Ensuring sustainable land use and land-use change at the wildlands-urban interface in the Garden Route against the backdrop of rapid informal urbanization and climate change

by

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Abstract

Public open spaces (PoS), and urban ecological corridors that often form the Wildlands-Urban Interface (WUI) in the Garden Route, South Africa, are being lost to unplanned informal settlement due to lack of proactive planning for the poor. Proactive planning for alleviating the experience of their poverty, through provision of shelter, basic services and access to PoS, means a more inclusive and community-informed dialogue on adaptiveco-management of the WUI. Drawing on field research, policy analysis and satellite mapping in the Garden Route—specifically Mossel Bay, Sedgefield and Knysna—in the Southern Cape, this dissertation argues for informing urban planning policy with a concept of an 'ecological commons', and for adaptive governance in land use management.The idea of 'ecological commons', as land that is not suitable for development but provides provisioning ecosystem goods and services as ecological corridors or PoS, can be viewed pragmatically such that communities manage resources sustainably, without state control or privatization. In this understanding of commons, maintaining PoS ensures access, even for the poor, to land that can be used to alleviate the experience of informal settlement dwelling. However, a more nuanced, systems thinking understanding of 'commons' is required to ensure that wilderness areas, within and surrounding urban areas, are preserved as functional spaces for civil society, and as a legacy for future generations where ecosystems do not collapse into a 'tragedy of the commons' through continued loss of ecological corridors, PoS, as well as exposure of these communities to polluted and degraded landscapes that are flood and wildfire prone.

The first paper makes use of a time-series mapping exercise to identify the settlement pattern of informal settlement in the KwaNonqaba township of Mossel Bay over a 16-year period, mapped against the Spatial Development Framework planning for the same time period. The findings of the paper are that the planning does not appear to be able to effectively adapt to the rapid expansion of this settlement type post-establishment. The second paper analyses the requirements for adaptive governance of the WUI, viewed against the risks of informal settlements within these areas to climate change induced wildfire. Provincial expansion plans for urban development along the Garden Route, in conjunction with likely climate change induced migrations, rapid urbanisation and increased wildfire risk at the WUI, suggest that the extent to which these landscapes are resilient is uncertain.

Preface

The research undertaken in this thesis was conducted in the School of Agricultural, Earth and Environmental Sciences, College of Agriculture, Engineering and Science, University of KwaZulu-Natal, Pietermaritzburg, from February 2017 to May 2023, under the supervision of Professor Robert Fincham and Professor Onisimo Mutanga

I, Stephen Stead declare that the work submitted in this thesis represents my own original work and has never been submitted for examination at any other university. Where the work of others has been used, I have duly acknowledged it in the text and reference sections of this thesis.

Stephen Stead

Signed: [redacted] Date: 19th September 2023

As the candidate's supervisor, I certify the above statements and have approved this thesis for submission.

Professor Robert Fincham

Signed: [redacted] Date: 19th September 2023

As the candidate's co-supervisor, I certify the above statements and have approved this thesis for submission.

Professor Onisimo Mutanga

Signed: [redacted] Date: 19th September 2023

Declaration

I, Stephen Stead declare that:

1. The research reported in this thesis, except where otherwise indicated, is my original research.

2. This thesis has not been submitted for any degree or examination at any other university.

3. This thesis does not contain other persons' data, pictures, graphs, or other information unless specifically acknowledged as being sourced from other persons.

4. This thesis does not contain other persons' writing unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:

a. Their words have been re-written, but the general information attributed to them has been referenced.

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5. This thesis does not contain text, graphics, or tables copied and pasted from the Internet unless specifically acknowledged and the source being detailed in the thesis and in the Reference section.

Signed: 

Dedication

With thanks to Professor Robert Fincham,

for all the inspiration, support and understanding –

for instilling within me a desire for 'life-long-learning'.

To Professor Onisimo Mutanga for his contributions to the thesis and key GIS technical inputs.

To my wife, for her unwavering support.

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Acronyms

AG	Adaptive governance
CBA	Critical biodiversity area
CBNRM	Community-based natural resource management
DEA&DP	Department of Environmental Affairs and Development Planning
GHG	Greenhouse gas
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
LUM	Land use management
NCP	Natures' contribution to people
NCS	Natural climate solutions
NAS	Network action situations
PoS	Public open space
RDP	Reconstruction and Development Program
SACN	South African Cities Network
SRCCL	Special Report on Climate Change and Land
SDF	Spatial development framework

SES	Socio-ecological systems
SLM	Sustainable Land Management
UCCRN	Urban Climate Change Research Network
UGI	Urban green infrastructure
UISP	Upgrading of the Informal Settlements Program
WUI	Wildlands-urban interface

CHAPTER 1

General Introduction

1.1 Introduction

Clark and Harley (2020) argue in their paper *Sustainability Science: Towards a Synthesis* that, without intervention, inequality has a tendency to snowball over time, resulting in wealth distribution becoming more unequal. The research on which this dissertation is based, as encapsulated in the two papers—and the second in particular, postulates that more pro-active, time responsive and adaptive governance, based on both environmental justice for the people and biodiversity conservation of the wildlands-urban interface in the Garden Route, is required for this unique region. As a researcher, my contention is that a reframed concept of planning is critical, as motivated by Wheeler in the report *Climate Change and Social Ecology*, where planning is focused on "changing underlying social structures, values, and ways of understanding the world so as to help sustainability innovations come about" (Wheeler, 2016, p. 8). While the intention of the thesis is to 'agitate' for a review of the current planning *status quo* for informal settlement in the wildlands-urban interface (WUI) areas, Clark and Harley emphasise that agitation needs to be informed by research. While agitation is required to challenge the powerful entrenched interests that disproportionately benefit afew, the proposed agitation also needs to be informed by better understanding of sustainability science, "so as not to blunder blindly forward pushing development down even more destructive pathways" (Clark and Harley, 2020, p. 23).

The unique landscape of the Garden Route, the 'route' from Mossel Bay to Storms River along the southern coastline of South Africa, named as such for the prolific vegetation and unique scenery of the region. This area that is the focus area of the thesis, forms part of the eastern portion of the larger Garden Route Biosphere Reserve that was proclaimed a UNESCO Biosphere Reserve in 2016 (Garden Route Biosphere Reserve, 2016). However, while the natural and cultural landscapes of this area reflect great beauty and ecological diversity, the apartheid-planning legacy inherent in South Africa's settlement landscape continues to reflect racial discrimination and segregation, with the main informal settlements located in townships usually relegated to peripheral areas away from 'white' residential areas. Within the local planning context, against the backdrop of colonial, apartheid-inspired settlement patterning, this research highlights that planning for

informal settlement along the wildland-urban interface is often exacerbated by short-term political thinking, and without intervention, is likely to result in the long-term loss of greater civil society wellbeing and of the ecological integrity of many of the urban riverine areas. As highlighted by Charlton in 2008, many of the concerns raised regarding post-apartheid planning reflected complexity, fragmentation, and uneven distribution. More recent studies by Bernstein (2020) indicate that these issues are likely to still remain unresolved, reducing the ability for government to effectively address rapid informality in settlement. Western Cape Provincial planning for the Garden Route indicate a priority for development of urban functioning regions (Western Cape Government, 2014) which, in conjunction with likely climate-change induced migrations (Rigaud et al. 2018) infers that associated rapidgrowth of informal settlement at the wildlands-urban interface is likely to be expected. Together with the expected increase in wildfire risk (Jolly et al. 2015; Wright, 2015), it remains uncertain how resilient these landscapes are likely to be.

To better frame the planning of informal settlement in the WUI, the literature review (Chapter 2) delves into the term 'sustainability', following a broad-view perspective on the need for socio-ecological systems (SES) thinking to address complex adaptive systems and possible climate change risks that southern Cape areas could face. Following this broad-brush appraisal of SES, the review focuses on the role of sustainable land management in influencing pathways to wellbeing and nature's contribution to people, against the backdrop of changing African landscapes at risk from climate change and associated rapid urbanisation. The literature review concludes with a brief study of the land use management in relation to informal settlement in South Africa, and the inherent planning complications that arise from the history of colonial inspired, apartheid legislation.

Using a mixed-method approach to better understand the interface between nature areas and the formal and informal settlement patterns that threaten to detract from long-term SES in the Garden Route, two papers are put forward discussing the topic of informal settlement in the WUI. The first paper looks at the 15-year evolution of informal settlement growth in KwaNonqaba (Mossel Bay), viewed against the Spatial Development Planning for the area over a similar period of time. The second paper extrapolates the findings of the first paper to the broader Garden Route area, looking at how expanding informal settlements in the WUI of Knysna and Sedgefield are significantly placing these

settlements at risk from wildfires.

The concept of reducing urban sprawl, following the existing tight urban edge planning policy stipulated by the Western Cape Provincial Administration (Western Cape Government, 2014), has effectively curbed formalised development 'leap-frogging', a term describing ad-hoc development taking place peripheral to defined urban areas thuscreate an urban sprawl effect in peri-urban areas. However, unplanned informal settlements within the urban edge, in areas defined as open space and ecological corridors, remain an often 'unspoken' challenge to existing planning policy and implementation. As such, a lack of proactive planning for informal housing is forcing poorpeople into marginal areas along ecological corridors. Failing to apply proactive, transformative management practice to land use and land-use change in the Garden Route region could negate the positive urbanisation opportunities and reduce opportunities for carbon sequestration from urban forestry, and other mitigations (such as heat island reduction) and human wellbeing realisation through increased access to functional recreational spaces within and surrounding urban areas (Creutzig et al. 2015; Griscom et al. 2017).

It is against the above backdrop that this thesis was initiated following the undertaking of the visual impact assessment (VIA) by the author, for the Upgrading of the Informal Settlements Program (UISP) for Precinct 2 and 3 in KwaNonqaba in Mossel Bay, South Africa, performed as part of a Section 24G EIA application (Reference Number: 14/2/42/2/3/D6/26/0008/18) (DEA&DP, 2018). The authorisation letter (incorporated into Annexure A) and the final VIA statement (included in Annexure B) reflect an essential planning stalemate of the EIA. The Western Cape Department of Environmental Affairs and Development Planning (DEA&DP) require the VIA findings to be incorporated as a condition of the authorisation. However, the resultant VIA informed layout, requiring a review of the single residential informed planning and an adequate setback from the river corridors so that Urban Green Infrastructure planning can be incorporated, renders the development program financially unfeasible within the financial requirements for the Urban Informal Settlement Program (UISP) government funding program.

This thesis in no-way detracts from the efforts of the planners, environmental practitioners, or competent authority to implement large scaled, low-cost housing developments, but rather highlights the growing disconnect between the design criteria

of conventional, government-driven development programmes and sustainability science research literature. Nor does the thesis place any blame on the informal settlement communities, who are seeking an economically viable place to stay with limited resources, and increasingly, less governmental support. The literature, supported by local planning guidelines, critically highlights the need for the retention of public open spaces (PoS) as a core component of sustainable development, and human wellbeing (Andersson et al. 2015). The thesis questions the extent to which the planning for informal settlement, in its current form, can effectively and timeously respond to the emerging pressures of rapid urbanisation, against the backdrop of climate change and the urgent need to ensure that these settlements evolve as more resilient, peopled places that do not have to draw down heavily on natural resources located in close proximity to urban areas.

The first paper (Chapter 3) is titled *A 16-year time-series spatial analysis of KwaNonqaba informal settlement and associated open space planning, Mossel Bay, Southern Cape, South Africa.* The paper examines where and why the KwaNonqaba informal settlement took place, and how status quo planning approaches resulted in a loss of natural or open space land uses that could have been used for recreation/ provisioning eco-systems services and enhanced wellbeing for the residents. It underlines how spatial planning for informal settlement appears not to reflect the dynamic nature of the settlement type, to the detriment of local biodiversity and public open spaces and increases locality risk to flood and wildfire events.

The second paper (Chapter 4) is titled, *Wildfire threat to informal settlement: A need for Adaptive Governance of the Wildland-Urban Interface in the Western Cape Province Garden Route region, South Africa.* This paper postulates how adaptive governance could assist in more effective management of the WUI in White Location (Knysna) and Smutsville (Sedgefield), two communities at risk to wildfires and which experienced significant property damage and loss of eight documented lives as a result of the 2017 Knysna fire (Vulcan Wildfire Management, 2017). Recognising that informal settlement is often, and increasingly, taking place in wildfire risk WUI areas, there is a need to view the ecological corridors as a 'commons' that could assist in defining communally consented wildfire setback buffers, allowing for more planned service provision/fire risk management by local government.

Research into the benefits of Natural Climate Solutions emphasis the need for effective

governance of open spaces and natural areas within and adjacent to urban areas will be increasingly important in the future, adding to local ecological resources, climate change adaption mitigation, and landscape appeal (Griscom et al. 2017). Without effective governance, the abundant wildland-urban interface in the Garden Route is likely to become a contested geographic space, subjected to unplanned land-use change and subsequent environmental degradation, with losses to both natural capital and provisional eco-system goods and services opportunities. However, with effective and proactive planning and better co-management, research suggests that the enhancement of this natural capital can lead to improved wellbeing and health derived from human interaction with nature (Guerry et al. 2015; Bratman et al. 2019).

With Africa's population set to double by 2050 (Fernandes et al. 2018), and the likelihood of up to half of Africa's population living in cities by 2040 (United Nations (UN), 2018), urbanisation of the continent is going to be one of the defining characteristics of African landscapes, and a significant source of greenhouse gas (GHG) emission if not successfully managed (Creutzig et al. 2016). In South Africa, with its legacy of colonial and apartheid spatial planning, low-income communities are usually faced with limited choices for settlement and cities facing large housing backlogs (Maharaj et al. 2021). Partof apartheid planning heritage includes a lack of planning when it comes to informal settlement due to the cadastral-based and administration-focused structures inherited from British colonialism, where the focus was predominantly on regulation of formalized development (Charlton, 2008). Consequently, planning for unplanned informal settlement is very often a reactive response, following ad-hoc, unplanned settlement thathas already taken place in areas that are often not suitable for formalized settlement.

1.2 The research problem

Spatial inequalities inherited from apartheid planning policies and plans have segregated society on racial and, increasingly, on economic grounds (Charlton, 2008), currently reflected in the Garden Route landscapes. In the light of increased costs for large-scale UISP programs that are dependent on National and Provincial funding, research by the author (see Paper 1) in KwaNonqaba (Mossel Bay) has shown that settlement establishment for poor communities is becoming more informal in nature. Topographic spatial constraints for general settlement in the Garden Route result in informal settlement (IS) trending towards expansion into common open spaces along river systems and natural areas that are not effectively managed by local government or

recognized as formal residential areas in planning documentation. This un-planned informal settlement in into urban ecological areas is often associated with increased exposure to drying vegetation biomass (Vulcan Wildfire Management, 2017) and therefore, as experienced in the 2017 and 2018 wildfires, will increase community exposure to wildfire risk. Informal settlements in the Garden Route are invariably located on steep ground areas, which increases fire intensity and limits access for municipal fire services to fight wildfires. Informal settlement is also prevalent in river flood plains, which increases the risk of communitiesto extreme floods events. In both scenarios, the terrain is not conducive to informal residential settlement. In addition, these settlements are often not provided with basic services due to increased costs to Local Municipalities, and/or from resistance to having to establish and maintain service provision in temporary settlement locations. Thus, resettlement is the only option for mitigation of the risk but carries with it associated increased social impacts on the community, including violet protest and demonstration against legal forced removal.

