



# **Understanding the social in a social-ecological system: A perceptions study on the Diep River estuary, Cape Town**

Carly Wise

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## **Supervisors:**

Dr Pippin Anderson (Department of Environmental and Geographical Science, University of Cape Town)

Dr Ernita van Wyk (ICLEI – Local Governments for Sustainability)

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## **Abstract**

Our ever-urbanising world has seen a rift form between humans and the natural environment. Nature is readily displaced in pursuit of development, despite the critical dependence of people on nature's benefits. The field of urban ecology addresses this challenge by re-integrating the natural and social sciences, bridging the gap in our understanding of how society interacts with nature in an urban context. There are areas in cities where these interactions and relationships between society and nature are extremely complex, with interlinking and interdependent social and ecological dimensions. One approach to grasping the complexities of human-nature interactions is to view them as social-ecological systems (SESs). The SES perspective reveals key links between the social and ecological dimensions that would otherwise be overlooked if studied separately.

Natural spaces in cities play an important role in providing multiple benefits to urban citizens and to the environment. But with urban nature under threat of loss and degradation, ecosystem services can be lost too. The Diep River estuary in Cape Town is an important system from both a social and an ecological perspective. However, there has been a significant decline in the state and health of the system. While the Diep River estuary boasts decades of meticulous ecological research, little is known or written about the ways in which urban citizens use, perceive and value this natural resource. This suggests that the estuary has historically not been viewed as a system with interconnected social and ecological dimensions.

To address this gap, this study examined people's perceptions of the Diep River estuary, both in the moment and through time, to gain a deeper understanding of the social dimension of the Diep River estuary SES. Following a predominantly interpretive case-study approach, historical data associated with the estuary were analysed to reveal changes in estuary use over time. Forty-five questionnaire surveys and seven key-informant interviews were conducted to gather deep insights and narratives from every-day as well as long-term estuary users. Findings from this research illustrated a deep sense of place relating to the estuary, which encouraged pro-environmental behaviour and a ubiquitous awareness of the estuary's state. There was also a clear relationship between the regularity of use of this urban estuary and local residents, highlighting the importance and relevance of accessibility to nature in urban spaces. The research suggests that the public hold valuable insights and deep understandings of natural systems, and effective ecosystem management should incorporate stakeholder understanding and perceptions. Furthermore, environmental stewardship can be cultivated through strategic urban planning that ensures access to natural urban spaces, encouraging their protection and the future sustainability of their benefits.

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## Chapter One: Introduction

The urban context is characterised by complex relationships between the natural and man-made environment. The field of urban ecology aims to integrate natural sciences (environments and ecosystems) and social sciences (people and society) to address the gap that exists in our understanding of how humans interact with surrounding natural systems (Niemelä, 2014). Limited appreciation of society's dependence on natural ecosystems, their finite ability to supporting human well-being, and the benefits they provide have caused social-ecological dissonance, and a dramatic alteration of ecosystems unlike any other time in history (Chapin *et al.*, 2010). Furthermore, the benefits that ecosystems provide are often over-exploited and unevenly distributed. A restorative and integrative management approach to curb environmental degradation is needed in order for people to benefit sustainably from nature's services. It is widely accepted that an approach to bridging the gap between biophysical and social dimensions is to view, study, and understand natural environments as complex social-ecological systems (SEs) (Liu *et al.*, 2007; Collins *et al.*, 2011). The use of the social-ecological systems framework (SESF) as a lens through which to view interconnected systems of people and nature has revealed key links, relationships and processes that would otherwise be overlooked if systems were studied using the biophysical disciplines or social disciplines exclusively and separately (Costanza *et al.*, 2017; Colding and Barthel, 2019). Social-ecological systems are not specific to cities. However, in an urban context where the influence of humans is more significant and ever-increasing, we look to the field of urban ecology to contextualise the linked social and ecological sub-systems that are relevant in this study.

Ecosystems provide a multitude of services, many of which are directly beneficial to people and society in the form of provisioning and cultural ecosystem services (Camps-Calvet *et al.*, 2016). Regulating and supporting services provide benefits for and contribute to Earth's natural processes in general (Camps-Calvet *et al.*, 2016). Ecosystems and their services are threatened as a result of an unprecedented rise in anthropogenic activity (Vitousek *et al.*, 2008). One of the most egregious activities which is changing global landscapes is urbanisation (Güneralp *et al.*, 2017). As the majority of the world's population live in urban areas that continue to grow in size and density, natural areas within and on the periphery of urban conurbations are placed under immense pressure. The ecosystem services that they provide become endangered too. Fragmentation and degradation of ecosystems compromises their healthy functioning, and reduces their ability to provided ecosystem services to society (Haberl *et al.*, 2007).

There is a growing awareness of and appreciation for natural spaces in cities and the role that they play in the lives of urban citizens. Pockets of natural ecosystems in cities (sometimes referred to as urban nature or urban green spaces) are acknowledged for being of great importance to sustaining life in cities and making urban areas more liveable through various processes (Pantshwa and Buschke, 2019). These

include but are not limited to microclimate regulation (e.g. cooling), habitat provision, and noise pollution filtering (Ward, Parker and Shackleton, 2010). Urban nature also offers urban citizens a better quality of life. Improved mental and physical health, improved social and psychological well-being, stress reduction, livelihood provision, human connection, and a peaceful escape from busy urban life are some of the societal benefits of green spaces in cities (Barbosa *et al.*, 2007; Ward, Parker and Shackleton, 2010).

Urban ecosystems exist in many forms, such as parks, greenbelts, forested areas, lakes, rivers, estuaries, national parks, mountain areas, and others. Estuaries, both within and outside urban areas, are remarkable systems that provide a wide range of ecosystem goods and services to humans and the environment (Van Niekerk *et al.*, 2013). They are highly productive and dynamic systems that support an abundance of life (Viskich *et al.*, 2016). However, they are also among the world's most degraded natural systems, especially in urban contexts. Estuaries often suffer the cumulative ill effects of upstream pollution, urban development pressures, as well as pressures from everyday resource users (Breen and Mackenzie, 2001). As a result of the pressures placed on them and their subsequent degradation, there is an urgent call for more effective management and restoration of urban estuarine ecosystems. It is essential that this is prioritised, “[because] as the health of estuaries deteriorates, so does their ability to deliver valuable ecosystem services” (Adams, Whitfield and Van Niekerk, 2020, p231).

Estuaries can be viewed as SESs (Jennerjahn and Mitchell, 2013). Humans rely on the many ecosystem goods and services that estuaries provide, and their use (or misuse) determines the state of the ecosystem to a certain extent. There are constant interactions between the social and ecological dimensions within estuaries systems, causing feedback loops and reciprocal relationships between society and ecosystems (Liu *et al.*, 2007). Furthermore, the institutions (rules and policies) that govern the use of estuary goods and services are established to direct, encourage and govern individual and collective behaviours that will ultimately promote a more desirable state of the estuary (Van Wyk *et al.*, 2016). Behavioural and social transformation are key in ecosystem restoration. This idea further supports the use of the SES perspective as a way to view estuaries among researchers, managers, and the general public. At this stage there is a growing consensus that estuaries should be considered as complex SESs (Barbier *et al.*, 2011; Adams, Whitfield and Van Niekerk, 2020). The interdependent relationships between social and ecological dimensions are becoming increasingly recognised and accepted as a “single inextricable system” (Rodríguez-Morales López, 2020). This is the case in urban estuaries (Anthony *et al.*, 2009; Rothenberger, Armstrong and Spitz, 2018) where all aspects of the estuary system are co-evolving and adapting to each other.

Due to the multiple uses, users, governing bodies, and natural processes, management decisions of estuarine ecosystems have far-reaching effects on many stakeholders. Science-driven approaches have

largely informed estuary management decisions (Elliott and Whitfield, 2011). However, social-driven approaches have the power to provide crucial knowledge regarding management and support a more holistic understanding of the system (Bowd *et al.*, 2012). Inadequate emphasis has historically been placed on the social dimension of complex systems (Dehens and Fanning, 2018). In addition to informing management decisions, scientific research contributes to the body of knowledge surrounding complex ecosystem functioning (Anthony *et al.*, 2009). There is evidently a deeper understanding of the ecological state of estuaries than of the social state, and societal benefits and perceptions of estuaries have not been sufficiently researched and understood. Social science-based approaches to management are as useful in the decision-making process as scientific-based and top-down, policy-oriented approaches. Understanding the links and relationships between these dimensions is key, as it bridges the gap between humans and nature (Adams, Whitfield and Van Niekerk, 2020), thereby providing the basis for a more integrated approach to natural resource management and one which is likely to attract greater public support.

Understanding the ways in which people experience and perceive SESs is a fundamental tool for articulating the social-dimension of natural systems (Bennett, 2019). Burger (2003) also argues that effective land management should involve understanding perceptions and attitudes of a wide-range of stakeholders. However, the study of the role that values and perceptions play in managing SESs is said to be neglected in literature (Hukkinen, 2012; Jones *et al.*, 2016). Concerted effort should be made to understand the diverse ways in which people use and value a resource. Once we have an understanding of people's perceptions of a certain area, we possess a value-based contribution to estuarine management informed by society.

Combined with the analysis of user perceptions of the Diep River estuary, another useful tool for enriching the social dimension of this SES is the analysis of historical material. Consulting historical data relating to the estuary is insightful because it reveals what the uses of the estuary were across a temporal scale. We can draw conclusions about the state of the estuary in a particular time period by identifying the uses during that time, and can infer perceptions of the state and value attached to the estuary based on evidence of historical uses. When social and ecological dimensions are separated conceptually, as they have been historically, it becomes difficult to understand how we can direct change in natural systems to achieve sustained estuary benefits to society (Redman, Grove and Kuby, 2004). Understanding estuaries and other natural systems through a one-dimensional theoretical lens has resulted in an uncoupling of complex systems. Therefore, it is suggested that the SESF is useful to understand and manage coupled social-ecological systems.

## **1.1. Rationale**

Accessible nature-based amenities are of great importance to urban citizens, especially as levels of urbanisation continue to rise (City of Cape Town, 2007; Nielsen and Hansen, 2007). The Diep River

estuary appears to be appreciated by residents and families from all over the city as being a place of recreation and peace within the city. However, the future health of the Diep River estuary is threatened by cumulative urban pressures that have caused severe ecosystem degradation and impacts on the provision of ecosystem services (Matthews, 2016). It is essential that its health is safeguarded by holistically-informed management. This aspiration can be strengthened by viewing the Diep River estuary as a social-ecological system, and by integrating different bodies of knowledge to ensure sustainable management (Hossain *et al.*, 2018). The Diep River estuary boasts decades of water quality and ecological research (Viskich *et al.*, 2016), but little is known about how people use and perceive this resource. An integration of the social and ecological disciplines for ecosystem management is a priority (Redman, Grove and Kuby, 2004).

## **1.2. Aim**

There is a gap that exists in the understanding of the social dimension of the Diep River estuary social-ecological system. This research aimed to address this gap by examining and articulating the uses and user perceptions of the state and benefits (i.e., ecosystem services) associated with the estuary, towards a deeper understanding of the social dimension of this system. With that, the research aims to provide a body of knowledge, based on a new understanding of the social system, to potentially inform future management decisions.

## **1.3. Objectives**

The objectives guiding this research are to:

- Gain a better understanding of the of the wide range of stakeholders by identifying the users and uses of the Diep River estuary;
- Examine and articulate user perceptions of the state of the estuary, its benefits, and the role of nature in an urban area;
- Document current and historical uses of the Diep River estuary to draw links between societal uses and ecological well-being over a temporal scale.

## Chapter Two: Literature Review

### 2.1. Urban ecology

Many modern societies have severed their connection with the natural world. This rift has caused people to lose sight of the critical benefits that nature provides, and is especially prevalent in an ever-urbanizing world where nature is readily displaced (McDonald *et al.*, 2018). Urban ecology is gaining traction as a field of study that addresses this disconnect by re-integrating the natural and social sciences (Niemelä, 2014). It is especially important to look towards the field of urban ecology as a framework for sustainability, as cities are at the forefront of decisions regarding the future health of our planet and its ecosystems (McPhearson *et al.*, 2016). In other words, what cities do, matters. People and cities have evolved into a force that affects ecosystems on a global scale (Collins *et al.*, 2000). As the world's urban areas keep growing, it remains imperative that urban development decisions ensure positive transformations, i.e., that social, economic and environmental objectives and trade-offs in cities are well-balanced, equitable and sustainable. The emergence of urban ecology is a result of people and cities developing novel ecologies of their own, playing a key role in future sustainability on a global level (Anderson and Elmqvist, 2012).

Some authors distinguish between ecology *of* the urban and ecology *in* the urban (Anderson and Elmqvist, 2012; McPhearson *et al.*, 2016; Pickett and Cadenasso, 2017). Ecology *of* the urban, as described by Gaston (2010) is similar to what Gaston refers to as “real” ecology, in that it encompasses the study of relationships between and movements of organisms, their environments, and each other. Therefore, ecology *of* the urban refers to the dynamic breathing system that is the city. Ecology *in* the urban refers to natural spaces within cities which are crucial to the city, and to the people within (McPhearson *et al.*, 2016). As human-dominated landscapes, the city has drastically altered ecosystems within them (McDonnell, 2013). These ecosystems can be referred to as complex social-ecological systems (SEs), which will be discussed in the following section. It is essential that these ecosystems are able to display resilience and sustainability, and the multidisciplinary field of urban ecology can be used as a tool for achieving these ideals (McPhearson *et al.*, 2016). There is an indisputable link between societal health and ecosystem health in the urban context (Smit and Parnell, 2012). Urban ecology invites stakeholders to use collaborative efforts in ensuring the continued functioning of healthy society-nature relationships (Barot *et al.*, 2019).

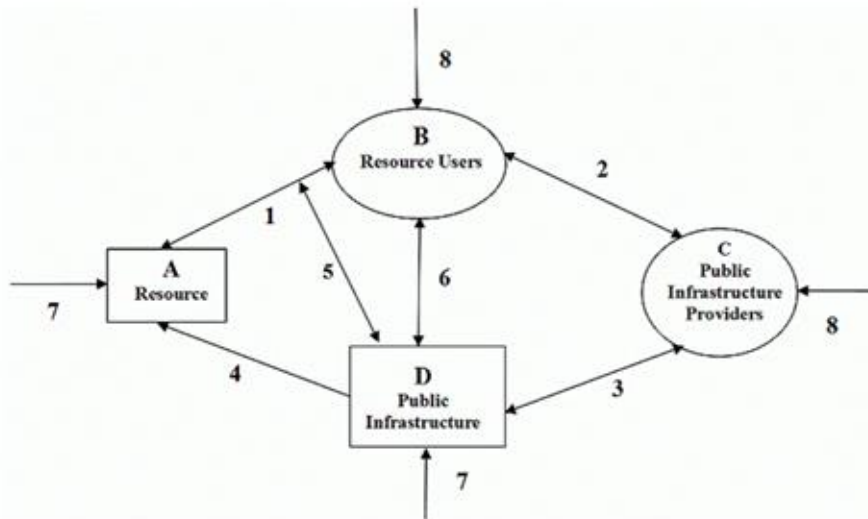
Urban ecology actively seeks to integrate a variety of disciplines, including urban design and infrastructure (Childers *et al.*, 2015). The resilience of ecosystems and their continued ecosystem services provision can be predetermined by their successful incorporation into the urban planning and design phases (McPhearson *et al.*, 2016). This can present itself in the form of civic processes (Childers *et al.*, 2015), where human and environmental well-being is pursued by individuals, professionals and institutions through interdisciplinary and participatory processes. The integrated knowledge of urban

planners, engineers, practitioners, residents, ecologists and institutions allows us to move toward an ecology *for* cities; an approach with transdisciplinary practices which is useful for viewing cities holistically (Childers *et al.*, 2014). Understanding the social structures and dynamics within a city is necessary for the sustainability of its ecosystems through the success of its urban design (Boone, 2013).

It is essential to adopt a more holistic approach that includes the public imagining and understanding of cities; the “transformational nexus” of ecology *for* cities (Grove *et al.*, 2016). Professionals, academics, civil society and government ideally play roles in the pursuit of similar goals (McPhearson *et al.*, 2016). Using the collective contributions of urban citizens can direct the design and development of cities to follow a creative, sustainable, inclusive, knowledge-to-action process (McGrath, 2018). A co-design process for sustainable urban development was undertaken in Australia, where urban challenges were emerging from larger cities such as Sydney and Melbourne (Webb *et al.*, 2018). Rapidly growing populations and the highest global per capita resource footprint (Webb *et al.*, 2018) were drivers of co-design workshops of multiple phases and a variety of stakeholders (urban policy makers, practitioners, local and national government representatives, city councils) that sought to develop a framework for sustainable urban development. The framework can be applied to other cities that are experiencing rapid growth at the expense of the environment. The field of urban ecology encourages a much-needed integrated approach to sustainable urban design in an age of rapid urbanisation, where the state of SESs is under constant threat. From an urban ecology perspective, garnering the public’s understanding of nature in cities, facilitates the incorporation of social sciences which can be integrated with other disciplines in sustainability agendas (Burger, 2003).

## **2.2. Social-ecological systems**

A social-ecological system (sometimes referred to as SES or complex system), consists of interdependent and interlinking social and ecological dimensions (Partelow, 2018). The SES approach is useful as it acknowledges the complex relationships between all aspects in a system. These aspects include its ecological attributes as well as its diverse range of stakeholders, actors and beneficiaries, and the policies or ‘public infrastructure’ that guides their shared behaviours (**Figure 1**). Thinking from a SES perspective can assist in the pursuit of reaching goals relating to sustainability, because the human feedback mechanisms in SESs are critical to the future ecological health of ecosystems (Masterson *et al.*, 2017). According to Colding and Barthel (2019) the concept of a SES was defined over five decades ago, but a general framework for understanding SESs in a broader sense emerged around two decades ago, aptly named the social-ecological systems framework (SESF), to be discussed later. There are multiple ways to interpret and define a SES (Colding and Barthel, 2019), but a useful visual representation (**Figure 1**) and definition has been taken from Anderies, Janssen and Ostrom (2004).



**Figure 1:** A simplified representation of a SES. The model displays the key elements of a SES and how these elements may be linked to each other in a number of different ways (Anderies, Janssen and Ostrom, 2004).

