropogenic influences, including the discharge of treated waste and untreated waste from both agricultural and urban waste sources, indicating the complexity of managing the Khayelitsha Wetlands Park. Since a number of users and management institutions are connected to the Khayelitsha Wetlands Park, their involvement in the management thereof is crucial for effectively solving the issues identified.

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Chapter 1

Introduction

1.1. Introduction

Global urbanization rates have increased dramatically in recent years (Kong & Nakagoshi, 2006; Lee & Maheswaran, 2010) and it is estimated that 60% of the global population will be living in cities by 2030 (Alberti *et al*., 2003). The urbanization rates in developing countries currently exceeds that of developed countries (UN-Habiatat, 2006; Ward *et al*., 2010). Recent studies show that urban areas in sub-Saharan Africa have the highest annual population growth rates (Ward *et al*., 2010). Urbanization and associated developments have major consequences for biodiversity and ecosystems in cities. This include the loss of urban green spaces, which threatens the ability of ecosystems to provide services necessary for sustaining life in cities (Pyle, 2003; Chiesura, 2004; Ward *et al*., 2010). Over the past 350 years Cape Town has lost much of its' green space and biodiversity due to rapid urbanization and development (Anderson & O'Farrell, 2012; Goodness & Anderson, 2013). Recent population statistics show that the City of Cape Town is home to more than 70% of the Western Cape's population (Goodness & Anderson, 2013) with about 3.86 million inhabitants (CoCT, 2015).

In the face of rapid urbanization, maintaining and preserving remnant urban green spaces has become a critically important aspect of achieving environmental quality goals and guiding cities and towns in achieving sustainable development (Ward *et al*., 2010). The City of Cape Town's spatial planning tools, including the Biodiversity Network (BioNet.) and the Metropolitan Open Space System (MOSS), have been developed to maintain and preserve the City's remnant biodiversity and associated ecosystems (CoCT, 2008; CoCT, 2011b). One of the most important ecosystems that form part of the City's urban green spaces are wetland ecosystems (CoCT, 2011b).

Wetlands, defined by the South Africa's National Water Act 36 of 1998, are "land which is transitional between terrestrial and aquatic systems, where the water table is usually at or near the surface or where

the land is periodically covered with shallow water, and where land in normal circumstances would support vegetation typically adapted to life in saturated soil" (DWAF, 1999:2). Wetlands are considered to be one of the most valuable ecosystems because of their ability to perform various functions and provide a variety of ecosystem goods and services (Prigent, 2001). These functions and services enable wetland ecosystems to play important roles such as, providing habitats for biodiversity and resources (genetic, medicinal and ornamental resources to name a few) and also regulating and maintaining ecological processes. For example, gas, climate and water regulations (de Groot *et al*., 2002). Wetland regulation functions reduce or slow water flow, thereby allowing for infiltration and ameliorating flooding, trapping sediments, and absorbing the nutrients and pollutants by absorption and uptake, thus improving water quality (Gopal, 1999; Mitsch & Gosselink, 2007). In addition, wetlands offer unlimited opportunities for cognitive development, through recreation and cultural and spiritual engagement (de Groot *et al*., 2002). All of these functions and services are considerably enhanced and enabled by vegetation in and around wetlands. For example, wetland vegetation absorbs nutrients and other toxic chemicals (Gopal, 1999). Despite the recognition of these ecosystem services being provided by wetlands, they are continuously being lost, indeed at a greater rate than any other ecosystem type, with urbanization being a key driver here (Finlayson *et al*., 2015). Urbanization negatively impacts on the integrity of wetland environments (Lundqvist *et al*., 2003; Lee & Maheswaran, 2010), through changes in land use, increased pollution levels, habitat degradation and loss of biodiversity (Ward *et al.,* 2010). According to recent climate projections for the City of Cape Town, drought is expected to increase in frequency and severity (CoCT, 2011b). This projected increase in drought events will place much pressure on water provision (Mukheibir and Ziervogel, 2006; Mukheibir and Ziervogel, 2007; CoCT, 2011b). Wetlands are likely to be key sites of ground water recharge for the Cape Flats aquifer, which has been identified as a potential key component of our future water supply (CoCT, 2011b). This makes the City of Cape Town's water resources as well as the associated important biodiversity more and more important and challenging to manage.

The character of a wetland is dependent on different components within its ecosystem and its temporal and spatial patterns. Disturbance of these components and patterns, particularly by human land-use change, may lead to degraded dysfunctional wetlands. However, we have an incomplete understanding of how these wetland systems function particularly in the broader socio-ecological context of cities. Therefore, in order to better understand them Ryan *et al*. (2007), proposes the use of the Complex Adaptive Landscape (CAL) approach. The Complex Adaptive Landscape approach is a conceptual framework, based on the Complex Adaptive Systems (CAS) thinking and landscape ecology, and is focused on better understanding systems and their functions (Ryan *et al*., 2007).

1.2. Research Aims

The current study focuses on the Khayelitsha Wetlands Park an urban park located in the Khayelitsha Township. The aim of this research is to assess the current vegetation and water quality status, towards understanding the ecological and social benefits of the Khayelitsha Wetlands Park. To explore the uses and ecosystem services provided by the Khayelitsha Wetlands Park and finally to understand how these factors relate to and are influenced by current management actions.

1.3. Research Objectives

1.3.1. To assess the structure and map the extent of the vegetation in and around the open water of the Khayelitsha Wetlands Park.

1.3.2. To evaluate the current status of the water quality in the upper, middle and lower sections of the Khayelitsha Wetlands.

1.3.3. To document the historical and current use and management of the Khayelitsha Wetlands Park.

1.3.4. To determine the social and ecological perceptions, benefits and drawbacks of the Khayelitsha Wetlands Park as well as the linkages between management and key social-ecological system elements.

Chapter 2

Literature Review

2.1. Urban open spaces

The importance of urban open spaces has received wide acceptance as a critical feature of our growing cities from various professionals including planners, architects, environmental consultants, scholars and the general public (Kang & Zhang, 2010). Despite this acceptance of urban open spaces as important, there is no consensus in the literature on the general definition of the term (Sutton, 2008; Koohsari *et al*., 2015). The term urban open space is often associated with other terms, such as public space, green space and open space (Sutton, 2008), and these are often used interchangeably in the literature (Swanwick *et al*., 2003; James *et al*. 2009; Lee & Maheswaran, 2010). Therefore, each of these terms will be briefly discussed through the exploration of their various definitions in order to understand the meaning of each term. However, the focus will be placed on defining these terms with relevance to the current study, so as to identify a single term which can be effectively used in this study.

The term open space has various definitions which often do not encompass all the possible components of open spaces (Sutton, 2008). For example, open spaces can be defined as underdeveloped land or water in and around urban areas that are not covered by cars or buildings (Woolley, 2003). In addition, Tankel (1963) states that the term open space is not only the underdeveloped land or water in and around urban areas, but it also encompasses the space and light above the land. The Johannesburg Metropolitan Open Space System Report (JMOSS, 2002) defines open space as undisturbed natural and remnant undeveloped land within an urban area and beyond the urban edge (City of Johannesburg, 2002). This definition makes it clear that there are different types of open spaces, i.e. urban open spaces and rural open spaces.

Open spaces can be either be privately or publicly accessible (Sutton, 2008). Publicly accessible open spaces are termed ‘public open spaces’ (Koohsari *et al*., 2015). The term public open space is commonly

defined with regard to its associated uses and functions (Fausold & Lilieholm, 1999). For, example, Koohsari *et al*. (2015) defines public open spaces as open spaces which are freely accessible to the general public, mainly for amenity and recreational purposes, regardless of their size, design or physical elements. Furthermore, the City of Cape Town (2015) defines public open space as land set aside for the public, for sporting or recreational activities, including parks, playgrounds, picnic areas, urban squares, nature areas and public gardens, as well as ancillary buildings, infrastructure and uses (CoCT, 2015).

The City of San Francisco's Open Space Framework (2008) defines open space in a more encompassing definition as "publicly-owned spaces and publicly-accessible-privately-owned spaces meeting the needs and desires of its citizens for a variety of social activities (including recreational) and the experience of nature, while conserving human and natural resources". These include, among others, "parks, play grounds, plazas, landscaped areas, beaches, rooftop gardens, and natural spaces linked by corridors such as parkways, trails, walkways, alleyways, and green streets that provide for human recreation and movement" (City of San Francisco, 2008:3).

An open space with substantial amounts of vegetation and semi-natural areas which are directly available for users are termed 'green space' (Jim & Chen, 2003; Kong & Nakagoshi 2006; Shackelton & Blair, 2013; Wolch *et al*., 2014). The term 'green space' is a relatively new term, which appears to have originated mainly from the Urban Nature Conservation Movement and the European thinking about green space planning. The term originated to emphasise that green environments in urban areas are more than just parks, playing fields and gardens (Swanwick *et al*., 2003). Urban green spaces often exist either as managed conservation areas such as parks, gardens and riparian areas or as remnant vegetation or landscapes in urban areas (Jim & Chen, 2003; Kong & Nakagoshi 2006; Shackelton & Blair, 2013; Wolch *et al*., 2014). The City of Cape Town, in which this project was carried out is located within the Cape Floristic Region, a unique area in one of the smallest Floristic Regions (Cowling *et al*., 1992; Myers *et al*., 2000; Holmes *et al*., 2012; Anderson *et al*., 2014). The area explored is an urban park which encompasses one

of the major river and wetlands systems in the City and has been identified as having important remnant patches of vegetation (Ewart-Smith *et al*., 2008). In accordance with the definitions set out above, the term 'urban green space' was used for the purpose of this study.

2.2. Urban green spaces

2.2.1. The urban green space concept

Although the term 'urban green space' is relatively new (Swanwick et al., 2003), the concept of urban greening is not a new concept to many city planners. From as early as the 1970s and 1980s; several planning norms have been based on this concept (Schiperijn *et al*., 2010). The concept has been influenced by various models including Ebenezer Howard's 'Garden City' model (Roelofs, 1999; Jim & Chen, 2003; Baycan-Levent & Nijkamp, 2009); Frederick Law Olmsted's large park ideal (Wilson, 1989; Jim & Chen, 2003); Charles Fourier's fantasy villages, self-named as "phalansteries", and Enerst Callebach's novel 'Ecotopia' (Roelofs, 1999; Baycan-Levent & Nijkamp, 2009). Currently the concept of urban green spaces is increasingly becoming a universally accepted term when addressing environmental issues of urbanization in cities (Jim and Chen, 2003) and achieving goals of sustainable development (Ward *et al*., 2010). Furthermore, these urban green spaces are globally valued for offering a wide-range of benefits essential for promoting livelihoods in cities (Jim & Chen, 2003; Baycan-Levent & Nijkamp, 2009). However, whilst some cities, particularly in the developing world, continually improve the quality, quantity and spatial distribution of urban green spaces and successfully create liveable green cities, some cities are still lagging behind (Jim & Chen, 2006a).

In South Africa, like in most countries, the concept of urban green space has received wide recognition and there has been a strong determination to create comprehensive networks of urban green spaces in cities (Gaston *et al.,* 2010). Metropolitan areas of South Africa have each developed a 'Metropolitan Open Space System' to support ecological, social and economic activities (McConnachie *et al.,* 2008)). The Cape

Town Metropolitan Open Space System (CMOSS) is an important tool for protecting Cape Town's unique biodiversity, ensuring access to open spaces for all (CoCT, 2010). The Cape Town Metropolitan Open Space system comprises seven types of open spaces, categorised in terms of function. These are ecologically determined open spaces that form part of the City's biodiversity network, namely agricultural land (including potential and existing agricultural areas), blue parks such as vleis and watercourses, scenic routes which are part of Cape Town's tourist and recreational experience, beaches and public edges and multipurpose urban parks serving various functions such as core conservation, sports activities, hiking and cemeteries. The CMOS is also comprised of socially determined open space such as recreational facilities, cemeteries and solid waste disposal sites (CoCT, 2007).

A spatial framework called the Biodiversity Network, which forms the backbone of the Cape Town Metropolitan Open Space System, was developed to conserve critical biodiversity areas within the City (CoCT, 2007). The Biodiversity Network was developed through the City's biodiversity conservation planning process, conducted in terms of the National Environmental Management: Biodiversity Act 10 of 2004, within the National Environmental Management Act 107 of 1998 (CoCT, 2008). The Biodiversity Network identified a network of sites required to conserve representative samples of Cape Town's unique biodiversity (CoCT, 2008). In the lowlands of Cape Town (the Cape Flats) the Biodiversity Network highlighted that a large number of vegetation types were lost, as only a few areas were conserved in the past (CoCT, 2008). To address this, the City of Cape Town plans to accelerate the implementation of the Biodiversity Network to conserve the lowland vegetation types found in remnant open spaces of the Cape Flats (CoCT, 2008). This places the focus on biodiversity conservation and less on social uses and the demands of green spaces.

2.2.2. Benefits of urban green spaces

Urban green spaces are important ecosystems in cities as they offer a wide range of ecological, social, physiological and economic services (Shackelton & Blair, 2013). These are defined as the benefits humans

derive, directly or indirectly, from ecosystem functions (Li *et al*., 2005). Direct benefits of urban green spaces include food, firewood, fodder and timber for construction (Konijnendijk *et al*., 2005), whereas indirect benefits include biodiversity conservation, soil erosion mitigation, air and water purification and regulation, urban heat island effect reduction functions (regulation of micro-climate) and noise attenuation (Li *et al*., 2005; Kong & Nakagoshi, 2006; Wolch *et al*., 2014). Urban green spaces have also been said to provide socio-cultural benefits such as stress reduction (Kong & Nakagoshi, 2006), increased attractiveness and social interactions as well as a space for joint learning (Shackelton & Blair, 2013). Urban green spaces provide a different experiential domain for children and offer a place for imagination and learning which they rarely encounter at school, home and other structured environments they are exposed to (Louv, 2006; Shackelton & Blair, 2013). Furthermore, cultural and natural heritage have become tourist attractions in cities with a rich historic past, and in this way urban green spaces are beneficial in attracting visitors and promoting cities as tourism destinations (Cianga & Popescu, 2013).

2.2.3. Disservices of urban green spaces

Although the benefits of urban green spaces are usually stressed in the literature, these environments also present ecosystem disservices (Lyytimaki & Sipila, 2009; Sreetheran & van den Bosch, 2014). Ecosystem disservices include damage of physical structures which can be caused, for example, by tree roots cracking and destroying pavements or animal digging nesting holes (Tyvainen, 2001). From an economic perspective urban ecological disservices can lead to financial loss. This can be seen, for example, through costs used to control or remove unwanted invasive species such as weeds, insects, birds and small mammals (e.g. squirrels) as well as with the depreciation of property values due to a bad reputation caused by proximity to unmanaged green areas (Lyytimaki & Sipila, 2009). In addition, animal waste such as bird and dog excrements are also considered an aesthetic and hygiene problem presenting an ecosystem disservice (Koskela & Pain, 2000; Lyytimaki & Sipila, 2009).

There are also disservices associated with urban green spaces that relates to security and health issues. Inadequately managed green areas are often seen as unsafe areas, particularly by women (Lyytimaki & Sipila, 2009). Security issues, such as crime and the fear of crime in urban spaces (Sreetheran & van den Bosch, 2014) may lead to society being unable to utilize and enjoy the benefits of visiting urban green spaces (Burgees *et al*., 1988). Dense vegetation in urban environments is often associated with criminal activities as well as the fear of crime (Hynes and Howe, 2004) caused mainly by the presence of beggars, homeless people, strangers, teenage delinquency, and substance abuse (Sreetheran & van den Bosch, 2014). Health related issues relating to urban green spaces include allergic reactions caused by plants (Patak *et al*., 2011; Lyytimaki & Sipila, 2009) as, for example, volatile organic compounds and pollen from some plants may cause severe allergic reactions for people with allergies (Patak *et al*., 2011; Lyytimaki & Sipila, 2009). The identification of urban green spaces' disservices is not to undermine the value and the benefits of urban green spaces, but rather to enable successful management of urban green spaces and to maximize access and benefits (Lyytimaki and Sipila, 2009).

2.2.4. Challenges towards management and provision of accessible and quality urban green spaces

a. The global urbanization trend

Global urbanization rates have increased dramatically in recent years (Kong & Nakagoshi, 2006; Lee & Maheswaran, 2010), and it is estimated that about 60% of the global population will be living in cities by 2030 (Alberti *et al*., 2003; Grimm *et al.,* 2008). This is due to factors which push rural populations to move into more urban areas such as rural poverty, better employment and education opportunities (World Bank, 2011; Chishaleshale, 2012) as well as political and religious oppression (Nwaogaidu, 2013). However, with this dramatic population growth accompanied by intensive development in urban areas (Kong *et al*., 2010), managing urban areas is becoming increasingly complex (Cohen, 2006). The magnitude of urbanization, particularly in developing countries, presents a number of formidable challenges (Cohen,

2006; Chen *et al*., 2008; Baker, 2008) such as overcrowding, environmental degradation, unemployment, poverty and social issues such as crime and violence (Baker, 2008).