The following points highlight possible challenges that the Garden Route is facing in relation to rapid informal settlement scenarios, as emerged in analysis of informal exchanges the researcher engaged in with local planners in the Garden Route:

- While sustainable development policy is applicable at National, Provincial and Local Governance levels, on the ground implementation is challenging where there is a lack of capacity to enforce the environmental policy in increasingly informal settlement in the WUI.
- Municipal management of open spaces within the urban context is being constrained by increased cost and lack of skills required for management and maintenance of these area.
- Silo mentality limits the ability to implement the required sustainable land management policy mix that emanates from different governmental agencies.

In summary, it is likely that the lack of trans- and inter-disciplinary governance, as a result of intra- and inter-isolation of governmental departments, is limiting integrated management opportunities where core governance requirements of effective management of ecological corridor objectives often fail to be enacted.

1.3 The study area

The area of study is defined as the Garden Route, an area in the southern Cape, within the Western Cape Province. The Garden Route falls within the larger Garden Route Biosphere Reserve (Figure 1), which was proclaimed by UNESCO in 2016 in the light of the internationally recognized terrestrial and coastal marine ecosystems of the area, which "innovate and demonstrate approaches to conservation and sustainable development" (UNCN and UNEP-WCMC, 2014, p. 1). The main towns along the Garden Route (Figure 2), are Mossel Bay to the east, George, Sedgefield, Knysna within the central area, and Plettenberg Bay in the west. As a result of the spatial planning legacy of apartheid, most of the urban areas remain racially segregated, with each of the main towns having a formalised township for either/ or 'so called' black and coloured communities. The main township in Mossel Bay is KwaNonqaba, Thembalethu and Pacaltsdorp in George, Smutsville in Sedgefield, Xoleni/ Whites Location in Knysna and KwaNonkuthula in Plettenberg Bay.

Climatically the area is zoned as a Temperate zone with above average national rainfall resulting in the growth of large tracts of indigenous and non-indigenous vegetation species such that the area has historically being perceived as a 'garden', or nature-based environment. The many steep sided river valleys and rugged terrain historically restricted access and settlement to much of the area. This has resulted in the area being rich in natural capital with large pockets of natural vegetation being retained. Over time this has defined the 'garden' senseof place and this landscape context has been linked to a growing tourism economy and the naming of the area as the 'Garden Route', as well as have the potentialfor reforestation, avoidance of forest conversion, improved natural forest and plantation management, avoidance of wood fuel use, and fire management as having natural climate solutions (NCS) potential (Griscom et al. 2017). Given the forested nature of much of the Garden Route region, this region could be used as a portion of South Africa's Intended Nationally Declared Contributions to climate change mitigation. However, the researchers indicated that in general, if NCS opportunities are to be enacted, better stewardship is needed if these (and other) resources are to represent a cost-effective climate mitigation. With rapid urbanisation, the wildland-urban interface is likely to become increasingly contested, and the resultant land use and land-use change need to be carefully evaluated.

For this reason, a review of the existing governance policy and planning is required if more sustainable pathways and long-term socio-ecological benefits of NCS can be achieved. Land use conflict is likely to be more contested in areas such as the Garden Route, where rapid in-migration (George Municipality, 2023) is taking place, with potential to increase pressures upon fragile ecosystems that underpin the ecological integrity of the region. Although initiatives for formal protection of parks and public open spaces are implemented in most of the formally planned towns of the Garden Route, the lack of proactive planning catering for the influx of lower-income groups is evident in the marginal areas where informal settlement has manifested in urban-fringe and ecological corridor areas in the Garden Route.

While some higher density, more centrally located and innovative planning for low-income housing is taking place in some Garden Route municipalities, the scale of the backlog in housing delivery has resulted in the 'site and service' approach being promoted by Government in the formalising of much of the existing informal settlement. When located along ecological corridors, the linear development restricts municipal accessto the river areas for settlement management, refuse removal resulting in pollution of theriver systems, wildfire risk and often a continued informal settlement expansion and further encroachment into natural areas. Without intervention, these informal settlements often result in continued spatial expression of lower density urban sprawl, increasing the potential for further loss of biodiversity and urban spaces that could be utilised as recreation areas.

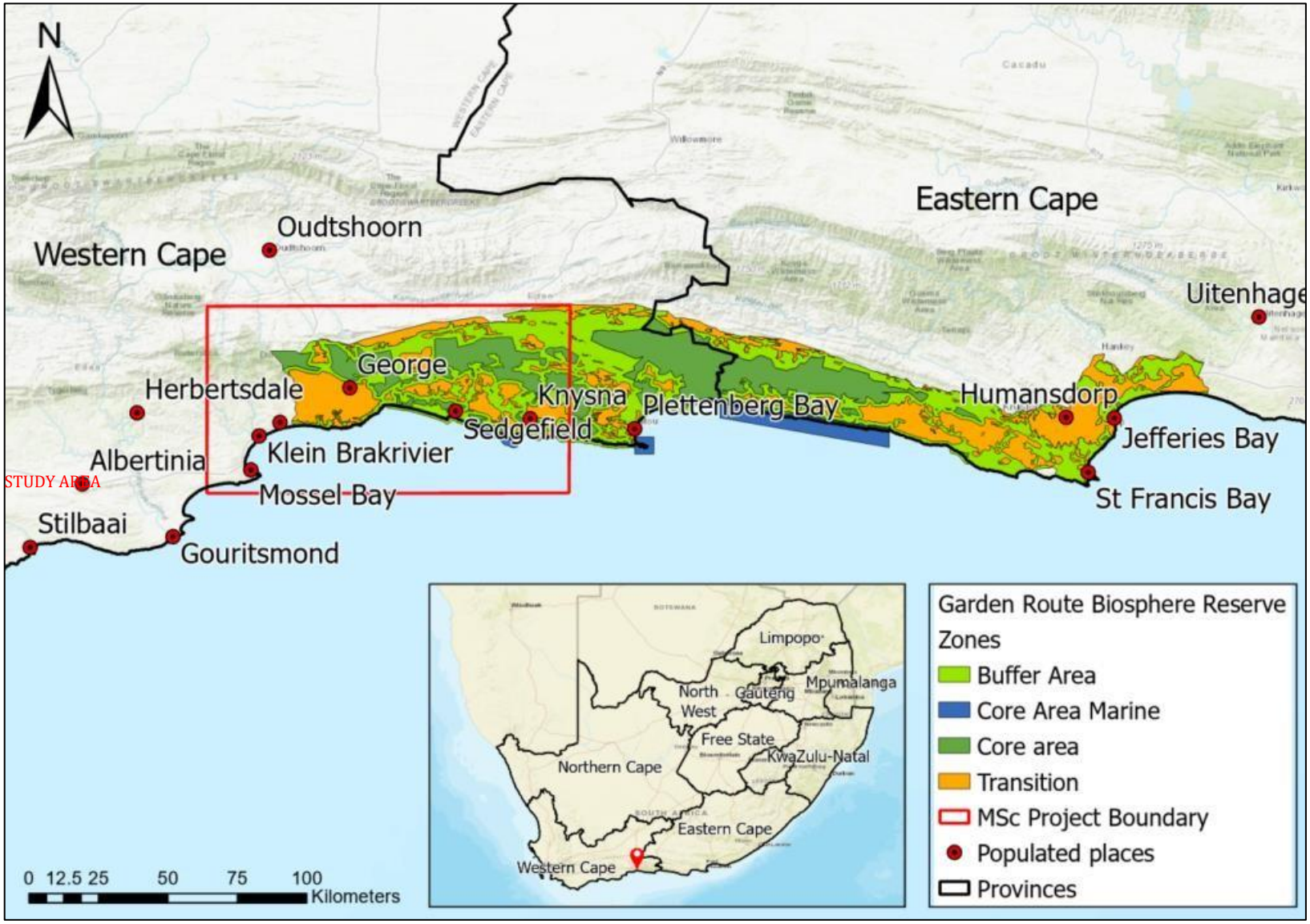


Figure 1. Situation map of the Garden Route Biosphere Reserve and the Garden Route study area. (Source: Garden Route Biosphere Reserve, 2016; ESRI South Africa, 2022)

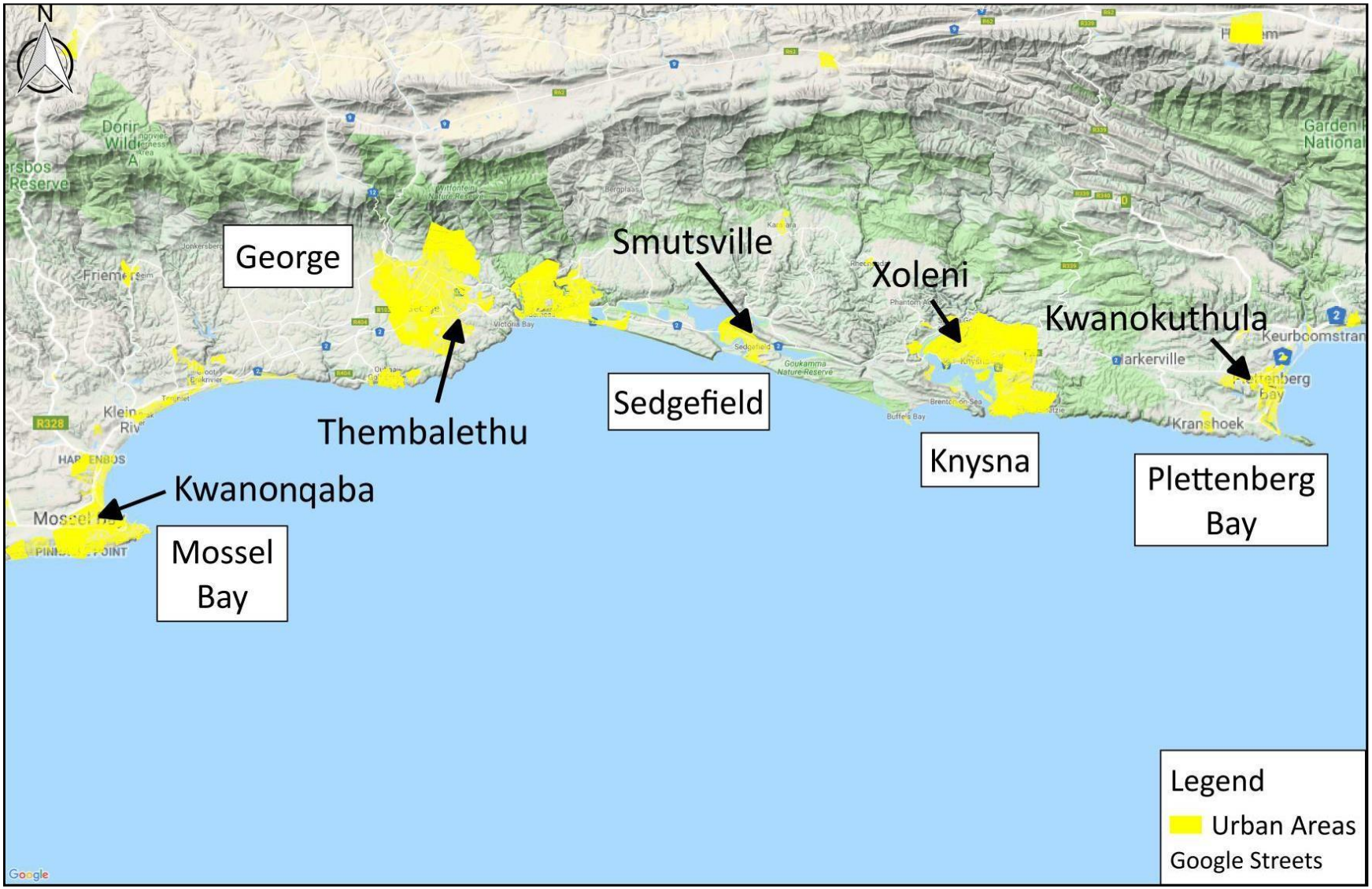


Figure 2. Core Garden Route urban areas depicting the main towns and township areas. (Source: Garden Route Biosphere Reserve, 2016; Google Streets Mapping, 2022)

CHAPTER 2

Theoretical Framework

2.1 The research problem

Within the context of assessing if the UISP planning can address the emerging trends of rapid urbanisation in the Garden Route, a clear theme emerges within sustainability science literature—namely: the imperative for improved governance of how humans' interface with natural capital, especially in the context of the rapidly urbanising landscape of sub-Saharan Africa. Critically, planners need to recognise the benefit, and climate change mitigations, that can be derived from natures contribution to people (NCP). This concept is broadly defined by Diaz et al. "as all the contributions, both positive and negative, of living nature (diversity of organisms, ecosystems, and their associated ecological and evolutionary processes) to people's quality of life" (Díaz et al. 2018, p. 270). Diaz et al. suggest that the beneficial aspects can include the provision of food, purification of water and artistic inspiration, and detrimental contributions arising from the loss of natural capital including disease and predation that negatively impacts people or their assets.

Fundamental to ensuring NCP, a different approach to management of the wildlands-urban interface is required such that the promoted sustainable outcomes are achieved. This chapter broadly looks at sustainability science framing required for better management earth systems and the underlying climate change risks that sub-Saharan Africa faces. As a component of climate change mitigation and human wellbeing, the second section provides a broad research overview of possible pathways to sustainable land management that can facilitate NCP. Following this, the theoretical framework delves into urbanising trends in sub-Saharan Africa, before considering land use management (LUM) risks inherent in South African planning that are hindering effective management of informal settlement (Charlton, 2008). To ensure sustainability of LUM inSouth Africa, the review concludes that a more informed sustainability science framing isrequired in the management of the WUI, referencing concepts put forward by Clark and Harley (2020) as key themes that could assist in achieving this objective, and after Ostrom, better conceptualise the 'ecological commons' (Ostrom, 1992).

2.2 Complex adaptive systems and climate change: Sustainability science framing

Clark and Harley (2020), reflect on the growing concern scientists have with regards to transformation of natural systems by humans. The authors note that within the dominant arrangements of powerful incumbent interests strongly influencing development, the subsequent pathways "appear unwilling to heed the ubiquitous distress signals of today's Anthropocene" (Clark and Harley, 2020, p. 3). Humanity is now facing the complexities of two perplexing and alarming trends that characterise modern existence: 'the great escape' and 'the great acceleration'. The great escape, described by Deaton (2013), outlines the rapid and unprecedented improvements that humanity has experienced in knowledge and wellbeing over the last two centuries, during which much of the world's population have managed to escape from grinding poverty. The second trend, described as the 'great acceleration' (McNeill and Engelke, 2014), reflects on the magnitude of global human impacts on nature due to the growth in population that results from unsustainable development and the subsequent increase in energy consumption and resource depletion. Arguably, the controversial paper *The Tragedy of the Commons* (Hardin, 1968) is playing itself out on the global climate change stage as the Greenhouse Gas 'commons'. The following quotation from Hardin could have relevance to today's predicament:

> *"The rational man finds that his share of the cost of the wastes he discharges into the commons is less than the cost of purifying his wastes before releasing them. Since this is true for everyone, we are locked into a system of "fouling our own nest," so long as we behave only as independent, rational, free-enterprisers".* (Hardin, 1968, p. 1245).