The representation is a simplified one that outlines various relationships and linkages in a SES, and is aided by the associated definition:

A social-ecological system is an ecological system intricately linked with and affected by one or more social systems. An ecological system can loosely be defined as an interdependent system of organisms ... [and] social systems can be thought of as interdependent systems of organisms. Thus, both social and ecological systems contain units that interact interdependently, and each may contain interactive subsystems as well. We use the term SES to refer to the subset of social systems in which some of the interdependent relationships among humans are mediated through interactions with ... non-human biological units (Anderies, Janssen and Ostrom, 2004, p3).

Thomas *et al.* (2012) offer an abridged definition of a SES as “a system of people and nature”. Further to that, Thomas *et al.* (2012) describe that the activities and resource use of one stakeholder group can affect other stakeholder groups that are using the same resource. These activities can also affect the existing biological processes and ecosystem services offered by the system. **Figure 1** allows for the visualization of the reciprocal relationships, drivers and feedback loops that exist in SESs.

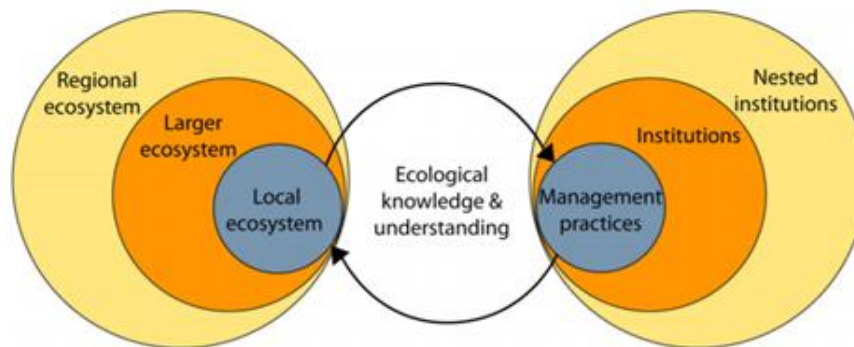
The SESF emerged as an integrative theoretical tool that better enables us to grasp the complexities of the interactions between social and ecological dimensions in complex systems (Guimarães *et al.*, 2018). Grasping these complexities is key for the systematic and holistic approach to management of natural systems. Having a thorough understanding of the social and ecological dimensions of a particular system - and their interdependent relationships - can provide decision makers with adequate insight to apply an integrated rehabilitative management strategy for that system (Guimarães *et al.*, 2018).

Due to heightened levels of amalgamation and interaction between people and nature in cities and on the urban fringe, the SESF is becoming increasingly relevant in understanding SESs in the urban context. Since the emergence of the SESF a number of decades ago, several authors have contributed to its evolution and further development. Ostrom's (1990) contributions to the framework are cited by many for being among the foundational understandings of complex systems (Basurto, Gelcich and Ostrom, 2013; Partelow, 2018; Colding and Barthel, 2019). Ostrom's (1990) widely discussed contributions stem from her work that challenges Hardin's conclusions in his well-known article *The Tragedy of the Commons* (Partelow, 2018). In her book titled *Governing the Commons* (1990), Ostrom offers the SESF as a tool for understanding complex systems, by outlining a number of components and interactions within them. Some of these interactions occur between the users of the system, managers of the system, and the natural processes present in the system. Ostrom also refers to the variables in a system that affect its future outcomes. As the title of her book suggests, Ostrom (1990) argues that under a certain set of conditions, users of natural systems or common pool resources are capable of governing the resource themselves. Ostrom's (1990) work is useful for this study because it illuminates the role that resource users play in understanding and directing a SES holistically. Her work provides a rationale for understanding who resource users are, and how they might play a role in governing a system. Ostrom's (2009) more recent work highlights the importance of employing a framework that integrates scientific and social knowledge to describe complex SESs. Furthermore, Ostrom (2009) and other authors (Berkes and Folke, 1998; Norberg and Cumming, 2008) acknowledge the importance of identifying linkages between SES elements at different temporal scales. Considering that the relationships between aspects of SESs can change the system, it is important to understand the past in order to understand the evolution and current state of SESs, and manage these resources accordingly.

Resource management failures may arise when humans and nature are viewed as separate entities (Berkes and Seixas, 2005), or when social systems are viewed as being outside of ecological systems. The dynamic interactions between the state of the resource, the human perception, values and behaviours, and the roles these factors play in how people use the resource, are sometimes not accounted for in resource management (Wood and Jones, 2019). This gives rise to natural systems being viewed as "primarily ecological problem[s]" (Cumming and Allen, 2017). It is crucial to view a complex system as having interacting and interdependent social and ecological aspects that are of equal importance. Viewing them in this integrated manner can improve the management of natural resources, especially those that are shared by the public or managed in the public interest.

There is importance in highlighting resource users' and locals' views on resource management. Local knowledge for resource management is deemed critical, especially when users depend on those resources for their livelihood (Defries and Nagendra, 2017). Community dependency on a resource drives better understanding and motivation for involvement in resource management and ensuring that benefits to users are sustained. **Figure 2**, a modified schematic used by Colding and Barthel (2019),

illustrates how local knowledge of a particular ecosystem is the central link between the ecosystem (left) and the institutions that manage them (right). This conceptual framework is a useful analytical tool for coupled SESs (Colding and Barthel, 2019). The SESF as a tool for sustainability of complex systems is useful because it provides context relating to the relationship between ecosystems, the users and use patterns, and the institutions that govern them. Once these roles and relationships are explained, it is possible to analyse what behaviours are drivers or results of social and ecological change (Epstein *et al.*, 2015).



**Figure 2:** Ecological knowledge as the key link between ecosystems and managing institutions (Colding and Barthel, 2019).

Another aspect included in the schematic (**Figure 2**) is the institutions that govern SESs. Institutional decisions regarding sustainability of a resource can be informed when a framework for understanding the relationship between all elements of the resource is applied. Natural systems typically include coupled elements that behave in a mutually responsive manner, and among these elements are institutions (the rules that govern the use of the resource) (van Assche *et al.*, 2019). As the state of SESs is in flux, it is necessary for governance of these systems to be adaptive (Baird *et al.*, 2019). Adaptive governance is flexible in that there are emerging interactions between all stakeholders and role-players in SESs, all in pursuit of a desirable and healthy state of the ecosystem and its associated benefits (Baird *et al.*, 2019). Adaptive governance calls for collaborative efforts between varying scales of resource users and managers, and it is of crucial importance that local knowledge is not undermined, and included in the process (Armitage *et al.*, 2009; Colding and Barthel, 2019).

The SESF is a useful theoretical tool for viewing natural systems because it illuminates both the ecological and social dimensions simultaneously. A key offering of the authors and theories mentioned above is the conceptualisation of dynamic natural systems containing complex and interlinking ecological and social aspects. Manfredo *et al.* (2017) suggest that adopting a systems framework to grasp how people perceive and value a system is more useful than understanding human perceptions and values as stand-alone concepts. This is because human values are tied in with their external ever-changing environments and are not static.

Highlighting the social dimension and societal benefits of a system can provide effective insights into system dynamics and feedback mechanisms, which are useful for management. One possible way of articulating the social dimension of complex systems is by analysing social perceptions, a key component of SES governance (Williams, Ford and Rawluk, 2020). Integrating and understanding human perceptions as they relate to SESs is an integral part of ecosystem sustainability, because these perceptions inform behaviour (Bercht and Wijermans, 2019), and human behaviour affects the state of ecosystems. This will be further explored later in this literature review.

### **2.3. Benefits of urban nature: A focus on estuaries**

This study places emphasis on coupled SESs because the ecological dimensions provide a multitude of diverse and valuable benefits to individuals and societies (social dimensions) (Choi, Park and Rigolon, 2020). These benefits, also referred to as ecosystem services, have been acknowledged for providing several benefits to urban dwellers in various forms. As urban areas continue to grow it is crucial to protect natural spaces within them. The concept of ecosystem services, which was initially referred to as “environmental services” when it first emerged in literature in the 1970s (Lele *et al.*, 2013), has gained traction amongst researchers in more recent decades (Fisher, Turner and Morling, 2009). The conceptualisation and valuation of ecosystem services ultimately allows us to understand the dependence that society has on nature (Lele *et al.*, 2013). The concept emerged from the realisation that there was a simultaneous over-demand and under-appreciation of ecosystem services that support human activities and well-being (Hirons, Comberti and Dunford, 2016). It is important to conceptualise ecosystem services in the urban context because of the sustainability challenges linked to rapid urban growth and the associated ecosystem degradation (Luederitz *et al.*, 2015). Urban areas are dependent on healthy ecosystems and continued ecosystem services provision (Luederitz *et al.*, 2015). Urban ecosystem services are those that are produced within urban regions (Jansson, 2013) and benefit urban dwellers. Urban planning and management can create opportunities for effectively sustaining urban ecosystems and their services.

A broad definition offered by the Millennium Ecosystem Assessment (MA) (2005) is that ecosystem services are “the benefits humans derive from ecosystems”. The MA publication (2005) was a turning point for the study of ecosystem services. The publication acknowledged that a significant portion of the world’s natural areas were in decline, which could negatively impact the future of human welfare (Fisher, Turner and Morling, 2009). Ecosystem services are commonly categorised into four main types of services, namely provisioning, regulating, supporting, and cultural services (MA, 2005; Camps-Calvet *et al.*, 2016). Examples of cultural ecosystem services relevant to estuaries include recreational activities such as fishing or aesthetic benefits (Pouso, Uyarra and Borja, 2018). Estuarine ecosystem services that fall into other categories include food supply (provisioning) and regulation of water supply (regulating), and supporting services, in particular nutrient cycling and provision of habitat for wildlife

(Ghermandi *et al.*, 2012). According to Lele *et al.* (2013) the ecosystem services concept has led to a shift in policies relating to ecosystem conservation and management. This is because the exploration of the viability of ecosystem services has allowed people to measure and value them. It is suggested that advocacy for estuarine ecosystem restoration has become more effective as they are expressed in terms of the benefits they provide and the associated beneficiaries (Hirons, Comberti and Dunford, 2016).

In the current study a broad ecosystem services approach was used to understand how a particular SES benefits society. It is outside of the scope of this study to visit the complex territory of economic valuations of ecosystem services in depth (Kenter *et al.*, 2016). Valuing ecosystems in terms of their economic benefits means focusing predominantly on the material goods and services that ecosystems provide (Raymond *et al.*, 2013), such as food or timber, and viewing them in quantifiable terms. Some authors argue that this approach may be restrictive in that it “crowds out [deeper] understandings of human-environment relationships” (Raymond *et al.*, 2013, p536; Costanza *et al.*, 2017). The success of a broad ecosystem services approach over a purely economic approach is that it allows us to hold sight of the other human-nature interactions that hold value, without viewing ecosystems in simplistic terms (Norgaard, 2010). It also invites us to account for sentimental, cultural, and emotional values that humans place on nature (Small, Munday and Durance, 2017). The majority of the unseen or unquantifiable benefits that nature provides are in the form of cultural ecosystem services.

Attention is paid to the usefulness of cultural ecosystem services in ecosystem management (Arslan and Kaymaz, 2020). Cultural ecosystem services offered by natural areas are often in the form of recreation, which is an important and necessary aspect of urban living (Arslan and Kaymaz, 2020). Even though cultural ecosystem services are not assessed to the same degree as regulating, provisioning and supporting ecosystem services, recreational ecosystem services are the services most assessed within the cultural ecosystem services field (Pouso, Uyarra and Borja, 2018; Arslan and Kaymaz, 2020). Studies have shown links between exposure to urban nature with improved physical and mental well-being (Jackson *et al.*, 2013; Shanahan *et al.*, 2015). Furthermore, implementation of effective management strategies calls for the socio-cultural values and sense of place felt by citizens to be understood and defined (Vierikko and Jari Niemelä, 2016).

This study used cultural ecosystem services as a focal point for informing ecosystem management, but does not engage with economic valuation in light of both the scope of the work, the SES approach, and the arguments outlined above. Kirchhoff (2019) raises that cultural ecosystem services are understood and viewed from an anthropocentric point of view. Viewing an ecosystem purely by how it benefits people can draw attention away from its biological or eco-centric benefits (Kirchhoff, 2019). While remaining aware of the criticisms and conceptual flaws of using cultural ecosystem services as an assessment method (Kirchhoff, 2019), it was still found useful in the current study because this particular system is already well-understood in terms of its ecological state and the associated benefits.

Continued ecosystem service provision calls for effective and integrative management of SESs. This study does not quantify ecosystem services of a complex urban estuarine ecosystem. Rather, it seeks to articulate user perceptions of the ecosystem to place value on the services that the estuary provides. However, in the case of the Diep River estuary and many ecosystems across the globe, there is cause for concern around environmental degradation. Ecosystems and their services are threatened as a result of the unprecedented rise in anthropogenic activities unlike any other recorded period in history (Vitousek *et al.*, 2008). One of the most egregious of these activities which is changing global landscapes is urbanization (Güneralp *et al.*, 2017).

## **2.4. Access to urban nature**

The majority of the world's human population live in urban areas and will continue to do so for the foreseeable future. Levels of urbanisation differ depending on the regions around the world (UN/DESA, 2018). The global level of urbanization is predicted to rise from 30% to 68% by 2050, with the African continent experiencing a faster rate of urbanization than any other continent (Anderson *et al.*, 2013; UN/DESA, 2018). Schäffler and Swilling (2013) point out that southern Africa is the most urbanised sub-region on the continent. Within this context, much importance has been placed on the conservation and management of natural areas that will come under pressure due to development (McDonald *et al.*, 2018). These areas play an increasingly important role in human and ecosystem wellbeing. Added to this, more than 60% of urban citizens in the southern African region are living in slum conditions with limited access to infrastructure and resources (Anderson *et al.*, 2013; Schäffler and Swilling, 2013). The concepts of social equity and nature conservation in an urban context are intersectional (Montambault *et al.*, 2018). The acknowledgement of their intersectionality is growing increasingly important because cities are transforming rapidly due to urbanization, the current model of which gives rise to exclusion, social divides and spatial inequalities (United Nations-Habitat, 2016). If cities are to be sustainable, a critical element to consider is natural spaces, which are currently unevenly distributed in cities across the global north and south (Choi, Park and Rigolon, 2020). In the case of the city of Cape Town, access to urban nature is unevenly distributed due to high levels of natural land loss, income inequalities, and better protection efforts of some natural spaces over others (O'Farrell *et al.*, 2012). This is especially prevalent in the low-lying areas of the Cape Flats (O'Farrell *et al.*, 2012).

As previously stated, there are important relationships between nature and human well-being (Shanahan *et al.*, 2015). Immersing oneself in a natural, safe and pleasant environment encourages physical activity, stress reduction, and human connection. Therefore, a lack of access to natural space is deemed as environmentally or socially inequitable, as benefits of natural spaces are reaped only by some (Rigolon and Németh, 2018). Some authors discuss equitable social and environmental access as having multiple facets, including distributional, procedural and contextual justice (Montambault *et al.*, 2018; Choi, Park and Rigolon, 2020). Distributional justice is associated with how resources and amenities

are allocated to citizens, procedural justice relates to the decision-making processes and their level of participation and inclusion, and contextual justice relates to the existing conditional structures in a given context (Montambault *et al.*, 2018; Choi, Park and Rigolon, 2020). Grasping the contextual facet of environmental justice means to understand the historical and political circumstances of a particular place, which encourages nuance to be considered in future decisions and interventions (McDermott, Mahanty and Schreckenber, 2013).

In the context relevant to this study, which explores an estuary in a rapidly urbanising city with a diverse set of users, there are additional challenges that have manifested themselves through a myriad of discrepancies initially caused by Apartheid (Goodness and Anderson, 2013). For example, abundance of urban nature is disproportionately distributed across Cape Town's lower- and higher-income areas (Venter *et al.*, 2020). Environmental injustice is also pervasive through ongoing sewage contamination in the estuary (OUTA, 2020). This is out of alignment with South Africa's Constitution which states that all South African citizens have "the right to an environment that is not harmful to their health or well-being; and to have the environment protected, for the benefit of present and future generations, through...[prevention of] pollution and ecological degradation (Constitution of the Republic of South Africa, 1996).

Ecosystem degradation is one of the challenges that urban nature faces as a consequence of rapid urbanisation. As the majority of the world's population live in urban areas that continue to grow in size and density, natural areas are placed under immense pressure (MA, 2005). Fragmentation and degradation of these habitats compromises their health and functioning (Haberl *et al.*, 2007). Therefore, the ecosystem services that they provide become endangered too, and will eventually diminish. Urban nature and its accessibility play an important role in enhancing the lives of urban dwellers. The combination of natural areas being lost due to development and pollution, and the need for social equality through fair access to natural areas and the benefits they provide, illuminates the urgent importance of managing them. Advocacy for protection of urban nature can be strengthened if their benefits to society are outlined (Haberl *et al.*, 2007). As an urban estuary is the natural space relevant to the current study, it will be discussed in further detail.

## **2.5. Estuaries**

An estuary is defined as the area where a river flows into the sea, causing freshwater and ocean water environments to mix. Further definitions describe estuaries as being "either permanently or periodically open to the sea" (MA, 2005), meaning that salinity levels are constantly fluctuating. This transition zone is an important ecological area that is highly productive and biologically rich (Viskich, 2014). The combined properties of freshwater and ocean water provide a nutrient rich environment, and are responsible for the many benefits to humans and the environment in the form of ecosystem services

(Jackson, Conrad and Carstens, 2011). It is generally agreed that estuaries are among the most important natural environments in terms of ecosystem service provision (MA, 2005). The geographical positioning of estuaries also makes them fairly sheltered areas which provide a level of protection from the open ocean (Jackson, Conrad and Carstens, 2011). This has provided them with the label of “nurseries of the sea” (Beck *et al.*, 2001). Estuaries are described using the nursery concept because this important ecological area provides a space for many juvenile bird and fish species to safely develop and grow (Beck *et al.*, 2001; US EPA, 2016). Furthermore, Beck *et al.* (2001) suggest that if estuaries are more widely accepted as nurseries for juvenile flora and fauna, they may be better managed and conserved.