Urban green spaces are increasingly being encroached on as cities grow to accommodate rapidly increasing populations (Kong *et al*., 2010). This encroachment leads to habitat loss, fragmentation and isolation of urban green spaces, thereby threatening and damaging biodiversity (Yli-Pelkonen & Niemela, 2005; Kong *et al*., 2010) and ecosystems in urban environments. As a result, the ability of ecosystems to provide the services necessary for sustaining life in cities is affected (Pyle, 2003; Chiesura, 2004; Ward *et al*., 2010). A major concern in this regard is that certain ecosystem services and functions offered by urban green spaces cannot be acquired from outside the city, which means these ecosystem services and functions can only be provided by ecosystems within that particular city (O'Farrell *et al*., 2012; Elmqvist *et al*., 2013). As urbanization continues to increase, these challenges are expected to increase most especially in sub-Saharan Africa where urbanization rates are among the most rapid in the world (Elmqvist *et al*., 2013). In most countries the demand for quality and close proximity to urban green spaces significantly exceeds the supply (Wolch *et al*., 2014).

b. ***Providing accessible urban green spaces***

The provision of accessible urban green spaces is a key factor which underpins the use and enjoyment of benefits offered by urban green spaces (Shackleton & Blair, 2013). A number of studies conducted on accessibility, link accessibility to proximity (McCormack *et al*., 2010). These studies suggest that people in close proximity to an urban green space (such as an urban park) use this space more frequently than those who live further away (Haq, 2011). Despite the growing literature on the importance of measuring access to urban green spaces, there is no consensus among scholars on how to measure access to urban green space (Wolch *et al*., 2014). The container approach is one of the most common approaches used by researchers. This concept conceptualizes access as the relationship between origin and destination

(Lindsey *et al*., 2001). The measurement of walking distance or time travelled from home to a green space has appeared to be the single most important precondition for determining access to an urban green space (Haq, 2011). In Europe, the European Environmental Agency (EEA), prescribes that people should have access to urban green spaces within a 15-minute walking distance from their homes, a standard which the majority of European cities meet (Barbosa *et al*., 2007; Shackleton & Blair, 2013). In South Africa, the City of Cape Town similarly recommends a 15-minute walking distance from residences to the nearest urban green space (Swilling *et al*., 2010).

Scholars such as Barbosa *et al*. (2007) argue that it is important to know how access to urban green spaces varies across urban societies as green spaces are seldom uniformly distributed within cities (Shackleton & Blair, 2013). The distribution of urban green spaces often shows pronounced disparities in different racial and social groups (Dia, 2011). In the United States of America, the levels of green spaces provision among white, high-income suburban locations exceed that of black, low-income areas (Estabrooks *et al*., 2003). In Glasgow, Scotland the provision of urban greens space was better provided in more affluent areas (Macintyre *et al*., 2008). The historical planning reasons of these disparities have rarely been investigated, but the relationship between green space access, abundance, use and socioeconomic variables (such as age, race and affluence) have been investigated (Dai, 2011; Shackleton & Blair, 2013). These studies reveal that these disparities may be overcome by better planning processes and environmental justice through promoting equitable access to urban green space (Shackleton & Blair, 2013). However, the majority of this research is comprised of contributions from developed nations (Shackelton, 2012), discussing historically highly urbanized areas and relatively low growth rates (Shackleton & Blair, 2013). In contrast, urban planners are struggling to keep up in developing-world countries experiencing high urbanization and population growth rates (UN-Habitat, 2006; Shackleton & Blair, 2013).

In South Africa, overcoming the disparities of urban green space distribution is particularly challenging due to former apartheid planning, which persistently overrides a number of current planning aspirations

(Turok, 2001). The Apartheid planning systems implemented and enforced various policies which separated populations according to social and racial groups (Turok, 2001) through, for example the Population Registration Act of 1950, an apartheid legislation which was used to officially classify all South Africans into four distinct racial groups (Coloured, Indian, White and Black) (Spinks, 2001; Seekings, 2010; Breckenridge, 2014). In urban areas, different racial groups were further designated to particular urban spaces, which were divided by buffer zones of open land, under the 'Group Areas Act' (Spinks, 2001). The government of the time delivered an unequal distribution of services (Willemse, 2015), where the more affluent white population areas received a variety of services (including parks), while the lower class racial population areas received only the most essential higher order services such as housing, water and electricity (Harrison *et al*., 2008). The uneven distribution of services such as green spaces persists between suburbs in the majority of South African cities and towns (McConnachie & Shackleton, 2010; Shackleton & Blair, 2013). The current democratic government sought to tackle the racially defined backlogs of public services delivery created under the apartheid government (Shackleton & Blair, 2013). However, while a number of rigorous programs and supporting legislation have been developed to address these issues, there are also budget constraints and conflicting demands which present limitations for implementation (Galant, 2011; Anderson *et al*., 2014). For example, infrastructure development, urban agriculture and natural resource conservation demands (UN-Habitat, 2006), often override the demand for the provision of accessible green spaces as they lack political support (Southworth, 2002).

c. Providing quality urban green spaces

The provision of high quality green spaces is increasingly taking at central position in current and future urban planning (Van Herzele & Wiedemann, 2003; Jim & Chen, 2005). Although there is increasing recognition of the importance of quality green space there is no standard definition and method for measuring and mapping the quality of urban green spaces (Hillsdon *et al*., 2007). This is because green spaces vary greatly in their features, physical landscape and/or perceptions of people interacting with the

urban green space (Chen *et al*., 2009). However, a number of research studies conducted on the features of urban green spaces suggests that green spaces with natural features, activities, recreational amenities and safety features such as lighting and the presence of security are perceived as good quality urban green spaces (Chiesura, 2004; Giles-Corti *et al*., 2005; Rishbeth & Finney, 2006; Kaczynski *et al*., 2009). A good quality urban green space is inviting and encourages use and outdoor activities, and as a result it improves the quality of life of urban residents (Lee & Maheswaran, 2010). On the other hand, low quality urban green spaces are often avoided by potential users (Jim & Chen, 2005) as they are linked with safety issues, insufficient or lack of facilities and poor maintenance of green spaces (Willemse, 2015).

The presence of low quality urban green spaces is more prevalent in areas of low socioeconomic status (McConnachie & Shackleton, 2010; Shackleton & Blair, 2013). A number of countries both in the developed and developing countries have made efforts to provide equitable quality green space. However, while most developed countries continue to successfully improve the quality and the distribution of urban green space, developing countries are still lagging behind in the provision of quality green spaces in urban areas (Jim & Chen, 2006a). A major challenge for developing countries is to establish the right balance between governance, policy, institutional mechanisms and resource allocation and provision (Wolch *et al*., 2014). As a result, urban planners often struggle to incorporate and maintain existing quality green spaces into urban planning and design (Jim & Chen, 2006a; Shackleton & Blair, 2013). A number of studies indicate that developing countries are facing financial constraints at city and district level which leads to inadequate development of quality green space and the maintenance of existing ones (Jim & Chen, 2008; Sutton, 2008; Kabisch, 2015). Furthermore, Kabisch (2015), argues that the greater the economic pressure for high class services such as residential development, the greater the pressure on green space. Developing housing while also developing and maintaining green infrastructure cannot be easily balanced (Kabisch, 2015).

In South Africa, the provision and the maintenance of urban green spaces remains a challenge, particularly in low-income township areas (Wolch *et al*., 2005; Sutton 2008; McConnachie & Shackleton, 2010; Shackleton & Blair, 2013). In township areas a major focus of the democratic government is on housing development, which aims to address the housing backlog created under the apartheid government and rapid urban population growth in the post-apartheid South Africa (McConnachie & Shackleton, 2010). This places a challenge on green space infrastructure development and maintenance, as municipalities struggle to balance their demands with the constrained budgets (Sutton, 2008; Kabisch, 2015).

2.2.5. Urban green spaces in Cape Town

The City of Cape Town is the oldest city in South Africa (Lemanski, 2007), situated at the most south-western tip of Africa (Besteman, 2008; George, 2010). It is geographically located in the Cape Floristic Region (Goodness & Anderson, 2013) and this region is the smallest, yet richest Floristic Region in the world (Cowling *et al*., 1992; Myers *et al*., 2000; Holmes *et al*., 2012; Anderson *et al*., 2014). For this reason, the City of Cape Town is recognized as a city of global biodiversity significance (CoCT, 2008). Cape Town is also recognized as one of the most popular tourist destinations for international and domestic tourists because of its spectacular natural landscapes, such as the majestic mountains towering over its beautiful oceans and beaches associated with its rich floral diversity as well as its celebrated wine industry (George, 2003; Lemanski, 2007; George, 2010). However, the city is also confronted by sprawling informal settlements, poverty and inequality within its population (Lemanski, 2007). Underlying this are the former apartheid laws, which emphasized social and racial segregation (Turok, 2001). During the apartheid regime, Cape Town became the country's most segregated city due to the wide acceptance of oppressive apartheid laws (Spinks, 2001).

The apartheid legacy is embedded in traditional social and institutional practices that persist, overriding a number of more recent policy aspirations (Turok, 2001). Cape Town remains a starkly polarized city

where affluent suburbs (occupied mostly by white residents) and flourishing economic centers boarder beautiful mountains and coastal areas while offering a wide range of opportunities. In contrast the poor townships (occupied by mostly black and coloured residents) remain densely packed at the urban periphery of the Cape Flats, where there are strong prevailing winds and flood-prone sand plains (Turok, 2001; Standing, 2003; Besteman, 2008; Ernstson *et al*., 2010). The Cape Flats consists of a vast number of townships characterized by extensive informal housing structures, where generally unemployment rates are high, income is low and living conditions are poor (Stanvliet *et al*, 2004; Goodness & Anderson, 2013; Williams, 2014). One such township on the Cape Flats is the Khayelitsha Township in which the current study explores an urban park, the Khayelitsha Wetlands Park.

Khayelitsha is a predominantly Xhosa-speaking township located about 30 km south-east of the Cape Town CBD (Central Business District) in the Cape Flats (Reuther & Dewar, 2006). Similar to other areas in the Cape Flats, Khayelitsha is characterized by high rates of unemployment, poverty and extremely low-quality infrastructure and services (Stanvliet *et al*, 2004; Goodness & Anderson, 2013; Williams, 2014). According to Statistics South Africa (2011), the economic profile indicates that Khayelitsha has an average unemployment rate of about 38%, which is above both the national and local (Cape Town average rate of 25.7 % and 24% respectively) rates. The 2011 census also indicates that about 55% of households in this township reside in informal dwellings (StatsSA, 2011). This township demonstrates how the social inequity of apartheid planning practices has eroded and continues to erode the capacity to conserve ecosystems (Ernstson *et al*., 2010). In particular, the coastal dune and wetland ecosystems that once characterized Khayelitsha and the rest of the Cape Flats continue to be eroded by development (Brown & Magoba, 2009; Ernstson *et al*., 2010) and as a result, functions of these ecosystems have become degraded or lost (Brown & Magoba, 2009). According to Rebelo *et al*. (2011), the earliest conservation plan of the City of Cape Town's "Greening of the City" report of 1982 included the conservation of the Kuils River and associated wetlands through the proclamation of a large park, namely the False Bay Coastal Park. The False Bay

Coastal Park was planned to connect the Cape Peninsula with the Hottentot Hollands Mountains, through the Kuils River and associated wetlands, the Cape Corp military conservation areas and the coastline (Rebelo *et al*., 2011). However, the apartheid government had decided that the majority of this area was going to be developed as a township (the Khayelitsha township), to cope with population growth of people in the City of Cape Town (Rebelo *et al*., 2011; Goodness & Anderson, 2013). As a result, much of this conservation-important landscape was lost to apartheid urban planning.

The Khayelitsha Township became Cape Town's fastest growing area, particularly after the termination of restrictive apartheid legislation (Lehohla, 2006). In recent years the area has become sprawling, primarily as a result of immigration of people mostly from the Eastern Cape Province (Poswa and Levy, 2006) who come to Cape Town in search of jobs or other forms of livelihoods (Ndegwa *et al.,* 2007). However, a large number of these rural migrants struggle to find employment (Poswa and Levy, 2006) and as a result remain in a state of informality, living in shack dwellings on remnant strips of sand dunes (Ernstson *et al*., 2010) and encroach on wetland areas in and around Khayelitsha (Brown & Magoba, 2009). The dunes in the area represents valuable remnants of the Cape Flats Sand Fynbos vegetation (Goodness & Anderson, 2013), and they have indeed been significantly eroded (Ernstson *et al*., 2010). As a result, this has affected the natural protection from the strong prevailing winds and has undermined provision of access to recreational space and opportunities to collect traditional medicinal herbs (Ernstson *et al*., 2010). The Khayelitsha Wetlands form part of the Kuils River catchment, a major river and wetland system in the city connecting the False Bay Coasts and Tygerberg Hills (CoCT, 2011a). According to Brown and Magoba (2009) the 'Kuils River dune-slack wetland system' was lost when the dune slack was bulldozed into the Kuils River wetland system to create space for low-income housing, namely the Khayelitsha Township. Consequently, residents in Khayelitsha along with adjacent neighbourhoods on the Cape Flats, experience seasonal flooding and inundation in winter as a result of the elevated dune slack water table, adding to the harsh conditions in these informal settlement areas (Goodness & Anderson, 2013). Despite the

Khayelitsha Wetlands being significantly altered, what remains still has substantial value as habitats for aquatic life, water purification and for recharging the Cape Flats aquifer (Brown & Magoba, 2009). A study conducted on the greater Khayelitsha Wetlands area in 1998 identified various land-use zones within this area. One of these zones was proclaimed as the Khayelitsha Wetlands Park (CoCT, 2014).

Chapter 3

Methodology

3.1. Study area

The study was conducted in the Khayelitsha Wetlands Park, which lies east of Spine Road in the Khayelitsha Township (Malan *et al*., 2014). The Park is bordered by the Silvertown settlement to the south, the Makhaza settlement to the east and the 9 South African Infantry (SIA) Battalion Military Base (formerly known as the Cape Corp Military base) to the north (Figure 1) (Ewart-Smith, 2015). The Khayelitsha Township is situated on the Cape Flats, the lowland areas of the City of Cape Town (Goodness & Anderson, 2013). The Cape Flats retains its marginalized character rooted in apartheid planning, mirrored by the predominantly poor housing infrastructure, high unemployment rates, and poverty associated with crime (Nleya & Thompson, 2009). These lowland areas of the City sit on the Malmesbury bedrock, covered by the Sandveld Group sediments, which were deposited during sea-level rise and movement of sand along the coast. This played a significant role in retarding river flow, thereby creating the Cape Flat wetlands, including the Khayelitsha Wetlands (Brown & Magoba, 2009). The park consists of a small portion of the greater Khayelitsha Wetlands which form part of the Kuils River Catchment, a major river and wetland system in the city connecting the False Bay Coasts and Tygerberg Hills (CoCT, 2011a). These wetlands play an important role in Cape Town's Metropolitan Open Space System (CoCT, 2011a; Ewart-Smith, 2015). Having a Mediterranean-type climate, Khayelitsha typically has dry summers and wet winters (Mucina & Rutherford, 2006) as well as strong winds in summer and in winter (Brown & Magoba, 2009). Khayelitsha being part of the Cape Floristic Region is characterized by Fynbos a vegetation type endemic to this region (CoCT, 2008). However, in Khayelitsha the wetland areas are generally invaded by alien tree species, such as *Acacia longifolia* and *Acacia mearnsii* as well as invasive wetland species including *Frontinalis antipyretica* and *Eichhorinia crassipes* (Brown & Magoba, 2009). This ecosystem also supports a variety of

both local and migratory bird species, including the Cape Orange throated long-claw and the African (Ethopian) snipe, among others (Ewart-Smith, 2015).

The Khayelitsha Wetlands Park offers various facilities to its neighboring communities (Figure 2), such as a play park for children, an outdoor gym and park benches, a skate park, walking and cycling paths, canoeing opportunities and visitors can enjoy walking their dogs on leashes in the park (CoCT, 2014). The park also offers economic and environmental education opportunities, for example through offering job opportunities and community environmental education events and workshops (CoCT, 2014).

Figure 1: Aerial photograph of the Khayelitsha Wetlands Park (KWP), the neighboring Silvertown, Makhaya, and Makhaza settlements, and the 9 SAI military base (Source: Google earth maps, 2016).

Figure 2: Images of the Khayelitsha Wetlands Park (CoCT, 2014): (A) The Wetland as viewed from Spine Road; (B) The view of the formal Park and Wetland area from the Makhaza canoeing area; (C) The Wetland as viewed from Makhaza showing birdlife in the park; (D) park benches overlooking the Wetland; (E) the outdoor gym and (F) the children's play park.