While clear benefits to human wellbeing have been achieved from the great acceleration, Clark and Harley highlight that these benefits have resulted in significant and growing inequalities between peoples and places and significant earth system transformation brought about by human activities. Tensions contained in these two global trends, and the resultant exposure to multiple, perplexing and alarming events, have resulted in whatis now referred to by many as the Anthropocene System, which is described by the authors as a term used by some to describe the framework that "captures the increasingly global and intimate intertwining of nature and society" (Clark and Harley, 2020, p. 3). Steffen et al. (2018) outline the concept of the Anthropocene as a proposed new geological epoch, based on scientific observation that human impacts on essential earth-systems have become so profound that the Earth has moved from the Holocene epoch, which is the only earth-system state known to support contemporary human societies. Multiple authors

highlight that the question of how to maintain the existing standard of living without destruction of the natural systems that sustain all life on earth remains unanswered (Rockström et al. 2009; Griscom et al. 2017; Hickel, 2018; O'Neill et al. 2018; Clark and Harley, 2020).

The Global Change Institute, in a paper titled *The Climate Risks We Face in the 21st Century*, emphasises that climate change does not happen in a vacuum, but acts as an additional stressor and threat multiplier to existing problems (Global Change Institute, 2020). This effect tends to make current threats much worse, exacerbating pre-existing systemic and structural issues. For many, the daily challenges associated with living in southern Africa tend to be a primary concern, hiding the true extent of the risk of climate change—namely that "climate change is not a problem of the future, but a problem of the present that becomes insoluble in the future if we do not take decisive actions now" (ibid p. 5). Steffen et al. contend that the earth-system is influenced by bio-geophysical feedbacks such that earth-system stability transitions to a different state, where the more stable Holocene-like conditions, are weakening relative to human activities. This increases the risk that positive feedbacks could play an important role in negatively influencing the Earth System's climate stability trajectory (Steffen et al. 2018), and argue that human activities, and their subsequent earth-system influencing actions, need to be recognised as a key component of the earth as a complex, adaptive system. The importance of this statement is that this framing focuses not only on the system dynamics that reduce greenhouse gas emissions, but also emphasises actions that "create or enhance negative feedbacks that reduce the risk to the Earth" (ibid). The authors emphasise that adaptive steps to reduce dangerous impact influencing earth-system stability are required, including effective monitoring and deliberate change in behaviour. The need to better understand the steps required to address the risk to earth-system stability, has led to therecent interest in the term socio-ecological systems (SES), which is defined as "action situation focus on how actors use resources in particular contexts, role of actors and institutions in governance outcomes, and multi-level (cross-scale) linkages" (Clark and Harley, 2020, p. 6).

The Future We Don't Want report is defined by the authors as "a collaboration between C40 Cities, Global Covenant of Mayors, Acclimatise, and the Urban Climate Change Research Network (UCCRN). The report is aimed at understanding and communicating key challenges cities are facing, and will continue to face, as a result of climate change" (UCCRN, 2018, p. 4). By means of scientific global data analysis, this technical report

serves to build narratives and key communication tools around global impacts of climate change on cities, and to provide possible responses that will serve as an inspirationfor other cities building their resilience plans (UCCRN, 2018). The report reflects a data analysis of six major global urban vulnerabilities to climate change, reflecting on the current threat status and the predicted 2050 threat status. While at a broad scale, southern Africa is represented on the UCCRN mapping. The six major urban vulnerabilities are:

- Extreme heat
- Extreme heat and poverty
- Water availability
- Food security, and
- Sea level rise and power plants

The report indicates that many of the cities that are susceptible to higher-than-average climate change impacts show particularly high growth rates—especially those in low-income countries of Asia and Africa where nearly 90% of the increase in urban population between now and 2050 is expected to take place (UCCRN, 2018).Key mitigations noted for assisting vulnerable communities include mobilising resources to improve equity and environmental justice, at the same time noting that under changingclimatic conditions participation of impacted communities and the involvement of civil society is necessary (UCCRN, 2018).

A more geographically relevant appraisal of the climate change risks was undertaken by the Global Change Institute (GCI) (2020), addressing climate change risks specifically in the southern African context. The emerging climate risks in southern Africa were assessed and clustered into five broadthemes—namely:

- Risks related to food insecurity and the agricultural sector
- Risks related to water insecurity
- Risks related to the energy system
- Risks to human health and wellbeing

Risk of loss of ecosystem services and biodiversity The GCI infer that food insecurity and risks to agricultural sectors could result in inadequate household and community nutrition due to crop

and livestock production failures, and to issues associated with the non-viability of agriculture-based activities related to both subsistence and commercial farming. Also related to food insecurity issues, water insecurity links to shortages of suitable water for domestic, industrial, and agricultural usage. Risks related to the energy system are associated with a lack of transition to future social and economic development, while health and wellbeing risks could result from heat stress. The GCI flag risks to ecosystems services related to loss of natural pollinators, nature-based tourism, and ecological stability.

A factor increasingly associated with climate change research is the added risk of wildfires. Jolly et al. (2015) highlight the likelihood that the fire weather season length will increase in ecosystems such as South Africa's Mediterranean fynbos, leading to more frequent severe burning conditions over a larger area that will shorten fire return intervals and threaten these biodiversity-rich shrublands. Blaxter et al. (2016) indicate that increased fire risk has implications for poorly planned urbanisation, and informal settlements, placing people at risk of fire, flood, and landslides.

Wheeler (2016) takes a different approach to the climate crisis, depicting the crises of global warming as a challenge of rapid social evolution. Wheeler makes reference to the term 'ecological thought' which he defines as "understanding the multiple, dynamic, evolving contexts in which we live" (Wheeler, 2016, p. 4). This approach allows for thinking across scales, across disciplines,across communities, and across time frames, and allows for an understanding of the interrelationships within systems, and, from this informed perspective, to perceive constructive ways to nudge evolutions in positive directions. This concept is drawn from the philosophical ideas of Social Ecology conceptualised by Murray Bookchin, which Wheeler describes as "sets of social organizations, values, beliefs, technologies, and environments that interact to determine the nature and evolution of a society" (Wheeler,2016, p. 4). Bookchin (1980) holds that the basic tenet of the climate crises is a social crisis. He argues that, if the roots of the present ecological crisis are to be found, rather than a focus on technology, growth and demographics, "*we must turn to the underlying institutional, moral, and spiritual changes in human society that produced hierarchy and domination — not only in bourgeois,feudal and ancient society, nor in class societies generally, but at the very dawn of civilization"* (Bookchin, 1980, p. 22).

Bookchin's argument is supported by Wheeler, who states that in order to address impending catastrophes and to evolve more sustainable development pathways, planners

need to focus on improving social ecology—with attention to values, mind-sets, and social organization. The steps to achieve this rapid evolution of society include improved democracy through institutional reforms, educational strategies to further the understanding of complex issues amongst the general public, and measures to prevent unsustainable shaping of societies by corporations and the wealthy. Given the powerful force of capitalism, Wheeler motivates for an ethics of the commons where the intrinsic value of nature could possibly "counteract the tide of commodification" (Wheeler, 2016, p. 132).

The question that Wheeler raises is whether humans can initiate social progress proactively, before crises escalate to a point where they endanger humanities very existence. Wheeler emphasises that it is crucial to consider whether communities can actively guide the development of desired traits themselves, opting to support a variety of cultures and values that align with both human and ecological wellbeing, rather than allowing corporations and the privileged few to make decisions on their behalf (Wheeler, 2016). The following section looks at the benefits that can be derived from nature,if more sustainable and human wellbeing aligned pathways are followed.

2.2.1 Nature's contribution: Pathways to sustainable land management

Griscom et al. (2017) define natural climate solutions (NCS) as "terrestrial conservation, restoration, and improved practices pathways, which include safeguards for food, fibre, and habitat that increase carbon storage and/or avoid greenhouse gas emissions across global forests, wetlands, grasslands, and agricultural lands" (Ibid 2017b, p. 1). This is not proposed as a stand-alone mitigation, but rather also requires carbon reduction planning and practices, with Griscom et al. emphasising that the concept of NCS does allowfor cost effective, enhanced sequestration of carbon in the near term, and increased resilience against extreme climatic events. The researcher concludes that NCS has the potential to fulfil more than a third of the cost-effective climatemitigation required between 2017 and 2030 in order to stabilize warming to below 2°C (Griscom et al. 2017). However, a key requirement for NCS success, if climate change adaption pathways are to be followed, is proactive and early alignment in planning for land use and land-use change (Griscom et al. 2017). The authors note conservation, restoration, and improved land management, as necessary steps for transition to a carbonneutral global economy and a stable climate. As there is a wide interpretation of the practice of NCS, the authors emphasise that confusion persists regarding the specific actions required to both increase carbon sinks and improve

land stewardship in such a manner that emissions from land use activities are reduced (Griscom et al. 2017). The authors note that of relevance to improving land stewardship, recent research has emphasised the need to view nature as an integral component of human survival, rather than simply as an economic service that humans can draw from infinitely.

Within this broad theme of improved land stewardship, the term 'living landscape' has been used by The Wildlife Trust in the United Kingdom to portray a different approach to nature conservation, where humans (a) move from being dominators and controllers of nature to appreciators and influences of nature; (b) change their perceptions of nature as special interest to viewing nature as providing the living conditions of humans; and (c) dismiss the situation of applying nature as a box, to engaging nature in the neighbourhood and within the landscape (The Wildlife Trust, n.d.). Increasingly, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has been emphasising that human civilisation cannot be sustained without nature (Díaz et al. 2019), motivating for a broader interpretation of ecosystems goods and services. To emphasise this broader view, IPBES introduced the term 'nature's contribution to people' (NCP), which is defined as "all the contributions, both positive andnegative, of living nature to people's quality of life" (Díaz et al. 2018, p. 1). Díaz et al. indicate that NCP builds on the conceptual framework of ecosystem services, popularised by the Millennium Ecosystem Assessment, but highlight that the concept has raised some scepticism, based on the perceived risks involving commodification of nature (Díaz et al. 2018). The authors argue that, for the term NCP to be more broadly accepted, it is necessary for the incorporation of broader viewpoints and stakeholders that are less likely to be subsumed within narrow market-based approaches as mediatingfactors between people and nature.

A key take-away from the IPBES report is that it highlights that nature and nature's contributions to people are vital for human existence and good quality of life, allowing improved human wellbeing for a harmonious co-existence with nature (Díaz, et al. 2019). Numerous other researchers highlight the importance of human well- being (Deaton, 2013; Bragg et al. 2015; Bratman et al. 2019). Bratman et al. (2019) make reference to a growing body of research that emphasises the value of nature experiences in relation to positive mental health, highlighting that, with rapid urbanisation and the resultant reduction in exposure (contact) to nature globally, crucial decisions need to be made about how to preserve and enhance opportunities for nature experiences. Bratman et al.

motivate that there is scientific evidence that supports an association between types of nature experience and increased psychological wellbeing, and a reduction of risk factors and burden of some types of mental illness. Of concern, the author notes that there is research that opportunities for some types ofnature experience are decreasing in quantity and quality for many people around the globe (ibid). The well-proven wellbeing benefits cited by Bratman et al. include happiness and wellbeing, community cohesion, improved manageability of life tasks and decreased mental stress.

At a planning level, research by Andersson et al (2015) and the organisation GreenSurge, highlights that resilience planning and utilisation of Green - Grey infrastructure has the potential to positively contribute to urban living. The term 'grey infrastructure' being conventionally used in engineering of water systems, with the term Green-grey used in UGI planning as the integration of stormwater systems/ pipelines with other kinds of infrastructure such as bike paths along rights-of-way below power- lines, gardens along railways, connecting parks and street trees that reduce the heat island effect and add landscaped value to urban areas. Andersson et al. (2015) look at the value of UGI in poverty eradication, inclusiveness and public spaces in Europe, stating that as demonstrated by multiple case studies, properly designed UGI can help achieve both environmental and social objectives, including poverty alleviation and inclusiveness (Andersson et al. 2015). Another key benefit of UGI highlighted by the authors is avoided costs due to economic efficiency, listing air quality improvements, psychological wellbeing, improved physical activity, improved mental health, and importantly, avoided costs incurred from flood damage and associated reduced insurance costs by prevention.

The recent IPCC Special Report on Climate Change and Land (SRCCL) looks at the relationship between climate change and desertification, land degradation, sustainable land management, food security and greenhouse gas changes in terrestrial ecosystems (IPCC, 2019). The importance of land use and land-use change in relation to climate change adaption is identified as an important mitigation pathway. The IPCC report assigns a high confidence correlation between changes in land conditions and global andregional climate (IPCC, 2019), noting that changes in land condition are related to land cover change, which includes deforestation, afforestation, urbanisation, land use and landstate. That land degradation is a pervasive, international issue is further supported by a recent report by the United Nations Food and Agriculture Organsation (FAO, 2019), indicates that combatting land degradation is an urgent priorityin order to protect the biodiversity

and ecosystem services vital to all life on Earth and ensuring continued human wellbeing.

To ensure that the significance of 'land management' is raised, the SRCCL report notes the importance of the term 'sustainable land management', (SLM), which is the link to the principal basis from which human livelihoods and wellbeing are derived (IPCC, 2019). SLM is defined in the SRCCL report "as the stewardship and use of land resources, including soils, water, animals and plants, to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions" (IPCC, 2019, p. 24). This definition differs from the famous Brundtland definition for sustainable development which is: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987, p. 41). Given the significant destruction of earth-systems perpetuated subsequent to coining of the Brundtland definition in 1987, recent research is highlighting that a better understanding of the term 'sustainable development' is required (Clark and Harley, 2020). Based on this mounting scientific evidence, there is a growing need to raise awareness with regards to land use and land-use change as a climate change adaption pathway, and to improve scientific understanding and standards with regard to the management of land use and land-use change in South Africa.

The following section looks at the rapid urbanisation in Southern African and reflects on the risks and opportunities related to rapid urbanisation, against the backdrop of climate change and the benefits that could be derived from nature contribution to people.

2.2.2 Changing African landscapes: Climate change and rapid urbanisation

The *State of the World's Cities 2012/2-13* report states that humanity has never encountered a series of interconnected crises of such magnitude as it has experience since 2008. The crises have encompassed multiple domains, including those linked to financial, economic, environmental, social and political spheres, leading to repercussions from escalating unemployment rates, scarcity of food, immense pressure on financial institutions, destabilisation of geo-political systems and increased feelings of insecurity (UN-HABITAT, 2012). To highlight these challenges and possible solutions within the urban context, the United Nations Conference of Housing and Sustainable Urban Development adopted the Habitat III New Urban Agenda in 2016. The Agenda notes that urbanization will be one of the 21st century's most transformative trends, with the world

urban population expected to nearly double by the year 2050 (UN, 2016). This is verified by the recent United National report *World Urbanisation Prospects 2018* that indicates that, in the next three decades to 2050, Africa and Asia urban populations will reflect a marked increase, and by mid-century the urban population of Africa is likely to almost triple (UN, 2018).