Tidal flows affect the water regimes of estuaries because they are open to the sea, either on a permanent or periodic basis (Retief, 2016). This means that water levels, water discharge, and salinity content fluctuate to a greater extent along the middle to upper courses of rivers (Jackson, Conrad and Carstens, 2011). In addition to providing a protected area for juvenile fish, bird and plant species to grow, the topographical characteristics and positioning of estuaries also makes them vulnerable to urban development (Jackson, Conrad and Carstens, 2011). The presence of water has been pivotal in the development of human settlements, and available water sources are critical for the survival of human communities. The majority of the world’s population live with 100 kilometres of bays and estuaries (Burger, 2003). Given that estuaries are sites of important ecological processes, and are also characterised by high levels of human engagement, they can be viewed as coupled SESs. The biological richness and desirable location of these environments makes them extremely vulnerable to external changes and modifications (Beck *et al.*, 2001).

### **2.5.1. Estuary degradation**

Estuaries are prone to degradation through modification caused by increasing pressures placed upon them. Modification and other pressures are amplified in urban estuaries as they are hemmed by urban and industrial developments over a long period of time (Viskich *et al.*, 2016). As the mouths of estuaries are situated at the end point before rivers drain into the sea, they experience the ill effects of all upstream pollution (Breen and Mackenzie, 2001; Schulz and Peall, 2001; Olisah, Adams and Rubidge, 2021). Common threats that estuaries face include pollution, dredging operations, surrounding urban and industrial development, introduction of invasive species and over-exploitation of natural species, and general mismanagement (Blaber *et al.*, 2000; Viskich *et al.*, 2016).

In the case of the Diep River estuary, researchers and users are aware that using the resource has become a public health concern (Paulse, Jackson and Khan, 2009; News24, 2020; OUTA, 2020; Olisah, Adams and Rubidge, 2021). For an extensive period of time the system has been exposed to major upstream pollution, which is primarily caused by sewage that enters the stormwater drainage system that flows into the lagoon (City of Cape Town, 2020). Waste enters the stormwater system because of overflow

and illegal dumping. In addition to recent pollution at the lagoon, there is evidence that degradation due to system modification has been cumulatively building for almost a century (Matthews, 2016; Viskich *et al.*, 2016). The Diep River estuary (the lagoon section in particular) has more recently been infamous among researchers and the general public for being far from a pristine environment (Matthews, 2016; City of Cape Town, 2020). If the Diep River estuary and other estuaries in general are to continue to provide ecosystem services and benefits, it is essential that they be managed and restored to a degree that allows for continued ecosystem service provision.

### **2.5.2. Estuary management**

Due to the vulnerability of estuarine ecosystems, they require specific care and management. In the South African context, the *National Environmental Management: Integrated Coastal Management Act* (2008) stipulates that estuaries are to have an Estuary Management Plan (EMP) that is effective and well-coordinated. However, this has not always been the case (Lamberth and Turpie, 2003; Retief, 2016). Jackson, Conrad and Carstens (2011) highlight that estuaries have not always fit neatly into the mandate of specific government departments, and this has resulted in a lack of accountability and subsequent mismanagement of estuaries. This was addressed through the National Estuarine Management Protocol (NEMP) that sought to establish estuary management objectives that encouraged co-operative governance and cross-sectoral planning and management of estuarine systems in South Africa (Cilliers and Adams, 2016). Monitoring programmes are now an integral part of EMPs.

The overall custodians for the monitoring of water resources in South Africa is the Department of Water and Sanitation (DWS), who have designed and implemented over 10 national monitoring programmes (DWAF, 2002). However, these programmes are typically associated with freshwater environments as opposed to estuarine environments (Cilliers and Adams, 2016). Using principles and best practices of these monitoring programmes, Cilliers and Adams (2016) designed a National Estuarine Monitoring Programme (NESMP) that can be applied to estuary management in South Africa. In specific estuaries, other management options such as zoning based on certain activities have been applied (Lee, Hosking and Du Preez, 2015), but this is not applicable to all estuaries. Each individual estuary management body is encouraged to have its own EMP that is aligned with the National Coastal Management Programme (CMP) (DWAF, 2002; Retief, 2016). A key aspect of estuarine management is the relevant and long-term collection of appropriate data relating to particular estuaries (Cilliers and Adams, 2016). This is necessary to ensure management interventions are relevant and focused and that a standard baseline of estuary quality can guide audits (DWAF, 2002). While the various policy documents are not analysed in great detail in the current study, it is evident that limited emphasis is placed on managing them as complex social-ecological systems (Lamberth and Turpie, 2003; Cilliers and Adams, 2016).

### **2.5.3. Estuaries as social-ecological systems**

Humans are integral parts of ecological systems (Anderson and Elmqvist, 2012; Adams, Whitfield and Van Niekerk, 2020). Estuaries, and urban estuaries in particular, are sites where there are daily interactions between people and nature. Barring private properties such as hotels, residences, businesses and sports-clubs that are situated there, the Diep River estuary is a public space that is accessible to all urban dwellers who wish to make use of it. This common area is an estuary with important natural processes and ecological well-being, as well as a space for communities to enjoy a range of nature-based benefits in an urban setting. As it is an area with access to facilities such as beaches, waterways, walkways, benches, open fields and historical features and information boards, the Diep River estuary can be described as a SES with common pool resources (Partelow, 2018). According to the SES frame, the resources that are available to members of the public, residences and other private entities fall into this common area that is influenced by policies (i.e., public infrastructure) and subject to the decisions of all those who are using it (See **Figure 1**).

Both in local and global contexts, several authors acknowledge that estuaries are highly valued by their surrounding communities, as well as by a broader range of beneficiaries for nature-based services such as storm protection and fisheries growth (Anthony *et al.*, 2009; Rothenberger, Armstrong and Spitz, 2018). It is widely recognised that the ecological state of estuarine systems is better defined than the social state (Anthony *et al.*, 2009; Elliott and Whitfield, 2011; Viskich *et al.*, 2016). When estuaries are viewed as complex SESs, management approaches can incorporate social as well as ecological benefits into plans for their restoration and conservation. Typically, estuarine systems are not viewed as complex SESs (Elliott and Whitfield, 2011), and user perceptions are considered to a limited extent (Lamberth and Turpie, 2003; Cilliers and Adams, 2016). When there is a decoupling of the social and ecological aspects within a system and conceptually, it becomes difficult to direct change that will result in continued societal benefits (Redman, Grove and Kuby, 2004). Therefore, it is important to describe the values that estuaries hold for people (Breen and Mackenzie, 2001). In order to view the Diep River estuary as a SES, this study contributes to understanding its social dimension over time.

### **2.6. Historical insights for current management**

Drivers of ecosystem modification and change emanate from historical human land-use patterns (Rautio *et al.*, 2016). A temporal scale perspective facilitates the measurement of long-term changes to the natural components in a SES. Ostrom (2009) and other authors (Berkes and Folke, 1998; Norberg and Cumming, 2008) acknowledge the importance of having a long-term view of SES elements. It is understood that human perceptions and values surrounding SESs and their governance can change and be changed alongside the dynamic nature of these complex systems (Williams, Ford and Rawluk, 2020). Therefore, understanding perceptions and uses of ecosystems as they shift over time can contribute to adaptive governance of SESs (Manfredo *et al.*, 2017). A grasp of changing human perceptions through

time can be central in understanding simultaneous temporal changing states of the ecosystem. Ecological states and human use and perceptions of ecosystems are interdependent. The various impacts on an ecosystem, which affect its health, determine how people are able to safely interact with and use that system at certain periods in history. Examining historical uses and events exposes the evolving relationship between ecosystem health and societal uses and benefits. Environmental history allows us to interpret a specific ecosystem in its past and present forms, and add context to the human dimension over a temporal scale (Bürgi and Gimmi, 2007).

Arguments offered by Szabó (2010) outline why understanding the historical context of an ecological system matters in its current and future management. Looking into historical patterns invites possible deductions to be made about current patterns and processes. This allows for better informed decisions relating to management and policy, while placing a particular ecological system in a wider context spanning multiple disciplines and scales (Szabó, 2010). By the late 1980s, literature increasingly acknowledged that humans were a key factor in the trajectory of ecosystems that could not be ignored (Bürgi and Gimmi, 2007). Acknowledging humans as being factors in the way that the history of an ecosystem unfolds allows us to frame ecosystems as complex SESs with natural processes that are impacted by humans. The way that the system is impacted (positively or negatively) causes the ecosystem to change, and subsequently, the way that humans interact with and benefit from that ecosystem changes too. This can be referred to as a feedback loop, a key concept in the SESF. It is not surprising that scholars use historical data as a tool for future restoration of ecosystems (Balée, 2006; Rautio *et al.*, 2016). Data used to assess how past land-uses have affected current ecosystems are related to population patterns, density, movements and concentration around the area in question (Rautio *et al.*, 2016). Across a temporal scale there can be measurable long-term changes to the natural components in a SES. It is understood that human perceptions and values surrounding SESs and their governance can change and be changed alongside the dynamic nature of these complex systems (Williams, Ford and Rawluk, 2020).

## **2.7. Perceptions as insights for management**

Burger (2003) notes the importance of understanding how people use and perceive natural areas as central to successful land management and conservation. Burger (2003) and other authors highlight the importance of ecosystem management as being a social process that should include public opinion and participation (Meffe and Viederman, 1995; Burger, 2003). Recreation, tourism and other ecosystem services that provide benefits to society could act as drivers for ecosystem sustainability. This echoes the ideas of Berkes and Folke (1998), that acknowledge user views as being integral for ecosystem sustainability. Human use of ecosystems is an indicator of ecosystem health, and expressing ecosystem health in terms of societal benefits (expressed through people's perceptions) could provide traction with decision-makers.

Individuals and societies develop attachments to natural environments, and they are especially valuable to people in urbanised areas, historically and in the present day (Reineman and Ardoin, 2018). These values formulate people's beliefs around ecosystems and their attitudes toward them. These personal and shared experiences of natural areas form a perception; the way in which something is understood. These values and perceptions are what drive individuals and societies to make certain decisions and behave in a particular way in the context of a natural resource. Studying people's perceptions of a natural system can provide deep insights into the social aspect of complex systems; a comparatively understudied dimension of SESs (Withanachchi *et al.*, 2018). The perceptions lens is used in this study to uncover elements of the social dimension of complex social-ecological systems. It should be acknowledged that the perceptions are at times viewed as different concepts to values or attitudes (Withanachchi *et al.*, 2018). In this paper, the perceptions concept is the primary focus. According to some authors, there is limited research that has managed to successfully articulate the insights provided by public perceptions relating to conservation and management of natural resources (Burger, 2003; Bennett, 2016). To address this, it is suggested that more emphasis be placed on perceptions and how to define them. The definition of perception from the SAGE Encyclopaedia of Qualitative Research Methods (2012) is used:

Perception ... is an individual's access to experience and interpretation in the world ... Perception is like a set of lenses through which [they] view reality. These lenses evolve from perspectives of ... subjectivity ... and the web of teachings imparted to the individual. Qualitative researchers are interested in individual perception to gain access to understanding the meaning of experience for an individual, a culture, and social groups. Individuals [voice] their perceptions through narratives, storytelling, behaviour, and reactions. (SAGE Encyclopedia, 2012).

An individual's perceptions may be influenced by a myriad of differing elements, including their history and background (Bennett, 2016), and are socially constructed. This reiterates that the perception of an individual becomes the truth for them, and with so many different people having varying interpretations of experiences, understanding perceptions is a complex element in environmental anthropology. People's demographic attributes, values, norms, preferences and knowledge also influence their perceptions (Moon and Blackman, 2014; Bennett, 2016). In the context of a South African city, where these kinds of factors differ vastly between individuals, it is likely that a wide-ranging difference in perceptions will be present, as has been the case in similar explorations of perceptions in a South African context (van Wilgen, 2012).

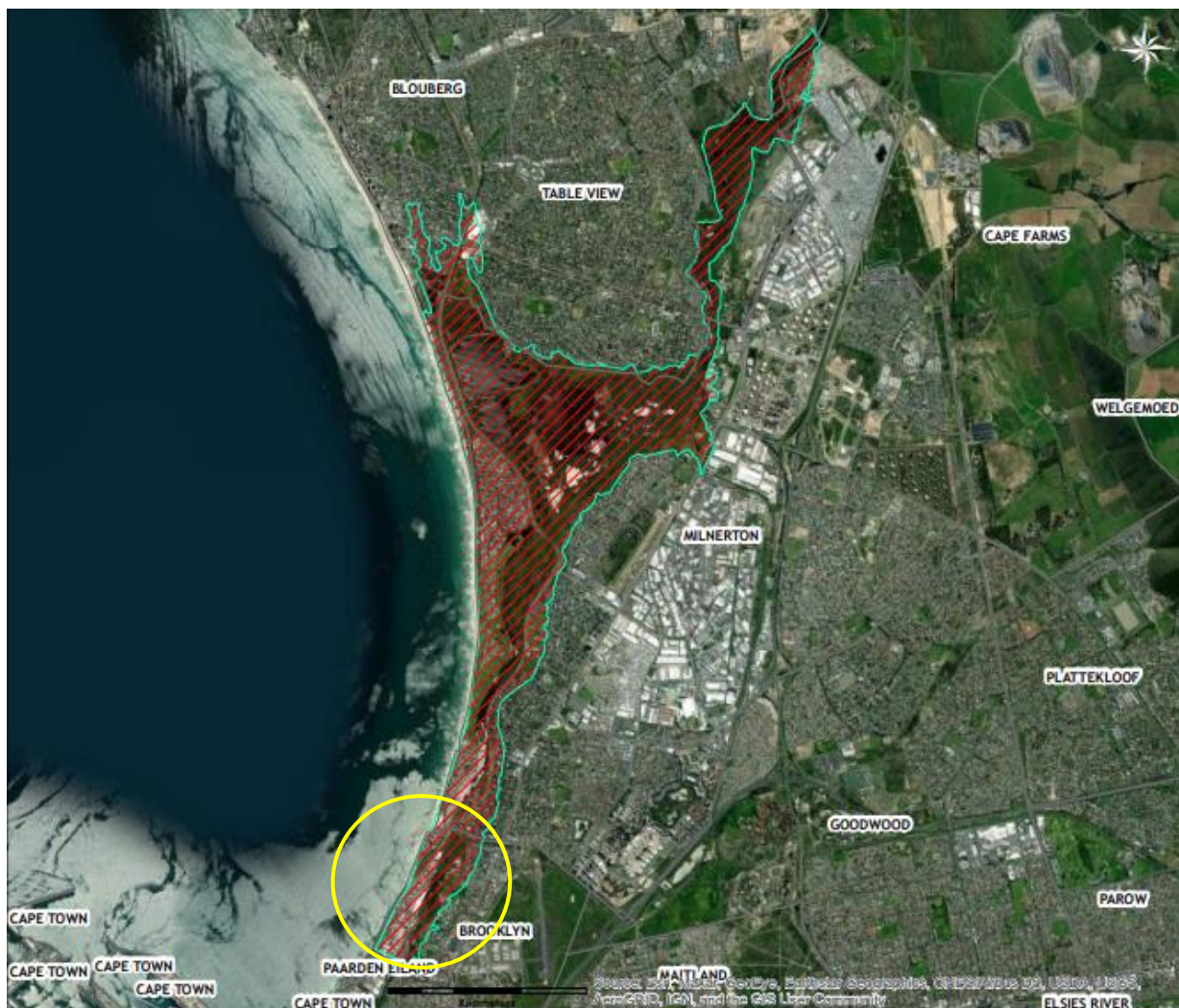
Perceptions data have been valued as being significant in natural resource management and in clarifying the social dimension of complex systems (Chanda, 1996). Chanda (1996) suggests that one of the reasons for accelerated environmental degradation and ineffective management is that there is too big of a discrepancy between the perceptions of scientists and managers, and local resource users. This

echoes the sentiments of Berkes and Folke (1998), who highlight the importance of viewing humans and nature as being linked, as opposed to separate entities. Some studies have shown the value of public perceptions as drivers for sustainable development (Nfotabong-Atheull *et al.*, 2011; Burger *et al.*, 2017). It is believed that public perceptions of resource users and recreationists have the power to sway environmental policy (Burger *et al.*, 2017). Studying perceptions, especially those relating to the use of natural environments, can provide clarity in the complexities of certain systems (Fernandes *et al.*, 2020). Including perceptions in research can assist researchers in understanding what drives certain behaviours and actions as they relate to natural spaces.

## Chapter Three: Methodology

### 3.1. Study area

Data collection was conducted at the Diep River estuary in Cape Town, South Africa [-33.888714, 18.485701] (both on-site and off-site). According to the Table Bay Nature Reserve (TBNR) management plan, the Diep River estuary is defined as comprising the Rietvlei wetland area and the Milnerton lagoon (hatched area in **Figure 3.1**). The lagoon section (i.e., the area between the river mouth and the bridge to Woodbridge Island, indicated by the yellow circle) was of interest in this study and is where open-access recreational visitors are most highly concentrated (Clark, 1998). The study site will be referred to as the “Diep River estuary” or “the estuary” going forward.



**Figure 3.1:** The Diep River estuary, comprising the Rietvlei wetlands area (the large wetland area between Table View and Milnerton) and the Milnerton lagoon (the narrow section where the river mouth enters Table Bay). The figure also shows where the estuary is situated within the Cape Town municipal area, with the river mouth about five kilometres north of Cape Town’s main harbour (map provided by the Environmental Management Department at the City of Cape Town, 2021).

The Diep River's origins lie north of Cape Town in the Riebeek Kasteel mountains, flowing through Malmesbury towards Cape Town for approximately 65 kilometres before entering the Atlantic Ocean at the suburb of Milnerton (Retief, 2016). The Diep River's tributaries include the Riebeek, Platklip, Swart and Sout Rivers, with the Mosselbank River being the major tributary (Grindley and Dudley, 1988). The total catchment area is estimated at 1 495 square kilometres (Grindley and Dudley, 1988; Retief, 2016), while the estuary section (i.e., including the Rietvlei wetlands and the Milnerton lagoon) is approximately nine square kilometres in size (DWAF, 2002).

A variety of land-uses, including agricultural and urban development, characterise the catchment and area around the estuary. This is due to its relatively flat topography, and ease of accessibility and proximity to Cape Town (Grindley and Dudley, 1988; Retief, 2016). While predominantly agricultural land-uses in the upper course of the Diep River have caused issues such as erosion and siltation, urban and industrial land-uses around the estuary have caused severe ecosystem degradation and pollution (Grindley and Dudley, 1988). The estuary's boundaries are constantly encroached upon by urban residential and industrial developments, and these include an oil refinery, a waste-water treatment works, multiple residential developments and various bridges built over the estuary (Viskich *et al.*, 2016). The Diep River estuary has been significantly altered and degraded compared to other estuaries around South Africa due to its location in a highly urbanised environment (Clark, 1998).