3.2. Methods

3.2.1. *Study approach*

The current study used a multi-disciplinary approach to evaluate the social and ecological benefits of the Khayelitsha Wetlands Park. Qualitative methods were used to assess the impacts of the historic and

current use of the Wetland on the vegetation status and water quality of the Khayelitsha Wetland, which forms part of the Khayelitsha Wetlands Park. Quantitative and qualitative semi-structured interviews were used to assess and evaluate how the community uses and perceives the Khayelitsha Wetlands Park as well as perceptions regarding previous and current management of the Park. The semi-structured interviews were conducted on the basis of the University of Cape Town's ethical approval conditions granted for this study (Appendix 1).

An appointment was arranged with the Environmental Monitoring Group to facilitate entry into the Khayelitsha Wetlands Park for this research. The Environmental Monitoring Group's Mr. Thabo Lusithi and Mr. Thabang Ngcozela assisted in facilitating access and providing background information on the Khayelitsha Wetlands Park. They also assisted with identifying key community organizations who are involved in the management programs of the Park. The organizations include the Makhaza Wetland and Food Growers, and the Khayelitsha Canoeing Club. Mr. Ngcozela, who works closely with these organizations as well as the rest of the community in the climate change and community development programs, assisted by recruiting an individual to ensure the safety of the researcher within this high-risk area. Mrs. Cynthia Wana, a member of the Makhaza Wetland and Food Growers, was selected in collaboration with both the Makhaza Wetland and Food Growers and the Khayelitsha Canoeing Club as a suitable candidate to ensure the safety of the researcher during data collection. Arrangements were also made with Mrs. Nosipho Memeza and Mr. Sandiso Nosombo to provide additional security during data collection around the Wetland area, as this area has been said to have a high incidence of crime.

3.2.2. Pilot survey

In December 2015, a pilot survey was conducted prior to the main survey at the Khayelitsha Wetlands Park in the Makhaza node. The pilot survey was intended as an exercise to identify water quality sampling points and to refine the main survey through engagement with Park users.

The pilot survey questionnaire was refined and this resulted in the development of two semi-structured questionnaires for distinct groups identified in the pilot survey. The first questionnaire (Appendix 2) was used to interview the local community groups. These groups included, park users/visitors, park workers, representatives from the Makhaza Wetland and Food Growers (MWFGs), Khayelitsha Canoeing Club (KCC) and the 9 South African Infantry Battalion military base. The first questionnaire was designed with Xhosa translations, to assist in simplifying and articulating questions to respondents who had difficulty understanding English. The second questionnaire (Appendix 3) was used to interview the identified park managers.

3.2.3. Biophysical study

a. Vegetation mapping

A field observation survey was conducted in May 2016, in combination with the visual analysis of aerial photographs of the area on Google earth (2016), to acquire a broad classification of vegetation found in and around the Khayelitsha Wetlands Park. The field observation surveys assessed vegetation at the Wetland margins while the visual aerial photographs, on Google earth, analysed vegetation in and around the Wetland. These visual aerial photographs were analysed section-by-section from east-to-west and north-to-south in and around the Wetland.

The overall accuracy of the Google earth aerial image was 90% at approximately 40 m root mean squared error (RMSEr). The data obtained from both field and visual observations was used to create a vegetation map to address the error in the georegistration of the google earth imagery that was used. Borders were drawn using the polygon tool on a Google earth aerial image to map the vegetation in and around the Khayelitsha Wetland. The polygons were created using different colours to distinguish the vegetation classes found in and around the Khayelitsha wetland. The wetland vegetation classification was established on the bases of dominant species assemblages (Little, 2013). The condition of each of these

species assemblages, illustrated in table 1, was described using vegetation classes adapted from The Western Cape biodiversity report (Turner, 2012).

Table 1: A table illustrating the vegetation classification criteria used to determine the condition of the vegetation found in the Khayelitsha Wetlands adapted from Turner (2012).

Vegetation condition	Percentage of vegetation condition	Vegetation state condition description
Good	+90%	Largely natural species composition
Moderate	50 %	Near natural vegetation composition (areas with low to moderate disturbance and alien invasive plants)
degraded	40 %	Degraded (areas which are largely disturbed and heavily invaded by alien plants)
Poor	10 %	Extremely degraded

High-resolution historical aerial images were also used to assess changes in vegetation structure and the extent of these changes in and around the Wetland. These historical images were obtained from historical wetland vegetation map done by King and Silberbauer (1991) during the wet winter months of 1988/1989 at a 19 m resolution (King and Silberbauer, 1991).

b. Water quality testing

Water samples were collected in December 2015 from the upper, middle and lower sections of the Wetland, according to the *ISO 17025* accredited sampling guidelines prescribed by Bemlab (2014). A total of 44 water samples were collected from 22 sample sites, using pre-treated/laboratory sterilized bottles from Bemlab (Pty) Ltd. The samples were kept in ice cooled containers prior to their delivery at Bemlab (Pty) Ltd, Strand, where the water quality assessment was conducted. Both biotic and a-biotic properties were tested using specific tests for each property as listed in Table 2.

Table 2: A table of tested properties with respective standard assessment methods used, including South African National Standard (SANS) methods (Bemlab, 2014).

Properties Measured	Reference Method Used
Biotic	
Total bacteria count	SANS 5221
Coliforms count	Colilert Method
Escherichia coli count	Colilert Method
A-biotic	
pH @ 25 °C	SANS 10523:2012
Adjusted sodium adsorption ratio	
Total dissolved solids @ 25 °C	SANS 7888:2005
Electrical conductivity @ 25 °C	SANS 7888:2005
Osmotic pressure	SANS 7888:2005
Ammonium (NH_4-N)	SANS 5217
Sodium (Na)	SANS 11885:2008
Potassium (K)	SANS 11885:2008
Calcium (Ca)	SANS 11885:2008
Magnesium (Mg)	SANS 11885:2008
Manganese (Mn)	SANS 11885:2008
Carbonate as (CO_3^{2-})	Titrimetric Method
Bicarbonate as (HCO_3^-)	Titrimetric Method
Sulphate as (SO_4)	SANS 11885:2008
Boron (B)	SANS 11885:2008
Fluorine (F)	SANS 10359-1:2002
Copper (Cu)	SANS 11885:2008
Zinc as (Zn)	SANS 11885:2008
Phosphorous (P)	SANS 11885:2008
Nitrate (NO_3-N)	SANS 13395: 1996
Chlorine (Cl)	SANS 9297:2013
Iron (Fe)	SANS 11885:2008

In addition, the irrigation water class were assessed and Langelier index. The standard United States salinity diagram proposed by Richards (1954) (Figure 3) was used as a basis to determine the irrigation water class, using the electrical conductivity and the sodium adsorption ratio data. In the salinity diagram, water is classified into C1, C2, C3, C4 classes on the basis of electrical conductivity (salinity hazard) and S1, S2, S3, S4 classes on the basis of sodium adsorption ratio (sodium hazard).

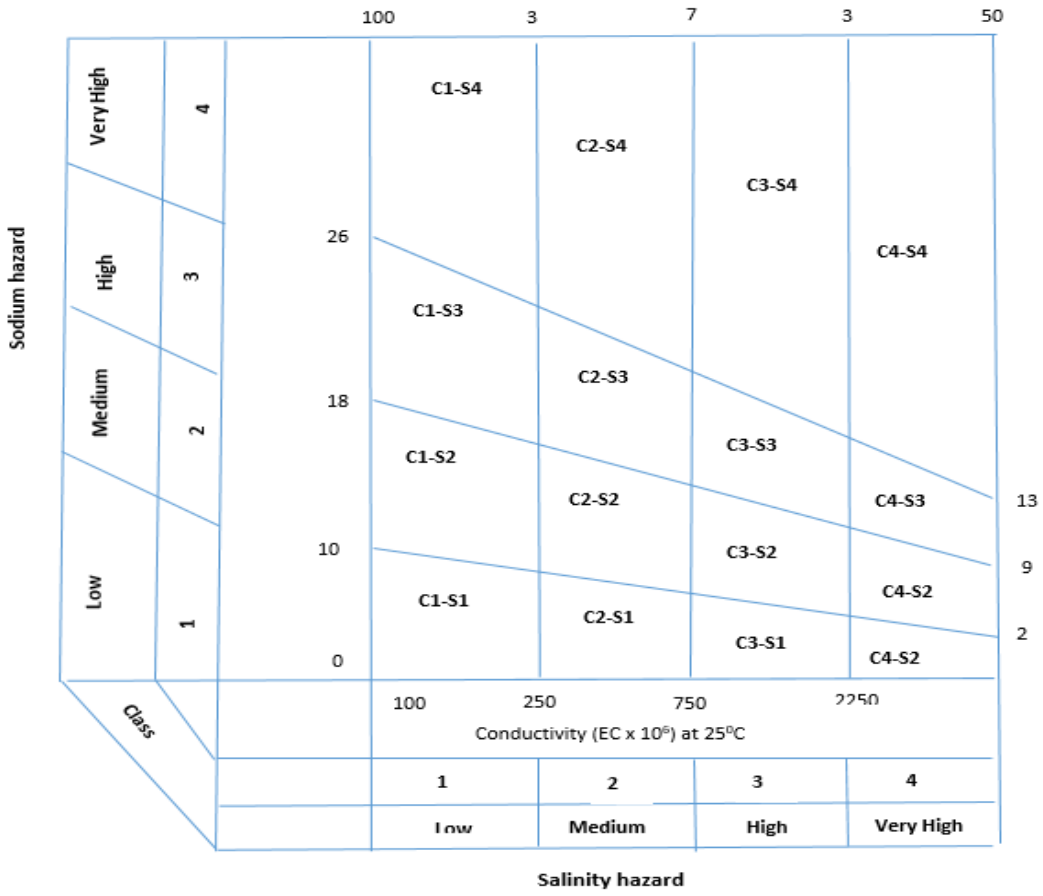


Figure 3: A diagram illustrating the irrigation water classification as adapted from Richards (1954).

The Langelier index was assessed by calculating the degree of the saturation of calcium carbonate (CaCO) in the water using the following formula:

$$LI = pH_a - pH_s$$

Where; LI is the Langelier index, pH_a is the actual pH of the water samples and pH_s is the calculated pH of the water samples, using alkalinity, total dissolved solids and temperature of the water samples.

c. Water quality analysis

Means and standard deviations for variables sampled from the Wetland (upper, middle and lower sections) were calculated and reported (Table 3). The means of each variable were compared against recreational use, domestic use, livestock watering and irrigation Target Water Quality Ranges (TWQR)

based on the guidelines developed by the National Department of Water Affairs (DWAF, 1996a; DWAF, 1996b; DWAF, 1996c and DWAF, 1996d).

To establish an understanding of water quality across the spatial extent of the Wetland, the variables were subjected to an F_{max} test of homogeneity of variance to determine if the data were normally distributed. Analysis of Variance tests (ANOVA) were conducted on the data of variables that were normally distributed. Whereas the data of variables that were not normally distributed underwent Kruskal-Wallis tests using the statistical package: Statistica 13 (Dell, 2015).

3.2.4. Social study

a. Local community survey

A community survey was conducted between February and April 2016 using the local community survey (Appendix 1). The neighboring community surveys were conducted from 10 am to 3 pm on weekdays in the most frequented site in the Park (the Makhaza node). Park visitors and park workers were interviewed by the researcher after an initial introduction, a short briefing on the research project and only after consent to be interviewed was attained. Appointments for interviews were arranged with the Makhaza Wetland and Food Growers and the Khayelitsha Canoeing Club through Mr. Thabang Ngcozela, and an appointment for interviews at the 9 SAI Military base was made with the Regional and National Department of Defense through Officer Daniel de Beer. Interviews were conducted with individuals of these groups and organizations. This was done to ensure that the ethical principles of the University of Cape Town were considered and applied in each interview. In addition, the researcher adhered to specified protocols for conducting research in the military base. These specifications were granted by the Unit, Regional and National Military Integrated Environmental Management of the South African Defense Department for the Military base to ensure safety of the researcher within the military base and to protect state confidential security information. Survey data collected included age, proximity to the park, general

knowledge of the area (e.g. size of the park, water movement), frequency of visits, facilities and resources used, perceptions towards the green space, issues relating to the management of the park and suggested improvements to the park.

b. Management survey

Management surveys were conducted in May and June 2016, using the Manager's questionnaire (Appendix 2), and involved participants from the organizations who are involved in the management of the Khayelitsha Wetlands Park. These organizations included The City Parks Department of the City of Cape Town, the Environmental Monitoring Group, and the Western Cape Water Caucus. A telephonic interview was conducted with Mr. Shepard Mdoda and a face-to-face interview was conducted with Ms. Vuyolwethu Flepu at the Khayelitsha Wetlands Park. Both of these individuals are based at the City Parks Department of the City of Cape Town. A face-to-face interview was conducted with Mr. Thabang Ngcozela and Mr. Thabo Lusithi both from the Environmental Monitoring Group at the Environmental Monitoring Group offices in Observatory, Cape Town. Mr. Thabo Lusithi is also a representative of the Western Cape Water Caucus. Interviews lasted for approximately one hour each. The interview questions included the following: involvement in the Khayelitsha Wetlands Park, key ecosystem benefits provided by the green space, challenges of providing open spaces in the City of Cape Town, challenges faced within the urban green space and future plans for the park.

While the Department of Water and Sanitation was identified as one of the key organizations involved in the management of the Khayelitsha Wetlands Park, no interviews were conducted with individuals from this department. They are however directly involved in facilitating the Adopt-A-River program, which is one of the primary management programs of the Park. Two individuals from the Department of Water and Sanitation were each contacted via email and telephone by the researcher to request interviews, but

neither of these individuals responded to the invitation despite numerous attempts at contact via both email and telephone.

3.2.5. Social-Ecological system mapping

The Complex Adaptive Landscape (CAL) approach (Ryan *et al*., 2007) was adopted to understand the social-ecological dimensions and feedback loops of the ecosystem under investigation. Two diagrams were constructed to illustrate the relationship between the ecosystem and land-uses associated with the Khayelitsha Wetlands Park. Information obtained from the social and ecological studies as well supporting literature was used to map the key landscape system components and the relationship between them, thereby illustrating the complexity of the landscape which is crucial for the effective management complex social-ecological landscapes.

Chapter 4

Results

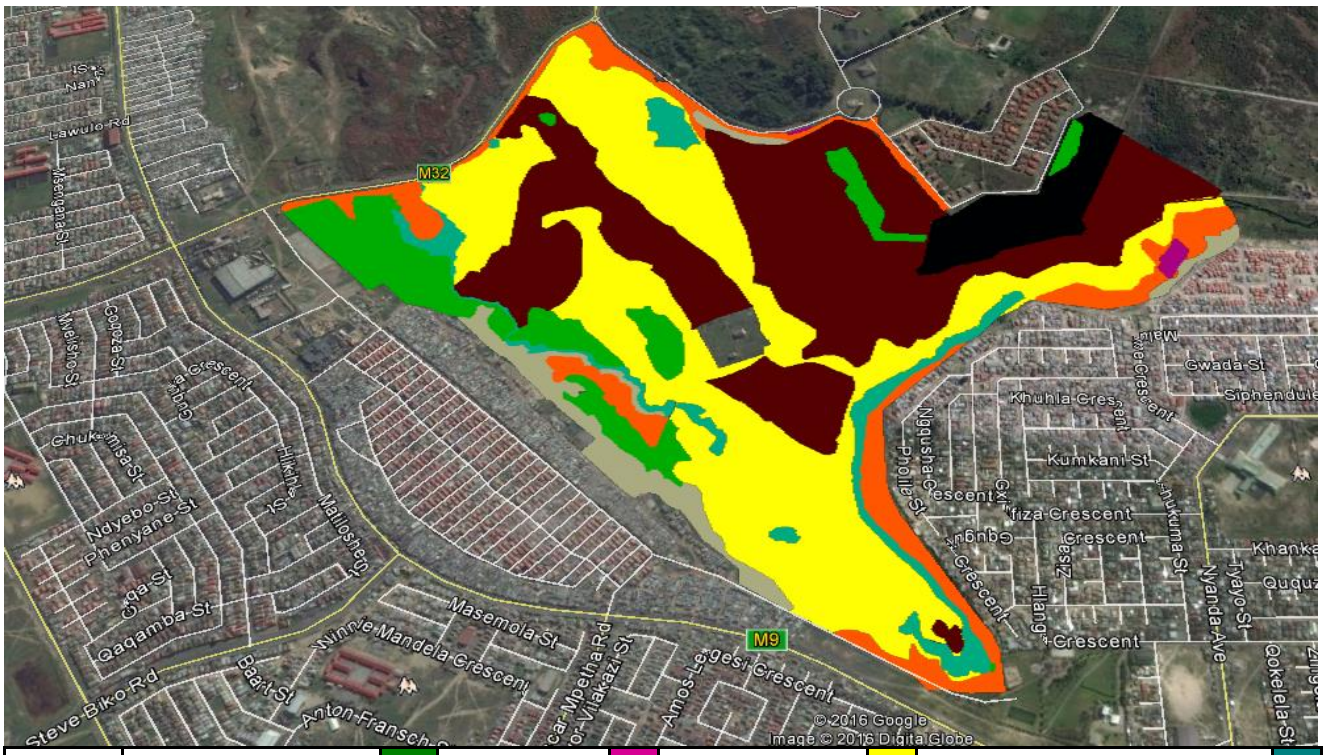
A. Biophysical study

4.1. Mapping the vegetation status in and around the open water body of the Khayelitsha Wetlands Park

The Khayelitsha Wetland south of Spine Road form part of the Khayelitsha Wetlands Park. This Wetland ecosystem consists of small isolated patches of remnant dune-slack; characterized by seasonally inundated dunes and depressions, characterized by moderate to disturbed condition wetland vegetation (Figure 4). A small isolated depression covered with Cape Flats Dune Strandveld vegetation represents good to moderate vegetation condition as the depression is largely covered with *Senecio halimifolius* (Tabokbos) and sedges such as *Juncus kraussii, Ficinia nodosa* and *Bolboschoenus maritimus*. Within the Cape Flats Strandveld vegetation community are *Eligia tectorium* (Cape thatching reeds) and *Zantedeschia aethiopica* (Arum lily). More elevated areas of remnant dunes towards the north-western area of the SAI 9 military base the vegetation condition is poor as it is largely infested with *Acacia cyclops* (Rooi kraans) and *Acacia saligna* (Port Jackson willow), with sparse patches of *Senecio halimifolius* and *Carissa bispinosa* (Natal plum).