Research also indicates that climate change is likely to compound the problem of rapid population growth and urbanisation in Africa through forced migration. According to the 2018 United Nations report *Groundswell: Preparing for Internal Climate Migration* (Rigaud *et al.*, 2018), under a pessimistic modelling scenario characterized by high emissions and unequal development, the projected number of global climate migrants by 2050 could exceed 143 million individuals. On average, the estimated figure stands at 118 million, with a minimum estimate of 92 million, contingent upon the specific modelling scenario employed (Rigaud et al. 2018). The modelling for Sub-Saharan Africa indicates that, in worst-case scenarios, as many as 85.7 million climate migrations could take placewithin the region. Riguad et al. find that rural-to-urban migration rates are growing rapidly in Sub-Saharan Africa, although the region is less urbanised than others (Rigaud et al. 2018). The reasons for this trend are cited as being, firstly, that Sub-Saharan Africa is highly vulnerable to climate impacts along exposed coastlines and in already fragile drylands. Secondly, the region's agriculture, which is a significant portion of the economy through employment opportunity, is highly dependent on rainfall for most its crop production (Rigaud et al. 2018). In terms of regional variations in migration within Sub Saharan Africa, Mariama Awumbila assesses the key trends and issue drivers of migration and urbanization in Africa. The findings indicate that major destination countries identified by people migrating within Africa are South Africa, Côte d'Ivoire, Nigeria, Kenya, and Ethiopia (Awumbila, 2017). Awumbila also refers to the Council for Scientific and Industrial Research (South Africa), indicating that the end of apartheid and the integration of South Africa into the South African Development Community region makes South Africa the preferred destination for many migrants.

Urbanization, according to the United Nations report *World Urbanization Prospects 2018,* is a multifaceted socio-economic process that involves the conversion of ruralareas into urban settlements and the relocation of people from rural to urban regions. This transformative process not only affects the physical landscape but brings aboutsignificant changes in various aspects of society. The report highlights that this urbanization process

leads to shifts in dominant occupations, lifestyles, cultures, and behaviours, that consequently alter the demographic and social structures of both urbanand rural areas. The urbanization process further results in changes in the quantity, land area, and population size of urban settlements, and in the proportion and number of urban residents in comparison to those residing in rural areas (UN, 2018). The UN report emphasises the relevance of recognising this expected rapid land use change, is to ensure that the resulting transformation is outcome-positive with the creation of urban areas where public and private services of high quality are available and where similar, urban basic services are more accessible than in rural areas.

The value of urbanisation is stated in the report as being related to the three dimensions of sustainable development: namely economic, social, and environmental. Effective urbanization management, along with other factors, can contribute to optimizing the advantages of this transformation, while mitigating environmental degradation and potential negative consequences of increasing urban population concentrations. By considering long-term population trends, well-informed urbanization strategies can help minimize adverse impacts, particularly in low-income and lower-middle-income nations that are projected to experience rapid urbanization between 2018 and 2050 (UN, 2018). Unplanned or inadequate management of urban expansion, in combination with unsustainable production and consumption patterns, can result in urban sprawl, pollution and environmental degradation. The UN report indicates that these negative effects can negate sustainable city initiatives, and that a lack of capacity of public institutions to manage the urbanisation process is a factor influencing sustainability outcomes.

Another benefit to well planned urbanisation is reduced GHG emissions. Research by Creutzig et al. analysing driving factors of GHG emissions in urban settlements found that proactive planning in some newly urbanizing places, especially in Asia, the Middle East, and Africa, could reduce future urban energy use by 20–25% between 2015 and 2050 (Creutzig et al. 2015). The authors found that in these places, most of the urban development that will be on the ground in 2050 is yet to be built, thus offering an unprecedented opportunity to develop low-carbon pathways from proactive scenario planning. The motivation provided for this demand-side solution for climate change mitigation, is also supported from a climate change perspective where low-carbon cities are easiest to build as there is no lock-in of entrenched urban form (Creutzig et al. 2016).

How African emerging urban areas are managed is critical to ensuring an end to poverty and allowing for sustainable economic growth in these vulnerable countries. Kariuk et al. (2013) look at harnessing the benefits of urbanisation to end poverty and boost prosperity in Africa. The finding of thereport is that global evidence supports that well-managed urbanization holds the potential to drive progress, foster economic growth, facilitate employment opportunities, and eradicate poverty, as "cities are engines of economic growth, attracting and galvanizing entrepreneurs and productive capital, and this potential can also be harnessed to achieve reductions in poverty" (Kariuki et al. 2013, p. 4). However, the report emphasises that strong commitment and a broad consensus is needed to: firstly, reform the policy and legal framework for better integration of city planning and management; secondly, increase the scale and quality of investments in infrastructure; and, finally, strengthen the institutions and systems that make cities both competitive andsustainable (Kariuki et al. 2013). Thus, research is pointing to the critical importanceof governance to effectively support a positive outcome from the urbanisation processes and planning.

In the book *Climate Change and Social Ecology* Wheeler (2016) emphasises that civil society needs to review planning, which should not be a bureaucratic, coercive and top-down exercise of municipal authority aimed just at managing their land development or economic growth. Wheeler motivates that, in order to move towards more sustainable pathways, planning needs to be seen as creative, participatory, and proactive groundwork for improving humanities ability to respond to such crises, and not just for reducing emissions and improving other sustainability indicators (ibid). To overcome the Anthropocene changes, Wheeler notes that multiple types of planning—including both pragmatic and the visionary approaches—allowing for a broad time-focus of near- term and the long-term that is also multi-scaled, is necessary so that social ecology is improved, and sustainability problems are addressed (ibid).

This move to new approaches to environmental governance is supported by Chaffin Gosnell and Cosens (2014) who note that, with the uncertainties of global environmental change, climate change and land use changes, governance systems need to become highly adaptive. The authors note the following as relevance to this emerging discipline:

> *"There is a need, therefore, to champion new approaches to environmental governance capable of confronting landscape-scale problems in a manner both flexible enough to address highly contextualized SESs and dynamic and responsive*

enough to adjust to complex, unpredictable feedbacks between social and ecological system components". (Chaffin et al. 2014, p. 55)

However, concern is raised by Chaffin et al. (2014) that the lack of alignment of the more bottom-up approaches that have emerged in response to the centralised state encumbrances often suffer from coordination problems in relation to complex geographies.

'Environmental governance' is defined by Chaffin et al. as "the system of institutions, including rules, laws, regulations, policies, and social norms, and organizations involved in governing environmental resource use and/or protection', to which, they state 'there are a variety of different approaches" (Chaffin et al. 2014, p. 54). An emergent approach that falls within environmental governance is that of'adaptive governance' (AG), aimed at promoting innovative environmental governance approaches that can effectively tackle landscape-scale challenges. This requires a flexibleframework that can adapt to highly contextualized SESs, the framework should be dynamic and responsive enough to accommodate complex and unpredictable interactions and feedback loops between different components of the social and ecological systems (ibid). Drawing on a synthesis of research on AG, Chaffin et al. note that the authors who defined AG also define what AG should do--namely:

- Provide information (science and local knowledge)
- Deal with conflict
- Induce rule compliance
- Provide infrastructure, and
- Be prepared for change.

While the process tends to be messy and is never the same in two places due to the organic nature of the process, the authors note that with the implementation of the above guidelines, adaptive capacity can be enhanced, which is essential for dealing with complexity and uncertainty associated with facing rapid global environmental changes. Of relevance to the study, Chaffin et al. note that AG can emerge where there is an initiation of a transformation movement, seeking new and more desirable states ofenvironmental governance, or when there is a reorganization in response to biophysical shocks to the system (ibid). Representing a dynamic link between social and ecological landscapes that encompass complex ecological systems, uncertainty and unknown feedbacks in the

management of ecological resources, AG is born from the social desire for holistic SESs management (Chaffin, et al. 2014).

Fundamental to achieving the required 'fit', Chaffin et al. (2014) cite Olsson et al.'s (2007) proposed three key social connectors, which have further relevance to the current study—namely, firstly, leadership by individual actors; secondly, coordinating actors across a multilevel governance system through networks; and, finally, activating social memory stored in social networks. The authors note that networking is a key aspects of the process to create cross-level and cross-scale linkages, allowing for broader participation and a system-wide scaled experimentation to establish a culture of learning to increase knowledge generation and learning across a multilevel governance structure (ibid). This proposition opens up the need to review the manner in which more adaptive planning is undertaken, within an AG framework, specific to South Africa land use management practice.

Thus, by embracing climate change transformative management strategies embedded within a sustainable land management framework, local governance structures in South Africa have the opportunity to ensure more adaptive, pro-active, socially just and sustainable socio-ecological outcomes through inclusive, AG processes. This requires a new, systems-thinking based approach where intra-institutional collaboration and cross- or inter-institutional collaboration must be implemented. Not applying proactive, transformative management to land management—that is, a more informed and participatory understanding of sustainable development—could result in increased urban-ecological land use conflict. How the expected rapid urbanisation relates to the South African land use management context is outlined in the following section.

2.2.3 South African land use management: Informal settlement and apartheid context

The Human Rights Commission report titled *The parlous state of poverty eradication* (Alston, 2020) emphasises the critical need to re-evaluate the international responses to the alleviation of extreme poverty. The report emphases that humanity is at an existential crossroads following multiple challenges, including a pandemic, a deep economic recession, devastating climate change, extreme inequality, and movements challenging the prevalence of racism in many countries. Further emphasised is the longstanding neglect of extreme poverty, which has been so clearly highlighted by the COVID-19 pandemic. Cobbinah et al., reflecting on COVID-19 and urban planning in Africa, also note

that the pandemic raises questions regarding the effectiveness of current urban planning. They suggest the need for more constructive protocols for planning thatpromotes public health on the continent by allowing, amongst other key themes, for integrating larger open spaces within the urban fabric (Cobbinah et al. 2020). It is within this context that South African planning is increasingly faced with challenges that arise with the merging of the inherited colonial cadastral planning system and emergent, post-colonial traditional land management systems centred around communal land management ideals. While emphasising the clear benefits of urbanisation, Bekker et al. (2021) note that history has shown that advantages ofurbanisation in Africa have tended to benefit only a few and that there has been a tendency for urbanisation to fail to provide sustainable space for all "physically, as well as in the civic, socio-economic and cultural dimensions attached to collective space" (Bekker et al. 2021, p. 2). Noting that as Africa's primary youthful labour force is expected to expand from 400 million to 1.2 billion before 2050, the economies are unlikely to produce sufficient employment for this expanding populous. A consequence of this is that the majority of the urban population in Africa continues to live in sprawling informal settlements, with half of the countries on the continent having an informal settlement incidence of at least 60%, and more residents are poorer in 2020 than in 1990. Urban planning in these citieshas not been able to keep up with this population growth and development (ibid). The statistics are relevant to the South African context, however within the South African context there is the added burden of many decades of apartheid ideological planning which has warped the South African settlement pattern.

The *Second South Africa Outlook*, published by the South Africa Department of Environmental Affairs in 2016, reflects a similar urbanisation discourse to the above stated research in urbanisation in southern Africa, with the exception that it maintains that South Africa is ahead of the global and sub-Saharan African urbanisation trend (Department of Environmental Affairs, 2016). As a result of this historic imbalance, the report emphasises that the population of South Africa has remained stratified along the lines of inequality. South Africa is ranked amongst the most unequal societies in the world, with 13% of the population living in first world like conditions and the greater majority remaining in poverty (Department of Environmental Affairs, 2016). The report emphasises that, with the change in legislation, urban centres and cities were not geared up or ready for the influx of population, which resultedin challenges of urban sprawl with the poor often relegated to the periphery of cities, deprived of access to basic services.

The South African Cities Network (SACN) (2016) report on the state of South African cities confirms the importance that cities have in driving growth, and notes that cities in South Africa are responsible for almost two-thirds of the country's economic activity, and over half of national employment. Cities are thus well positioned to take a lead in economic recovery and development in South Africa. However, the report notes that there are issues of exclusion that are a concern, in that cities exclude many of those wanting to participate in the economy. While cities create the perceptions of promise and opportunity and continue to attract many people from less prosperous cities and rural areas, few arrive with the necessary skills and resources to enter into increasingly scarce formal employment. As a consequence, poverty, unemployment and overcrowding are increasing, resulting in social tension. The report cites that the resultant collective violence that often ensures, could be due to the "inability of cities to meet their inhabitants' rights and expectations to access urban resources, services and opportunities" (ibid p. 10). However, the report emphasises, many of the problems cannot be solved by local government alone, and it is thus important for different levels of governance to work together and involve communities, especially in areas such as education, health, and social development.

In terms of urban sustainability, the SACN (2016) report warns that the resource-intensive growth path South African cities have been following suffers from inefficiencies across sectors, listing such domains as energy, water, waste, food and transport. Critically, the authors indicate that the reliance on energy derived from fossil fuel, the increasingly limited space for landfill sites, the constraint placed on freshwater resources and increasing greenhouse gas emission reflect unsustainable development pathways. A key factor highlighted by the report is a need for spatial transformation to allow cities to be more productive, inclusive, and sustainable. Two reasons are cited as combined causes for the lack of spatial transformation apparent in South Africa cities. Firstly, the apartheid legacy and subsequent spatial displacement of the black population and neglected public transport, and, secondly, the post-1994 developments that continued with the practice of peripherally locating subsidised housing and poorer populations. To overcome the stated challenges, the recommendations of the report are for a reconfiguration of institutions and systems to support positive urban growth, requiring a recognition and appropriate support across government for the shared role in the governance of cities. Crucially, this requires better intergovernmental cooperation across broad sectors of public spheres, conducive relations with the private sector, and a strengthened role for constructive

participation of an active civil society to better facilitate greater use of the knowledge industry. To better understand the spatial dynamics associated with the apartheid legacy, a more detailed understanding of the history of LUM in South Africa is required.

In the paper *The State of Land Use Management in South Africa* by Charlton, Ovens et al. (2007) are cited as defining LUM as the "process by which "land is developed, usageof land is defined, and activities on land are regulated" (Charlton, 2008, p. 3). Charlton notes that LUM in South Africa originated from British town planning activities in response to the impacts to urban areas from the industrial revolution, with regard to improving health and safety, but evolved into a system of control and regulation with the objective of "organizing urban space and urban activities into ordered, safe, hygienic environments where uses and activities were prescribed and controlled" (ibid). Charlton notes that town planning as a profession and system of management of land, developed in parallel with the historic concepts of 'nature' and the growth of urban areas in Britain and North America. The assumptions were that these cities and towns would be the places where most economically active people would be formally employed in the same job, in the same area, with residences placed physically separate from working environments, supported by good transport systems. As such, Charlton notes that regularity-orientated approach to LUM for much of South Africa is aimed at controlling ofperceived negative impacts and consequences, ignoring more recent ideas that emphasis a promotion of desirable development.

Charlton highlights that, in conjunction with the British land use planning models, LUM was further overlain by apartheid objectives. Charlton refers to Mammon's (Mammon, 2008) explanation that between the 1960s and 1980s local government planning in South Africa was focused on implementing control measures on land use and development to ensure support for modernist planning, while reinforcing the objectives of the Group Areas Act to segregate citizens racially, resulting in the creation of distinct areas for different racial groups (Charlton, 2008). Charlton notes that in South Africa, under apartheid planning, the exclusion of the majority from owning residential and business land created a complex, racially based overlay of inclusion and exclusion in the property-ownership landscape (ibid). As a result, the author indicates that the resultant land use systems reflect complexity, fragmentation, and uneven distribution, with the overall framing being cumbersome and confusing (Ibid 2008). Charlton citing Berrisford and Kihato (2008), note that while in theory all change in land usage requires planning

permission, there are many areas where in practice, no planning control exists at all. A consequence of this dualism in land use management is that an unevenness in the enforcement of land use regulations took place. Charlton (2008) points out that when public systems fail or are inadequate, poor people living in informal settlement areas possess limited financial resources or other means to secure private infrastructure and other necessary services.