Upstream abstraction of water due to agricultural development has resulted in limited freshwater flow from the upper sections of the Diep River to the estuary and the mouth (Viskich *et al.*, 2016). For some years now, the main source of flow into the lower sections of the estuary is treated effluent from the Potsdam Water-water Treatment Works (PWTW), as well as stormwater drain output (Viskich *et al.*, 2016). This was not always the case as historical records show that the Diep River used to be deep enough for boats to navigate upstream as far as Vissershok, close to the hills of Durbanville (Jackson *et al.*, 2008). The Diep River estuary has been extensively modified over the last 100 years.

From an ecological perspective, the Diep River estuary has been recognised as an important and biodiverse point of attraction for waterbirds and other wildlife (Clark, 1998; Viskich *et al.*, 2016). In past reports and studies, a variety of vegetation species were identified that provide habitats for birds (Jackson *et al.*, 2008). Additionally, many aquatic invertebrates, fish and other freshwater species contributed to a once healthy ecosystem (Jackson *et al.*, 2008). Bottom-dwelling invertebrates such as sand-prawns used to be abundant and commonly collected and used as bait for fishing, and were reportedly harvested at a sustainable rate (Clark, 1998; Jackson *et al.*, 2008). Sand-prawn populations have declined significantly, and some studies report that none have been found since 2003 (Jackson *et al.*, 2008). However, Viskich *et al.* (2016) suggest that sand-prawns burrow deeper when water quality is compromised. Nonetheless, sand-prawns are a keystone species in the Diep River estuary, and their presence (or lack thereof) determines the catching abilities of fish and wading birds who feed off them.

The estuary's biodiversity is directly impacted by the state of the ecosystem, which is affected by human interventions and modifications made to the estuary over time (Jackson *et al.*, 2008). The changes in biodiversity have been significant and the human impacts have "taken their toll" on the estuary (Clark, 1998).

The Diep River estuary boasts a significant body of knowledge relating to historical human impacts and altered geo-hydrology (Viskich *et al.*, 2016). Decades of meticulous zoological research has tracked the system's decline in water quality, as well as the steady loss of native estuarine species (Clark, 1998). Despite this well-documented history of events and records of declining biodiversity that have led to an overall decline in the state of the system, the Diep River estuary remains highly polluted, and is currently a health hazard for those who use this resource (City of Cape Town, 2020).

### **3.1.1. Focus on an open-access social-ecological system**

The current study focused on the lower reaches of the estuary as it is the portion with open (unregulated) public access. The Rietvlei wetland section of the estuary is not open access, and in this study, there was particular interest in the part of the estuary that is accessible to the general public. Since the Rietvlei wetland section has regulated access, user groups and activities are well studied and understood (Retief, 2016). From an ecological perspective, the estuary is of high biological interest and has received disproportional biological research interest. However, the particular area of interest in the current study has not been studied from an in-depth social perspective, a key intention of this study.

## **3.2. Methodological approach**

In line with the social-ecological systems philosophy and practice, SES research draws on a number of disciplines, theories, frameworks and research tools and methodologies (de Vos *et al.*, 2022). Similarly, in this study, while there are elements of quantitative research in the methods for purposes relating to historical and demographic analysis, the study is predominantly qualitative in nature, and follows an interpretive research paradigm (Hudson and Ozanne, 1988). This study is more suitably aligned with an interpretive as opposed to a positivist approach, as it assumes that there are multiple versions and interpretations of a particular reality or context, due to differing perceptions, perspectives and diverse values and meanings held by a variety of groups and individuals (Hudson and Ozanne, 1988). In contrast, the positivist approach generally views human behaviour as being determined and predictable. The interpretive approach acknowledges that behaviour is unpredictable, and research is aimed towards understanding and elucidating instead of predicting it (Hudson and Ozanne, 1988).

Within qualitative research, a number of qualitative designs may be used (Creswell *et al.*, 2007). An overarching method relevant to this study, outlined by Creswell *et al.* (2007), is the case study approach. The case study approach is useful when the intention is to present a detailed understanding of the case

or context in the study. Yin (2013) suggests that the case study approach is suitable when conducting research into a complex case-specific phenomenon. A case-study approach was appropriate for this study as it explores the uses and perceptions relating to the Diep River estuary over a long period, with specific emphasis on the value of this urban natural resource, and how the state of the system has changed in response to ongoing human intervention. The case study approach provides an in-depth understanding of the people and the place through descriptive questions (Yin, 2013).

In this study, a narrative research method was used within the case study approach. Narrative research, a qualitative mode of inquiry, describes the process of gathering data and identifying emerging themes and discourses with particular focus on people's stories (Polkinghorne, 1995; Creswell *et al.*, 2007). Narrative research, which has its origins in anthropology and sociology, is now a well-recognised tool used in multiple fields of study (Chase, 2005). A narrative approach was selected for this study to invoke stories as expressed by interviewees, collected through interview techniques that contributed to a deeper understanding of human interactions with the Diep River estuary across a temporal scale. The narrative approach was chosen also to interpret historical material, as it facilitates the process of assembling narratives and stories together to form a chronological understanding of events. Elements of the narrative research method were combined with the Critical Discourse Analysis (CDA) approach, which was adopted to examine the narratives that are manifested in historical text and photographs (Catalano and Waugh, 2020).

### **3.3. Data collection methods**

#### **3.3.1. Historical material collection**

A useful tool for understanding the social dimension of the Diep River estuary is the analysis of historical material relating to the area. Consulting historical data associated with the site is insightful because it reveals changes in the uses and benefits of the estuary across a temporal scale (historical and contemporary). Conclusions can be made about the state of the estuary during a particular time period based on the uses during that time. Collection and analysis of the following types of historical data were included to provide a historical frame for the estuary relating to social uses at a temporal scale:

1. A range of historical texts were obtained and examined in the reading room at the Western Cape Archives in Cape Town, on four separate occasions between February and May 2021. Two online databases were used to search for documents: "Cape Town Archives Repository" and "Cape Town Records Centre". Once the database was accessed, keywords and terms included in the search were: "Diep River", "Diep River estuary", "Milnerton", and "Milnerton lagoon". The combination or omission of some of these words produced titles of documents, of which some were chosen to explore further. Extensive notes were made based on this material, which was later organised thematically.

2. Historical photographs were gathered with the help of members of the Milnerton Historical Society (MHS) Facebook Group. A post was published to the Facebook page, describing the objectives of the study, asking if any members would like to share their annotated photographs for the study, and if so, to email them to the researcher. Four people responded, sending a total of 15 photographs together with a date and short description and narrative related to the photograph.

Analysing the historical documentation and photographic material included making extensive notes while reading through historical letters and reports. Photographs were organised thematically and linked to relevant text and interpretation in the analysis.

### 3.3.2. Surveys

Surveys were conducted to get a sense of the present-day users and uses of the Diep River estuary. Between January and March 2020, questionnaire surveys were completed on-site by a total of 45 individuals at the Diep River estuary. Respondents were approached in the area between the bridge crossing to Woodbridge Island and where the Diep River mouth meets the sea (**Figure 3.2**).



**Figure 3.2:** The area in which survey respondents were approached fell between the red markers on the map. Map provided by the Table Bay Nature Reserve (map provided by the Environmental Management Department at the City of Cape Town, 2021).

With the help of a research assistant on some occasions, surveys were administered on both weekdays and weekends between 09:00 and 16:00. Survey respondents were randomly approached. The survey included questions of both a qualitative and quantitative nature (see Appendix A). The quantitative questions were designed to support a socio-demographic analysis of estuary users, as this is relevant in the context of the South African city. Qualitative questions in the survey related to the uses and perceptions of nature in cities, with particular reference to the Diep River estuary. The quantitative questions were closed-ended while the qualitative questions were open-ended and encouraged longer and more content-rich answers if the respondents wished to provide them. Most respondents completed their own surveys in their own time. After surveys were completed, some respondents engaged in conversation about the nature of the study, where more narratives were gathered with their permission.

All survey information was captured in Microsoft Excel, where data were organised and managed. Quantitative information relating to demographics was organised using graphs, while narrative information was organised by capturing respondents' answers in MS Word, and extracting key words and phrases from responses. Key themes were identified and incorporated into the interpretive section of the results. Apart from key themes, categories of ecosystem services (MA, 2005) were used to interpret results expressed as estuary benefits to people.

**Table 3.3:** Ecosystem services categories. Adapted from Millennium Ecosystem Assessment (2003).

<b>Provisioning services</b>	<b>Regulating services</b>	<b>Cultural services</b>	<b>Supporting services</b>
Food	Climate regulation	Spiritual and religious	Soil formation
Fresh water	Disease regulation	Recreation	Nutrient cycling
Fuelwood	Water regulation	Ecotourism	Primary production
Biochemicals	Water purification	Aesthetic	
	Pollination	Educational	
		Sense of place	
		Cultural heritage	

Responses were organised based on the types of ecosystem services offered by the estuary. Ecosystem services can be categorised and assessed based on their benefits to society and the environment (Turnpenny and Russel, 2017). Provisioning services are mostly tangible goods and services from ecosystems, regulating services relate to the ways in which ecosystems regulate processes, cultural services are the non-material benefits derived from ecosystems, and supporting services indirectly support and contribute to the production of provisioning, regulating, and cultural ecosystem services (MA, 2005).

### **3.3.3. Key informant interviews**

Key informant interviews commenced in January 2020 and were completed in March 2020 (see Appendix B). A total of seven key-informant interviews were conducted with four local residents, one

business owner, one manager, and one user of the recreational facilities in the area. Interviewees were chosen based on their long-term, close connection with the estuary. All interviews were conducted face-to-face and at various locations, mostly at the interviewees' homes. Interviews lasted approximately one hour, and were audio-recorded with permission from the interviewee. During these interviews, a few questions were asked about the general background of interviewees to get them settled into the pace and atmosphere of the interview. After they became more comfortable, the conversations were more free-flowing, while covering key aspects relating to their changing uses and perceptions of the Diep River estuary over time. Interviews were later listened to and transcribed. Common themes and the key quotes that encapsulated these themes were identified, and this was visualised through using mind-maps. The themes were later collated to support the narrative findings of the study. Mind-mapping techniques were used to visualise data from all data-collection methods.

The key informant approach was chosen to produce extensive narratives to reflect deep insights into the perceptions, values and uses of the estuary, specifically by long-term users. This is linked to the narrative qualitative design of Creswell *et al.* (2007), where research is focused particularly on people's stories. This approach and method elicited stories embedded in context which could then be interpreted in the social-ecological systems frame. Key informant interviews provided the opportunity to understand people's long-term and changing perceptions of the estuary over time, whereas the surveys provided a present day "snap-shot" of estuary users and benefits. Key interviews were semi-structured and questions open-ended. Since most of the interviewees wanted to continue living and working near, and using the Diep River estuary, they provided their views on what they thought a sustainable future would look like at the estuary. Furthermore, key-informant long-term experience at the estuary meant that interviewees were able to articulate how their perceptions had changed over time, and they were able to provide an in-depth interpretation of the use of the estuary.

While not applied in a systematic manner, field observations are noted in a few instances where they support findings established through the other more systematic data collection methods.

### **3.4. Ethical considerations**

As this research entailed soliciting people's views and perceptions, ethical clearance was sought from the University of Cape Town. The Faculty of Science Research Ethics Committee approved the application for research ethics clearance with the approval code **FSREC 119 - 2019**. Before each survey and interview started, participants were informed on the purpose of the study, provided with a form of consent, and invited to participate in the research with the option to skip questions or withdraw at any stage of the process. Anonymity was assured and permission was requested to record answers electronically or manually. Further ethical clearance for the study was sought from the Biodiversity Management Branch of the City of Cape Town in order to conduct research on in of the City's nature

reserves. Permission to conduct questionnaire surveys at the Table Bay Nature Reserve, specifically in the lagoon section of the Diep River estuary was approved for the period of February to July of 2020.

### **3.5. Limitations**

The key limitation in this study was that the data collection was cut short due to Covid19-related lockdowns which limited interactions. While key-informant interviews were done remotely, site surveys could not continue. The limited timeframe meant that seasonal and holiday-specific days where the site might be used more or in different ways could not be captured.

## Chapter Four: Findings

### 4.1. Historical material collection

The gathered materials aimed to describe the relationship between people and nature in the context of the Diep River estuary. While the surveys and interviews are able to articulate present-day relationships, historical material was used to imagine and understand how these relationships have changed over time. Historical material relating to the interdependence between people and nature can assist in understanding particular social-ecological systems (SESs) with an added temporal dimension, an important consideration when thinking about ecosystem change over time. Developing a historical picture allows us to historically frame and contextualise the Diep River estuary before exploring its present-day context and place in society.

#### 4.1.1. Ecosystem health and livelihood

Some historical pieces made reference to livelihoods that were supported at the Diep River estuary. A letter titled *Fishing in the Diep River* (dated June 1907), which was addressed to the governor of Cape Town regarding the outcome of a fisheries survey, contained comments on long-term and consistent fishing at the Diep River mouth. The evident success of fishing at the mouth highlights the abundance of fish that was in the estuary in the early 1900s, enough to have secured the livelihoods of some.

In a different letter addressed to the governor, a member of the Secretary in the Agriculture Department asked to have fishing in the “Milnerton river” regulated. In this letter, titled *Fishing in River at Milnerton* (dated April 1909), the author believes that the river is perennial in its flow, and for that reason should be regarded as a public river. The author argued that with greater use, regulation is necessary. The letter implies that historically, people were making use of the estuary for recreational fishing and other kinds of recreation. Furthermore, the call for river regulation suggests that there was cause for concern around the volume of use and its impact on the state of the estuary. The emphasis on fishing indicates that not only did the estuary possibly contribute to people’s livelihoods, but was also recreational in nature. These cultural, supporting and provisioning ecosystem services are subsequently no longer present in the system for the most part. The decline of aquatic fauna (from various causes) has resulted in the loss of recreational fishing, which is a cultural ecosystem service.

#### 4.1.2. Environmental concern and protection

In the early 1900s cultural ecosystem services such as the aesthetic value and the enjoyment of wildlife at the Diep River estuary were prominent and valued by society. There is also evidence that people showed concern for the ecological systems that underpin these services. Today, there continues to be a strong sense of ownership and concern for biodiversity around the estuary. The desire for protection of cultural and aesthetic benefits is highlighted in a number of historical letters and proposed development

plans around the Diep River estuary, both close to the mouth and further upstream. An example of this is illustrated in a series of letters (dated July 1907) regarding a boat-shed and a floating landing stage that had been granted building permissions. One of the parties show discontent with the decision, stating that the proposed development will cause restricted water flow into the sea, and “a large bank of sand forming due to river mouth closure”. The writer also states that the quality and the freshness of the water will decrease dramatically “if this state of affairs continues”. After some letters in between and a non-compromising conversation, the discontented writer advises that developers allow for “the high spring tides to have access to the river by means of an artificial channel, sufficiently deep, cut through the bar from time to time whenever necessary”. Not only does this letter display concern for the estuary’s natural biological processes, but it also illustrates long histories of interference and management concerns around altered ecology due to development. Presently, similar efforts are being made to artificially open the estuary mouth in the hopes of flushing out polluted water.

In September 1908, just over a year after the aforementioned letter, another letter titled *Waste-lands at Diep River Mouth* was addressed to a governor reporting the progress (or lack thereof) of a dredging scheme at the river mouth. The letter implied that financial resources were being used in other places, such as building a new race-course and a “capacious” grand stand for horse racing events on the Milnerton estate. This shows what is valued by certain people at various points in history, and at this particular juncture the health of the estuary was largely being ignored. The title of the letter is descriptive of the state of the estuary at that time.

Concern for the protection of ecosystem services was observed in later examples. A large report dated 1965 is a proposed development report and is organised in the form of an environmental impact assessment. The report proposes that a small harbour is built higher along the estuary, along with a power station that will be developed shortly thereafter. The area was pinpointed for development because of access to coal via railway lines and the vicinity to water for cooling the power station. Included in the report are responses to the proposed development, and an outline of potential problems that may arise. One of the major problems outlined was that the lower reaches of the Diep River would no longer be a “sanctuary or a biologically important” area. This reflects the estuary’s role as a ‘nursery’, and a safe place for juvenile fish and bird species to grow and thrive. It indicates that the ecological dimension of the estuary was taken into account in this instance.

Cultural ecosystem services are further defended as reference is made to this development, causing a “serious objection from an aesthetic point of view”. Other issues associated with building a harbour include silt deposition at the mouth, potential flooding, canalization of the remainder of the Diep River to the mouth, and extensive wildlife loss. The historical material indicates a long history of care and involvement for the Diep River estuary.

### 4.1.3. Events as drivers of ecosystem state

Another historical document contains meeting minutes that were taken during a community meeting (dated 1966) regarding the management of the estuary. A Mister Lilley, titled in the minutes as ‘Milnerton’s Consulting Engineer’, verbalises concern about the effects of development close to the estuary mouth. He also makes reference to a new sewage scheme that discharges treated effluent into the Diep River. He mentions a dire need for a new scheme due to the fact that the effluent has a high nitrate content. The concern over the effluent discharge into the Diep River aligns with when the Potsdam Wastewater Treatment Works (PWTW) was built in 1960 (Viskich *et al.*, 2016). Viskich *et al.* (2016) provide a timeline of events that occurred in and around the estuary between 1899 and 2004 (See **Table 4.1**). It illustrates the interference with estuary ecology over time and how this may have affected the way it was used.