The permanently inundated areas of the Wetland consist of a group of aquatic macrophytes indicating low to moderate disturbance to the vegetation condition. The first group known as the emergent aquatic macrophytes include, the predominant and dense *Typha capensis* (bulrushes) and *Phragmites australis* (common reeds). The second group known as the floating-leaved aquatic macrophytes consisted of *Zantedeschia aethiopica* (arum lily), *Burela erecta* (Lesser water-parsnip), *Eichhornia crassipes* (Common water hyacinth) and *Centella asiatica* (Centella). The last group, the submerged macrophytes, are characterized by the *Fontinalis antipyretica (*Common moss). The vegetation condition on the wetland

margins was in a degraded condition. In some areas of the wetland margins the vegetation is eroded (bare) and the rest was covered with grasses dominated by *Cynodon dactylon* (Couch grass), *Stenotaphrum secundatum* (buffalo grass) and *Centella asiatica* (Centella) scattered on the grass. On the southern margin a few *Syzygium cordatum* (Water berry trees) were identified. There is also a one-year old burnt vegetation patch at the north east edge of the Park.



Legend	Cape Flats Dune Strandveld vegetation		Other natural vegetation		Emergent aquatic macrophytes		Aquatic floating and submerged aquatic macrophytes	
	Marginal grasses		Acacia species		Burnt vegetation patch		Bare patch	

Figure 4: Image of the vegetation map showing vegetation in and around the wetland. Created using Google earth maps (2016), in combination with in-field vegetation cover mapping.

4.2. Water quality Analysis

The Wetland under investigation can be classified as an urban wetland ecosystem which is surrounded by poorly serviced informal settlements of the Khayelitsha Township. The local residents who are dependent on the Wetland ecosystem have different water quality requirements. The physiochemical requirements

of some of the identified users of the Khayelitsha Wetland area are livestock watering and grazing, irrigation and recreational use. Livestock graze and drink through the Wetland landscape while irrigation and recreational activities are undertaken in the middle and lower sections of the Wetland. To assess the fitness of water in the Khayelitsha Wetland mean concentrations of tested variables were compared against Department of Water Affairs and Forestry (DWAF) water quality standards.

Table 3: Shows water quality fitness for: livestock watering against DWAF water quality guidelines (DWAF, 1996b), irrigation purposes against DWAF water quality guidelines (DWAF, 1996a), and human use against the Water Quality Guidelines for domestic use (DWAF, 1996c) and recreational use (DWAF, 1996d). The Table also shows significance of across the Wetland ecosystem using the ANOVA test for parametric data and the Kruskal-Wallis test for non-parametric data.

Fitness of water for current uses							Statistical significance	
Variable	Section (mean±STDEV)			TWQR: livestock watering	TWQR: Irrigation use	TWQR: Human use	ANOVA test	Kruskal-Wallis test
	Upper	Middle	Lower					
pH @25°C	8.08±0.44	7.63±0.31	7.87±0.07	6.5-8.5	6.5-8.4	6.5 - 9.0		6.78 < 0.05
Adjusted Sodium Adsorption Ratio	4.25±1.22	3.64±0.05	3.64±0		1.5			N.S
Langelier index	0.90±0.48	0.43±0.34	0.64±0.07		-0.2 to 0.2			N.S
Irrigation class	C3-S1	C3-S1	C3-S1					N.S
Total dissolved solids	700.78±157.22	630±9.40	629.37±3.96	2000	40	450		N.S
Electrical Conductivity (ms/m)	109.51±24.58	98.45±1.44	98.29±0.58	308	40	70		N.S
Osmotic Pressure (kPa)	39.42±8.85	35.44±0.52	35.40±0.22					N.S
Sodium (mg/l)	117.02±44.06	95.93±1.23	95.24±0.65	2000	70	100		N.S
Potassium (mg/l)	15.51±0.83	16.47±0.98	15.81±0.62			50		N.S
Calcium (mg/l)	72.02±3.11	71.37±1.49	71.56±0.62	1000		32		N.S
Magnesium (mg/l)	13.73±6.07	10.68±0.18	10.77±0.12	500		30		N.S
Iron (mg/l)	0.21±0.06	0.27±0.20	0.14±0.05	10	5	0.1		N.S
Manganese (mg/l)	0.01±0.01	0.08±0.20	0±0	10	0.02	0.05		N.S
Chloride (mg/l)	143.55±51.32	127±5.62	123±6.02	3000	100	100		N.S
Carbonate (mg/l)	7±16.15	0±0	0±0				N.S	N.S
Bicarbonate (mg/l)	314.22±36.32	291.17±11.26	303±2.78					N.S
Sulphate (mg/l)	62±13.39	60.67±9.50	52.5±1.07	1000		200		15.58 < 0.01
Boron (mg/l)	0.20±0.08	0.16±0.01	0.15±0	5	0.0005		N.S	N.S
Fluorine (mg/l)	0.31±0.03	0.30±0	0.30±0	2	2	1	N.D	N.D
Copper (mg/l)	0±0	0±0	0±0	0.05	0.2	1	N.S	N.S
Zinc (mg/l)	0.01±0	0.02±0	0.02±0.01	20	0.001	3		N.S
Phosphorous (mg/l)	1.56±32	1.87±0.36	1.88±0.06					N.S
Nitrate (mg/l)	0.02±0.01	0.04±0.01	0.09±0.04	100	0.5	6		N.S
Ammonium (mg/l)	0.39±0.05	0.65±0.34	0.42±0.02		0.5	1		N.S
Total bacteria/ml	2328.75±1015.25	2068.33±1443.61	1667.5±765.03	200	1000	100	N.S	N.S
Coliform/100 ml	2420±0	2420±0	2420±0	200	1000	130	N.D	N.D
E. coli/100 ml	278.625±166.38	1223.83±987.21	1263.75±741.33	200	1	130		8.66 < 0.05

Legend	Data not Significant	N.S	Significance not determined	N.D	Target not required		No available data		Data within/below TWQR		Data exceeds TWQR	

4.2.1. Water quality analysis: a comparison against DWAF water quality standards

a. Livestock watering

Unacceptably high coliform counts significantly above Targeted Water Quality Ranges (TWQR) were found in all sections of the Wetland ecosystem (Table 3). A pathogenic coliform type, namely *Escherichia coli,* was detected on an independent *E. coli* assessment. The assessment showed high *E. coli* counts, particularly in the middle and lower sections of the Wetland, all exceeding the TWQR (Table 3). The presence of high *E. coli* in the waterbody indicates that the water in the Khayelitsha Wetlands is not fit for Livestock watering as it presents a health hazard to livestock which depend on the Khayelitsha Wetland as a drinking source.

b. Irrigation

The DWAF (1996a) Water Quality Guidelines for irrigation use were used as a basis of assessing the water quality fitness for irrigation purposes. The comparison of physiochemical elements and microbes against the DWAF irrigation standards (Table 3), indicate that water in the Wetland is not fit for irrigation purposes. The Wetland water pool contains unacceptably high concentrations of boron, chloride and sodium throughout the Wetland (i.e. upper, middle and lower sections) and zinc in the middle and lower sections. Manganese was also present, but was found only in the middle reach of the Wetland. The adjusted sodium adsorption ratio and electrical conductivity exceeds the TWQR significantly (Table 3). The Langelier index (LI) when compared against the TWQR (Table 3), is beyond the target ranges (-0.2 to +0.2). These ranges of the LI of the water in the Khayelitsha Wetland can cause scale formation on leaves of crops and negatively affect the quality of the produce. The irrigation class throughout the Wetland is a C3-S1 class which is suitable for the Cape Flats soils which can be leached easily (Bemlab, 2014). Furthermore, as indicated in Table 3, microbial counts of total bacteria, coliforms and *E. coli* significantly exceed DWAF irrigation standards.

c. Human use: swimming, canoeing and baptism

The DWAF Recreational Use guidelines group water contact activities into the following categories: full-contact activities such as swimming and baptism; intermediate-contact activities such as canoeing, and noncontact activities such as walking and sitting along water bodies (DWAF, 1996c). In the current study, the targeted water quality ranges for recreational use (DWAF, 1996c) were used as guidelines for assessing the fitness of the Wetland water quality for human use. These set guidelines refer specifically to the effect of pH and microbial contaminants. Chemical and physiological contaminants were assessed against water quality ranges for Domestic use (DWAF, 1996d), in order to establish an understanding of the viability of the Khayelitsha Wetland for human use.

The comparison of chemical contaminants against the DWAF guidelines for Domestic Use showed high mean concentrations of ammonium, potassium, iron, magnesium, sodium and manganese exceeding the targeted water quality ranges they were compared against (Table 3). A comparison of microbial contaminants against Recreational Use guidelines; indicates that total bacteria, coliforms and *E. coli* were present in significantly high counts (Table 3). The overall analysis results for human use, suggests that water in the Khayelitsha Wetland is not fit for human use.

4.2.2. Water quality analysis: Statistical significance

The statistical analysis of the tested phytochemical data across the Wetland ecosystem indicates that only two non-parametric data variables, namely pH and sulphate were statistically significant. The pH across the Wetland was significant at $H2; 20 = 6.78; p < 0.05$, and the sulphate was significant at $H2; 20 = 15.58; p < 0.01$. The pH level was significantly high at the upper reach compared to the middle reach of the Wetland, while the sulphate concentration was significantly low at the lower reach as compared to the upper and middle reach of the Wetland. The other variables were not found to be significantly different at any reach of the Wetland.

The microbial data (Table 3), indicated statistical differences in *E. coli* at H2; 19 = 8.66; $p < 0.05$. The *E. coli* counts were significantly less in the upper reach of the Wetland implying the water has less sewage entering from the upper reach and more sewage entering in areas close to the park bordering the middle and lower sections of the Wetland

4.3. Social study

4.3.1. Social profiles and perceptions of park users and workers

Semi-structured interviews were carried out with a total of 87 individuals from communities neighboring the Park (Makhaza, Makhaya, Silvertown and the 9 SAI Bn. Military base). Respondents surveyed were of various age groups ranging from people under 18 years to people age 65 years and older (Figure 5). Figure 5, indicates that most respondents were from the '35 to 44' age group, accounting for more than a quarter of the interviewed respondents (28%). Figure 5, also indicates a clear lack of representation of two user age groups; the 'under 18 age group' which is represented by six individuals and the 65 and older age group which is represented by only three individuals.

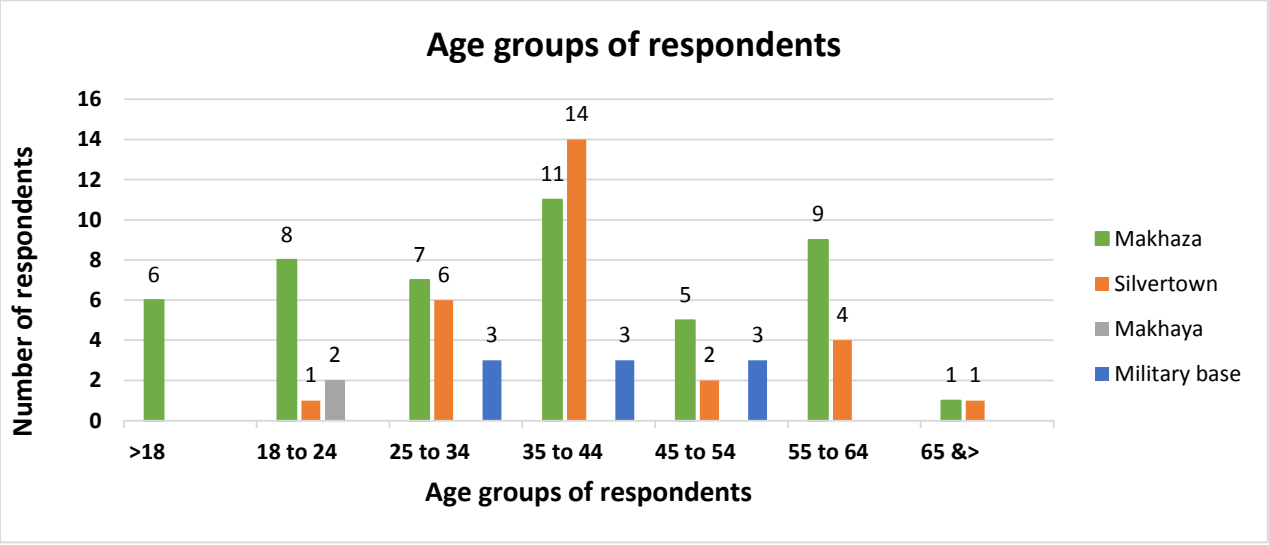


Figure 5: A cluster column showing the distribution of respondent age groups of the neighbourhoods in the Khayelitsha Township.

4.3.2. Proximity of respondents

About 75% of respondents live within 15-minutes walking distance of the Park. A significant number of these respondents live within a 5 to 10 minutes walking distance from the Park (Figure 6). The group of respondents living in close proximity to the Park includes residents of the Makhaza, Makhaya and Silvertown communities. However, at the military base respondents live more than 20 minutes' walking time from the Khayelitsha Wetlands Park (Figure 6).

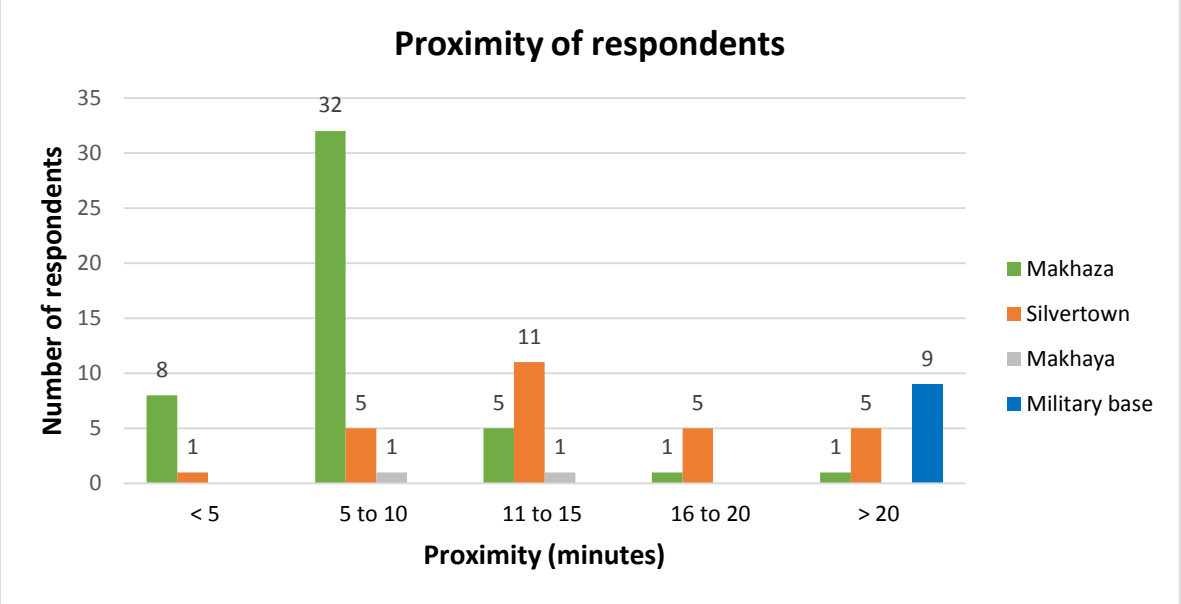


Figure 6: A cluster column showing proximity of the Park to the respondents from various neighbourhoods in the Khayelitsha Township.