Support for this argument is further motivated by Charlton in citing Mammon, who states that as separate laws and standards are administered at local and provincial government level to regulate the development of settlements based on wealth, and as such argues that land use regulation plays a significant role in retaining inherited apartheid economic structural disparity (Mammon, (2008), in Charlton, 2008). In concluding on fragmentation and complexity of land use systems in South Africa, Charlton flags the need for a better understanding of the implementation of equity, noting that confusion can arise through mixing of the notion of equity with that of uniformity, as the latter is one ofthe easier ways for bureaucrats to achieve equity, despite it being the case that "an equitable approach to an issue does not necessarily need to take a uniform form" (Charlton, 2008, p. 11). On the issue of land use management in relation to the post- apartheid planning situation, Charlton (2008) notes that LUM systems are critiqued in two senses. Firstly, that LUM is not well positioned to support strategic approaches. Secondly, there is limited innovation in LUM approaches in the vastly altered context of urban South Africa. As such, LUM is contested, particularly with regards to informality and unregulated areas, which are inadequately conceptualised (Charlton, 2008), particularly in the sense, that, given the apartheid context for LUM, established legislation tends to reinforce apartheid land-use rights patterns (Charlton, 2008).

Charlton (2008) also notes that current LUM approaches to addressing informality are unresolved, are a challenge to LUM conceptualisations and a major source of conflict, resulting in a binary understanding of informality. The Charlton report highlights that there is a tendency for policymakers to prioritize formal approaches as the preferred option, with informal methods often viewed as inferior and undesirable, and therefore subject to efforts to eliminate them quickly. Charlton (2008) highlights the ambiguous attitude of officials to the informal economy, and the failure to recognise the survivalist role that informality plays for the poor, inciting official approaches to ensure that these areas become under controlof the formalised planning systems. Another key issue raised

is that despite extensive government-led housing development initiatives, household ownership remains elusive for a large number of people who are unlikely to obtain this ownership in the short-term due to large backlogs and slow delivery.

The relevance of the Charlton (2008) paper is that, although dated, the issues highlighted still appear to be very relevant to current planning practice. In the report *Building Better Cities A new approach to housing and urban development*, Bernstein(2020) acknowledges urbanising trends, stating that the existing urban population in South Africa is expanding as people are moving from rural areas where the poverty and unemployment levels are high. As a consequence of rural-urban migration based on perceptions of better employment opportunities, and of the history of apartheid planning,the bulk of settlement takes place on the outskirts of sprawling cities where land is cheap.Bernstein further notes that the rural-urban migrants 'may then qualify for government provided RDP housing, which is unfortunately also situated on the outskirts of the city forthe same reason" (ibid p. 1).

Bernstein (2020) highlights that the South African Government has not set out to segregate the poor from opportunities but that, due to the fixed policies of providing free-standing RDP housing for all South Africans earning less that R3500 per month, large urban informal settlement program housing developments have limited choice in that they have to acquire cheaper land, which is usually on the urban perimeter. Bernstein further emphasises that, given existing and future problems of mass unemployment and the location of the majority of RDP houses on the city's outskirts, beneficiaries of RDP houses find it too costly to look for, or secure, employment opportunities located in distant city centres. Bernstein (2020) questions why, if South Africa has been so successful in delivering housing units, is there such a continuum of the large and entrenched disparity between the demand for, and supply of affordable housing? Bernstein moots that the reason couldbe due to the current approach of the South African government with regard to RDP housing projects, where emphasis is placed on quantity-driven, cost-minimising implementation. In following this approach, Bernstein argues, the government has little chance of keeping up with the changing and economically determined demand—driven by the rural to urban migration trends in Africa and South Africa and the rapidly growingpopulation—for housing amongst poor South Africans.

It is perhaps due to the inherent constraints on the planning system, as highlighted by Charlton (2008) and Bernstein (2020), that inconsistencies in the planning for informality

continue to take place. As historic research is indicating, there is possibly a policy gap in allowing for effective management of informal settlement. If poor people, with limited option for land, are forced to build dwellings in ecological corridors where they are exposed to flood and wildfire risk, a better understanding of this emerging 'commonage' needs to be provided if loss of life urban continued loss of life is to be curtailed, and PoS within urban ecological corridors are to be retained.

2.2.4 Towards an ecological commons: Framing for a Land-Ecology-People Nexus

Ostrom outlines that communities have the ability to effectively manage resources that they depend upon in a sustainable manner, without state control or privatisation (Ostrom, 1992). However, in a more recent paper entitled *The struggle to govern the commons* (Dietz, Ostrom and Stern, 2003), the difficult question is raised of whether it is possible to govern critical commons such as the oceans and the climate without resulting in a 'tragedy of the commons'. However, they state that they remain 'guardedly optimistic' basedon the evidence from their research on the commons has shown that a wide diversity of adaptive governance systems has been effective stewards of many resources. Moving from the global to the local context, the authors state that sound science is necessary for governance of the commons, but not in itself sufficient in that too many strategies for governance of local commons are designed in ignorance of local conditions, ultimately with adverse effects and often locally tragic. With the rapidly expanding human footprint, the challenge is for humanity to develop and implement largescale governance of the commons "quickly enough to avoid the large-scale tragedies that will otherwise ensue" (ibid p. 1910). To provide some rules of engagement, Dietz et al. (2003) distilled the following requirements for effective commons governance:

- The resources and use of the resources by humans can be monitored, and the information can be verified and understood at relatively low cost.
- Rates of change in resources, resource-user populations, technology, and economic and social conditions are moderate.
- Communities maintain frequent face-to-face communication and dense social networks—sometimes called social capital—that increase the potential for trust, allow people to express and see emotional reactions to distrust, and lower the cost of monitoring behavior and inducing rule compliance.
- Outsiders can be excluded at relatively low cost from using the resource (as new entrants add to the harvesting pressure and typically lack understanding of the

rules); and

- Users support effective monitoring and rule enforcement. (Dietz et al. 2003).

Dietz et al. (2003) note that few places in the world have all of these conditions at once. The goal is to create systems and organizations that can either create these conditions, or effectively address governance challenges when the ideal conditions are not present.

Within the South Africa planning context for informal settlement and public open space (PoS), given the lack of governmental capacity to effectively engage with informality and unregulated areas, (as implied by Charlton, 2008), and users who can come from a range of geographies, a strict interpretation of the above list would offer limited support to effective management of PoS. Without effective governance, the expansion of informal settlement is unlikely to be appropriately managed, and without intervention is unlikely to achieve a sustainable outcome. Within the Garden Route landscape context, wilderness areas are well integrated into urban areas and without a more proactive and timeous approach to curbing unplanned informal settlement, it is likely that many of the urban ecological areas will become degraded. However, as 'single-residential' thinking is well established, challenging the status quo requires the use of researched agitation (Sen, 2013) to facilitate greatergovernment and community capacity to address this complex socio-ecological problem. Equally problematic would be to implement an ill-conceived 'solution' as if it were 'the' leverage point. Meadows (1999), who is credited with the introduction of the term 'leverage points' in consideration of complex socio-ecological issues, warns that as leverage points are not intuitive, that caution should prevail. The following quote from *Leverage Points: Places to Intervene in a System* has relevance:

> *"Magical leverage points are not easily accessible, even if we know where they are and which direction to push on them. There are no cheap tickets to mastery. You have to work at it, whether that means rigorously analyzing a system or rigorously casting off your own paradigms and throwing yourself into the humility of Not Knowing. In the end, it seems that power has less to do with pushing leverage points than it does with strategically, profoundly, madly letting go".* (Meadows, 1999, p. 19).

This warning aligns with the observation of Clark and Harley (2020) that a sustainability process requires piloting of interventions as experiments, allowing flexibility in the process for revision once more information becomes available, and the courage to abandon the experiments when they do not work. While using socio-ecological systems thinking as a key framing, it would also be pertinent to understand the existing networks

and structures within and surrounding the action area.

This approach is highlighted by Kellner (2022) looking at the use of leverage points to resolve complex relationships with water resource use in Switzerland. Kellner outlines systems thinking as an integrated and holistic way to understand the interaction of different system components and how they generate overall outcomes. Citing Biggs et al, Kellner states that sustainability challenges of the twenty-first century are unlikely to be addressed without recognising the systemic nature of the problems and understanding interdependencies in complex resource systems, which can lead to the identification of leverage points for interventions that allow shifts in the system towards more sustainable resource uses.

To better understand the complexity of the Water-Energy-Food (WEF) at the policy level, Kellner introduces the concept of 'network of actions situations' (NAS) to systems thinking. Citing Villamayor-Tomas et al. (2015), Ostrom et al. (2014) and Sanneh(2018), Kellner defines NAS as an approach where an "actors decisions depend on the institutional structure of a particular situation and the decisions made in related situations" (Kellner, 2022, p. 2). This recognises that the decisions made by individuals are influenced by the rules and framework of the specific situation they are in, and the decisions made in other related situations. While Kellner specifically focuses on the WEF nexus, the possibility emerges that the ecological commons, as a Land-Ecology-People nexus, couldgain from a better understanding of systems thinking approaches and the use of leverage points.

The key outcome of the model, as expressed by Kellner, is that deep leverage points relating to a shift in mental models are required for the 'deep' transformation of a system. However, as emphasised by Kellner, a better understanding of the institutional structure and network of the actions in the local and surrounding areas influencing the actor's action is required. The question remains, using the framing of systems thinking and NAS, whether the Land-Ecology-People interaction be viewed as an ecological common 'nexus', and whether deep leverage points, as identified in Switzerlandexample, could be used to good effect in addressing social and ecological justice in the Garden Route WUI context.

As expressed by Clark and Harley (2020), a key challenge of governance for sustainable development is to guide the use of shared resources down pathways that do not degrade the ability of those resources to nurture future wellbeing. The authors note the potential

in the growing trend towards polycentric governance arrangements that could be a useful strategy for collective action in the management of natural resource commons. Clearly, the abovementioned research indicates that if society is to achieve the benefits of urbanization, and the benefits of NBS/ NCS and UGI that allow for more resilient urban landscapes in the growing uncertainty from extreme climate change events, a more appropriate and adaptive governance of PoS framed as an ecological commons needs to be defined in line with the thinking of Ostrom, Charlton and Wheeler.

2.2.5 The research question

The current study focuses on understanding the spatial dynamics of land use planning for unplanned informal settlement located adjacent to ecological corridors, or areas defined as open space, within the region defined as the Garden Route (Figure 1). Spatial dynamics is defined as "the process, whereby a specific area of land is converted from one use to another, including from 'wild' to human centric uses that relate to the immediate, local cause of the change" (Lee-Gammage, 2018, p. 4).

Specifically, the research will examine whether UISP planning is suitably adaptive and flexible to deal with rapid urbanisation trends and climate change risks, especially highlighting whether planning for the ecological corridor is adequate to deal with rapid urbanisation events, such as at KwaNonqaba. The 16-year time series looks at the evolution of the ecological areas from 2006 to 2021, in relation to the spatial development planning documentation for the same time period. The focus will not be on backyard informal structures within formalised urban areas but will focus on informal settlement area within, or in close proximity to, public open spaces and ecological corridors.

Two papers are proposed within the realm of informal settlement at the wildlands-urban interface, with the following questions guiding the research:

<u>Paper 1:</u>

- How does the spatial expansion of informal settlement relate to spatial development planning during time period from 2006 to 2022?
- Is there a strong spatial trend for expansion of informal settlements into ecological corridors?
- Is the current planning for informal settlement suitably responsive to expected rapid urbanisation trends?

- Is the planning such that development can become more sustainable and resilient to address the complex, systemic challenges of future expansion and climate change risks events taking place in the wildlands-urban interface in the Garden Route?

Paper 2:

- Is the current planning for informal settlement suitably responsive to growing wildfire risks and the WUI?
- Would framing the complex problem as 'common pool resources' result in better management of the ecological resources at the WUI?
- Could the adoption of adaptive governance methodologies assist in a better understanding of the complex socio-ecological problem and, if this method could assist, how could the existing 'single-residential' status quo thinking be challenged?

2.3 Methodology

The study uses a mixed-method approach to better understand the interface between nature areas and the formal and informal settlement patterns that threaten living landscape outcomes, detracting from long-term socio-ecological sustainability in the Garden Route. This entails the following:

Method 1

A literature review of policy and planning informing unplanned informal settlement, and literature pertaining to climate change influences requiring resilient human settlement as an expression of sustainability science.

Method 2

The use of GIS mapping and Google Earth satellite imagery to spatially capture the informal settlement dwellings development making use of Google Earth historic satellite imagery. This methodology used the forecasting methodology based on broad-brush spatial trends mapped against proposed spatial development planning. A GIS analysis was undertaken, using ArcGIS software, to generate 1 in 4 steep slopes areas, and an overlay analysis to define ecologically sensitive areas that could be better used as natural/ public opens space than as informal development. This overlay analysis was implemented making use of ArcGIS software and generic functioning provided within thesystem.

Paper 1 will focus on the temporal spatial patterning over the last 16 years in KwaNonqaba in Mossel Bay, in which a well-entrenched trend for development of informal structures in PoS areas highlighted as important for recreational and biodiversity land use in local spatial development planning documents has been established. The mapping makes use of Google Earth satellite imagery and thematic mapping in ESRI ArcGIS geographic information systems to identify spatial trends in the patterning of informal settlement, and how the historic settlement has been shaped by planning policy.

Based on the historical spatial trends generated in Paper 1, Paper 2 extrapolates the geographic trend to the greater region, specifically looking at two other informal settlement nodes—namely White Location in Knysna and Smutsville in Sedgefield—in relation to wildfire risk. Prior to focussing on these two informal settlements, a broad spatial mapping process identified all likely informal settlement nodes in the Garden Route Biosphere Reserve. This was to provide the basis for possible emphasis on the need for better planning clarity at a broader regional level with respect to unplanned informal urbanisation. Sustainability science thinking and the need for 'informed agitation' is highlighted as a method to create awareness of the lack of governance of the PoS, to ensure that future informal settlements in the regions are less prone to growing wildfire risk.

2.4 Conclusion

Climate change is contextual but acts as an additional stressor and threat multiplier to existing problems. Against this background of uncertainty, urbanisation of the continent of Africa is going to be one of the defining characteristics, and a major source of GHG emission mitigations if not successfully managed. It is vital that the established benefits of good governance of urbanisation outweigh the identified risks of unplanned urban sprawl. Critically, a better understanding of governance, located within a sustainability science framing is required. As demonstrated from the literature reviewed, sustainable development pathway alignments are likely to be framed in a socio-ecological context which allows for diverse, polycentric governance arrangements, with actor- and situation-appropriate interventions where the resulting mix can be mutually supportive in the guidance of collective action.

Within the South African LUM context, the sustainability science framing calls for the need to address capacities for addressing (in)equality, and (in)equity for achieving sustainable development. As several of the cited authors have alluded to, ingrained inequality of the apartheid planning system, with its overlay of the previous British colonial system, resulted in imposition of control measures on land use and development in support of modernist planning and racially defined segregation. The resultant land use systems thus reflect complexity, fragmentation, and uneven distribution. More recent South African governmental development approaches favour projects of large scale, often influenced by the visions of provincial elites, and thus connected to politically motivated contestation between national, provincial, and local structures.