**Table 4.1:** Adapted outline of events that occurred at the Diep River estuary (Viskich *et al.*, 2016).

Date	Event
1899	Start of construction of Wooden bridge across Milnerton Lagoon
1905	Sections of Milnerton Lagoon dredged
1929	First house built on Woodbridge Island (Zonnekus)
1960	PWTW built (Treated and raw effluent discharged into Diep River)
1961	Otto du Plessis Drive bridge built across Diep River, separating Rietvlei and Milnerton Lagoon
1973	Rietvlei dredged (9-meter depth) to provide fill for construction in Cape Town Harbour
1974	Lagoon again dredged for the Woodbridge Island development
1985	New concrete bridge built across Milnerton lagoon, replacing the old wooden bridge
1985	Area below wooden bridge dredged to provide fill for Woodbridge Island housing development
1991	Treated effluent discharged from PWTW channelled along the eastern boundary of Rietvlei
2004	Upgrade and expansion of PWTW

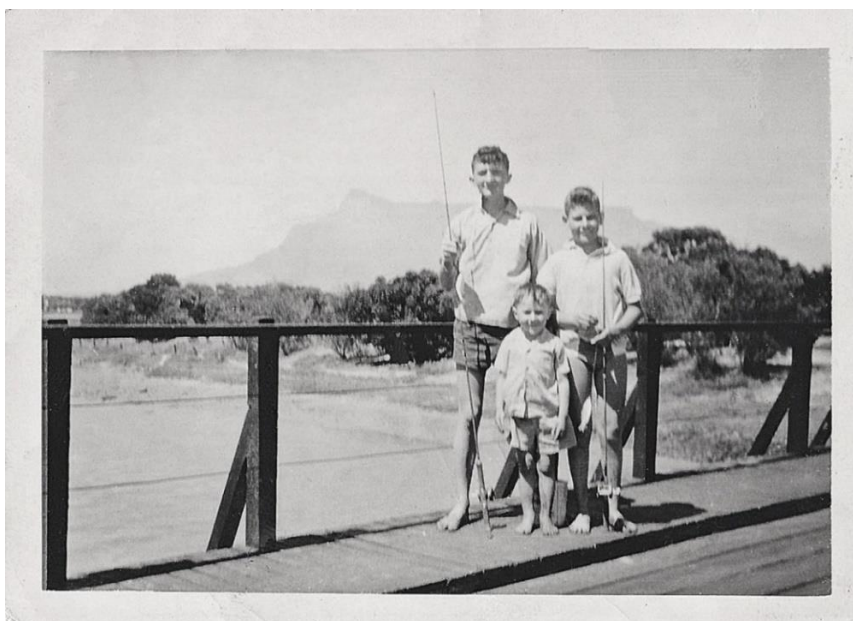
### 4.1.4. The estuary’s value to society

The photographic material that was sourced mostly demonstrated society’s use and value of the estuary, and it complemented other historical material found in the Cape Archives. Some parallels can be drawn between the photographs and the major events that occurred in the area over the last 100 years. An undated photograph (**Figure 4.2**) taken by photographer Arthur Elliott shows cows grazing on the banks of the estuary with Table Mountain in the distant background. The photograph displays the area on the ocean side of the estuary, presumably where the Milnerton Golf Course is currently situated. This photograph displays that there is little to no urban development on this side of the estuary, allowing the assumption that it was taken prior to 1929, when the first house on Woodbridge Island (named Zonnekus, which still stands) was built.



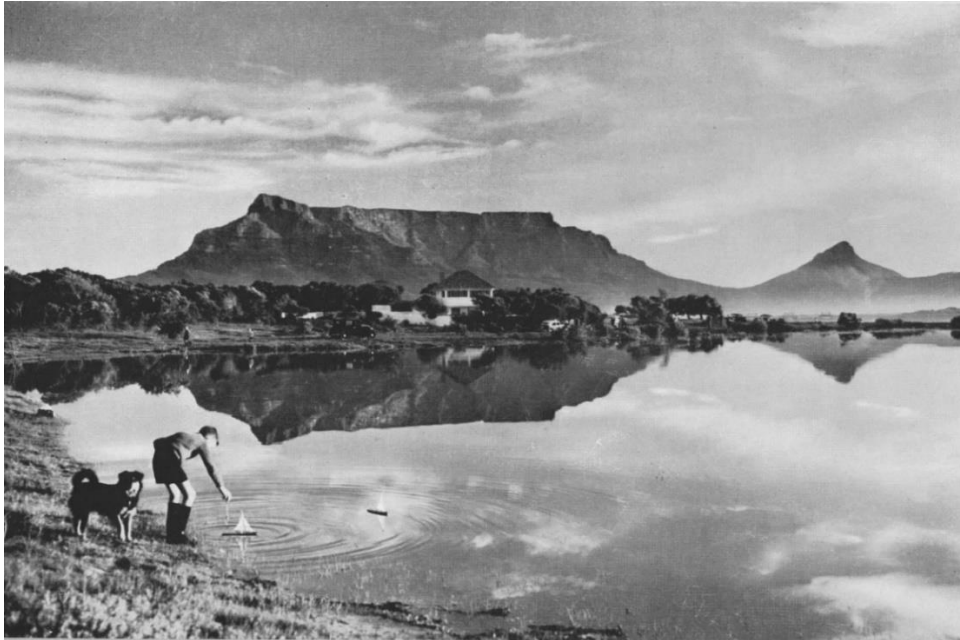
**Figure 4.2:** Cows grazing on the banks of the Diep River estuary. Undated. (Photographer: Arthur Elliot. Supplied by Simon Winter, MHS).

After the wooden bridge was built (1899), the estuary became more accessible to the public for recreational purposes, notably recreational and livelihood fishing. **Figure 4.3** displays three brothers about to fish in the estuary from the wooden bridge. A member of the MHS Facebook group reported that in the past, the Harder fish (*Liza richardsonii*) were extremely plentiful. This member, a canoeist who frequently used the Diep River estuary for recreation, reported one of these fish jumping into his canoe, demonstrating the once sheer abundance of fish in the estuary.



**Figure 4.3:** Michael Mangiagalli and his older brothers about to fish in the lower part of the estuary from the wooden bridge in 1957. (Supplied by Simon Winter, MHS).

In addition to fishing, the estuary was a place for other forms of recreation such as canoeing, boating, paddling activities, as well as small-yacht sailing. **Figure 4.4** displays a boy with his toy yacht on a pristine looking estuary in 1942. This image portrays a state of health of the estuary that could support its recreational value.



**Figure 4.4:** A boy sailing his yacht on Milnerton lagoon, dated 1942. (Supplied by Simon Winter, MHS).

**Figure 4.5** contains two images that also display yacht sailing activities. The beaches in the background are on the ocean side of the estuary and have motor vehicles on them. This was a popular activity that drew people from other parts of the city.



**Figure 4.5:** Small yacht sailing in the Diep River estuary in 1971. (Supplied by Pete Lilley).

Those who provided the photographs remember the estuary as being a place they visited regularly as children. In the summer, families would splash around without risk of deep water and be protected from the strong currents of the open ocean (**Figure 4.6**). Many fond memories are attached to the Diep River estuary, including memories of clean and clear water. As **Table 4.1** suggests, much of the construction and urban development-related interferences with the estuary increased after 1970.



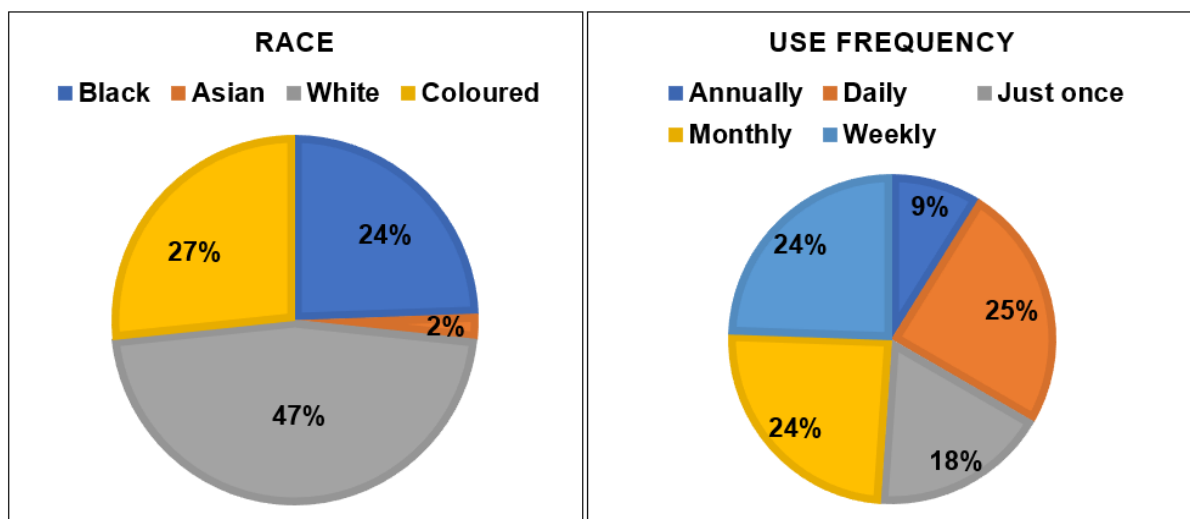
**Figure 4.6:** Children playing in a safe and clean lagoon in 1966 and 1970. The left image is taken on the ocean side of the estuary, illustrating the safety of the shallow waters for crossing (Supplied by Pete Lilley).

The historical data collected for this study focused on society's use of the Diep River estuary through time. There are parallels between society's use and ecological well-being of the estuary. The overarching link that can be drawn between use and ecological health over a temporal scale is that prior to developments related to urban growth, the Diep River estuary was a healthy and widely used ecosystem with few health risks to users.

## 4.2. Surveys

### 4.2.1. Who uses the estuary? A socio-demographic analysis

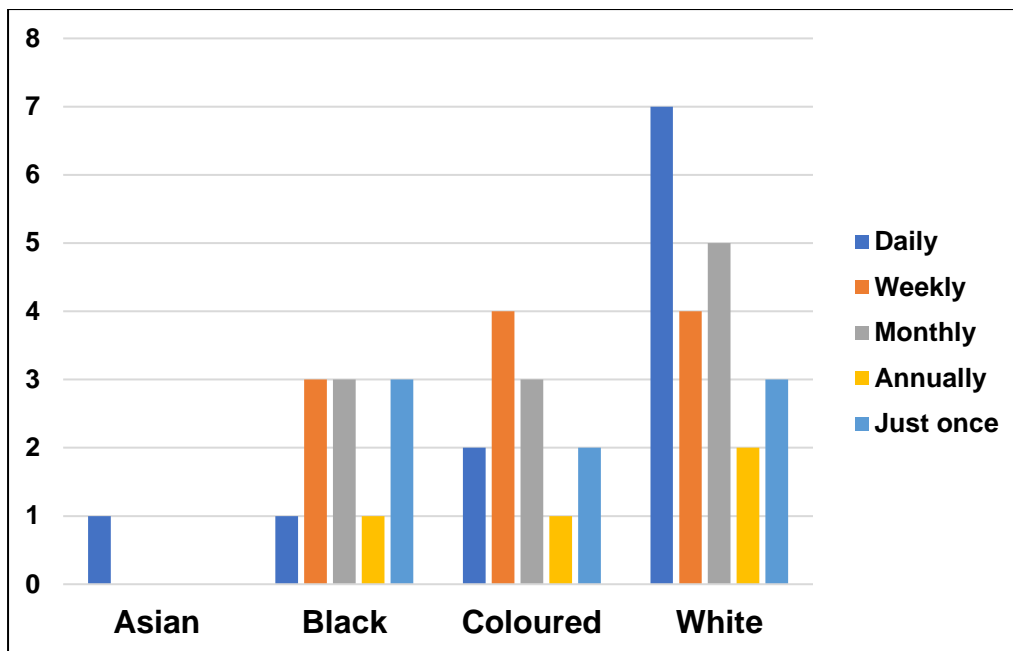
Of the survey respondents 53% were female and 47% were male. The ages of respondents were mixed, ranging between 13 and 84 years old. Just less than one third of respondents (27%) fell into the age category of 25 to 34; the largest age category of respondents. Almost 50% of the respondents identified as White<sup>1</sup> approximately 25% identified as Coloured, just under 25% identified as Black, while only 2% of respondents identified as Asian (**Figure 4.7**). Twenty-five percent of the respondents use the estuary every day, and just less than 25% of the respondents use the estuary weekly or monthly. This indicates that the majority of users are repeat visitors in any given year. A relatively smaller portion of respondents use the lagoon annually, just once or “for the first time” (**Figure 4.7**).



**Figure 4.7:** Racial composition and use frequency of respondents at the Diep River estuary.

Overlaying the information from **Figure 4.7** reveals that the majority of daily users are White (**Figure 4.8**). This highlights that those who have daily access to the estuary are likely living within walking distance of it. This is also reflective of the general racial composition in Milnerton, a suburb with a White population making up approximately 50% of the total population (Frith, 2011).

<sup>1</sup> While acknowledging the constructed and contested nature of racial classification, for the purposes of this study, the South African racial classifications of White, Coloured, Black and Asian are utilised.



**Figure 4.8:** Race and use regularity of survey respondents at the Diep River estuary.

The estuary is visited by people from many parts of Cape Town, as well as tourists who visit from outside of the city. Most of the respondents (60%) were from immediate neighbouring suburbs within a ten-kilometre radius of the estuary, indicating the importance of the estuary to the neighbouring population. Repeat visits by locals indicate place attachment by the resident population of Milnerton and surrounds. Approximately 24% of the survey respondents visited the estuary from suburbs that were between ten and 29 kilometres away. Thirteen percent of respondents were not from Cape Town, and were either visiting from elsewhere in the Western Cape, elsewhere in South Africa, or from abroad. Two of the 45 respondents were homeless, living in temporary shelters within a few minutes walking distance of the estuary.

#### 4.2.2. Primary uses of the Diep River estuary

**Table 4.9** outlines the main uses of the Diep River estuary, as communicated by respondents. Uses were of interest in this study because the characteristics of an estuary provide a particular set of opportunities for use, which in turn shapes the kinds of experiences and benefits associated with the estuary. The use count describes the main reasons people seek out and enjoy nature-based experiences in this section of the estuary.

**Table 4.9:** The primary uses of the Diep River estuary according to survey respondents.

Uses of the Diep River estuary	Count
Walking along the estuary's walkways	31
Walking to the beach	16
Local resident enjoying the area (walking distance from home)	13
Walking the dogs	5
Bird-watching	5
Using the nearby restaurants	4
Tourism and sight-seeing	4
Collecting fossilised shark teeth	2
Exercising	2
Prawn pumping	1
Looking for a potential wedding venue	1
Checking on the state of the estuary	1
Using the canoe club	1
Spiritual and religious reasons	1

Respondents were asked to elaborate on their use of the estuary and why they found it particularly important to them. There were common themes among answers, which include the society-place relationship, concern for the environment, and livelihood.

### ***Society-place relationship***

A significant number of respondents (69%) indicated that they use the estuary simply to be present there, in a pleasant space that is available to them. Of the estuary-users, 29% are Milnerton residents who walk along the estuary walkways daily or multiple times per week. Given the close proximity of the estuary to local residents enjoying the area, many of them were walking their dogs (See **Figure 4.10**). One of the respondents said that they were visiting the estuary in search of a potential wedding venue, which suggests public view of the area's aesthetic value. A small number of respondents (9%) were tourists who were visiting the area and staying in nearby accommodation, including the Lagoon Beach Hotel. A respondent visiting Cape Town states that, "*usually people stay in the centre of town, but this area is central to us. We spend most of our time between Milnerton and Blouberg. You can literally walk from here to there, and further, on the beach*".



**Figure 4.10:** A Rugby resident completing a survey under the watchful eye of their dog. Notice the estuary entering the Atlantic in the background. (Photo credit: Carly Wise, 2020).

While only two participants stated that they were exercising along the walkways of the estuary, there were a number of people evidently using the area for exercise. Jogging and personal training were observed, but not interrupted for survey purposes. While only one respondent stated that they were visiting the estuary for religious reasons, religious ceremonies (e.g., baptisms) were observed taking place close to the mouth of the estuary. Thus, there is a wide variety of meanings that respondents attach to this natural space.

#### ***Interest in and concern for biodiversity and the environment***

Often, the uses of the estuary were motivated by the biodiversity that it offered to nature enthusiasts. Of the respondents, 11% were avid bird-watchers and had a specific interest in the nature that characterised the area. One respondent with binoculars said that, *“the bird-life doesn't seem to be affected by the pollution. It's more eventful than ever. I know that the greater flamingos enjoy feeding in flocks in the shallow water, so I come and observe their behaviour when I can.”*

One respondent expressed that their sole purpose for visiting the estuary was driven by their concern for the water quality and state of the ecosystem. As part of their daily commute, they would stop at the estuary to see if the water looked any cleaner, or if the reported foul smells had subsided. People were observed picking up litter that they saw scattered on the walkway, which was a clear indication of their concern for the environment and engagement with its protection. Among the respondents there was a ubiquitous concern for the environment. Almost all survey respondents were aware of the severely

polluted water in the lower reaches of the Diep River estuary. One survey respondent said, *“I think the City really needs to address the quality of the water, or probably do infrastructure maintenance first, and then the improved quality might follow. I’m not sure how it works but if there is an overflow or sewage issue there should be a prompt response. Does disaster management get involved? I hope that the City finds a solution quickly.”* Additional evidence of the pollution issues can be seen on information boards close to the mouth of the estuary (**Figures 4.11** and **4.12**).



**Figure 4.11:** A sign erected by the City of Cape Town close to the estuary mouth warns against use of the water. The sign in English reads, “WARNING - Polluted water: unfit for swimming, playing or drinking.” (Photo credit: Carly Wise)



**Figure 4.12:** Another sign warning of the risks in using the estuary. The sign in English reads: “WARNING - Polluted water: For health reasons swimming and recreational activities in these waters are at your own risk.” (Photo credit: Carly Wise)

From the surveys and in general conversation with respondents, there was a sense of disappointment and hopelessness around this topic. This indicated a strong sense of motivation for ecosystem stewardship and need for protection associated with the Diep River estuary.

### ***Livelihood***

Fishing and prawn pumping was once a daily occurrence at the estuary, made evident through respondent stories and official reports. It is evident that the estuary has played a role in contributing to the livelihoods of users in the past (Clark, 1998). During the survey period, only one respondent stated that they were there to pump for prawns, which highlights that while the estuary was once a place that supported livelihoods through prawn pumping and fishing, it is presently not used in that way to the same extent. When asked why they thought there were so few people pumping prawns presently the respondent answered, *“I don’t think people trust what comes out of this water”*.

Further to the livelihood point, two of the survey respondents, who were homeless and living near the estuary, were using the space to search for fossilised shark teeth. At the low-tide on the north and south sides of the mouth, it is common to find fossilised shark’s teeth (de Greef, 2015). Some lucky beach-goers are able to find them (see **Figure 4.13**). However, others such as two of the respondents, search for shark’s teeth in order to sell them as souvenirs to tourists and other visitors to the area as a form of income. Shark tooth sellers can fetch anything between R50 and R200 per tooth, depending on its size and condition.