4.3.3. The association of individuals and organizations to the Khayelitsha Wetlands Park

There are a number of individuals, community, governmental and non-governmental organizations involved in managing and/or using the Park. The graphical representation given in Figure 7, shows the involvement of different individuals and organizations in the use or management of the Park.

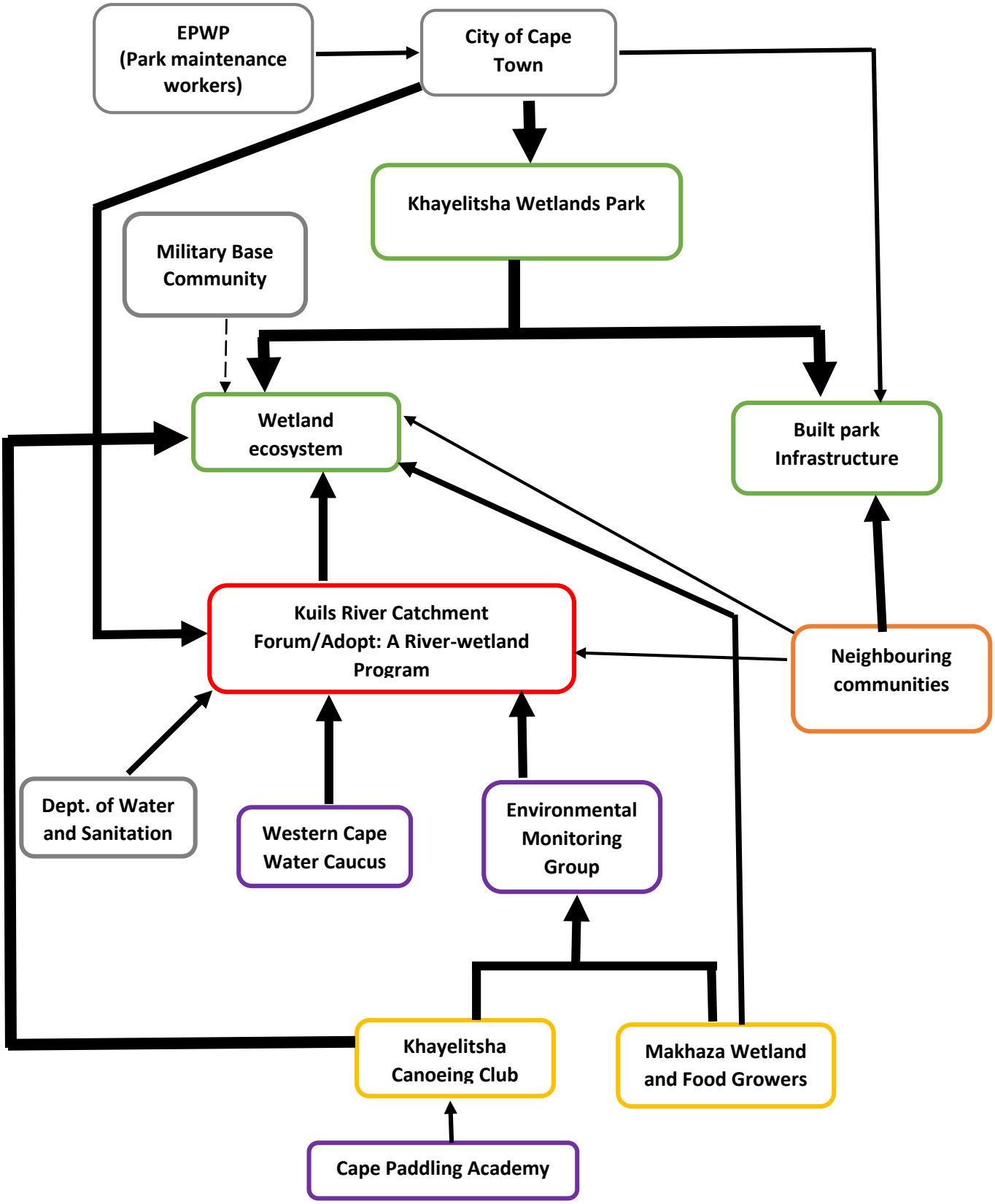


Figure 7: A diagram representing organizations and communities involved in the Khayelitsha Wetlands Park and the relationships or connections between these groups and the Park features.

4.3.4. Uses of the Khayelitsha Wetlands Park

The Park is visited by neighbouring communities at different frequencies for uses offered by the Khayelitsha Wetlands Park. While most users visit the Park several times a week (49%), others visit it only a few times in a month (27%) or a few times a year (24%), with a general decline in colder months across all users. The Park users (66 surveyed) visit the park for numerous and varying reasons (Table 4). A significant number of visitors use the Park to relax and enjoy the aesthetic beauty of the Park (93%), create and maintain social relations (59%), exercise using outdoor gym facilities (20%), and for sports and recreation (15%). This is shown in Figure 8. A small number of respondents visit the Park to spend time with their children (3%) and to walk dogs (1%). Some respondents (3%) indicated that they do not visit the Park directly, but rather only use the Park paths to access other areas of Khayelitsha.

There are five workers who are employed in the Park on weekdays to clean the area. Occasionally, these workers return to visit the Park over weekends in order to relax and enjoy the aesthetic beauty provided by the natural landscape, as well as spend quality time with significant others.

All respondents (4) from the Makhaza Wetland and Food Growers (MWFGs) use the Park for relaxation and enjoying nature; spending time with their families and friends and sometimes for meetings and team building sessions for their organization. The MWFGs also collect reeds from the Wetland to make compost for their food gardens and to feed the biogas digester at the local crèche, which is used to cook the children's meals. One member of the Makhaza Wetland and Food Growers indicated that they use the Park to exercise at the on-site outdoor gym, especially in summer mornings.

Interviewed members of the Khayelitsha Canoeing Club use the park primarily for canoeing (Figure 9c). They note that canoeing provides relaxation, the enjoyment of nature and creation and maintenance of social relations. They also noted that the Wetland is used for swimming by younger community members

(Figure 9b).

A large number of individuals of the different user groups indicated that the park is also used for livestock watering and grazing (Figure 3). This was validated by field observation which revealed cattle and goats drinking and grazing in and around the Wetland (Figure 9e-i) and three cattle kraals (Figure 9a-b and c). The field survey also revealed that the Wetland area is also used for vegetable gardens (Figure 9j), and solid waste and sewage waste discharge (Figure 9l). The 9 SAI military base occasionally harvests wood from the Wetland for cooking purposes. Sand mining is also taking place at the edges of the Wetland.

Table 4: A Table of uses of the Khayelitsha Wetlands Park identified through interviews with various participants.

Uses of the Khayelitsha Wetlands Park
Livestock watering and grazing (Cattle and goats)
Solid and sewage waste discharge
Collection of raw material (Fish, wood, reeds and lilies)
Sports and recreation (soccer, canoeing and swimming)
Exercising (outdoor gym)
Relaxation and enjoyment of aesthetic beauty
Spiritual and religious uses (mainly by churches and traditional healers)
Creation and maintenance of social relations
Events (weddings and wetland awareness events)
Walking and jogging
Dog walking
Sand mining

Figure 8: Images showing activities and uses of the built environment of the Park (CoCT, 2008).

Figure 9: Images showing activities and use of products provided by the Wetland ecosystem (Photo credit: Fezile Mathenjwa, 2016).

4.3.5. Socioecological services of the Khayelitsha Wetlands Park

According to management of the Khayelitsha Wetlands Park, the Park provides various ecological and social services to the neighboring communities. These include: sports and recreation; areas for cultural and spiritual fulfilment, flood attenuation, raw materials (e.g. fire wood and lilies), water treatment, air quality regulation and local climate regulation services. The Park provides water for gardening crops and livestock watering as well as grass for grazing livestock. There is also a general agreement among respondents (Makhaza, Makhaya, Silvertown and 9 SAI Bn. Military base residents) that the Khayelitsha Wetlands Park offers the aforementioned services. However, a number of respondents argue that the park does not provide; flood attenuation (17%), water purification (43%) and air quality regulation (20%) services. A commonly used counter- argument was that "*lomgxobozo umndaka, futhi une-vumba ingakubi ebusuku*", meaning that the Wetland is dirty and has a foul smell and therefore does not provide water purification and air quality regulation services. As some houses are flooded/inundated in winter, these respondents also argued that the Wetland does not attenuate flooding, as floods often threaten to enter into their house when it rains heavily in winter.

Although cultural and spiritual practices (such as baptism, dumping of sacrificial animals) are discouraged by management because of their potential impact on the Wetland ecosystem and the potential effects of Wetland water to human health, they are still carried out. The management noted that "there are churches and traditional healers who continue use the water to baptize people in the wetland" despite efforts by management to discourage these activities.

The Wetland is used by the Khayelitsha Canoeing Club to provide canoeing lessons to youth of the Khayelitsha Township. Although the City of Cape Town recognizes canoeing in the Wetland it has not formalized this recreational activity due to poor water quality of the Wetland.

4.3.6. Perceived negative and positive features of the Park

The Khayelitsha Wetlands Park provides a sense of place to a large percentage of its neighboring communities. All respondents agree that the Khayelitsha Wetlands Park is a positive feature of the Khayelitsha Township. Most of these respondents described the Khayelitsha Wetlands Park as "one of the best Parks in the City of Cape Town". However, a few respondents argued that although the Khayelitsha Wetlands Park is a relatively high quality park when it is compared to parks in other townships in the City, it is still rated by these respondents as a low quality park when it was compared to the parks in more affluent areas of Cape Town. These respondents noted that this is because parks in more affluent areas have better facilities.

The respondents identified features which they perceived as positive and negative features. Here, most respondents identified park facilities and infrastructure such as the outdoor gym, children's play park and park benches as positive features of the Park. Overall the green infrastructure (e.g. the flowers, the lawn and trees), within the area with built infrastructure, was perceived as positive features of the Park. The Wetland ecosystem was also perceived by some respondents as a positive feature as it complements the Park's built infrastructure, thereby increasing the overall beauty and aesthetic value of the Park. However, 21% of respondents, more specifically those from Silvertown, felt that the Wetland feature and the associated vegetation are negative features of the Park. These perceptions are linked to various ecological and social ills of the Wetland area of the Park.

These respondents associate the Wetland with foul smells which result from effluent and solid waste discharged into the Wetland by local residents and upstream users. There is also a perceived incidence of skollies[1] and gangsters who conceal their criminal activities by hiding behind the dense wetland

[1] 'Skollie' is a South African (Afrikaans) word which refers to, to naughty and ill-mannered children or teenagers and is often associated with gangsters and homeless people.

vegetation. Some of the criminal activities reported include substance abuse and dumping of unwanted components of stolen goods. The wetland vegetation was also perceived a nuisance by some respondents, as it causes seasonal allergic reactions such as skin irritation, affects sinuses and causes hay-fever.

A small group of respondents, predominantly Silvertown residents, also noted that they fear the Wetland due to their belief in a creature called *umamalambo.* This creature is believed to be a mythical snake-like supernatural entity living in the water, feeding on the blood and brain matter of sacrificial mammals (Morphy, 2010). Those who believe that there is *umamalambo* in the wetland hold the belief that children are lured into swimming in the wetland, where this creature then drowns and devours its victims.

4.4. Management of the Khayelitsha Wetlands Park

The Khayelitsha Wetlands Park is managed by different institutions and interested members of the community. The following questions were used to identify different institutions involved in managing the Khayelitsha Wetlands Park and to understand their roles and the challenges they encounter in managing this Park.

4.4.1. Who manages the Park and how has it been managed over the years?

Information obtained from community surveys indicated that the Park was established and managed by the City Parks Department of the City of Cape Town, but now is managed by the City Parks Department together with the Kuils River Catchment Forum who manage the Wetland section of the Park. The Kuils River Catchment Forum is comprised of various organizations such as the Environmental Monitoring group, the Western Cape Water Caucus, the Department of Water and Sanitation and community organizations, namely the Khayelitsha Canoeing Club and the Makhaza Wetland and Food Growers as well as other interested community members.

The City of Cape Town manages the daily operation of the Park and has hired community members to undertake daily maintenance activities required within the Park. According to the City Parks Department managing the Khayelitsha Wetlands Park, the staff are community members who are registered on the Expanded Public Works Programme (EPWP) database. The Park maintenance staff is responsible for gardening and cleaning the Park. However, park maintenance staff is not involved in cleaning the Wetland area of the Park as The City of Cape Town tenders a contract for cleaning and removal of reeds around the Wetland at least once a year. From management surveys it emerged that, despite the involvement of various organizations in the Kuils River Catchment Forum, the Forum does not have a formal structured committee to ensure effective implementation of its planned actions. As a result, a number of projects and events are conducted on a voluntary basis by members of the Forum. For example, the wetland section of the Park is voluntarily cleaned by members of the Kuils River Catchment Forum.

Management also indicated that the Kuils River Catchment Forum maintained various programs which were incorporated into the park before the park was upgraded. These programs include World Wetlands Week celebrations, Adopt-a-River/Wetland, the Working for Wetlands Program and an annual event to celebrate the International Rivers and Wetlands Day. These programs are aimed at educating the local community about the neighboring Wetland environment and recent focus has been placed on improved education in local schools, such as the Sinakho High School and Noxolo Xauke Primary School. Noxolo Xauke Primary School learners took part in the 2016 World Wetlands Week celebration (Figure 10).

Figure 10: An image with Noxolo Xauke Primary School learners at the 2016 World Wetlands Week event (Mpumi, 2016), which is one of the key management programs aimed at educating the community about the wetland ecosystem.

4.4.2. Challenges of managing the Khayelitsha Wetlands Park and the provision of green spaces in Cape Town in general

Management of the Khayelitsha Wetlands Park face various challenges, including high rates of unemployment within surrounding communities, related crime and poverty rates, lack of service delivery (such as proper housing and toilet infrastructures), pollution of the Wetland through waste discharge and dumping, and agricultural practices (crop and domestic farming) in and around the Wetland. Other challenges identified by management include political forces which are sometimes are said to sabotage

developmental programs to fulfill their own ulterior motives, the lack of commitment of some government departments and institutions of higher learning involved in managing the Park is another challenge for management.

One of the major challenges noted by the management of the Park is providing readily available and accessible quality open spaces, as it is often overridden by other conflicting demands such as the demand for financial and land resources required to develop formal housing infrastructure and service delivery (e.g. hospitals and schools). Emerging from interviews with management is the view that recent rezoning and planning in Cape Town has designated more land and budget to housing and other developments, while reducing land and budget for open spaces creation and management. As a result, low-quality open spaces such as roads/streets, railways and riverine ecosystems remain predominant within the Khayelitsha Township as well as many other areas on the Cape Flats. Children still play in the streets and riverine ecosystems in these areas as a result of limited funding provided for open spaces. This stems from the conflicting demands for the use of this space, and is further influenced by large areas of land in the City being privately owned, making it inaccessible to the public.

4.4.3. Identified changes in the Park with changes in management

According to Mr. Shepherd Mdoda (City Parks), "the upgrade primarily widened the scope of the Makhaza local park to accommodate the broader community by incorporating a portion of the Khayelitsha Wetland (from Makhaza to Spine) into the Makhaza local park, to form the district park known as The Khayelitsha Wetlands Park". Infrastructure and facilities were also incorporated into the Park as part of this upgrade. Most surveyed local community members noted that the Park previously had two pieces of park equipment for children to play on and the rest of the park space was sparsely vegetated with a few shrubs. During the Park upgrade various facilities and infrastructure were incorporated to accommodate communities and users of all ages and genders. The infrastructure and facilities incorporated into the Park

include an outdoor gym, soccer field, children's play park and park benches. Respondents also noted that the crime has been significantly reduced since park workers patrol the site daily. One of the respondents who lives less than a minute away from the Park, recalled that before the upgrades, sand from the Park would be blown into their houses, especially in the windy season. She appreciates that the Park is now covered by grass and pavement as "I no longer have to deal with much sand coming into my house."

Mr. Thabang Ngcozela (EMG) indicated that the Khayelitsha community was very sensitive with regards to involvement in the Park's affairs, as a result of what seems to be empty promises that had been made by the former management structures of the City Parks Department. The involvement of the community during the developmental planning of the upgrade of the Makhaza Park to the Khayelitsha Wetlands Park has assisted in stabilizing the management-community relationship. The incorporation of some of the facilities and infrastructure that had been suggested by the community also assisted in management in gaining the communities' trust and has created a sense of ownership of the green space. Mr. Thabang Ngcozela also indicated that educational programs which were incorporated by management into outreach pre-existing activities has raised some environmental awareness within the Khayelitsha community. However, emerging from community surveys only 28% of respondents were aware that the Kuils River, originating from the Durbanville Hills, flows into the Khayelitsha Wetlands and then drains into False Bay coast. Most of the respondents had no idea of the origin of the water or where it flows to after it leaves the Wetland. According to a member of the Makhaza Wetland and Food Growers, the lack of knowledge among the majority of community members implies that there is a need for environmental education programs that will educate more people within the Khayelitsha community.