The need to understand the expansion of informal settlement into PoS areas, in the context of common open spaces, opens the opportunity for adoption of tools for work in adaptive governance and adaptive planning spaces. Failure to apply a proactive, transformative approach to land management, entailing a well informed and participatory understanding of sustainable development and a safeguarding of natural systems within the many ecological corridors in the region, will result in increased conflict between formal and informal settlement planning, and the potential for significant loss of critical biodiversity areas where these land uses are in close proximity. The following two papers (Chapter 3 and Chapter 4) provide examples of the influences of lack of proactive management of informal settlement on the ground and provide motivation for the need to move towards more adaptive planning practices located within an adaptive governmental framework.

In conclusion, there is ample evidence that it is necessary to embrace a more socio-ecological, evolutionary perspective to planning for sustainable development. Proactive planning for alleviating the experience of poverty, through provision of basic services and access to public open space, means a more inclusive and community-informed dialogue for informing urban planning policy, and possibly with a broad framing of an 'ecological commons'. The idea of 'ecological commons', as land thatis not suitable for development but provides provisioning ecosystem goods and services as ecological corridors or Public Open Space. In this understanding of commons, maintaining public open space ensures, even for the margionalised to have access to land that can be used to alleviate the experience of informal settlement dwelling. However, a morenuanced, systems thinking understanding of 'commons' is required to ensure that wilderness areas, within and

surrounding urban areas, are preserved as functional spaces for civil society, and as a legacy for future generations where ecosystems do not collapse into a 'tragedy of the commons' through over extraction.

CHAPTER 3

A 16-year time-series spatial analysis of KwaNonqaba informal settlement and associated open space planning, Mossel Bay, South Africa

Abstract

Unplanned informal settlement along the Garden Route, South Africa, is increasingly taking place along ecological corridors within and adjacent to urban areas in a settlement transition zone that is conventionally termed the Wildlands-urban interface (WUI). While these corridors do provide close access to employment, they are not without risk, specifically from flood and wildfire. Where settlement encroaches on ecological corridors, communities lose access to common open spaces and, in addition, biodiversity is lost, resulting in the loss of benefit derived from provisioning eco-system goods and services. This paper depicts the spatial development trend in KwaNonqaba (Mossel Bay, SA) informal settlement over a 16-year time period, compared with the spatial development planning for the ecological areas within this urban area. As shown in the time series mapping, using Google Earth and ArcGIS mapping, informal settlement encroachment into spatially planned ecological corridors has gone unchallenged, with local government struggling to manage rapid urbanisation and associated unmanaged land use change. Key suggestions in preventing the loss of ecological commons include an emphasis on local planning that recognises the need for an adaptive co-management strategy for shared landscape value around appropriate setbacks, coupled with much shorter and more flexible planning processes that facilitate access to more suitable land for 'managed' informal settlement better designed for municipal service provision.

Keywords: ecological corridors; socio-ecological planning; sustainability science; GIS mapping.

3.1 Introduction

In response to the loss of life in the 2022 KwaZulu-Natal floods, Minister Nkosazana Dlamini-Zuma, stated "As we build back, we should be building back better. No one should be building on the riverbanks and in flood plains; also, in some of the areas which are (not) (sic) geographically right for residential areas." (Polity, 2022). In South Africa, with its legacy of colonial and apartheid spatial planning, low-income communities are usually faced with limited choices for settlement with cities facing large housing backlogs(Maharaj et al. 2021). To ensure that loss of lives does not continue, a more proactive approach to management of informal settlements along rivers and ecological corridor are required.

Part of apartheid planning heritage includes a lack of planning for informal settlement, due to the cadastral-based and administration-focused structures inherited from British colonialism that largely focused on regulation of formalized development (Charlton, 2008). Consequently, planning for unplanned informal settlement is very often a reactive response, following ad-hoc, unplanned settlement that has already taken place in areas that are often not suitable for formalized settlement. In the Garden Route setting,this is taking place along ecological corridors and public open space (PoS), driven by the locational advantages provided by access to river water and proximity to formalized employment nodes, and planning legislation that restricts local municipality action in terms of forced removal. Wedged between natural boundaries and other formal dwellings, leaving no room for access roads, such settlements quickly become inaccessible for emergency services, and for more everyday municipal services, such as solid waste removal and provision of electricity and water.

In addition to the importance of emergency services access, healthy communities and healthy individuals require access to public open spaces. The value of the river valley as Public Open Space cannot only be viewed from a purely aesthetic perspective. Andersson et al. (2015), looking at the role of urban green infrastructure (UGI) benefits in economics, identify a wide range of ecosystem services that are provided by natural systems if diverse natural areas can be effectively managed as an interconnected whole through UGI planning (Andersson et al. 2015). These ecosystem services include: provisioning services in terms of grazing for animals; medicinal resources and raw materials; provide regulating services for local climate control and improved air quality; carbon sequestration and storage; and moderation and physical buffering of extreme weather

events. The PoS areas can provide cultural services in the form of recreation, physical and mental health support, and tourism at the same time as providing spiritual benefit from the natural sense of place (Andersson et al. 2015).

Based on the case study of KwaNonqaba, in the Mossel Bay municipality in the Southern Cape, this paper makes three main points: firstly, that informal settlement patterns can be spatially analysed, through easily accessible historic satellite imagery provided by Google Earth. Secondly, where informal settlement takes place on ecological corridors, if not checked, they predictably will expand into public open space areas and result in a loss of biodiversity and environmental degradation. Thirdly, despite the Western Cape Provincial administration and Local Municipality planning support for conservation and recognition of the importance of maintaining ecological corridors (Western Cape Government, 2014; Mossel Bay Municipality, 2022), the current planning policy appears to be unable to effectively respond to rapid informal settlement.

The paper suggests that, given the predictable, negative outcome from loss of ecological corridors to local ecology and loss of recreational spaces that could benefit long-term human wellbeing (HWB), proactive urban planning, with sustainability science as its foundation, has the potential to reduce the pressure placed on ecological corridors. However, challenges remain. Clark and Harley, (2020), indicate that today's development pathways are tightly bound with powerful incumbent interests that reflect the dominant arrangements of states, markets, and firms. The problem, as outlined by the authors, lies in the unwillingness of these incumbent socio-political forces to heed the distress signals of 'business-as-usual' approaches to development. Breaking such blockages will require a radical restructuring of the politics of our time if society is to enable a serious pursuit of sustainability (ibid). The authors offer possible solutions to address complex socio-ecological problems, suggesting (amongst others) adopting a more nuanced understanding of sustainable development using sustainability science as a framework, and "building capacity for qualitative transformation of regimes that are associated with unsustainable pathways of development" (Clark and Harley, 2020, p. 28).

3.1.1 Landscape context

KwaNonqaba is a township in Mossel Bay, historically providing formalised residential housing for people of colour under apartheid planning. It is within the Mossel Bay Local

Municipality and is located on the southern Cape coast of South Africa in the Western Cape Province (WCP). KwaNonqaba provides a clear example of rapid informal urbanization along ecological corridors. The Western Cape is attracting migration from other parts of the country. In terms of the 2016 census undertaken bySTATSSA (2018), the WCP is relatively well-off in terms of economics and service delivery. The province supports 11.3% of the South African population with a 7.8% increase since the 2011 census, second only to Gauteng Province. Mossel Bay 2022 Draft Final 1 Spatial Development Framework (SDF) indicates that semigration is a factor thathas impacted the number of permanent residents in the locality (Mossel Bay Municipality, 2022) and, historically, rural Eastern Cape Province populations have migrated to seek employment in the Western Cape, with the Garden Route seen as a stopping point en route to Cape Town. As a result, the KwaNonqaba area has been part of a rapid urbanization event over the last few years.

The spatial geography of Mossel Bay reflects the resilience of apartheid segregated planning, with predominantly black and coloured residential areas to the north of the city, and the white residential areas to the east and south, often taking the form of gated estates along the coastline. The latter include Pinnacle Point Beach and Golf Resort and the Mossel Bay Golf Club residential estate (Figure 3). The central business district of Mossel Bay is located to the west. KwaNonqaba is located in the central west of the Mossel Bay peninsular, on north facing and undulating terrain that is drained to the east by a series of small rivers flowing into the Indian Ocean. Prior to 2006, these river valleys have operated as well-established ecological corridors that have been historically recognized in subsequent SDF plans as having biodiversity value and as having community recognition for the potential for recreational activities as part of a public open space system (Mossel Bay Municipality, 2017).

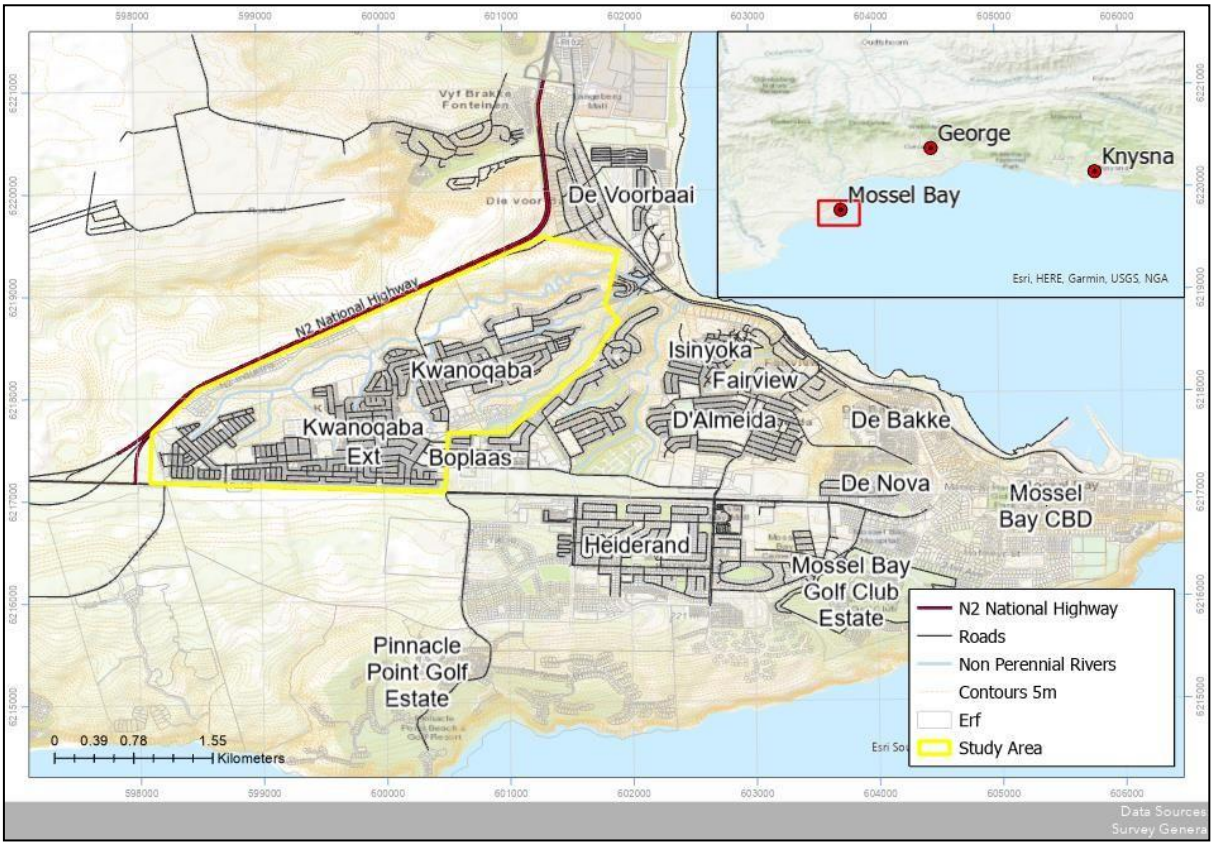


Figure 3. Locality of KwaNonqaba within greater Mossel Bay.
(Source: ESRI South Africa, 2022; Survey General, 2022)

This study found that prior to 2006, most dwellings within KwaNonqaba were formal and there was no precedence for informal settlement in the township. However, dwellings in this locality have increasingly become associated with an informal settlement pattern, with ad-hoc shelters constructed on vacant land along the ecological corridor (see Plate 1 on the following page). As a result of limited choice for the poor and recent rapid urbanization pressure, ecological corridors have been targeted for informal settlement as they arein close proximity to employment opportunities in nearby industrial areas of the Voorbaai, as well as provision of water. While most of this area is suitable for formalized urban settlement, there are areas that are at risk from flooding, as well as areas mapped to be retained as PoS as part of a larger ecological corridor network (See Plate 1 on the following page).

Plate 1. Photograph of typical informal settlement in western KwaNonqaba (Mossel Bay).

The Mossel Bay Municipality commenced implementation of an Urban Informal Settlement Program (UISP), funded by National Government, in 2014. In 2022 this was still in the planning stages and, as a 'static' policy that essentially requires a single-residential development typology, insufficient space has been found to address the rapid increase in informal settlement. Two UISP programmes are currently in completion stages, in Asazani JCCC Camp and in Isinyoka (settlements nearby KwaNonqaba but not in the study area), accommodating approximately 647 informal structures established since 2005 in this high density/ multi-story development. Due to the increased number of informal settlements, the UISP programmes proposed for KwaNonqaba make use of an *in-situ* development approach, where the structures that are on the property are moved off-site to adjacent areas, allowing for the original site to be reconstructed into a medium density, single residential type settlement and services with potable water and sewage.

In replacing the informal settlement structures with formal structures, the land use requirements are larger as there is additional space requirement for services and roads, and a cadastral space for the development of the 'single residential' footprint, referred to as 'site-and-service'. To accommodate the space shortfall, higher density units were developed in Asazani JCCC Camp and in Isinyoka, allowing for more formal housingto be created within the small space available. However, due to cost restrictions, the higher density-type development that took place in these areas is not proposed for KwaNonqaba. The initial UISP program planned for KwaNonqaba was for site-and-service, which does not allow for higher density, multi-story structures.

Making use of historic Google Earth satellite imagery, the dwelling count from this research found over 9000 informal structures within the KwaNonqaba district, with the vast majority taking place in 2020 and 2021. According to Zutari (previously Aurecon), the contract-holder planning the UISP development, there is no uniform standard size for all erven in the layout. Erven will range from a minimum of ±48m2 to approximately 70m2. Consequently, as informal settlement was not restricted from occupying vacant lands identified for the UISP, Zutari found that there is insufficient space to accommodate the increased number of informal dwellings making use of the site-and-service method (Zutari, 2021).

Plate 2. Photograph of informal settlement in KwaNonqaba adjacent to the river line with solid waste pollution dumped into the river system due to no access for formal solid waste removal.

As is visible in Plate 2 above, the riverine areas are becoming degraded by solid waste litter accumulating in the drainage line as a consequence of informal structures developed alongside the drainage lines without the provision of access for municipal services to these areas. While less applicable to the KwaNonqaba area where the streams are non-perennial, the riverine area as a water source is also compromised by limited/ no sewage service provision.

3.2 Methodology

To evaluate the spatial expansion of information settlement adjacent to KwaNonqaba public open space areas over time, Google Earth historic satellite imagery of the KwaNonqaba township informal settlement from 2006 to 2021 was captured as point

data. The data were then incorporated as a layer into a Geographic Information System from which thematic mapping could be generated. To evaluate the effectiveness of the Mossel Bay Spatial Development Planning documents in managing the informal settlement expansion over the same time period, a review of the three Spatial Development Planning documents was undertaken to evaluate the intention of the planning for the ecological areas within this area, and the evolution of the planning for informal settlement in relation to the defined biodiversity protection measures proposed.