**Figure 4.13:** A fossilised shark tooth in good condition found on the north side of the lagoon mouth. (Photo credit: Carly Wise, 2018)

### 4.2.3. The perception of nature in cities

The previous section on the uses of the estuary reflects the activities and experiences that people seek out in this natural urban space, and why they use it. The current section deals with how users interpret and perceive their experiences in this space.

#### *Positive aspects of the Diep River estuary*

*What are the most favourable aspects of the Diep River estuary?* This question was included to understand what society likes about estuaries in an urban context. The most dominant theme to emerge from responses to this question was the desirability of accessible and free, open space. This was acknowledged by many respondents when given the opportunity. One respondent said, *“I guess I didn’t think about it before, but considering that this lovely area is free and open to all at any time makes me really grateful. I know that beaches and parks are free but now that I think about it, I appreciate it a lot more.”*

Other aspects that were favourable among respondents were generally aligned with their reason for being there, causing a theme overlap in the findings. For example, those who said that they were using the space to walk along the estuary and head towards the beach, found the ocean and the water to be the most positive aspects. Those who were using the space for exercise and walking stated that the walkways, the wide-open spaces, and the presence of other people (highlighting the importance of safety) made it a favourable place to engage in exercise. Many respondents acknowledged the dynamic nature of the space. One respondent in particular stated that the best thing about the space that it is *“dynamic and moving with different things happening constantly. Birds, fish, waves, canoeists, walkers; it is full of life, variety and diversity”*. This view is supported by the dynamic and diverse nature of estuaries. See the greater flamingos in **Figure 4.14**, a common bird sighting in the Diep River estuary, often in more impressive numbers.



**Figure 4.14:** Pairs of Greater flamingos and Hartlaub's gulls feeding in the estuary. The bank in the background (the south side of Woodbridge Island) protects the estuary from the open ocean. The figure depicts nature in the heart of the city. (Photo credit: Carly Wise, 2020)

### ***Facilities provision at the Diep River estuary***

Respondents were asked to share their thoughts on the facilities at the estuary. Constructed facilities are created to encourage use and enjoyment of green urban spaces. The presence of facilities is likely to affect how users perceive the quality of their experience. The area around the Diep River estuary has been curated and adapted to encourage use. Through this question, the study articulates how members of the public perceive facilities provision and management around the estuary. Respondents were asked what facilities they enjoyed the most and thought were important, and what facilities they thought were lacking, but necessary. Furthermore, respondents were given the opportunity to share their perceptions on how the space can be improved.

The three facilities frequently mentioned as most favourable were the public beach access, the proximity of restaurants to the beach, and the walkway infrastructure around the estuary. One respondent was aware of limits to access at other parts of the beach, by saying, “*around the corner almost in front of Spinnakers there are fences erected on the beach. They are quite close to the actual property, but still on the beach. I’m glad for the access to the beach at other points*”. Other respondents who had been using the area for over 20 years reflected on a time when the walkway had not yet been built, “*the walkway is the most inviting aspect of this place*”.

Another facility enjoyed by a number of users are the information boards, of which many respondents mentioned that they would like to see more of. There are two information boards at present, one close to the estuary mouth, where a part of a shipwreck has been preserved and displayed (see **Figure 4.15**), and another at the historical wooden bridge that was the original crossing to the present-day Woodbridge Island. People were drawn to these information boards and showed a clear interest in this facility.



**Figure 4.15:** An information board on the ship: Commodore II. (Photo credit: Carly Wise, 2020)

Respondents were also asked to point out what facilities they thought should be in the space, but were not presently there. As stated earlier, facilities are created to encourage use and enjoyment of space. It is useful to understand what people enjoy and would like to see more of. This is insightful for future decision-making relating to facilities management at this estuary and at other natural spaces for public use. Facilities that people wanted to see more of at the estuary include the provision of ablution facilities, shaded areas with grass and trees, affordable kiosks, better security in the area, and more information boards about biodiversity, ecosystems and tides.

### ***The role of urban nature***

*What role does urban nature play in the life of an urban citizen?* Among the answers there were a variety of perceptions on the role of urban nature and dominant themes emerged. The phrases that appeared most frequently included “*places to destress*”, “*places to relax*”, “*places for recreation*” and “*places to take a break from the city*”. These are all indicative that for some, the high pressures of an urban lifestyle are eased by connecting with nature. For a few respondents, the role of nature in cities is “*a place to escape*” as they did not have access to similar facilities at or near their home. One respondent stated that they had neither a swimming pool nor nearby swimming facilities, which is why they use beaches, rivers, and other water sources for swimming. The Diep River estuary in particular is a popular swimming area, which highlights the importance of maintaining its cleanliness and safety. Despite the current-day poor condition of the estuary and water quality, people, often children, still swim in the water when the weather is fair (**Figure 4.16**). One possibility is limited awareness of the poor water quality, or awareness of quality but an overriding need to use the estuary as an easily accessible recreational resource within the city.



**Figure 4.16:** The public swimming in the estuary. (Photo credit: Ernita van Wyk, 2018)

Another commonly perceived role of nature in cities is the offering of “*human connection*” and “*social interaction*” between “*people from all walks of life*”. One respondent provided an anecdote to support their perception:

*I once witnessed the police arriving at the mouth. It was a hot day and they were with their police dogs. I assumed they were looking for something or someone. Instead, they allowed their dogs to have a swim in the water. They were chatting to some other people who were here. All types of people can connect here. There is something for everyone.*

The roles that nature plays in cities according to the perceptions of respondents are to provide a place to de-stress, relax, escape from the city and connect with the people around them.

### ***Individual and societal values related to urban nature***

The overarching aim of this research was to gain a better understanding of the social dimension of the Diep River estuary. The objectives guiding the research are associated with understanding how people use, perceive and value this natural space. After respondents were asked about the role that nature plays in cities, they were asked to outline what they personally value in natural urban spaces, from a general standpoint. The answers to this question reveal the underlying values and worldviews that inform and influence people’s perceptions. The way in which people value a particular space will likely inform how they interact with it. The findings in this section highlight deeper values and emotional aspects of humans within a SESs context. While questions are similar and answers may have overlapping themes, it was the aim to elicit deeper responses by encouraging respondents to think deeply about nature in urban spaces. In this question, “*What do you personally value about urban nature?*”, we are able to conclude what benefits people seek from urban nature as opposed to what they currently get from it, and what they think they should be getting from it. Key quotes have been extracted from the surveys and conversations. These quotes aim to illustrate deeper human values, and what people find important in life, as it relates to urban nature.

*For me it’s about walking, exercising, being active and being outdoors. Physical exercise and movement are really important to me and doing it somewhere in nature is even better. Especially if it’s somewhere I can get to without a car.*

The majority of respondents highly value living an active and healthy life, especially one that is outdoors. This indicates that natural spaces that are suitable for physical activity and movement are a necessity, especially in a highly urbanised environment. Results showed that the freedom to walk, exercise and be active is important to people. One of the respondents stated that having the opportunity to be active and outdoors as an urban dweller is “*vital to one’s being*”.

Other valued aspects of nature are its aesthetic qualities and peacefulness. In the case of the Diep River estuary, many respondents, especially local residents, displayed pride in this natural area and its beauty. The peacefulness and calmness in natural spaces highlights the slower pace that nature brings, in contrast to fast-paced urban living. These aspects are illustrated in the following quotes extracted from surveys: “*Cities are sometimes beautiful but nature in cities is always beautiful*”, “*I value the peace that you get when you just go into nature*”, and “*The pleasant scenery of nature just brings me so much appreciation, I instantly feel better*”.

An aspect that was highly valued by users was the human interaction and connection that the space offered. Being with family, friends and loved ones was of great importance to users. Respondents valued the opportunity that nature gives people to bond with each other meaningfully. One respondent articulates,

*Living in a big city like Cape Town, I see anger between people, usually on the roads. It doesn't seem like they (strangers) like each other. I also don't really see people interacting too much, mostly they are on their phones or living their own lives. And me too, to be honest. We keep to ourselves you know? But to tell you the truth, I love interacting with people here. It's like it's easier to talk to people when you're somewhere nice outside, feeling happy and relaxed.*

When asking people what they particularly value and want from nature in cities, dominant themes include the desire to be active and outdoors, enjoy somewhere peaceful and beautiful, and get the chance to truly connect and interact with others. By outlining these values, we are able to compare them to what people experience and have available to them at the Diep River estuary. Furthermore, these values elucidate society's understanding of nature's role, and what they want and need from nature in an urban context. They also suggest that the loss of nature will invoke feelings of loss and disappointment. The key takeaway from these responses is that society, for the most part, have a sense of awareness and are cognizant of the benefits of nature in their city.

### **4.3. Key informant interviews**

While surveys provided a present-day “snap-shot” of estuary users, the key-informant interviews aimed to produce extensive narratives and deep insights relating to estuary users. Key-informants were chosen based on their long-term, close connection with the estuary.

#### **4.3.1. The estuary’s ecosystem services**

This study offers a narrative analysis relating to the benefits (ecosystem services) offered by the Diep River estuary and how they contribute to people’s lives. Most of these benefits discussed below fall into the *cultural* ecosystem services category. The key informant interview results clarify how these cultural ecosystem services impact the lives of users of this complex system.

##### ***Mental and physical well-being***

Mental and physical health benefits were among the most dominant cultural ecosystem services offered to users of the estuary, as communicated by interviewees. Reference was made to the therapeutic values and benefits relating to people’s general well-being. The sentiments described by users emphasise that people need nature in cities, which is evident in the following quotes from respondents who live in the area:

*It’s got a very calming influence. I feel privileged that I have that stretch of water to walk along, so walking and exercising are the physical benefits that I get from using this area. Other than that, I love seeing all the activity on the water. Aesthetically it’s really nice, in addition to the way it makes me feel mentally and physically.*

*Being out here is a huge stress-reliever for me. It’s nice to relax, take a break and not worry too much. I love crossing the wooden bridge and walking along the walkways. It’s beautiful, scenic, and there’s so much nature.*

*There are the benefits of being outdoors, walking, and being active. We love the ocean and we love the beach. Being outdoors keeps me calm and de-stressed, and it does the same for the family. It’s an escape from the busy city.*

##### ***Aesthetic benefits***

It was widely agreed amongst interviewees that the space has considerable aesthetic value. All interviewees made reference to their appreciation of the beauty of the space. One of the key reasons that people use the area relates to the aesthetic benefits offered by the estuary.

*It's on my doorstep which is convenient, and it's absolutely beautiful. Where the river flows into the sea, on Milnerton beach, I believe that is the most beautiful beach in Cape Town. You have the mountain in the background, and a massive, pristine beach.*

*I mainly come here to use the golf-club because of its proximity to my home and because of the quality of the golf course, of course. Besides that, I find it truly beautiful here.*

### **Recreational benefits**

Estuary users indicated that the area is a space of recreation for them, and having this kind of space is important to them as urban citizens. They communicated that having a recreational space allows them to “take a break from the usual tick-box lifestyle” and do activities “purely for the joy of it, not because we have to”. Having areas of this nature in a city are greatly important aspects of urban life, as noted by an interviewee and local resident:

*We moved to Milnerton 14 years ago. The kids were young, and we are a family that loves the beach and being outdoors. Settling close to the estuary was ideal, you could walk across and be on the beach. We would stand-up paddleboard, surf, kite-surf, lots of dog-walking, pump for prawns and look for fossilised shark's teeth. Really, all the things this area has to offer we would do. We used to drive here all the way from Sea Point, when we lived there, just to add to the shark-tooth collection. We have hundreds. I also like this part of Milnerton, it's apparently the oldest part of the suburb. There's something special about this nook in particular. The estuary and lagoon mouth were in pristine condition. You could swim in it, all day every day. So there were loads of reasons we chose to live here.”*

The Diep River estuary is a space where recreational facilities, such as the Milnerton Golf Club and the Milnerton Canoe Club, are situated. These facilities are positioned at the estuary by virtue of their accessibility to nature that is user-friendly and allows for recreation.

### **Valued historical aspects**

Among interviewees, there was a deep sense of attachment to and preservation of the historical value of the space. Some interviewees had heard stories relating to the history of the estuary, and others who had been using the estuary for decades had seen history unfold themselves. A local business owner stated, “we've had a commercial property at Lagoon Beach for over ten years. I worked at the offices for five of them, so I've seen a lot come and go, a lot of change”.

Interviewees often had friends or family that remember the estuary well from a bygone generation, and were able to pass on anecdotes about the space that interviewees enjoyed re-telling and visualizing. One interviewee shared:

*The Diep River was once so deep. The road you travelled on to get here, Vissershok road, gets its name from this very river that empties out in Milnerton. The Diep River courses through the Durbanville hills. The ships used to come and load grain on the top of the hillcrests in the 1700s. There were fishermen's huts where these activities would take place and where the fishermen would rest - Vissershok. It's so sedimented up now though. It was a seriously big river.*

Another interviewee shared a memory, *"I will always remember this main road from when I came here as a child, with all those palm trees and the wooden bridge with its history. So many aspects of this place add to the history of this area"*.

An interviewee's father was a local resident too, and recalled a story that he shared. *"My father and his friends would hitch-hike toward the Durbanville hills. This was around 1950. They would go up there with big inflatable tractor-tyre inner tubes, hop in the river and float all the way back down towards the mouth. The river was always in flow, and it was wide and deep"*.

During the interview process, it was discovered that some members of the community had a particularly keen interest in the history of the area. This became evident when one of the interviewees shared their personal involvement in the official preservation and placement of the Commodore II shipwreck.

*The piece of wreckage on the bank has huge value to the community. When I tried to remove a small piece to take home, I was approached by a furious resident. They said that this wreckage is an important part of history and shouldn't be interfered with! After I did lots of research, we sent an application to the NHC<sup>2</sup>, because this piece of maritime history needed to be preserved. With a lot of work, it was eventually put onto the bank with an information board. The idea was to use the wreckage to provide value to the community. The residents as a collective do indeed highly value this space. It's a place for people to meet and breathe and find some ownership. They love having history in the area, the place is steeped in it. It's something from people's childhoods that they can connect with. It closes the loop and connects people from all different generations. This piece of coast has so much cultural and historical value. Having these cultural depots are important because they connect you to the past, and to a preferred future.*

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<sup>2</sup> The National Heritage Council of South Africa is a statutory body that is responsible for the preservation of the country's heritage ([NHC, 2019](#)).

*You understand that preservation has value. If something is looked after from the past, what we have now is worth looking after for the future.*

### ***Loss of ecosystem services***

When interviewees described how certain ecosystem services benefitted them, they did so with contentment and reflected in fondness. However, the tone of the conversation changed when interviewees were asked how their perceptions of the space had changed over time, and if the benefits they receive now are the same as what they were in the past. There was a distinct change in the perceptions of users, and a clear awareness of ecosystem deterioration and ecosystem service loss over time<sup>3</sup>. Interrogating how people's perceptions have changed over time provides evidence for the coinciding change in the state of an area. This is well captured in the following quotes from interviewees.

*When we moved here it was perfect. Well, almost perfect. We spent a lot of time in the lagoon. I would spend my days on the island that formed during the low-tide with my dog, my book and my umbrella. This was 2007 or 2008. I used to absolutely love it. Then slowly but surely, it started deteriorating. You could see and smell something was not right. For me the first big sign was when the birds stopped visiting. And when the fishermen stopped pumping prawns, which was a regular and daily occurrence - you knew that something was going on. It would fluctuate. Some months it would be okay, other months it would be disastrous. But then, it got worse and worse. Then in the past five years it's really deteriorated significantly. But right now, it's inaccessible. You cannot go in that water.*

*We once had it good, but it has been fairly polluted for a long time. The sewage spill brought the stink, but E. coli has been present here and the count has been way too high for a very long time. Water pollution and water hyacinth have been around here for years. So if I think about how my perception has changed, it hasn't been overnight, but like the water quality my positive perception of the estuary has deteriorated, if I can put it like that.*

In addition to cultural ecosystem service loss, interviewees made reference to the loss of supporting and provisioning ecosystem services, such as species habitat loss and species loss respectively. Some interviewees described this noticeable change in wildlife and their habitats. In this case, the loss of prawns for pumping and bait collection (supporting service) had a knock-on effect on the livelihoods

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<sup>3</sup> The Diep River estuary is severely polluted, which is common knowledge among Milnerton residents and other estuary users. The pollution issues related to the Diep River estuary have been widely publicised in the news and among concerned communities.

of some who fished (provisioning service) in this particular estuary. Interviewees reflect on changing supporting and provisioning ecosystem services:

*If you speak to people that have lived here for their whole lives, older people, they used to catch the most unbelievable fish close to the mouth. Yellowtail... Steenbras... This river was once loaded with fish, bursting with life!*

*The most special thing that I once saw here were Cape clawless sea otters. I used to see them come up into the estuary through the mouth of the lagoon, and I'd sometimes see their paw-prints on the beach. I don't know where they are now though, because I think they need freshwater as well. I'm not sure they are getting their freshwater needs here anymore.*

*Over the years I have seen changes in wildlife. Funny enough, only the flamingos are still here. The geese have all gone, and they used to live on the water. I know this because they were always on my roof making such a noise! Not one goose in sight. The flamingos are loving something though. I wonder if the species is more resilient to varying water conditions? I do see the herons are still there. No more prawns though, zero. When it wasn't as bad, there were still prawns and fishermen would come and pump them. Sure, they were few and far between but they were still there. They would make a sarmie after gathering their bait and go fishing straight afterwards, it was wonderful to see! But sadly, they are not coming here anymore.*

Recreational benefits have been compromised as people communicated that they do not feel safe using the estuary anymore. With regards to the anecdote describing floating down the river with an inflatable tube all the way to the mouth of the estuary, the same storyteller stated, “*I don't think anyone would dream of doing that now. It's canalised, not really flowing, polluted at every turn*”. This illustrates the loss of recreational benefits over time. Another interviewee describes their changing perception, “*yes, I mentioned that it was beautiful, and a stress reliever, and I used to love swimming here. Unfortunately, the only thing the place has going for it is that it only looks pretty now. It's too bad we can't use of it like we used to*”.

These changing narratives offer evidence that the estuary provides individuals, communities and society with a number of benefits in the form of ecosystem services. While most fall within the cultural ecosystem service category, there is evidence of provisioning and supporting services, mostly in the form of wildlife.