4.4.4. Suggested improvements of the Khayelitsha Wetlands Park

The respondents made various suggestions for improving the Park, and these were classified according to four key themes that emerged. These include: improving safety and security measures in the Park, by

incorporating, for example, 24-hour security and lighting in the Park and increasing facilities in the park, specifically within the Silvertown section of the Park. Some community members suggested that more efforts should be afforded to improving the Wetland ecosystem through the incorporation of amenity features and more frequent environmental education programs to discourage antisocial behaviors such as dumping of solid waste into the Wetland area. Few respondents suggested enclosing the Wetland with a fences to discourage antisocial behaviors and also to protect children from drowing in the Wetland. However, the City Parks Department noted that fencing-off the Wetland is not aligned with their long term goal of encouraging the use of the Wetland ecosystem for recreational purposes.

Members of the Khayelitsha Canoeing Club suggested that they would like the City of Cape Town to formalize canoeing in the Wetland as they believe that this can help in addressing some of the socioeconomic issues of communities of the Khayelitsha Township. Members of the Khayelitsha Canoeing Club, for example, believe that canoeing can contribute in keeping local youth from taking part in criminal activities such as gang violence and drugs. The Khayelitsha Canoeing Club argues that such initiatives are crucial for communities within the Khayelitsha Township as a high number of youth in the community is unemployed and is therefore prone to being involved in criminal activities.

4.4.5. Future plans for the Khayelitsha Wetlands Park

Mr. Shepard Mdoda and Miss Vuyowethu Flepu both from the City Parks Department noted that the City Parks and Urban Renewal Departments will soon be implementing its planned development of establishing a Tourism Centre, which will have an amphitheater, eco-village, boardwalks, bird-hides, and a multi-functional precinct, called the Vuyani Precinct. The planning process involved the community as well as the Kuils River Catchment Forum. Mr. Thabang Ngcozela from the Environmental Monitoring Group noted that the Kuils River Catchment Forum, as part of their Adopt-a-River program, plans to establish a green economy project, where the community will be empowered to sustainably harvest green resources from the Wetland ecosystem such as harvesting and selling of lilies and wood from invasive

acacia trees. This project is still within the developmental stages and the Kuils River Catchment Forum still need to strategize broadly on the project structure before the community members can be involved in the project planning.

4.5. Social-ecological system mapping

4.5.1. The Complex Adaptive Landscape framework

A set of four states of this green space have been developed, and each state is linked to a response of changes in land use over time. These states were identified as: The Khayelitsha Wetlands in their natural state (state I, Figure 11) were seasonally inundated wetland pools and dune ecosystem comprising of predominantly the Cape Flats Dune Strandveld indigenous vegetation. The area was cleared to create space for wheat farming in the 1980s and a portion of the farm was later sold to the South African Military Department for the development of the 9 SAI Infantry Battalion Military Base (state II, Figure 11). The rest of the farm land was sold to the South African Government to develop the Makhaza settlement to accommodate the growing urban population. Here the Wetlands system were infilled with dune material, to create space for the development of the Khayelitsha Township, and most of the indigenous vegetation aquatic fauna have been lost for the wetland-and-dune ecosystem. Over the years this, along with increased runoff and sewage discharge from surrounding communities has led to the permanent saturation of these wetlands (state III, Figure 11), exacerbating the growth of alien vegetation. The local park and Wetland ecosystem have been merged together to form the Khayelitsha Wetlands Park (state IV, Figure 11) in the latest land use change. This merger was strategically aimed at providing social and cultural services to the local community whilst protecting the Wetland ecosystem. While the CAL diagram (Figure 11) is useful in illustrating how the Wetland ecosystem has responded to change in land use over time, it does not clearly indicate the complexity of the landscape's current status. Therefore, a causal loop

diagram was constructed to illustrate the complex interactions of key components of the Khayelitsha Wetlands Park (Figure 12).

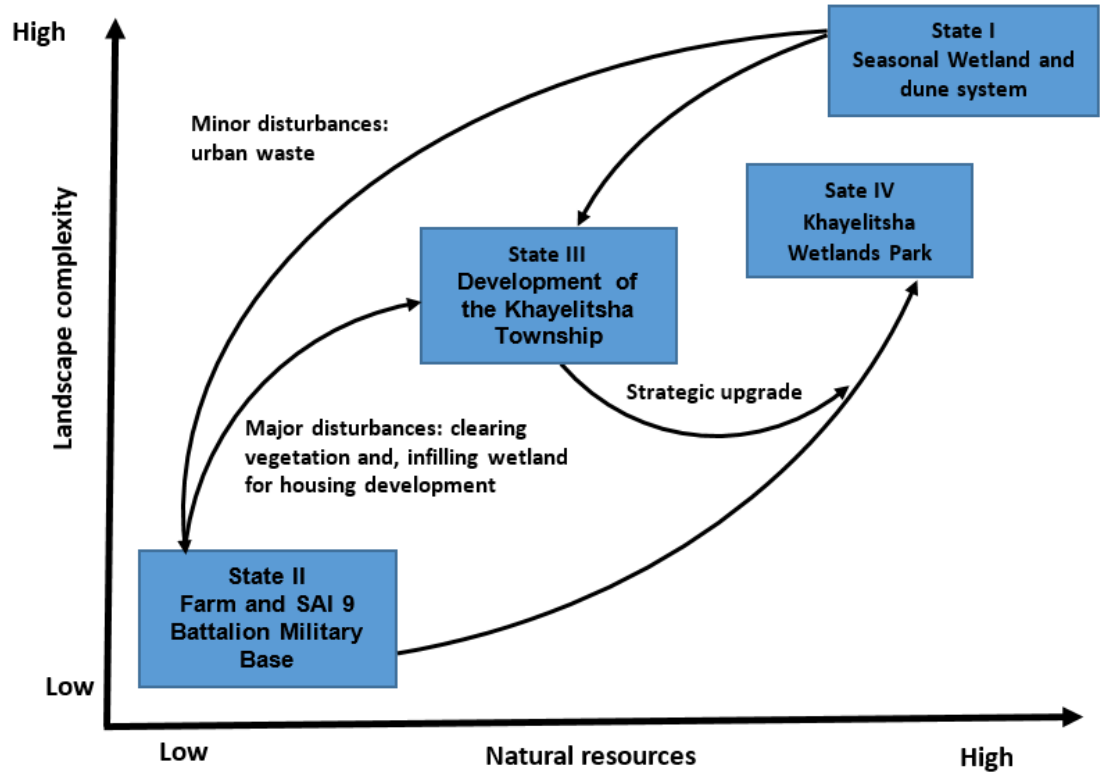


Figure 11: A State and Transition diagram representing the complex adaptive landscape (CAL) of the Khayelitsha Wetlands Park.

4.5.2. Key landscape system components and relationships within the Khayelitsha Wetlands Park

The Khayelitsha Wetlands Park provides various socioecological benefits to the residences of the Khayelitsha Township. Thirty-seven interconnected networks and four causal loops are highlighted in Figure 12. The Khayelitsha Wetlands Park provides environmental education, promotes skills development and has created Jobs for the Khayelitsha community (Figure 12 #1) during the upgrades and

related daily maintenance of the Park. This has, and will continue to, promote community development (Figure 12 #4) and assist in alleviating poverty (Figure 12 #5).

The relevant contextual literature review identified the Khayelitsha Township as an area characterized by a high unemployment rate associated with poverty (Figure 12 #7) and crime (Figure 12 #9). Crime and the fear of crime, particularly in the Wetland area (Figure 12 #34), creates a negative image for the Park (Figure 12 #11) and as a result discourages use of the park. However, active use of the park for various activities, such sports, recreation and relaxation (Figure 12 #3) could facilitate the creation of social connections (Figure 12 #11) among local users. This could result in a reduced crime rate and fear of crime in the Park (Figure 12 #12). Sports, recreation and relaxation may assist to improve the health and wellbeing of park users who regularly include these activities in their lifestyle (Figure 12 #10).

Owing to its location, structure, function and composition, the Khayelitsha Wetlands Park provides beautiful scenery to the Khayelitsha community (Figure 12 #8). The Khayelitsha Canoeing Club believe that the scenery provided by the Wetland presents eco-tourism opportunities which could benefit the community, especially the youth (Figure 12 #15). As stated in the manager's survey results, the City of Cape Town plans to develop infrastructure such as an ecovillage and birdwatching facilities to enhance tourism within the area. It is believed that tourism generation (Figure 12 #16) can lead to, and assist in, maintaining the park by creating employment opportunities, skills development and education in the area (Figure 12#16). This may enhance community development (Figure 12 #19) and contribute to solving some of the predominant socioeconomic issues such as poverty in this area (Figure 12 #5 and #19).

Opportunities for economic development are also offered by raw materials found within the Wetlands Park (Figure 12 #33), such as reeds, lilies and wood (*Acacia cyclops*). These vegetation components speak to the dynamic structure of this ecosystem and to the associated potential economic development opportunities of these raw products through the identified Green Economy Development Initiative. This Initiative will be established and facilitated by the Kuils River Catchment Forum to encourage invasive alien plant clearing, while promoting income generation for the community; alleviating poverty (Figure 12 #12) and enhancing community development (Figure 12 #19).

The structure, function and composition of the Khayelitsha Wetlands Park regulates the air and climate (Figure 12 #19), for communities surrounding the Wetland and other neighboring areas. The Wetland and the associated vegetation contributes to the cooling of surrounding air. Biotic and a-biotic structural components of the Wetlands filter water flowing through the Wetland, thereby improving water quality in the system (Figure 12 #29). The structure also helps to attenuate floods (Figure 12 #23) in this flood-prone settlement area. However, as reflected in the water quality analysis results, the current water quality of the Wetland is poor, due to various impacting activities and uses by the urban community (Figure 12 #28).

The apparent mismanagement of this space has impacted on the ecosystem structure, function and composition (Figure 12 #30). The nutrient rich ecosystem promotes proliferation of emergent vegetation, such as *Typha capensis* stands (Figure 12 #31), which outcompetes indigenous vegetation (Figure 12 #37) and has resulted in biodiversity loss. In addition, aquatic emergent vegetation grows very rapidly and

blocks water flow, resulting in stagnation of water and worsening water quality in the Wetland (Figure 12 #32). Furthermore, the current state of the water quality in the Wetland poses a health threat (Figure 12 #25) to community members who have direct water contact, e.g. canoers and children who swim in the Wetland. The ecosystem structure, function and composition has also been impacted by the significant loss of indigenous vegetation as a result of clearing of the dune-system, which supported indigenous vegetation, to create space for other uses such as agriculture and urban development (Figure 12 #27 and #37).

4.5.3. Feedback loops of the interconnections within the Khayelitsha Wetlands Park

The casual loop diagram (Figure 12) highlights components of the ecosystem presenting a reinforcing effect (Burns *et al*., 2011). The different loops also indicate opportunities for regulation and provision functions of the urban landscape system.

The first loop (L1), reveals that frequent use of the Khayelitsha Wetlands Park for various activities (e.g. sport, recreation and relaxation) has enhanced the social connection among users over time. As a result, this has helped to reduce incidences of crime and the fear of crime in the Park, thereby enhancing the social value of the park.

The Second loop (L2) indicates that the ecosystem structure, function and composition of the Khayelitsha Wetlands Park, promotes opportunities for ecotourism in the area. Ecotourism development is expected to stimulate economic development for the Park. This can in turn be used to maintain the Park and to support further development of the area. A tourism component in the local economy may also assist in creating more jobs, educating and enhancing skills of more people and perhaps assist to alleviate poverty and promote community development.

The third loop (L3) shows that the ecosystem structure, function and composition may have local microclimatic benefits and broader air quality regulating benefits. Regulating local micro climates has the benefit of providing cooler urban spaces for township residents, particularly those who live in shack dwellings (as is the case for the majority of residents in the surrounding area). The shack dwellings are built on small plots of land without insulation and residents are exposed to extreme variations in temperature.

The fourth loop (L4) is a negative feedback cycle where activities and uses of these regulatory and provision services exceeds the system's capacity to purify the water quality and thus offer these services. Treated wastewater, untreated sewage waste, agricultural and urban runoff as well as solid waste enter the ecosystem upstream and within the study area, polluting the water in the ecosystem. Water within this ecosystem is enriched with nutrients which encourage the spread of emergent vegetation, such as *Typha capensis*. *Typha capensis* along with other emergent vegetation have colonized the ecosystem causing stagnation of water and outcompeting of indigenous vegetation, and has thus negatively impacted on the ecosystem structure, function, water quality and composition. The vegetation structure in this ecological system has also been changed by infestation of nonaquatic alien vegetation such as *Acacia cyclops,* and through the clearing of indigenous vegetation in green spaces for land-uses such as agriculture and urban development. Thus impacting recreation and tourism opportunities in the area.

The fifth loop (L5) shows further negative feedbacks within the socioecological system. While the ecosystem helps to attenuate floods (Figure 12 #23) for the urban community (Figure 12 #24), the urban communities discharge and dump waste into the Wetland. This affects the ecosystem structure, function and composition (Figure 12 #27), which negatively impacts on its ability to perform various functions, such as flood attenuation. For example, the invasive vegetation species reduces the diversity of the vegetation's structural forms, which makes the system less able to cope with flooding.

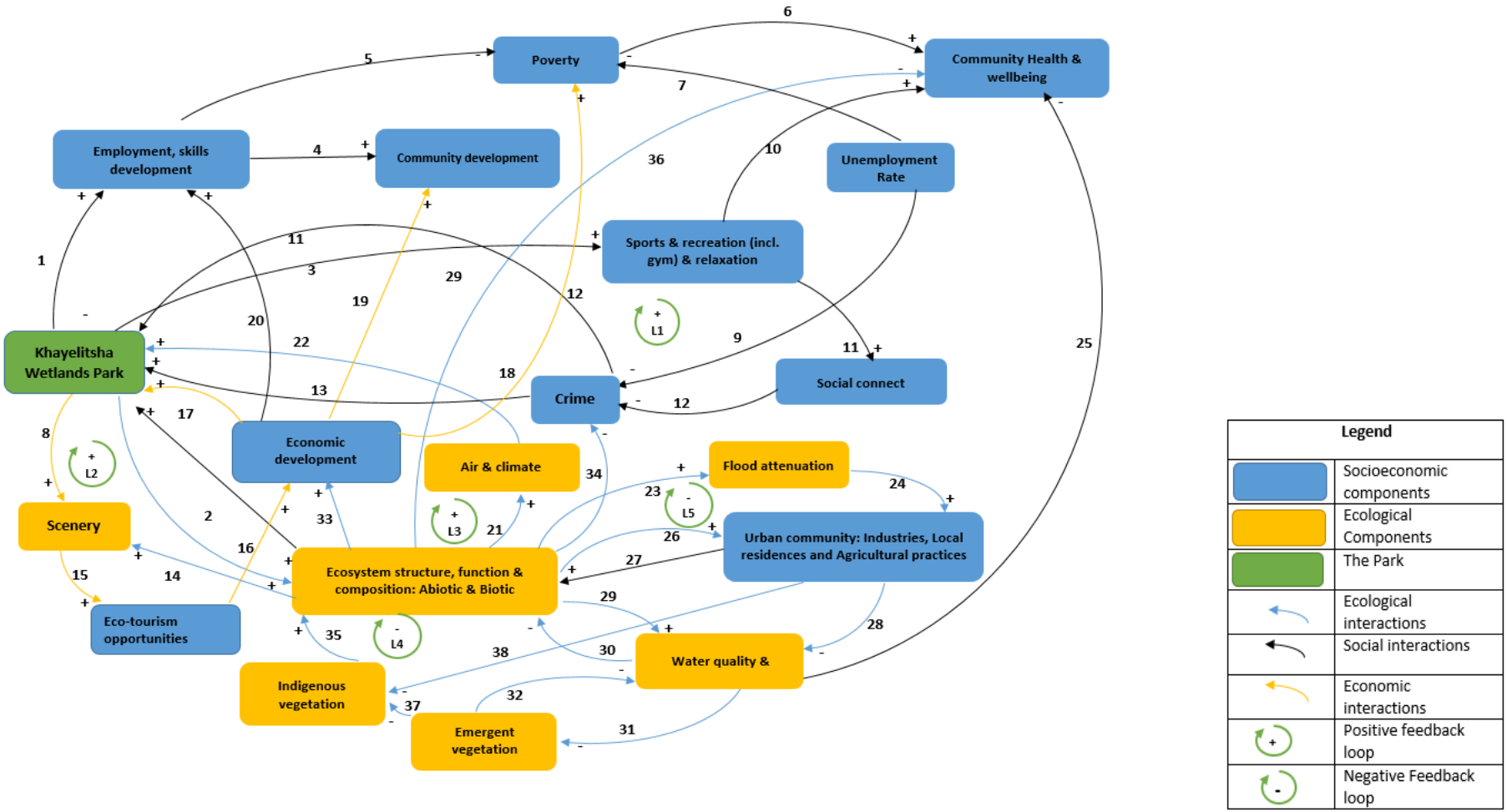


Figure 12: Causal loop diagram illustrating interconnections/relationships and feedback loops