Three series of thematic maps were generated: firstly, the baseline defining the potential public open space that could have been protected if proactive planning was inplemented; secondly, the change in the SDF mapping for KwaNonqaba in relation to the public open space and informal settlement; and, finally, the evolution of the informal settlement landscape over the time periods relating to the SDF planning. Table 1 below summarizes the approach used.

Table 1. Time series mapping explanation

Reference	Description
The KwaNonqaba 2006 Public Open Space Baseline (Figure 4)	The Baseline Landscape Mapping depicts land use in KwaNonqaba as of 2006. Baseline landscape mapping focuses on the bio-physical characteristics of the defined area, as a canvas on which human settlement planning impacts on ecological integrity. Critically, the baseline refers to biodiversity planning in the Spatial Development Framework to define what the baseline for KwaNonqaba Public Open Space could have been if these planning objectives had been achieved. The preferred public open space corridor in KwaNonqaba was informed by specific setback criteria listed in the 2006 and 2014 Draft SDFs.

Planned Ecological Setback Mapping (Figures 5 & 6)	This map is derived from the Spatial Development Planning ecological corridor planning for the area. Making use of the ecological management criteria for a suitable setback from the river area as illustrated in Figure 5, a Concept Ecological Setback area was generated from the study area, as mapped in Figure 6 including 1 in 4m steep slopes and 32m river buffer requirements of the three SDFs, and mapping for critical biodiversity areas (CBA).
Spatial Development Plan Mapping (Figures 7 & 8)	Three Spatial Development Plans were generated since the informal settlement mapping that started in 2006. In 2008, a planning document was compiled for the Mossel Bay Municipality by Taylor van Rensburg van der Spuy Architects and Planners. No maps were provided in this SDF (Mossel Bay Municipality, 2008). The second SDF was undertaken by CNdP Africa (Pty) Ltd (starting in 2014 and concluding in 2018) (Figure 7) to address general planning for the towns and addressing the informal settlement that had alreadytaken place since 2006 (Mossel Bay Municipality, 2018). The most recent SDF (Figure 8) was compiled by De Kok planningand is, at the time of writing, in Draft Final V1 (Mossel Bay Municipality, 2022).
Evolving Informal Settlement Landscape Mapping (Figure 9, 10 & 11)	Evolving landscape mapping reflects the development of informal settlement land use status quo as of 2021, depicting the 16-year unplanned land-use changes that have taken place since the 2006.

3.2.1 Mapping

The thematic maps were derived by making use of a range of GIS tools and data sources The following tables outline the GIS software used (Table 2) and the data utilised in the generation of the land use mapping layers (Table 3).

Table 2. Software used in data capture and thematic mapping.

Software	Action	References
ArcGIS Pro	• Thematic mapping. • 1 in 4 slopes analysis. • Capture of 2021 expansion of informal settlementdwellings.	ESRI ("Maps throughout this thesis were created using ArcGIS® software byEsri. ArcGIS® and ArcMap™ are the intellectual property of Esri and areused herein under license. Copyright © Esri. All rights reserved. For more information about Esri® software, please visit www.esri.com.")
Google Earth satellite imagery	Capture of historic informal settlement polygons for2006, 2011, 2014, 2017, 2019 & 2021. As these are the time periods when satellite imagery is available.	GOOGLE EARTH PRO (Google earth SIO, NOAA, U.S. Navy, NGA, GEBCO. TerraMetrics 2023, DigitalGlobe 2023. http://www.earth.google.com [June26, 2023].)

Table 3. Data sources used in thematic mapping.

Data	Organisation
5m contours. Erven cadastral. Municipal boundaries.River and Stream.	South African Survey General (Chief Surveyor General - Documentation(drdlr.gov.za))
Ecological Support Areas (ESA) Critical Biodiversity Areas (CBA)	SANBI's Biodiversity GIS web site(http://bgis.sanbi.org)

A retrospective mapping methodology was used to determine when informal settlements were constructed prior to 2017. Point mapping of informal settlements in the KwaNonqaba area first took place in 2017, when this layer of satellite imagery was available as ESRI Open Source for QGIS and ESRI software products. The individual informal settlement dwellings were mapped at a scale of approximately 1:10 000, and a generalised mapping procedure was utilised, with a single point added toeach separate dwelling within the defined study area. To ascertain the approximate time period when the dwelling was constructed, polygon areas were captured directly from Google Earth historic satellite imagery for the years of 2006, 2011, and 2014. These KMLfiles were then imported into ArcGIS Pro and converted to shapefiles. The 2017-point data were then overlaid onto the historic polygon data and, making use of the selection and update function, the points located within the time series polygons were assigned a date.

Any informal settlement constructed up to 2006 was assigned the date value of 2006, and any informal settlement constructed between 2006 and 2011 was assigned a date value of 2011. The data were also updated for 2014-year informal settlement development. The remaining points were assigned a date value of 2017 as this was the year in which they were captured. Once the spatial database for the historic data were compiled, the subsequent years of informal settlement development could be mapped as new satellite

imagery layers became available in the subsequent years. Any informal settlement development between 2017 and 2019 was assigned a time value of 2019. The last time series mapping was in May 2021. For the 2006 layer of land use mapping, Google Earth satellite imagery was geo-referenced using the cadastral data as common reference points, making use of the georeferencing function in ArcGIS Pro. To ensure continuous coverage, a 750m grid was generated in ArcGIS and the individual satellite images clipped to the grid boundary. This allowed for a suitable resolution for identifying on-screen land-use typologies at a 1:5000 scale. As Google Earth Pro was used for data capture, andno detailed modelling was required of the data, a Geographic projection was utilised for all spatial data.

3.2.2 Limitations

Limitations of the mapping exercise include the lack of a specific time when the informal structure was constructed, and the inconsistencies of when historic data were available. Low resolution Google Earth satellite imagery indicated that there was no informal settlement in the open space areas in 2000. However, as 2006 was the first time when higher resolution satellite imagery was made available in Google Earth, this meant that there was a six-year period where mapping of informal structures could not take place. Another limitation is that the mapping method could not look at infill for the earlier time periods as these time periods were retrospectively assigned from polygons. The later data time periods did take densification into consideration by re-examining the earlier coverage areas to see where gaps had been filled which were not correlating with a point value. These limitations were not a significant risk to the data integrity in that the mapping was more generalised: broad trends in land-use change were assessed over time, tracking the total area of land subject to change from nature to informal settlement. Densification modelling was not used in the thematic mapping but could well provide useful insight into the nature of informal settlement growth in the future, should the database continue to be updated. It is important to note that 'infill' informal settlement has taken place in the KwaNonqaba area, which is typically referred to as backyard shacks. According to Bernstein (2020), this is an appropriate manner of densification that needs to be encouraged. However, it was excluded within this study as this type of settlement falls within a formalised cadastral erf. The study focuses on unplanned informal settlement, outside of a defined cadastral erf defined as residential, within, or

adjacent to, public open space/ nature area.

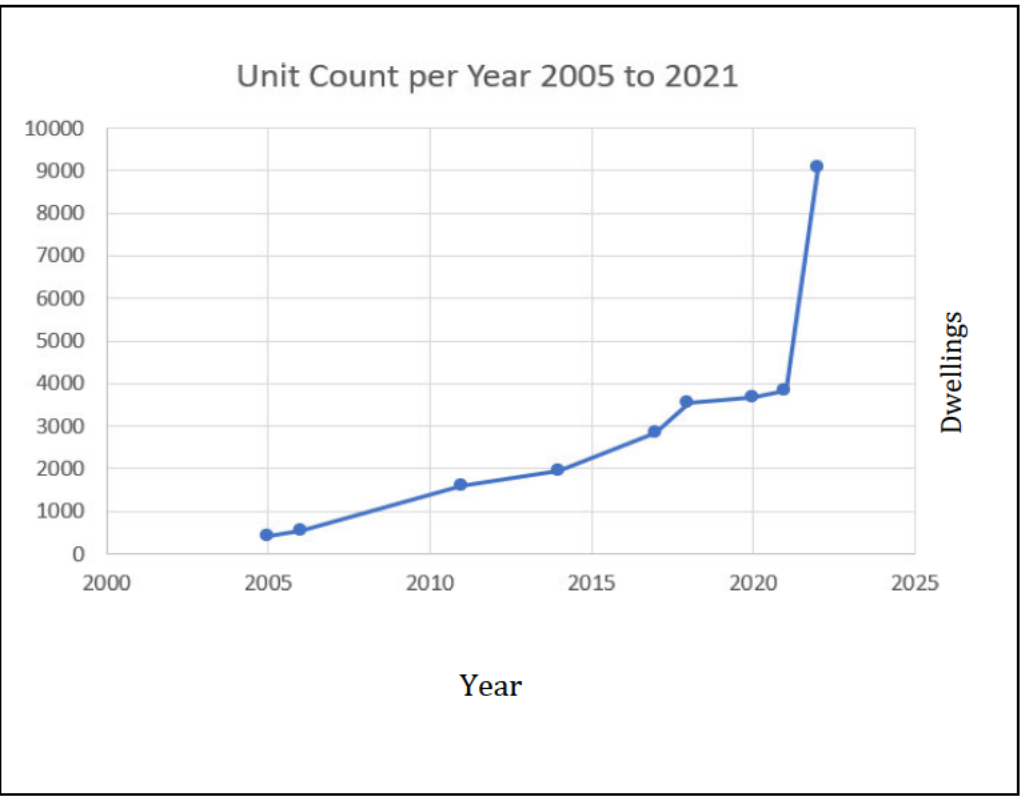
Further limitations to the study derived from absence of investigation of the local authority processes for decision-making and of consultation with the community, and of interaction with the provincial and national governments. While critically important to addressing the 'bigger picture' of effective governance of informality in rapid urbanisation, these dialogues were beyond the scope of this thesis. However, the study was able to significantly reduce the impact of this limitation by analysing key planning outputs in the form of the SDF plans, that essentially expressed national, provincial and local government intention for development within the local municipality and included a dialogue with the communities as part of the planning process.

3.3 Results

In order to better understand informal settlement expansion as a rapid urbanization event, the increase in informal settlement structures that was mapped over the 16-years, was graphed. Table 4 depicts the number of informal settlement structure per period. Significantrecent growth reflects a rapid urbanisation profile post 2020 with over 5000 units builtduring the time period, and a total count of 9134 dwellings as of the end of 2022. Mapping development in KwaNonqaba between 2006 and 2021 has shown that informal settlement has encroached significantly on public open spaces, resulting in loss of biodiversity and restriction of municipal access to these riverine areas. Further, analysis of the three SDF planning documents for Mossel Bay (often with specific reference to KwaNonqaba) has shown that planning acknowledged the importance of the protection of the KwaNonqaba ecological corridors as public open spaces and provided specific criteria to define restriction of development with little effect on the expansion ofthe informal settlement.

Table 4. KwaNonqaba informal settlement structure count per year and postulated trend line.

Year	Unit Count
2005	406
2006	+ 154
2011	+1054
2014	+326
2017	+916
2018	+705
2020	+123
2021	+163
2022	+5236



3.3.1 Socio-ecological setback mapping

The baseline mapping sets the context for the pre-development of the ecological corridors in the KwaNonqaba areas. In Figure 4, the baseline land use map of KwaNonqaba derived from Historic Google Earth satellite imagery from 2006, shows how the PoS along the river were still accessible for recreational and municipal purposes, and no informal settlement precedent had taken place within the study area. The study area is indicated in yellow, depicting the formal Survey General Erven cadastral and no informal settlement within the ecological areas along the KwaNonqaba drainage lines and ecological corridors.

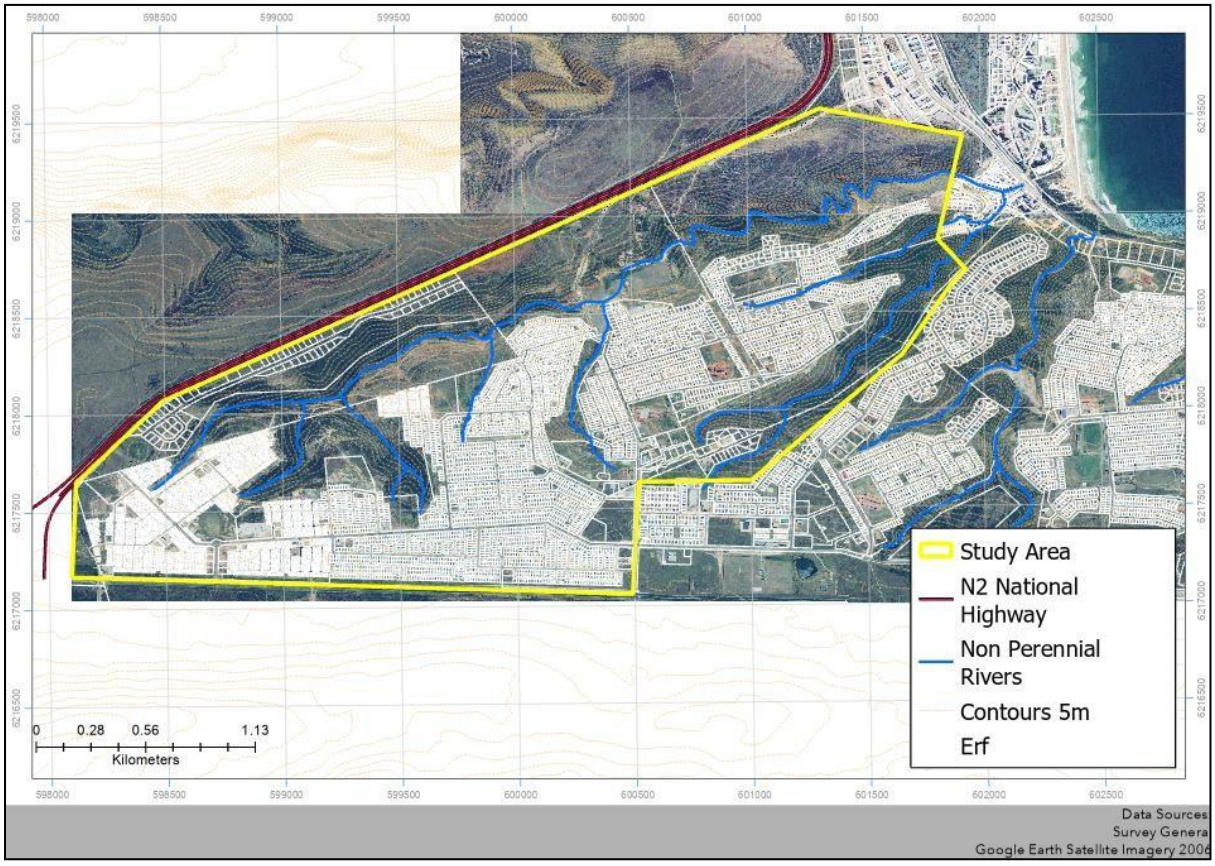


Figure 4. KwaNonqaba ecological corridor landscape in 2006.

(Source: Google Earth, 2006; Survey General, 2022)

A review of the three Mossel Bay SDFs (2008, 2018, 2022) found that similar development constraints were listed with regards to ecological corridor setbacks (see Table 5). The first category of constraints captures the 'ethos' of the SDF with regards to the ecological corridors, and the second refers to specific planning requirement to protect/ manage the ecological buffers. In terms of ethos, all the SDFs make reference to the need to develop an integrated public open space system. The 2008 SDF makes the connection between public open space and sustainable living, enhancing biodiversity, recreation as well as the need for sound management of such areas. In 2018, the SDF emphasis on the need for open spaces as part of a meaningful urban structure is emphasized, highlighting the importance of linkages between these aeras and aligning them with public buildings where applicable. The 2022 SDF acknowledges that the community have identified the network of river valleys and open spaces as an important asset, emphasizing that this has value for both the community as a recreational area, as well as a provisioning ecosystem. The threat to this community asset is strongly highlighted and emphasizes that can not be developed need to be protected from

squatting via rezoning and that the open space network must be a usual natural area, and community education and alien clearing projects should be implemented.