### 4.3.2. Ways forward

#### *Perceptions relating to management*

Interviewees offered ideas for management of the estuary, often based on their understanding of the source of pollution. This is an important emerging theme because it suggests the need for a catchment approach to management, and the need to influence behaviours in other sub-systems that impact the state of the lower reaches of the estuary. This is a noteworthy focal point for managers, because drivers of the state of the estuary emanate in areas remote from the estuary mouth. The following quotes illustrate that interviewees understand the estuary's state to be a result of upstream pollution caused by neglected infrastructure, industrial waste, human negligence, and unsustainable urban development:

*The major pressure is the pollution and sewage flow, from more than one outlet it seems. There's an outlet just beyond the hotel, along that long pier. For years I've been walking to that pier and the water coming out of there is dark brown with a foul smell. It might be industrial waste when I think about the fact that we're surrounded by Paarden Eiland, Montague Gardens and Salt River.*

*Managers sorting out the sewage is most important. Second is sorting out the water hyacinth. Also, maybe the Black River could do with a weir? Because on the beach, after a storm, there are always lots of nappies that come down one of these two rivers. Either the Black River or Diep River. There must be a creche or something up the river and those nappies land up in the river. It's not a normal amount. But that's a citizen thing, not a government thing. But really, if they can put a weir up it would make a huge difference, to stop things from reaching the sea.*

*It started off as the most beautiful playground for children to swim in. Fun and safe, but you just can't do that anymore, I've watched it deteriorate. Also keep in mind that we came to Milnerton before all the development. Before Woodbridge Island was here, before the hotel was here, so I do feel like urban development has played a role.*

*Infrastructure replacement is the bottom line. Too many people relying on infrastructure not built for those kinds of numbers is the issue. For now, improve the signage that says you aren't allowed to swim there. I mean I don't agree with fixing the symptoms instead of the problem, but for now, making people aware of the situation could help.*

*It's a pity that there is not a lot of recreation on the estuary. A fortune was spent on that new bridge, but I can't understand why the water wasn't sorted out and made more user-friendly. It's great to use water. For kids, adults, everyone.*

### ***A desired future state***

Interviewees were asked to describe what a desired future state would look like to them. Managers can use these perceptions to inform future estuary management, or to contribute to the process of public participation. With this question about future desired state included, the study offers expressions of the past, present and desired future states of the Diep River estuary.

*More value can be added to this area by making one of those red ‘hop-on hop-off’ busses stop here, at this end of the world. There’s a whole bunch of stuff to see. There are also a lot of plans for Paarden Eiland from a tourist and housing point of view because they’ve really got prime real-estate there. Only problem is it’s an industrial area. Developers are looking to buy and transform those sea-facing properties and we’re looking to do the same thing. I wouldn’t be surprised if gentrification of Paarden Eiland is on the horizon.*

*I’m not sure why the place is so undervalued and why the government won’t fix it. You know that pier at the end of Lagoon Beach Hotel? I used to walk along that pier, and that’s where all my most important business and life decisions were made. Now out of that pier flows dark brown dirty water. But when this is eventually fixed, there are some amazing ideas in the pipeline. The whole area from the Cape Town Foreshore all the way to here should be an integrated green belt with bicycle tracks, walkways, and other attractions. Over here you have the best view of the 8th wonder of the world.*

*I think that it shouldn’t just be brought back to a “not-smelly” state, but it should be water where people can swim and fish and paddle in. I wonder if that’s possible.*

*All I want is for the estuary to be usable again. I haven’t put my foot in that water for more than six months. It’s just a major loss of something really special. It would be really nice to see the canoe club and others to reclaim their playground! I want to see people having fun in the estuary like they used to. Us humans need to have a bit of fun in our lives and lighten up a little. For me, that looks like spending time in a beautiful, clean, healthy area. Families used to picnic on the side, children playing in the water. I imagine a future that looks a bit like the past.*

The key informant interviews were used to articulate long-term, deeper and changing perceptions of the Diep River estuary. This was achieved by interviewing people who have been using the estuary for long enough to have witnessed a change in its condition and surrounding developments. Considering that interviewees had an understanding of the estuary from the past, they were able to provide well-informed and encouraging ideas for the future social-ecological state of the estuary.

## Chapter Five: Discussion

A social-ecological analysis of the Diep River estuary proved useful in understanding the relatively less explored social dimension of this social-ecological system (SES). Exploring the social dimension uncovered a number of dominant themes, which form the basis of the discussion that follows. These themes include sense of place, response to ecosystem health, and accessibility to urban nature. A sense of place was displayed as people are emotionally connected and attached to this space for a number of reasons, indicating a positive relationship between urban nature and the people who use it. The cultural ecosystem services provided by the Diep River estuary contribute to this relationship, and have fostered in users a strong sense of place. Responses to ecosystem health were observed as there are shifts in the uses and perceptions of the Diep River estuary in response to system health. There is evidence of a ubiquitous concern for the health of the system. While there is a long history of care for the system, there is an equally prevalent shared sense of a system in decline. Relationships between people, location, and the regularity of use of this natural asset, points to the importance of fair accessibility to urban nature.

### 5.1. Sense of place

For most of the respondents, there is a deep emotional connection to the estuary. One of the key themes to emerge from the study, evident in the survey responses and interviews, is the considerable fondness and appreciation for this space. Users find it special to them based on the various benefits that the estuary provides. These include mental and physical health, recreational, aesthetic and community-related benefits. Sense of place describes the connection that people have with a particular environment (Frantzeskaki *et al.*, 2018). The sense of place concept was popularised partly by human geographer Yi-Fu Tuan in the 1970s, and has been described as “complex” and “elusive” (Haywood, 2014; Ried *et al.*, 2020). However, it is also described as a progressive and insightful way of making sense of the complex society-nature relationship (Ried *et al.*, 2020). Experiences, memories, perceptions and meanings that respondents associate with the Diep River estuary all contribute to their sense of place.

The variety of responses shared by users in terms of why, how, and when they use and value the estuary are all ways in which they experience the space. Experiences are a central element in the sense of place concept (Korpela *et al.*, 2014; Masterson *et al.*, 2019). Through people’s experiences during their visits to the estuary, they form bonds and attachments to it. Literature suggests that natural spaces most frequently described as meaningful and important to people are bodies of water, and places with biodiversity (Foley and Kistemann, 2015), which aligns with the current study site. It is well documented that immersing oneself in nature and stepping away from the stresses of urban life strengthen attachments to certain places (Jackson *et al.*, 2013; Shanahan *et al.*, 2015), which is supported by the findings of this study.

Sense of place is considered a cultural ecosystem service itself (Hausmann *et al.*, 2016). Another cultural ecosystem service, health and well-being, is briefly discussed here, because both concepts are described as non-material ecosystem services (MA, 2005). Furthermore, it is partly due to other cultural ecosystem services provided by the Diep River estuary that deepen users' sense of place. Research and policies have traditionally overlooked the contributions of cultural ecosystem services to the health and well-being of ecosystem users (MA, 2005). There are multiple benefits of nature that enhance people's quality of life (Hausmann *et al.*, 2016). It is especially important that people are exposed to nature's benefits if they are living in an urban environment, as studies have shown that urban living is associated with negative mental health effects such as anxiety and high levels of stress (Shanahan *et al.*, 2015). The findings emerging from this study that relate to the positive effects on human health and well-being derived from use of the estuary are well-documented in literature (Shanahan *et al.*, 2015; Hausmann *et al.*, 2016). Many survey and interview respondents communicated how being at the estuary was associated with personal stress-relief. It is widely accepted in the literature that stress reduction is closely associated with exposure to nature (Frumkin *et al.*, 2017). Other benefits offered by exposure to nature include enhancing people's moods, promoting social cohesion, reducing crime and other aggressive behaviour, and forming a communal identity (Hausmann *et al.*, 2016). While acknowledging that sense of place and human well-being are separate concepts and ecosystem services, they are tightly linked in this study, and findings appear to be consistent with other research in this area.

Recent studies suggest that sense of place plays a critical role in ecosystem governance and sustainability (Masterson *et al.*, 2017, 2019; Frantzeskaki *et al.*, 2018). Understanding how people emotionally connect to natural places, can offer powerful insights relating to pro-environmental motivations and stewardship behaviours associated with ecosystems (Zhang *et al.*, 2015). While this sense of defending the environment is largely a result of having a strong sense of place, it was a dominant theme in itself and will be discussed later. There is also an increasing need to shift the management of ecosystems toward an integrative approach that encompasses the needs of humans and of nature, and acknowledges complex social and ecological dynamics; the SES approach (Masterson *et al.*, 2019). Engaging with the sense of place concept allows researchers to deepen their understanding of SESs, by making sense of the social dimension (Masterson *et al.*, 2019) of SESs. This is the comparatively under-examined dimension of ecosystems, especially in the case of the Diep River estuary where there is limited formal inquiry and exploration of the emotional connection that users have with the space (Elliott and Whitfield, 2011).

Sense of place encompasses the place attachment concept (Zhang *et al.*, 2015). The attachment to nature is of particular importance, and has been characterised as its own form of place attachment (Zhang *et al.*, 2015). Authors make reference to four dimensions of place attachment: place identity, place dependence, affective attachment, and social bonding (Wynveen, Kyle and Sutton, 2012; Zhang *et al.*, 2015). The multi-dimensional concept is used to effectively analyse and capture people's attachment to

a place on a detailed level, and can be applied to the current study. Place identity is the extent to which a person feels that a place contributes to their identity (Wynveen, Kyle and Sutton, 2012). In this study many respondents, especially local residents, displayed pride in this natural space in their vicinity, demonstrating place identity. Considering the high percentage of users who live close-by further illustrates this. This finding also speaks to place dependence, which relates to the ability of certain spaces satisfying the needs of the users over alternative spaces (Zhang *et al.*, 2015). The described uniqueness of the Diep River estuary in terms of its historical, geographical and ecological value contributes to residents' willingness to make use of the nature that they have on their doorstep.

Affective attachment describes human connectedness and belonging to the natural world, characterised by bonds and interactions between people and nature (Zhang *et al.*, 2015). Affective attachment is strengthened when people have positive experiences in nature, such as the enjoyment derived from canoeing, swimming, walking, or connecting with others at the estuary. Conversely, affective attachment is weakened through negative experiences, such as witnessing the steady degradation of a natural area (Zhang *et al.*, 2015). The social bonding dimension, which is a particularly important factor in forming place attachment, is the shared experiences and interpersonal relationships that are formed and maintained in a natural space (Zhang *et al.*, 2015). This is one of the highest valued aspects of the Diep River estuary as demonstrated by respondents.

As mentioned, sense of place has recently been described by authors as an ecosystem service itself (MA, 2005; Hausmann *et al.*, 2016). The flow of ecosystem services is lost in conjunction with ecosystem deterioration (Hausmann *et al.*, 2016). This is evident in the loss of supporting and provisioning ecosystem services that were once provided by the estuary but are no longer existent, aligned with continued human intervention at the estuary over time. The ecosystem services concept is important because there is an increasing focus on these services to motivate environmental protection agendas on a large scale (Armsworth *et al.*, 2007). Tangible ecosystem services are largely quantifiable (Raymond *et al.*, 2013). However, there is a gap in the valuation efficacy of intangible ecosystem services (Hausmann *et al.*, 2016). The majority of intangible benefits that nature provides are in the form of cultural ecosystem services, one of these is 'sense of place'. However, there is a gap in the valuation efficacy of intangible ecosystem services (Hausmann *et al.*, 2016). The concept is flagged as being a key integrative tool between understanding ecosystem functioning and ecosystem management (Hausmann *et al.*, 2016). Williams and Stewart (1998) suggest that "by understanding, anticipating, and responding to peoples' relationships with places, managers are better equipped to develop management activities that will avoid conflict and gain public support". To unpack the sentiments of Williams and Stewart (1998), the implications of using the cultural ecosystem service of sense of place in the management of natural areas will be briefly discussed.

An individual's or society's connection to nature, and the subsequent strengthening of their sense of place, encourages their involvement in environmental protection (Hausmann *et al.*, 2016). There is a call for a far-reaching and collective responsibility for the protection of the environment. Exposure to nature, especially in urban contexts, provides an increasing sense of awareness and appreciation of the natural world, and encourages conservation (Hausmann *et al.*, 2016). This highlights the importance of ensuring that highly urbanised areas offer equitable access to natural space. This point is expanded on in relation to spatial geography and historical planning later in this discussion.

Using sense of place for ecosystem management can bring about complexities related to many people perceiving the same environment in many different ways. Understanding human perceptions is complex, as someone's perceptions may be influenced by a myriad of differing elements, including their history and background (Bennett, 2016). However, as the findings show, the complexities of people's varying perceptions add texture and depth to our understanding of the social dimension of the estuary, and may expose clusters of shared perception. Another implication of using sense of place for ecosystem management is that it strengthens the understanding of the human-nature relationship on a place-specific level (Stewart *et al.*, 2013; Frantzeskaki *et al.*, 2018). Each local environment has its own particular complexities that can be most effectively understood through local perspectives. The Diep River estuary has a unique history in terms of its modification and biophysical characteristics, which is a backdrop to a wide-range of stakeholders and users with varying interests. Frantzeskaki *et al.* (2018) argue that in order to transition toward sustainability, place-specific understandings of sense of place can provide key insights for management. The current study offers a place-specific understanding of users' sense of place as it relates to the Diep River estuary. The concept contributes significantly toward social-ecological systems research (Masterson *et al.*, 2017).

## **5.2. Response to ecosystem health**

Having a strong sense of place motivates behaviours that are supportive of environmental protection (Armsworth *et al.*, 2007), and it is likely that people protect what they love and feel connected to. Concern for the health of the Diep River estuary was a clear theme to emerge from findings across all methods, indicating a long history of care and concern, while no doubt much longer, but dating back to the early 1900s, within the scope of this study. There was also a shift in use patterns and activities in the estuary which aligned with a changing state of the ecosystem. This highlights that users respond to the fluctuating state of the ecosystem. Perceptions and behaviours can be seen as feedback loops and pathways in social-ecological systems (Masterson *et al.*, 2017). In a sense, they can be seen as indicators of the state of a system. This theme presented itself through people's responses in two ways: people responded by voicing concern for this degraded environment (and some acted on it), and to a greater extent, people implicitly responded by changing their usage patterns within the estuary. Changing use patterns can be interpreted as human feedback mechanisms, indicating a response to the state of the

ecosystem, a common function within a SES (Masterson *et al.*, 2017). This section explores people's 'environmental defence' in response to the state of the estuary.

Findings to emerge from the methods used reveal a history of community concern for the Diep River estuary. The historical material consulted in this study indicates that at least from the early 1900s, stakeholders recognised that the estuary needed protection if ecosystem benefits were to be sustained. Nearly all survey respondents were aware of the severely polluted water manifesting in the lower reaches of the estuary. Evidence shows that some respondents were acting on their concerns by picking up litter or by sharing their concerns with others. There are other ways that people have been involved in the protection of the estuary, but it is outside of the scope of this study to expand on those efforts. The persistence and increasing severity of the pollution in the estuary recently catalysed civil society to draw upon the support and the involvement of the Organization Undoing Tax Abuse (OUTA), a civil action and advocacy organisation. This follows several years of resident complaints, as their sense was that engagement with the City of Cape Town did not result in what they felt to be adequate solutions to the pollution problem (OUTA, 2020). The protest behaviours from residents and other users of this natural resource are indicators of public concern around the state of the estuary and the desire for environmental stewardship at the local level (Bennett *et al.*, 2018).

Environmental stewardship is any activity associated with conservation, restoration, or sustainability activities relating to natural resources. It can be characterised by a number of actions, which include intentionally lessening environmentally damaging activities, reducing pollution, establishing protected areas, or initiating sustainable community-based projects (Bennett *et al.*, 2018), such as beach clean-ups or community gardens. Bennett *et al.* (2018) highlight that seemingly small individual daily decisions that are environmentally-conscious are also forms of stewardship. The ability for individuals to make noticeable differences in environmental issues has been contested, as typically issues manifest at scales larger than an individual's influence. However, Bennett *et al.* (2018) argue that resource users at the local level play a crucial role in environmental stewardship. These users are usually living in close proximity to the resource, are connected or attached to the resource, and in some cases, rely on the resource for subsistence (Bennett *et al.*, 2018). In this study, the findings show that present-day users of the Diep River estuary are deeply connected to the space. Furthermore, local residents make up a large proportion of users, and display pride in this area. The historical material shows that, to a certain extent, the estuary was a form of subsistence to some. There are evidently parallels between what Bennett *et al.* (2018) describe as local users that are inclined to be stewards of the environment, and the users of the current study site. Therefore, we can assume that the users of this space are prime candidates for supporting the protection of the Diep River estuary. This idea links to the Literature Review, where Ostrom (1990) suggests that users of natural systems or common pool resources are capable of governing the resource themselves.

Stewardship highlights the significance of a management approach and policy that integrates the public with stakeholders across institutional scales. However, while it may be clear that environmental care, concern, and stewardship are prevalent among users of the Diep River estuary, they may not have the necessary tools (such as collective identity) or empowerment to initiate or drive real ecological change (Mosimane, Breen and Nkhata, 2012; Sayles and Baggio, 2017). Mobilization of environmental stewardship that drives positive ecological change is dependent on factors such as people's incentives or the supporting institutions available to them (Bennett *et al.*, 2018). Environmental stewardship can be compromised as a result of economic, social and institutional barriers (Henderson, Reed and Davis, 2014). With regards to the Diep River estuary, motivation for ecological protection may exist among users, but they do not possess the necessary tools or institutional support to actualise environmental stewardship. For example, a Friends of Rietvlei group exists, but this group's interest is focussed on the wetlands at the northern end of the Table Bay Nature Reserve.

Governance can either enable or inhibit stewardship. 'Governance' includes institutions, policies, laws and structural processes (Bennett *et al.*, 2018). This landscape might hinder local-level environmental action through unavoidable bureaucratic processes. However, intentional governance principles such as authentic public participation mechanisms, meaningful inclusion of all necessary stakeholders, maintaining stakeholder trust, and fostering knowledge co-production, are all enablers of a suitable stewardship landscape (Lockwood *et al.*, 2010). This literature allows us to reflect on management approaches at the Diep River estuary, and whether users who display environmental stewardship are empowered and enabled enough to contribute toward the future health of the estuary.