Chapter 5

Discussion

5.1. Vegetation mapping

The analysis of the vegetation map revealed a general predominance of *Typha capensis* and a mixture of indigenous and alien (neutralized exotic) species (Figure 4). The indigenous species identified were all typically widespread and abundant species that are considered species of 'Least Concern' according to the Red List of South African Plants (SANBI, 2012). The prevalence of alien invasive species and the general distribution of cosmopolitan indigenous species is associated with complex anthropogenic influences, derived from local and upstream land-use activities which are linked with this Metropolitan Open Space System. Studies suggest that quantity (volume) and quality of water in an ecosystem have considerable influences on the vegetation structure of wetland ecosystems (Govender, 2004; Verhoeven, 2006). In light of the dire status of the water quality in this Wetland ecosystem (Table 3), as revealed by the water quality results of this study, it is not surprising that *Typha capensis* and *Phragmites australis* were the most dominant species, occurring particularly on the margins of the Wetland (Ramjukadh, 2014). *Typha capensis*, in particular, flourishes in poor water quality conditions when compared to most other species found in the Khayelitsha Wetland (Govender, 2004; Brown & Magoba, 2009). It can therefore be assumed that, *Typha capensis* has outcompeted other indigenous species, particularly the Cape Flats Standveld vegetation which once dominated this Wetland area and would undoubtedly have grown close to the margins. This assumption is supported by various studies, which noted the considerable loss of indigenous flora and fauna from the Khayelitsha Wetland as is result of rapid proliferation of *Typha capensis* and alien invasion (Hockey, 1999; Govender, 2004; Ewart-Smith, 2015). Similarly, these studies conclude that this has impacted significantly on species and habitat diversity, leading to the loss of heterogeneity in the ecosystem. The loss of heterogeneity of an ecosystem affects ecosystem functioning and consequently impacts on the provision of ecosystem goods and services (Turner *et al*., 2000). For example, the spread

of *Phragmites australis* and *Typha capensis* stands clogs the system, affecting water purification processes of the Wetland, as well as recreation and ecotourism opportunities (Ewart-Smith, 2015).

The current vegetation structure of the Khayelitsha Wetland indicates a degraded system and implies low conservation efforts within the Wetland ecosystem. However, despite this less than optimal functioning of the system, the vegetation structure of the Khayelitsha Wetland still plays an important role in the water purification and flood attenuation of high volumes of drastically polluted water entering the Wetland (Govender, 2004). The remnant dune spurs, even though they are mostly vegetated with alien invasive species (*Acacia cyclops* and *Acacia saligna*) contributes to the hydrological functioning and habitat diversity of the system. The wetland vegetation also provides a habitat for a diversity of aquatic fauna and various bird species (Brow & Magoba, 2009; Ewart-Smith, 2015). Taking this into consideration, Shand and Nicks (1999), described the Khayelitsha Wetland ecosystem as a 'distinct habitat' that is not found elsewhere in the Kuils River Metropolitan Open Space System (MOSS). Furthermore, the Wetland ecosystem is described as having high rehabilitation potential (Ewart-Smith, 2015), confirming the need for management to implement restoration efforts that could encourage vegetation diversity back into the Khayelitsha Wetlands.

The vegetation structure in the Wetland is also affected by the presence of livestock which trample on the vegetation (Day *et al*., 2005; Ewart-Smith, 2015), as this is one of the few areas in Khayelitsha where livestock can graze and drink. This means that vegetation restoration efforts should strongly consider the impact of livestock on vegetation as well as other factors, such as water quality. This is not to dismiss the importance of the practice of livestock-keeping in Khayelitsha as it forms part of this complex socio-ecological system, but it is rather to note that the potential ecological and conservation implications and associated social and recreational outcomes, which warrants investigation, discussion and careful management.

5.2. Water quality assessment

A number of studies have reported that the Khayelitsha Wetlands are linked to a numbers of pollution sources which contaminate the water body (Govender, 2004; Fourie, 2005; Brown & Magoba, 2011; Malan *et al*., 2014). These include treated effluent discharge from various treatment facilities and untreated agricultural, industrial and urban waste. It was therefore not surprising that the water quality analysis of this present study revealed that the surface water of the Khayelitsha Wetlands Park was highly polluted with various chemical and microbial contaminants (Table 3). For example, the adjusted sodium ratio, electrical conductivity, total dissolved solids, sodium, calcium, iron, manganese, chloride and zinc, all exceeded their respective national water quality targets, for irrigation use (DWAF, 1996a), human use (DWAF, 1996c), or both at different sections of the Wetland. Total bacteria, coliform and *Escherichia coli* bacteria also exceeded the targeted water quality ranges for livestock watering (DWAF, 1996b), irrigation (DWAF, 1996a) and human purposes (DWAF, 1996c) throughout the Wetland. In this study, the general presence of microbial contamination, particularly the significant increase of *E. coli* in the middle and lower sections of the Wetland can be linked to the poorly structured and serviced communal toilet facilities in the adjacent Silvertown settlement. Sewage effluent was observed during sample collection, to be flowing directly into the Wetland from this settlement. According to Govender (2004), the lack of adequate sewage system services in the Khayelitsha Township has undoubtedly added to the faecal coliform and nutrient pollution of the Khayelitsha Wetland water body. These results raise a significant health concern for individuals who use the Wetland for recreational activities and agricultural purposes.

5.2.1. Agricultural activities

Open spaces are increasingly used by the urban poor in a majority of developing cities for agricultural activities as a primary livelihood strategy (Bryld, 2003; Lovell, 2010). A number of studies have noted the importance of agricultural activities in Khayelitsha for household food production as widespread poverty and high rates of unemployment intensify the need for low cost food production (Govender, 2004;

Reuther & Dewar, 2006; Nel, 2012). This microscale (subsistence) agriculture allows the poor to supplement their diet and to lessen their dependence on bought food (Reuther & Dewar, 2006). However, agricultural opportunities in the Khayelitsha Township are threatened by a number of issues (Minor *et al*., 2004) such as land use, financial and water-related issues (Reuther & Dewar, 2006; Nel, 2012). In this study, we focused on the impact of water quality on livestock and vegetable farming practices, as well as the implications for management of the Khayelitsha Wetlands Park.

The findings of this study indicate that the Khayelitsha Wetland is an important source of drinking water for livestock in the area. However, unacceptably high levels of bacteria found in the Wetland pose severe health implications for livestock as the total bacteria, coliforms and *E. coli* exceeded the targeted water quality range for livestock watering by approximately a factor of six (DWAF, 1996b). There is particular concern with regards to *E. coli* counts as this may contribute to outbreaks of coliform related illnesses, such as diarrhoea, urinary tract infections, mastitis and more severe and lethal diseases to livestock (e.g. goats and cattle) which drinks water from the Khayelitsha Wetland (Brew *et al*., 2009). Livestock drinking from the Wetland can also contribute to the spread of infectious diseases to other animals and humans (DWAF, 1996b).

This implies that strict management interventions are crucial for the protection of livestock from possible health impacts along with the protection of the Wetland in general. Livestock farming activities, particularly livestock keeping, has major impacts on the water quality and other components which are important for the functioning of the Wetland. It has also been stressed in the Environmental Management Plan of the Khayelitsha Wetlands that livestock should be prohibited from the Khayelitsha Wetland. This will contribute to the protection of the Wetland ecosystem (Day, 2011). Getzner (2002), revealed that it is crucial for wetland protection plans to consider the social context in which wetlands exist. In Khayelitsha where a majority of its residents are unemployed and poverty rates are high, it must be considered that some residents depend on the Wetland for agricultural produce as available open space for agriculture is

limited in Khayelitsha (Reuther & Dewar, 2006). The formalization of allotments for livestock farming within the Park, specifically in areas of the Park where livestock may have limited contact with the water body, is one of the strategies that can be used to limit water related health issues for livestock. Allotments are a conspicuous feature of urban agriculture used in many cities to promote and support multiple uses of open spaces to meet the local social, economic and social needs (Mougeot, 2005; Jansen van Vuuren, 2016). However, Reuther & Dewar (2006) argue that agricultural activities within marginal areas such as the Khayelitsha Wetland might not be a viable option as it could pose ecological threats to the ecosystem. Therefore, alternative land for agricultural activities should be considered, such as using vacant school- and churchyards as alternative land for agricultural activities (Reuther & Dewar, 2006).

In the Khayelitsha Wetland, as in other water bodies in the Cape Flats, a combination of faecal coliforms and chemicals make the water quality in the Wetland unsuitable for crop cultivation (Griffin & Grobicki, 2000; Grobicki *et al*., 2000). For example, this study revealed that total bacteria and faecal coliform exceeded the targeted water quality ranges for irrigation throughout the Wetland (DWAF, 1996a). The faecal coliform levels found in the Wetland will have no significant impact on the produce directly, but may impact on human health through the consumption of this produce. Faecal coliforms, such as *E. coli,* cause enteric diseases, such as cholera and dysentery, to humans if ingested (Ashbolt, 2004). This means that water in the Khayelitsha Wetland is not fit for irrigating crops, as it can lead to the transmission of faecal coliforms to humans consuming crop produce (DWAF, 1996a). The second issue related to irrigation with water from the Wetland is the high chemical concentration. Total dissolved solids, adjusted sodium adsorption ratio, Langelier index, electrical conductivity, chloride and zinc, all exceeded the targeted water quality ranges for irrigation purposes (DWAF, 1996a) throughout the Wetland. The absorption of water contaminated with high amounts of chemicals during irrigation or through root absorption may cause damage to the leaves and may reduce the crop yield (DWAF, 1996a). Therefore, the cultivation of crops on the Wetland edges as well as the use of the Wetland water for irrigation is not viable in the

production of uncontaminated quality produce. As with livestock watering, vegetable cultivation is not a viable option given the significant health concerns and the impact of water chemistry. Evidently, the current condition of the Khayelitsha Wetland cannot support these important livelihood activities. Therefore, it is important for management to consider ways in which these agricultural activities can be pursued safely. The management could facilitate these community members in acquiring alternative agricultural land or provide allotments for crop gardens elsewhere in the Park.

5.2.2. Impacts of poor water quality on Human use

The Khayelitsha Wetlands Park is progressively becoming an important urban green space for cultural activities such as recreational and religious activities (Malan *et al*., 2014). However, according to a number of studies, the continued use of the Wetland for these activities is not safe due to the severely poor water quality and the potential related risk to human health (Davids, 2008; Pereira, 2012; Malan *et al*., 2014). This is evident in this study (Table 3), as coliform and *E. coli* bacteria were found in levels exceeding their recommended water quality target ranges for both intermediate and full contact recreational activities (DWAF, 1996d). Particularly, the presence of *E. coli* indicates faecal pollution linked to sewage contamination, and poses the risk of gastrointestinal diseases such as cholera and gastroenteritis to the community members using the Wetland for canoeing, swimming and baptism purposes (DWAF, 1996d). Although faecal coliforms such as *E. coli* are a primary indication for the suitability of water for recreational use, the South African guidelines for recreational use also acknowledges the health risks associated with chemical contamination (DWAF, 1996d). The chemical analysis results of this study, shows that only total dissolved solids and the associated electric conductivity exceeded the recommended level for human recreational activities (DWAF, 1996c; DWAF, 1996d). These chemicals may affect kidney functioning if ingested (possibly during swimming) in amounts exceeding 100 ml per exposure during swimming, or cause skin discomfort due to prolonged exposure and excessive drying of the skin (DWAF, 1996c).

These results suggest that the continued use of the Khayelitsha Wetland for canoeing, swimming and baptism poses a health risk to individuals who participate in these activities. This implies that the management of the Khayelitsha Wetlands Park should implement measures, such as signage, to prohibit the use of the Wetland for these activities. Examination of the social dimensions of recreation during the interviews with members of the Khayelitsha Canoeing Club indicated that the use of the Wetland for recreation provides an escape from the socio-economic ills (e.g. crime, unemployment etc.) of the Khayelitsha Township. The Khayelitsha Canoeing Club also has a strong desire to develop ecotourism opportunities through canoeing, in spite of the poor water quality of the Wetland ecosystem. The City of Cape Town plans to develop ecotourism opportunities through incorporating various infrastructure such as an amphitheatre, boardwalks and a bird watching hide, as an ecotourism development strategy. This indicates that these interest groups have different, albeit non-conflicting, objectives that have not been sufficiently addressed by the management of the Khayelitsha Wetlands Park. It is necessary for management to emphasize the risks associated with the current poor water quality for related recreation and the health implications it may have on people who will be involved in the associated ecotourism opportunities. Although there are a number of challenges linked to water quality improvements, primarily the high financial costs (Keeler *et al*., 2012), it is important for future management plans to consider the improvement of water quality of this water body at least to an acceptable state for recreational use. This will assist in supporting the Khayelitsha Canoeing Club to pursue their ecotourism development goals. This could also improve stewardship of the Khayelitsha Wetlands (Ruby & Kenings, 2008).

5.3. Social profiles and the management of the Khayelitsha Wetlands Park

5.3.1. Use of the park

A number of studies that have explored the factors informing the use of urban green space suggest that use is influenced by a number of factors (Chiesura, 2004; Giles-Corti *et al*., 2005; Lee & Maheswaran, 2010;

Schipperijn *et al*., 2010). For example, proximity, environmental features, amenity and safety features all emerge as important influencing factors in green space use (Giles-Corti *et al*., 2005). The results of the present study revealed that, although the local community appreciates both the amenity features of the built environment and the Wetland feature of the Park, most users prefer the built infrastructure associated with the Wetland area, rather than the Wetland feature itself. The avoidance of the Wetland area of the park is attributed to the fear of crime linked to previous crime incidents. This finding is supported by studies conducted by Shand & Nicks (1999) and Pereira (2012) which also acknowledge that the local community avoid the Wetland area, as it is associated with criminal activities such as muggings and assaults. These criminal activities are linked to the dense wetland vegetation, and in particular the dense *Typha capensis* stands growing on the Wetland margins and *Acacia cyclops*. This reinforces the need for measures to control invasive vegetation, and re-introduce the indigenous vegetation which was lost from this landscape. Controlling invasive vegetation and the introduction of indigenous vegetation could maintain the Wetland area in a condition that is less attractive to criminals and is also less threatening to the community (Allsop *et al*., 2014)

Another contributing factor in the avoidance of the Wetland area is a belief that the Wetland hosts a water spirit, called *umamlambo,* which means 'mother of the river'. It is reported to take the form of a beautiful woman or mermaid, but the form of a serpent has also been reported (Morrow & Vokwana, 2004; Madondo, 2012). Some respondents in this study believe the creature takes a serpent-form, although none of the respondents have reported that they have seen this creature themselves. While the notion of *umamlambo* is generally considered as mythological, particularly in the Western sense (Wood, 2000), this study notes the role that sociocultural influences (i.e. beliefs) have on the perceptions, attitudes, and behavioral responses (avoidance) towards environmental features such as the Khayelitsha Wetland. A number of studies argue that sociocultural dynamics are important and complex issues which should be incorporated into the planning of urban green spaces (Balram & Dragicevic, 2005; Bjerke *et al*.,

2006; Lopez-Mosquera & Sanchez, 2011; Baur *et al*., 2013). The Park management indicated that they are aware of this belief among some members of the community and to address it, the City of Cape Town, in consultation with the community, plans to incorporate various facilities along the Wetland area, such as an amphitheater, bird hides, and a boardwalk. The City of Cape Town anticipates that this will positively influence the perceptions and attitudes of the local community, thereby encouraging them to use the Wetland area for leisure. The importance of incorporating amenity features and recreational facilities in ecosystems like the Khayelitsha Wetland has been recognized in various studies (Briffet, 2001; Ryan, 2005; Gobster, *et al*., 2005; Gobster, 2007; Baur *et al*., 2013). For example, Gobster *et al*. (2007) argued that the change of spatial composition of ecological and social features to create functional links between ecosystems and local communities are key to the sustainable management of ecosystems. These changes are often useful in positively influencing people's perceptions and ultimately affecting their actions towards a given landscape (Gobster, 2005).