Apart from the need for supportive institutions and management planning to sufficiently include public opinion and stakeholder participation in protection efforts of the estuary, it must be stated that it is not assets and governance alone that guarantee environmental stewardship (Bennett *et al.*, 2018). Various authors suggest that it comes down to an individual's personal motivations, whether or not they have the necessary resources or external support (Cetas and Yasué, 2017). Cetas and Yasué (2017) offer two broad categories of motivation for environmental stewardship - extrinsic and intrinsic motivations. Extrinsic motivations are associated with external rewards, recognition or acceptance for stewarding natural resources (Bennett *et al.*, 2018). Intrinsic motivations are associated with people's personal ethics, morals and values, and how they relate to fair treatment of the environment (Bennett *et al.*, 2018). These values are rooted in people's connection to the environment, intertwined with feelings of sense of place. Intrinsic motivations push would-be stewards to take protective environmental action because it will bring them personal satisfaction. While the literature on motivations as they relate to environmental stewardship is extensive and will not be engaged with in its entirety in this study, it is noteworthy that intrinsic motivations are associated with sense of place, a previously discussed emergent theme from the narratives of Diep River estuary users. Cetas and Yasué (2017) highlight how intrinsic motivations are more persistent drivers of environmental stewardship than extrinsic

motivations. The implication is that the environmental defence and ownership expressed by past and present-day users of the estuary is embedded in their emotional connection and fondness of the space. It can be suggested that increased positive experiences at the estuary can result in them taking ownership for its protection. Time at and experience in natural spaces is closely related to their level of accessibility, which will be discussed further on.

Another way in which people responded to the state of the estuary ecosystem was by changing their use patterns. This demonstrates the responsive relationship between the biophysical and the social system. For continued ecosystem service management and provision, the integrated relationships between humans and nature need to be better understood (Miyasaka *et al.*, 2017). A well-documented phenomenon in SESs are feedback loops (Masterson *et al.*, 2017; Miyasaka *et al.*, 2017). Feedback loops describe the dynamics of interacting components in a SES that are continuously co-adapting and co-evolving in response to each other (Miyasaka *et al.*, 2017). What makes SESs so complex is the mosaic of ecological processes (including varying land uses and topography) interacting with social processes (individual and societal behaviours or values) (Liu *et al.*, 2007). Miyasaka *et al.* (2017) suggest that these actions and reactions based on individual human behaviour and place-specific environmental processes are what make SESs “intrinsically heterogeneous”. This makes it difficult to apply general frameworks to all SESs in the same way.

The concept of feedback loops is brought to life in this particular system at various points in history. Consulting historical as well as present-day data relating to the uses and state of the estuary is useful because it provides a more detailed understanding of how the estuary’s ecosystem services have been affected, and how people responded. This idea is supported in the work of Miyasaka *et al.* (2017), who state that “ecosystem services are inherently related to each other via coupled feedback loops in space and time [and] ecosystem service trade-offs can occur in spatial, temporal, and social dimensions” (Miyasaka *et al.*, 2017, p708). This can be applied to the Diep River estuary.

This study shows a number of human interventions that affected the estuary throughout the last century. Some ecosystem services were threatened or lost as a result of these interventions. However, human interventions can be spatially separated or temporally delayed (Miyasaka *et al.*, 2017). For instance, the construction of the Potsdam Waste-water Treatment Works had effects on the estuary further downstream (spatially separated) and it has taken many years for the cumulative effects of (treated and untreated) effluent discharge to become a public health concern (temporally delayed) (Miyasaka *et al.*, 2017). Human responses, adaptations and reactions to these changes might trigger unintended degradation to the system in other ways (Larrosa, Carrasco and Milner-Gulland, 2016). For example, if the mouth were to be continuously dredged to encourage ocean ‘flushing’ in the estuary, unexpected erosion could occur higher up the water-way (Jackson, Conrad and Carstens, 2011). Another aspect to consider is that there are residential and commercial properties in close proximity to the estuary, making

erosion a serious issue. This example that has occurred over a long temporal and spatial scale illustrates the multiple factors to take into account while making management decisions (Miyasaka *et al.*, 2017). While this example is a feedback loop relating to ecological processes, sometimes results are demonstrated through the state of the estuary. For example, users at the local level are likely to be negatively impacted on by poor water quality. Taking note of behavioural change can be a good indicator of the state of the system. The findings across all methods reveal that people stopped using the estuary for certain activities throughout ecosystem modification. Historical photographs and stories shared by respondents allows us to see and hear how their uses and perceptions of the estuary have changed over time.

Observing people's behaviour and the inclusion of society's concerns over environmental degradation enables active participation, which is an important stage of management of social-ecological systems (Withanachchi *et al.*, 2018).

### **5.3 Accessibility to urban nature**

The majority of the Diep River estuary users live between one and five kilometres away from the estuary. In keeping with Choi, Park and Rigolon (2020), this suggests that having nature-based amenities in one's residential vicinity encourages more frequent use. Use of urban nature should be encouraged, because there is a large body of literature that substantiates the benefits that nature provides to urban residents, affirmed in this study where users note multiple mental and physical health benefits that the estuary brings to them (Shanahan *et al.*, 2015; Hirons, Comberti and Dunford, 2016; Choi, Park and Rigolon, 2020).

A central element of sustainable cities is the provision of nature (Choi, Park and Rigolon, 2020; Venter *et al.*, 2020). Therefore, for cities to truly promote sustainability, urban nature should be accessible to all urban residents and intentionally be included in urban planning strategies (Venter *et al.*, 2020). Cities will continue to grow, as will the urban populations that live within them (UN/DESA, 2018). Therefore, it is essential to intervene with conservation, management and fair access to natural areas that will likely come under pressure due to consistent development (McDonald *et al.*, 2018). Not only will these interventions be beneficial for nature itself, but they will be highly beneficial to the urban citizens who use them. Protection of urban nature and social equity related to nature are intersectional (Montambault *et al.*, 2018), and should be understood in an integrated manner.

Literature suggests that, on a global scale, nature in cities is unevenly distributed, and not all citizens have the same level of access to high quality urban nature (Venter *et al.*, 2020). Inequitable access to green space means that citizens do not benefit equally from nature's many ecosystem services (Venter *et al.*, 2020). In the South African context, where social and spatial discrepancies originally caused by Apartheid still persist (Goodness and Anderson, 2013), access to clean and safe urban nature is unequal.

During the political system of Apartheid, a racially-informed forced separation of South African citizens was implemented (Schäffler and Swilling, 2013). In an urban context, the separation constructed what is known as the ‘Apartheid city’ (Venter *et al.*, 2020). The spatial boundaries upon which people were separated based on their racial classification are the same boundaries that exist today, because of the deeply institutionalised legacy of Apartheid (Goodness and Anderson, 2013). More recently, it has emerged from literature that uneven distribution of accessible nature-based amenities in cities is another lasting Apartheid legacy that shares these boundaries (Shackleton *et al.*, 2018; Venter *et al.*, 2020).

The Diep River estuary mouth lies in the suburb of Milnerton, which was historically zoned as a white area during Apartheid under the Group Areas Act (SAHO, 2011). Some associations between use regularity, user residency, and user racial classification are evident in this study. The findings show that the highest percentage of users are White, and the users who visit the estuary on a daily basis also fit into this classification. This could suggest that the user demographics of the estuary reflect the general racial composition in Milnerton, a suburb with a White population making up just under 50% of the total population (Frith, 2011). Even though this is less than half, it is the highest proportion.

While the estuary is accessible to all, its historically racially-informed geography, combined with social notions such as sense of place and belonging, means that it is less physically and psychologically accessible to some. The key observation is that some, albeit limited change has been made to many South African suburbs over the last 25 years, in terms of racial re-distribution (Venter *et al.*, 2020). Economic inequalities and lower-levels of income are difficult to escape (Venter *et al.*, 2020). Having an economic disadvantage relates to an inability to move and travel as freely, and a lack of access. This relates to urban nature, in which users can be seen as indicators of nature availability across cities. If cities are to be sustainable and ensure health and well-being among citizens, accessible urban nature provision should be included in spatial planning agendas (Shackleton *et al.*, 2018). Accessibility to clean and safe urban nature is a form of environmental justice, as there are multiple benefits that it provides to urban citizens (Choi, Park and Rigolon, 2020). While this study acknowledges the contested social construct of racial classification, demographic information relating to use of urban nature in the South African context is useful for future management and spatial planning. It also provides more insight relating to who is using what natural resources.

#### **5.4 Implications for management**

Understanding people’s perceptions, uses and behaviours as they relate to urban nature can be useful for management of these spaces. Authors note that ecosystem management is a social process, and should include elements of public understanding and public participation (Meffe and Viederman, 1995; Burger, 2003). The Diep River estuary suffers the impacts of human development from as far back as 150 years ago, and there have been plans to ameliorate the pollution of the estuary (Matthews, 2016).

An example of when management interventions came to fruition, is in the Diep River Estuary Management Plan (EMP) of 2011, where external consultants and the City of Cape Town sought to address multiple issues at the estuary (Jackson, Conrad and Carstens, 2011). Public participation processes are included in the EMP for the Diep River estuary (Retief, 2016). It is stated in the EMP that public meetings should be facilitated and hosted on an annual basis in order to share implementation progress of the management plan (Retief, 2016). The public are also to be informed of any important updates relating to water quality, and published plans should be available for public comment (Jackson, Conrad and Carstens, 2011). Public education facilities are also available for those who wish to raise awareness on the Diep River estuary (Jackson, Conrad and Carstens, 2011). The EMP emerged from the need to manage the estuary from a scientific perspective, and the objectives that guide the EMP are largely driven by scientific understanding (Jackson, Conrad and Carstens, 2011). Although extensive research has been carried out in the formulation of EMPs, and while there is an understanding of the need for public engagement, limited acknowledgement is made to the idea that user perceptions of an ecosystem are integral to ecosystem sustainability (Berkes and Folke, 1998).

Recognising the knowledge and experience of local stakeholders and system users is important in management, because articulated benefits to society can act as drivers for sustainability (Berkes and Folke, 1998). Considering “what people care about” (Masterson *et al.*, 2017) in the context of nature can inform goal-setting relating to SES sustainability. Additionally, better-informed management requires an integrative understanding of the ecological and social dimensions of complex systems (Burger, 2002). More recently, all nature reserves within the City of Cape Town, including the TBNR, are required to coordinate a Protected Area Advisory Committee, which has representatives of the various public constituencies in the area. These committees reflect the intention to incorporate public concerns, skills and capacity into reserve management, therefore showing an implicit desire to address the reserve as an SES.

Several conclusions can be drawn from the findings that outline the most meaningful connections for users of the Diep River estuary. People’s past and present uses and perceptions, combined with their future ideals relating to the estuary, can provide direction in formal management policies. Many survey respondents indicated their interest and enjoyment of the historical information boards at the estuary, especially the one that described the shipwreck. Future adaptations of EMPs might find insights such as these useful to include, if stakeholder needs are to share the centre of management plans with ecological needs. Similarly, the desire for safe contact recreation for all, indicates the need for greater accessibility to the resource and improved water quality, which could be formulated as major goals for estuary management.

Acknowledging perceptions is useful as it allows managers to get a general consensus of what the perceptions are relating to a particular complex system (Burger and Tsipoura, 2019). Differences in

knowledge and perceptions of a particular environment could be attributed to a number of factors, including use frequency and exposure (Burger and Tsipoura, 2019). The findings offered in this study demonstrate that the greatest concern for most users is the severe pollution in the estuary. This information can be used in management by acting as a priority and driver for ecosystem change, towards meeting both urgent ecological restoration as well as social needs. As this is a coupled system, we can foster the society-nature relationship by having a thorough understanding of integrated ecological and social knowledge. Indeed, some authors argue that ecosystem restoration will be most effective when formulated from a social-ecological perspective (Fischer *et al.*, 2021). Finally, this kind of study and its methodologies can be used by management as a baseline for future student research to ‘track’ changing perceptions over time so that current perceptions can be known as part of an improved understanding of the social-ecological system and for incorporation into the management planning process.

## Chapter Six: Conclusion

This study contributes towards enhancing our understanding of integrated management approaches toward environmental sustainability and protection. In the context of recent sustainability agendas, more emphasis has been placed on incorporating the social sciences to a similar extent as the natural sciences. The field of urban ecology provides an arena to reintegrate these disciplines in order to address the evidently complex interactions between society and nature (Niemelä, 2014). Furthermore, viewing nature-society interactions through the social-ecological systems (SES) frame allows us to grasp the complexities of these relationships (Anderies, Janssen and Ostrom, 2004). The application of the social-ecological systems framework (SESF) requires a thorough understanding of the social and ecological dimensions in a particular system. These insights can provide decision-makers with information that can inform more effective ecosystem management strategies that are holistic and integrative in nature. There is a need to protect nature and ecosystems because they offer society a myriad of benefits, particularly in urban areas (Choi, Park and Rigolon, 2020). While many ecosystem goods and services are quantifiable, there are a multitude of benefits that nature provides that cannot be seen or quantified. These occur mostly in the form of cultural ecosystem services. Using a broad ecosystem services approach to analyse the benefits of nature allows us to account for the deeper sentimental values that humans place on nature. This is also a useful way to understand the social dimension of a social-ecological system; an overarching purpose of this study.

Among authors, managers, and the public, the Diep River estuary is not typically known and described as a social-ecological system. The findings in this study reveal that the estuary is a complex SES, with daily interactions between its dynamic tidal ecology and a range of users with diverse interests. There is also historical evidence of the long-standing nature of these interactions, as well as hopes for an improved social-ecological state into the future. As the estuary's ecology has previously been described in detail (Viskich *et al.*, 2016), this study has contributed toward describing its social dimension. With this knowledge, change can be directed and managed to achieve sustained benefits to users, as well as to the environment. The insights gathered relating to the social dimension fill the gaps in the conceptualisation of the Diep River estuary as a coupled SES.

While steps for public engagement are included in management plans for the Diep River estuary (Retief, 2016), there has been little inquiry into understanding who the public (in this particular context) is, and what they value. By making use of the case study approach to understand this SES and its users, case-specific insights revealed the Diep River estuary to be a nuanced natural system with humans making up integral parts of its history, current functioning and its future. It might be beneficial to think about other urban green spaces in this manner. Furthermore, exploring and articulating the deep emotional connection that humans have with urban nature is a powerful driver in management. There are innovative ways in which managers and decision makers may choose to implement these insights, but

it is useful for managers to take these variables into account while developing and implementing policy. The public are also likely to be more engaged and supportive of management processes if they feel connected to a place, and their sense of place is acknowledged (Masterson *et al.*, 2017).

The results of this research support the idea that environmental care, concern, and stewardship is cultivated through the development of relationships and attachments to a particular space (Armsworth *et al.*, 2007). A demographic-related investigation in this study has shown that the majority of Diep River estuary users live close to the resource, often within walking distance. Taken together, these results suggest that accessibility to urban nature is foundational to motivating pro-environmental behaviours and sustainability. Ensuring that urban citizens have access to clean and safe urban nature is critical for urban sustainability. While the purpose of this study is not centred around spatial planning, a recommendation for future research is to examine the links between societal behaviours towards urban nature and urban citizens' access to it.

This exploratory research into the perceptions, uses and stories of Diep River estuary users points to interesting insights and considerations that may be helpful in choosing appropriate management and protection strategies for the estuary. Overall, the estuary continues to provide a range of benefits to users despite its apparent ecological deterioration. One of the more significant findings to emerge from this study is that the public hold deep concern for the estuary's health, which is rooted in personal experiences at this space. If acknowledged and enabled, the public can offer decision makers a detailed and improved understanding of society's needs and priorities as they relate to urban nature. These priorities should be taken into account in order for policy to meaningfully meet the needs of humans and the environment, fostering, in turn, societal support to environmental management.

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# Appendix A

## Section One: Respondent Profile

1. Age

-12	13-18	19-24	25-34	35-44	45-54	55-64	65-74	75-84	85+

2. Gender

Rather not state	Male	Female	Other

3. Race

Rather not state	Black	White	Coloured	Asian	Other

4. Education

Rather not state	Primary school	High school	Diploma	Under-graduate	Post-graduate	Master's	PhD

5. Which suburb do you reside in?

.....

6. How did you get to the estuary?

Walked	Bicycle	Car	Taxi	Bus	Train	Other

7. Which option(s) best describe(s) your primary reason for visiting the estuary today?

Going to the beach	Walking the dog	Restaurant patron/employee	Canoe club	Golf club	Fishing / prawn pumping	Walking along the lagoon	Other (write below)

.....

8. How frequently do you use this estuary? Write the number of times below

Daily	Weekly	Monthly	Annually	Just once
N/A				N/A

9. Why is using the Diep River estuary important to you?

.....

.....

**Section Two: Respondent Perceptions**

1. What are the most favourable aspects of the Diep River estuary?

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2. What are the best facilities at the estuary?

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3. What facilities are needed at the estuary?

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4. What role does urban nature play in the life of an urban citizen?

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5. What do you personally value in natural urban spaces?

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## Appendix B

### Section One: Respondent Profile

1. Age

-12	13-18	19-24	25-34	35-44	45-54	55-64	65-74	75-84	85+

2. Gender

Rather not state	Male	Female	Other

3. Race

Rather not state	Black	White	Coloured	Asian	Other

4. Education

Rather not state	Primary school	High school	Diploma	Under-graduate	Post-graduate	Master's	PhD

5. Which suburb do you reside in?

.....

6. How do you usually get to the estuary?

Walked	Bicycle	Car	Taxi	Bus	Train	Other

7. Which option(s) best describe(s) your primary reason for using the estuary?

Going to the beach	Walking the dog	Restaurant patron/employee	Canoe club	Golf club	Fishing / prawn pumping	Walking along the lagoon	Other (write below)

.....

8. How frequently do you use this estuary? Write the number of times below

Daily	Weekly	Monthly	Annually	Just once
N/A				N/A

9. Why is using the Diep River estuary important to you?

.....

.....

## **Section Two: Respondent Perceptions<sup>4</sup>**

1. Please provide some background regarding how you are connected to the Diep River estuary.
2. Describe how you utilize the estuary on a regular basis.
3. In what ways does the estuary benefit you (or your household)?
4. In what ways did the estuary benefit you, but no longer does so in the same way?
5. What do you value the most about the Diep River estuary?
6. Describe how your perception of this piece of urban nature has changed over time.
7. What do you think are the major pressures on the condition of the estuary?
8. How would you go about addressing these pressures?
9. Are there any other comments you wish to make about the estuary?

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<sup>4</sup> These questions largely guided the conversations. However, interviews were free-flowing and did not all follow the same structure.