Despite the general avoidance of the Wetland area by community members, some residents do use the Wetland for recreational activities and agricultural practices. Both of these practices are common in global cities (Jim and Chen, 2006b; Wagner & Zalewski, 2009; Kremer *et al*., 2016) as the use of urban green spaces for agricultural practices are more prevalent in cities of developing countries than cities of developed countries. This is due to the crucial part these spaces contribute to basic survival and food security for rural-urban immigrants (Bryld, 2003; Lovell, 2010; De Bon *et al*., 2010). This is mainly due to the lack of formal employment opportunities in many developing cities for the growing number of rural immigrants in cities (Lovell, 2010). In most cities in Africa, agriculture is not limited to vegetable gardening, but also includes livestock farming, which is a significant part of the culture and traditions of many households (De Bon *et al*., 2010). In the context of rural areas, livestock plays an important economic and socio-cultural role for the livelihoods of many rural areas. Livestock is increasingly viewed as a form of capital in the same sense as financial or monetary capital. A number of studies note the importance of

livestock for the fulfillment of rituals and social obligations for families and communities, and for strengthening social networks (Meltzer, 1995; Nel, 2012; Bettencourt *et al*., 2013). For example, cattle are used as a bride price and are slaughtered for funerals, weddings and other traditional ceremonies (Nel, 2012; Bettencourt *et al*., 2013). In the City of Cape Town, the popularity of livestock farming is linked to migrants of the former Eastern Cape homelands practicing livestock and crop farming in the rural areas and continuing with this agricultural practice upon their arrival in Cape Town as a livelihood strategy (Nel, 2012). However, as in many other cities of the developing countries, many sites used for urban agriculture in Cape Town are occupied illegally (De Bon *et al*., 2010). Reuther & Dewar (2006) argued that this is because allocation of land for agricultural activities is often not prioritized due to a number of competing and conflicting demands for land in the City of Cape Town. Another issue, which Lovell (2010) notes, is that land for agricultural activities is allocated in some instances, but marginalized groups often lack the means to purchase this land for agricultural practices. This is recognized by the Urban Agricultural Policy of the City of Cape Town (2007), and as a solution it provides for leasing of the land allocated to urban agricultural activities to individuals who cannot afford to buy the land. According to this policy, leasing of the land allocated for agricultural activities should be done through a permit system, which is facilitated by the City of Cape Town's Urban Agricultural Unit. However, the majority of individuals who are taking part in agricultural activities in Khayelitsha are involved primarily for their basic food needs and their activities are on a small scale that presumably would mean they cannot afford to lease this land, as permits are provided at a certain cost. This implies that there is a need for more sustainable low cost agricultural land for individuals who cannot afford land, yet rely on agriculture as a primary livelihood strategy. For example, the formalization of allotments is a cost effective strategy that should be considered in other areas of the Khayelitsha Wetlands Park to support urban agriculture. The formalization of allotments in the Park could be a viable option in growing vegetables for basic needs and associated small-scale activities, if crops are grown in pockets of the Park where contact with the water body is limited. In

addition, as suggested by Reuther & Dewar (2006), considering vacant schoolyards and churchyards as alternative land for agricultural activities is a possible solution. This strategy has also been used by the Environment Monitoring Group to assist the Makhaza Wetland and Food Growers, one of the community organizations which were growing crops on the Wetland edge, to acquire land at Sinakhokonke Primary School for their farming activities. Therefore, this strategy could be pursued to assist other individuals who are currently using the Wetland for agriculture to acquire alternative land, through engagement and negotiation with community leadership. A recent study conducted by Cilliers *et al*. (2017) has indicated that in South Africa the government has establishment of a number of health clinic gardens for the provision of health services and to contribute towards the nutritional requirements of local communities. The use of these alternative open spaces will not only address the issue of food security, but could also contribute to the greening of churches, schools and clinics. This will promote multipurpose use of urban open spaces, while assisting to limit such land-uses which are conflicting with the Wetland protection objectives of the City of Cape Town and the Kuils River Catchment Forum.

5.3.2. Management of the Khayelitsha Wetlands Park

It is well recognised that urban green spaces provide maximum ecosystem services when they are properly managed (Madge, 1997, Boone *et al*., 2009). With regards to the Khayelitsha Wetlands Park it is impressive that the City Parks Department of the City of Cape Town, through the key upgrades which entailed the incorporation of various infrastructure (e.g. outdoor gym, recreational facilities, benches etc.), has managed to improve the Khayelitsha Wetlands Park. Through the upgrade, this urban Park now offers the local community a number of health and recreational benefits. The City Parks Department has recently started with the second phase of upgrading the Wetland area of the Park. These upgrades will include the rehabilitation of the Wetland with indigenous vegetation and incorporation of different facilities such as bird hides and a boardwalk, to enhance the aesthetic appeal and ultimately discourage antisocial behaviours (e.g. crime) within the park. Although the City Parks Department is the primary

management authority of the Park, it shares the role of managing the Wetland area of the Park with a number of governmental and non-governmental institutions, local community members, and other relevant stakeholders, through the Kuils River Catchment Forum. It has been recognised that such social networks are crucial in managing complex ecosystems, like the Khayelitsha Wetland (Olsson *et al*., 2004). This type of management is known as co-management and it enables the exchange of ideas, expertise and knowledge, and contributes to improved management of constituent land-uses, which often combine various sociocultural objectives with conservation goals (Colding *et al*., 2006). However, an apparent challenge in this area is limited cooperation and coordination among institutions and community members involved in managing the Khayelitsha Wetland. While some institutions and community members involved in the management of Kuils River Catchment Forum appeared to be more active, others were less active and lacked commitment to their respective duties of managing the Park. A study conducted by Graham and Ernstson (2012) also reported on issues of commitment in a co-management arrangement to manage the Macassar Dunes in Cape Town. This implies that co-management arrangements are not easy to pursue. One possible reason for this is that there are often no appropriate governance systems that ensure accountability of all those who are involved in management (Puppim de Oliveira *et al*., 2013). Emerging from the management interviews the Kuils River Catchment Form, no management structure has been put in place to ensure commitment and accountability among organisations and individuals involved in managing the Khayelitsha Wetland Park. There is a sense among members of the Forum that not all parties are active in attending arranged meeting and lacked commitment to their respective duties of managing the Park. According to Carmona *et al*. (2004) this creates a major barrier to management efficiency. Therefore, it is crucial that an approach to ensure commitment and accountability among members of the Kuils River Catchment Forum, and in turn ensure efficient implementation of the developed management plans. According to Puppim de Oliveira *et al*. (2013), the role of central authorities and clear accountability measures are crucial in ensuring

management success. In light of this suggestion the establishment of a partnership agreement (e.g. memorandum of understanding) and structured coordination of the Kuils River Catchment Forum could assist in facilitating commitment and accountability of institutions and actors involved in managing this Park.

5.4. Feedbacks of social-ecological interactions of the Khayelitsha Wetlands Park

There is a growing body of research that acknowledges the multiple complex interactions between components and the feedbacks mechanisms that underpin the state of an ecosystem (Olsson *et al*., 2004; Folke, 2006; Ryan *et al*., 2007; Armitage *et al*., 2008; Perring et al., 2015). A causal-loop diagram (Figure 12) was used to highlight the key social-ecological components of the Khayelitsha Wetlands Park, and the usage and management of this urban green space, to better understand how the quality of life and ecological aspects are linked, and how they influence this complex socio-ecological system. The results also revealed reinforcing effects where the amenity features and infrastructure incorporated into the Park landscape have encouraged more frequent use of the Park for various activities including sports, recreation and relaxation. This has enhanced social networks among users and as a result this has reduced incidents of crime and fear of crime within the Park. This supports suggestions made in various previous studies that infrastructure in urban green spaces is linked to stronger social interactions and may reduce both fear and incidences of crime (Kuo, 2003; Wolf, 2010). The incorporation of amenity features in the Park demonstrates an effective management strategy and reinforces the importance of well managed urban green spaces to improve the quality and value of these spaces. Ecotourism development, an option which is under discussion by members of the Kuils River Catchment Forum, would also be expected to stimulate economic development through job creation, contributing to development and poverty alleviation while promoting conservation of the Wetland ecosystem (Sims-Castely, 2004, Li, 2006; Coia & Calfucura, 2012). Coia & Calfucura (2012) noted an important consideration for ecotourism development, where local communities often fail to implement successful ecotourism projects as a result of various

factors, such as isolation and the lack of financial resources, management skills, and infrastructure. Ecotourism is not the panacea it is often made out to be. In this case it implies that ecotourism development in the Khayelitsha Wetlands Park would require significant involvement by Park management to promote involvement from, and provide support to, the local community. This would require careful planning for successful collaboration of the community and Park management to ensure successful ecotourism development that would benefit the community and promote ecosystem protection.

A prominent negative feedback in this complex socio-ecological system is the poor water quality resulting mainly from the use of the Wetland for the discharge of large volumes of treated effluent, and untreated agricultural, industrial and urban runoff. The poor water quality is linked to a number of subsequent impacts, such as the potential health implications for humans and livestock and the growth of invasive vegetation. This outcompetes the indigenous vegetation resulting in the loss of effective attenuation services due to a homogenized vegetation structure. Consequently, settlements on these flood prone areas are damaged during flood events. It is important for management to be able to respond to such feedbacks in ecosystems to ensure maximum functioning of these ecosystems and its affiliated services and benefits (Olsson *et al*., 2004; Black *et al*., 2011). This supports findings from previous studies, including Ewart-Smith & Ractliffe (2002), Govender (2004) and CoCT (2014) that have documented the need to control waste water discharged into the Khayelitsha Wetlands and the Kuils River Catchment as it flows into the Khayelitsha Wetlands. The persistent failure to resolve this negative environmental situation requires attention. The identified social and ecological interactions and feedback loops of this landscape show that this is a complex socio-ecological ecosystem where elements cannot be considered in isolation but rather the system must be considered in its entirety, where all the relevant parties need to be included in decision-making and management towards an improved socioecological ecosystem.

Conclusion

In keeping with global trends in understanding the benefits of urban green space to city dwellers, this study highlights the importance of quality urban green space in a specific part of Cape Town, in the Khayelitsha Wetlands Park. The Khayelitsha Wetlands Park is well received and used by the neighbouring community, matching global trends and provides support to literature that have documented the importance of green space in cities. This Park offers multiple social, physiological and ecological benefits and here is an evident desire that the Park should offer ecotourism development opportunities in future. It is also anticipated that more benefits will be offered by the Wetland area as amenity features will be incorporated in this area of the Park.

While the Park is well received and clearly forms an important, desirable and quality urban green space within the Khayelitsha community, there remains space for improvement to both the social and physical environment. There are some internationally recognized social and physical problems that were also present in this context. The key social issues that emerged from this study include the high incidence of crime and drug use, dumping of solid waste within the Park itself, dumping of solid waste, and discharge of wastewater and raw sewage in the Wetland area of the Park. These issues are linked to poor service delivery provided to the Khayelitsha Township, as evidenced by waste discharged from the poorly serviced communal toilet facilities in Silvertown. The results of the biophysical study showed that the Wetland has a poor water quality and a vegetation structure that is highly homogenised due to the spread of invasive plant species which are favoured by the poor water quality condition of the Wetland ecosystem. This indicates that different elements within this landscape affect each other in one way or another.

The Complex Adaptive Landscape (CAL) model is both useful and necessary to understand how these various elements all impact on each other and the feedback loops that inform the ecological state and the use of the urban green space. It is therefore crucial for green space to be investigated from both a social and a biophysical angle so that they are truly understood and effectively managed. The current ecological

state, i.e. the poor water quality and the highly alien dominated vegetation structure, is an indication of multiple negative feedbacks from a number of local and regional anthropogenic impacts. It is imperative that management understands and effectively manage these issues to ensure the provision of maximum benefits from this urban green space to the local community in future.

The map of the social players shows a large number of interested and involved parties. This presents an opportunity for collaborative management initiatives which if well-coordinated could assist in reaching established goals for this urban green space. This study suggests the formation of a collaborative unit that will facilitate coordination and accountability amongst individuals and institutions involved in the management of the Khayelitsha Wetlands Park as well as other urban green spaces within the City of Cape Town. As a result can help to overcome environmental justice that continue to persist in this City, particularly with regard to the distribution of quality urban green spaces.

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Appendices

Appendix 1: Ethical approval letter

UNIVERSITY OF CAPE TOWN
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2 December 2015

Fezile Mathenjwa
Department of Environmental and Geographical Sciences

Exploring the ecological and social benefits of Khayelitsha Wetland

Dear Fezile Mathenjwa

I am pleased to inform you that the Faculty of Science Research Ethics Committee has approved the above-named application for research ethics clearance, subject to the conditions listed below. You are required to:

- Implement the measures described in your application to ensure that the process of your research is ethically sound; and
- Uphold ethical principles throughout all stages of the research, responding appropriately to unanticipated issues: please contact me if you need advice on ethical issues that arise.

Your approval code is: FSREC 64 – 2015

I wish you success in your research.

Yours sincerely

Signed

Dr Richard Hill
Chair: Faculty of Science Research Ethics Committee

Cc: Dr Pippin Anderson, Supervisor

Appendix 2: Park survey

Name and surname/igama neVan:
Age:
Place:
Distance from the Park:
Contact details:
Date:

Interview questions

A. Use of the Khayelitsha Wetlands Park

1. Do you know the Khayelitsha Wetlands Park?

Yes		No	

2. Do you know how long it stretches?

Yes		No	

3. How often do you visit the park?

Everyday		Every week		Only on weekends		Once - few times a month		Once – few times a year	

4. How is/was the wetland used?

Use	Y	N	Comment
1. Water use/sebenzisa amanzi			
1.1 drinking/ukusela			
1.2 Irrigation/ukunkcenkceshela			
2. Waste treatment (dumping waste)/ukulahla inkunkuma			
3. Provision of natural resources			
3.1 Food resources (e.g. gathering fish/kuloba)/ukuthola ukutya (e.g inhlanzi)			
3.2 small-scale subsistence farming (agriculture and livestock)/ukondla imfuyo nkutyala			
3.3 Raw materials (e.g. wood, fuel and fodder)			
3.4 Medicinal Plants/imithi yesixhosa (e.g. Ikhala)			
3.5 Ornamental resources (e.g. resources for handcraft, jewellery decoration and souvenirs such as feathers, flowers and other cosmetic plants, fish etc.)/utyani, izimbali(intyatyambo) (e.g. Lilly-inyibiba, ingcongolo/reeds)			
4. Cultural and information functions			
4.1 Tourism and recreation (e.g. outdoor sports such swimming/uku-quba/ukudada)/ukhenketho Kanye nemidlalo nolonwabo			
4.2 Relaxation and enjoying the aesthetic beauty			
4.3 Use for spiritual, religious or historic purposes (e.g. cultural and heritage value of natural ecosystems and features)/ukwenza izinto zamamasiko, nenkolo (e.g. izitradition and rituals zesi Xhosa (igqirha, inyanga), amacawa)			
4.4 Creation and maintenance of social relations			
4.5 Science and education (use of wetland for school excursions etc.)			

5. Are there any other ways on which you use the Khayelitsha wetland? (Answer the following questions by using a tick √)

Yes		**No**	

6. If you answered yes in question 4, name them in the box below

5. Wetland water

a) Do you know or understand where water in the wetland comes from and where it is going?

Yes		**No**	

b) If yes, could you briefly describe where water in the wetland comes from and where it is going?

B. Perceptions of the wetland/imbono nge-Khayelitsha wetland

1. Does the Khayelitsha wetland provide the following?

	Yes	**No**
Sense of place		
A place which provides storm/flood reduction benefits		
A place for Dumping waste		
A place which provides water regulation and purification		
A place which provides air regulation/umoya		

2. How would you rank the Khayelitsha Wetlands Park in relation to other parks in Cape Town?

Good		Bad	

3. What features does the KWP have that you like and dislike (positive/negative)??

C. Management/uhlelo logada nocleana idamu, umfula, umgxobozo)

1. Briefly discuss how the Khayelitsha wetland has been managed over the years?

2. How is the Khayelitsha Wetlands Park currently managed? And how has the state of the wetland Park changed over the years, with different management systems over the years?

3. What do you think can be done to improve the KPW i.e. would you prefer that the KWP have more infrastructure, more nature/natural features or more infrastructure to access nature?

Appendix 3: Managers interview questionnaire

Name and surname:

Organization/company:

Position:

Date:

1. How long has your organization or department been involved in managing the Khayelitsha Wetlands Park? And how long have you been working in this Open space?

2. What has How changed since you/your organization got involved in managing the Khayelitsha Wetlands Park?

3. What are key management programs of the Khayelitsha Wetlands Park?

4. What has been the key challenge with managing (implementing management programs) the Khayelitsha wetland

5. Have you observed any changes in the way the community perceives and uses this green space, since the current upgrades and implementation management programs?

6. What are the key ecosystem benefits/services of the wetland and the greater KWP?

7. What are the key challenges facing management in providing and managing Open Spaces in the broader context within the City of Cape Town?

8. What are the future plans for the Khayelitsha Wetlands Park?