In terms of ecological management of these areas, the 2008 SDF specifically highlight that 1:4m slopes around the river areas need to be excluded from development, as well as a 30m buffer on either side of the river course and enforce a 1:50 year flood line. The increased pressures placed on this ecological corridor is raised in the 2018 SDF, where land use changes associated with agriculture and development with 32m from the river needs to be restricted. In 2023, the SDF is now focusing on the development pressures on the river systems, emphasizing that monitoring and management is required to reduce pollution, but also taking cognizance of global warming, with a recommendation that 1:100 year exclusion zone should now be considered. The risk to the PoS network is also highlighted in the most recent SDF, with the planners indicating that the KwaNonqaba area is under threat from illegal occupation and increased pollution.

Ultimately, as stated in the 2022 Mossel Bay SDF, the spatial development vision is to achieve a "sustainable, integrated and compact city in a sustainable natural and rural environment with adequate resources" (Mossel Bay Municipality, 2022, pp. 19), and comprises a well recognized planning team to generate a working document that guides the planning such that there is alignment with the above objectives. As such, these documents often reflect a best practice in planning, highlighting the importance of the open space network as a defining element in the urban landscape, and this is recognized in all the Mossel Bay SDFs.

Table 5. Mossel Bay historic SDF reference to ecological corridor management and planning.

SDF	2008	2018	2022
Ethos	"To maintain and develop an integrated public open space system within the Mossel Bay Municipal Area that will: lead to sustainable living, enhance biodiversity, add tothe enjoyment of recreational experiences; and promote the sound management of such open space systems." (Mossel Bay Municipality, 2008, p. 10)	"Create open space systems that integrate the elements of a settlement to contribute to a meaningful urban structure. This can be done by: Providing connectivity between open spaces. Establishing linkages between open spaces. Aligning the open space system with public buildings; and Ensuring an improved quality of linkages through the continuation of special activities or functions along major routes." (Mossel Bay Municipality, 2018, p. 416)	"The network of river valleys and open spaces through this sub-area, particularly KwaNonqaba, have been acknowledged by the community as an important asset that should be managed and maintained for both the ecosystem services that it offers and for its recreational and amenity value to the surrounding community. The Open Space network in the KwaNonqaba area is under great threat from illegal occupation and pollution. The areas deemed undevelopable in terms of the UISP project must be protected from squatting via land-use allocation which suites (Sic) the applicable area. The open space network must become part of the urban environment as a usable natural area. Community education and alien clearing project must form part of the conservation initiatives. The open space network is a land use that is defining the urban landscape and should be managed according to its various functional areas." (Mossel Bay Municipality, 2022, p. 63, 66)

SDF	2008	2018	2022
Ecological/ River Management	"Facilitate river corridor linkages between the catchment areas and the coastline. Include all buffered perennial and nonperennial rivers and all 1:4 slopes. Enforce 1:50 year flood line. No development to be allowed within 30m either side of a river course." (Mossel Bay Municipality, 2008, p. 10)	"Keep ploughing and urban development at least 32m from riverbanks or up to the 1:100 year flood lines." (Mossel Bay Municipality, 2018, p. 415)	"No new development rights are to be allowed below the 1:100-year flood line around estuaries and rivers. Creation of 32m/1:100-year flood line conservation buffers next to all rural rivers should be encouraged. The protection of riverbanks against agriculture and alien vegetation should be a priority. The impact of settlements and bulk infrastructure along rivers and estuaries must be monitored and managed to minimize pollution. … Development on slopes steeper than 1:4 should only be considered in exceptional cases and with caution concerning visual impact, erosion, and cut-and-fill scars." (Mossel Bay Municipality, 2022, p. 27, 29)

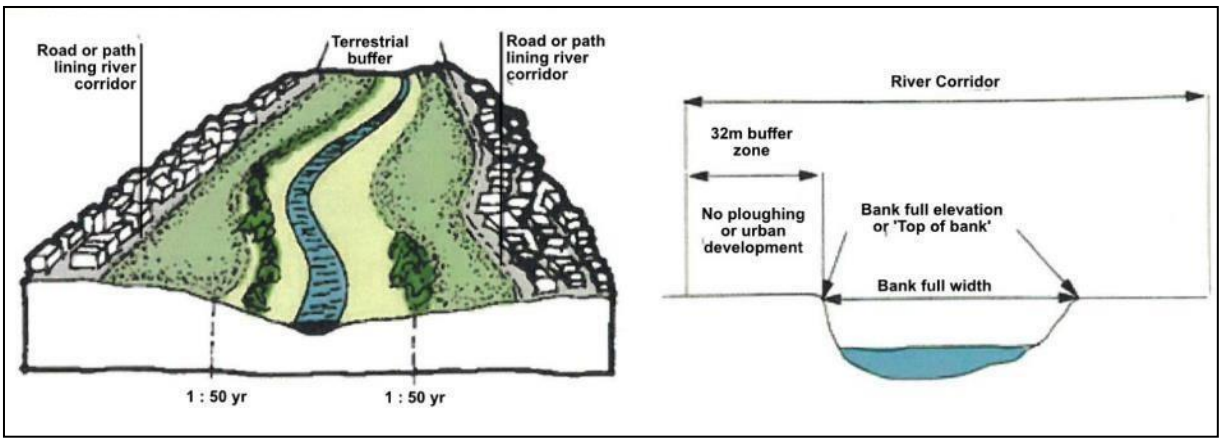


Figure 5. Best practice planning for spatial management of river corridors in Mossel Bay. (CNdP, 2018)

Best practice, in terms of planning for ecological corridors and a terrestrial buffer, is conceptualised in the diagram from the 2018 SDF (Figure 5). This conceptual diagram depicting a river section with urban settlement on either side, is broad brush in nature but is informed by local planning specifications from the 2018 Mossel Bay SDF, with a 1:50 year flood line setback and a 32m buffer zone from the 'top of bank' of the riverarea recommended as a development non development area.

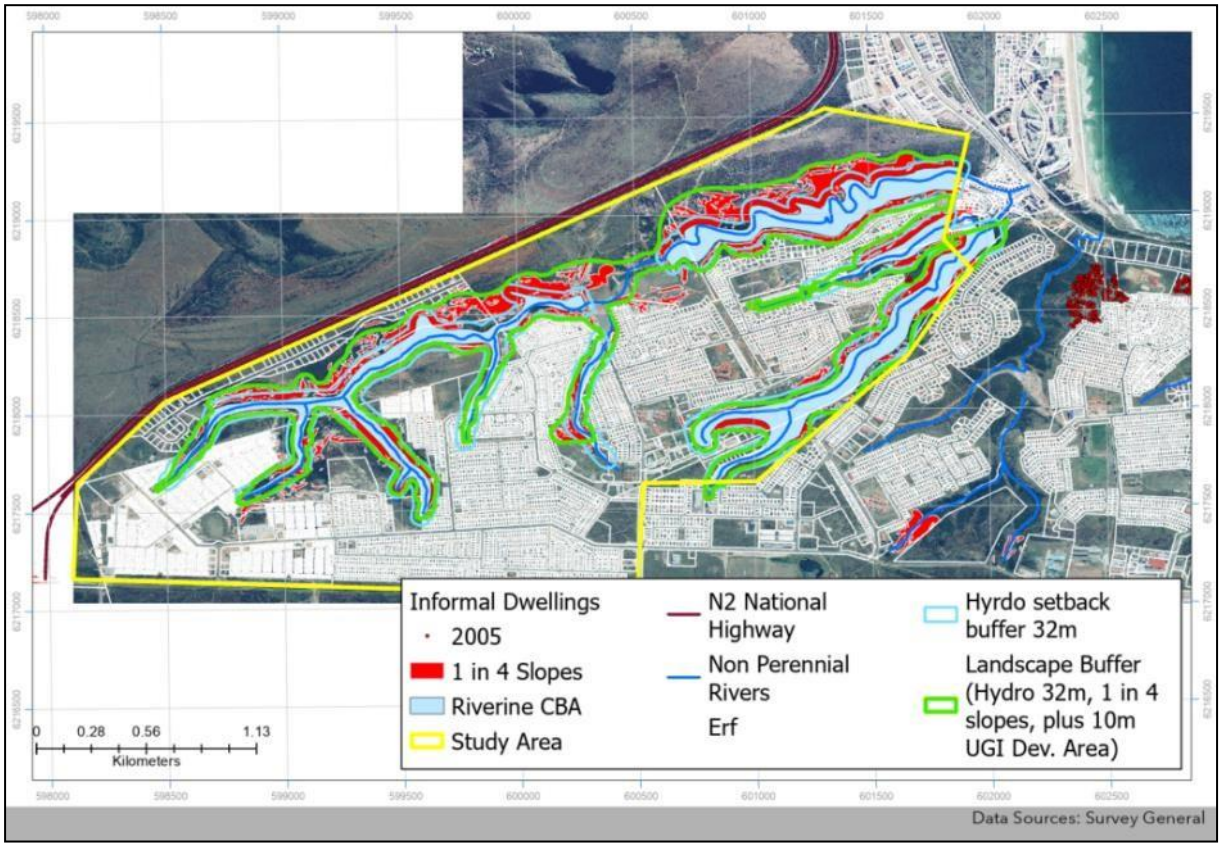


Figure 6. Proposed ecological corridor for KwaNonqaba study area. (Source: Google Earth, 2006; Survey General, 2022; SANBI, 2019)

Furthermore, the diagram depicts a 'road or path lining the river corridor', creating a physical and linear form that divides the ecological/ recreational area from the urban development area. Making use of the above ecological management criteria for a suitable setback from the river area, a Concept Ecological Setback area was generated for the study area, as mapped in Figure 6 on the previous page. Other than the 1 in 4m steep slopes and 32m river buffer requirementsof the three SDFs, Mossel Bay biodiversity mapping was also included for riverine criticalbiodiversity areas (CBA). The setback area is demarcated as a light green line that should effectively be retained as a non-development area. Hypothetically speaking, had an effective management plan been derived for this area in 2006, this area could have been retained for ecological integrity and recreation and provisioning eco-system goodsand services where applicable.

3.3.2 Planning for an ecological buffer

This section looks at successive Spatial Development Framework planning for the KwaNonqaba ecological commons area to evaluate the extent to which the themes defining the management of the ecological corridor were met. The 2008 SDF did not include any detailed mapping. Mossel Bay Municipality commissioned CNdP Planners to update the SDF for Mossel Bay in 2016, resulting in the Draft Status Quo Report published in 2016, finalised in 2018 (Mossel Bay Municipality, 2018). The planning map extracted from the report is depicted in Figure 7 on the following page. The report highlighted challenges and opportunities that would be needed to inform future planning for the area. The main opportunity highlighted in the planning documentsrefers to the network of river valleys and the open spaces, noting in the 2016 SDF that "the network of river valleys and open spaces through this sub area, particularly KwaNonqaba, have been acknowledged by the community and others as an important asset that should be managed and maintained for both the ecosystem services that it offers and for its recreational and amenity value to the surrounding community" (Mossel Bay Municipality, 2018, p. 55). The report notes the challenges of historic informal settlement in KwaNonqaba that line some river valleys, noting there is an urgentneed to address the housing backlog (Mossel Bay Municipality, 2018).

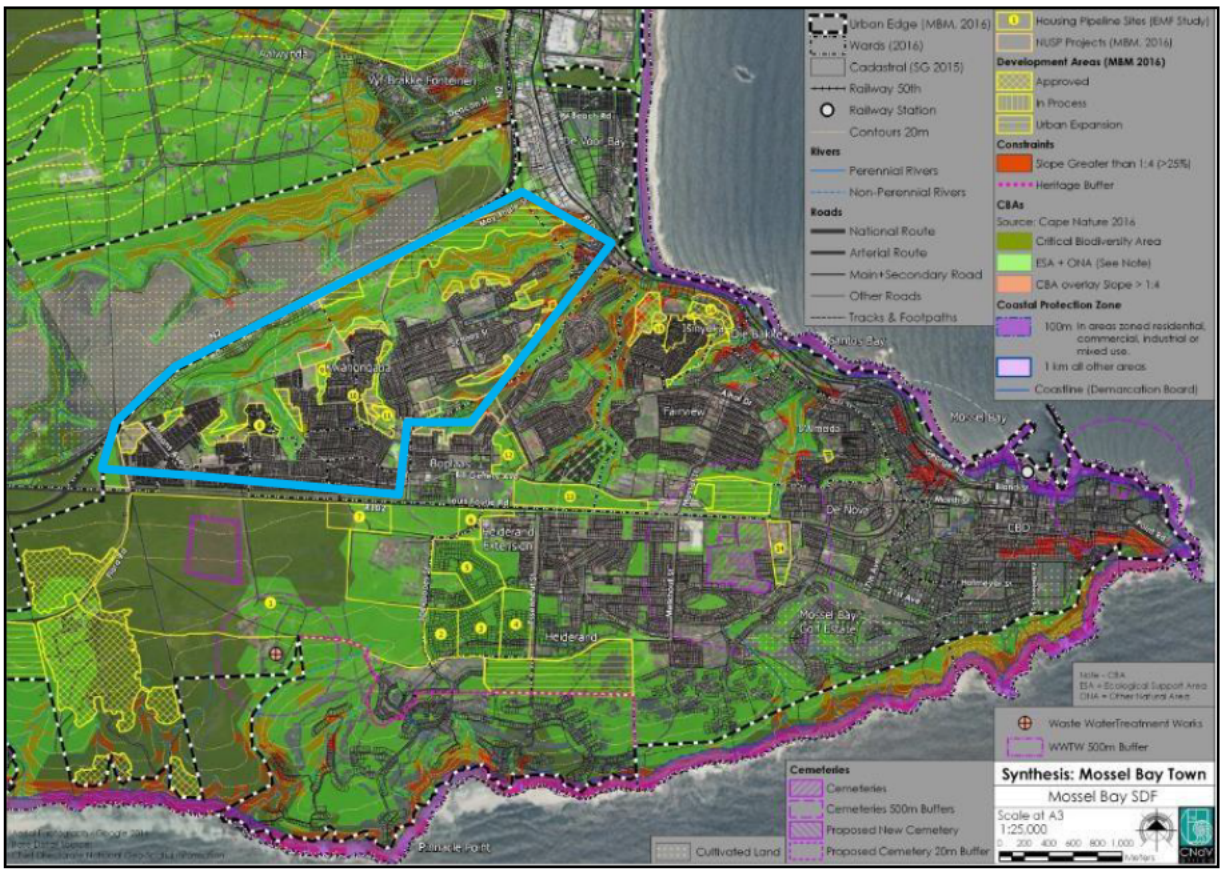


Figure 7. Extract from Mossel Bay 2016 SDF of Figure 5.6.1.2 titled Mossel Bay Town Synthesis, with the KwaNonqaba study area identified as the light blue polygon. (Source: Mossel Bay Municipality, 2017)

'Drilling down' into the ecological corridors proposed by the CNdV report identified the importance of the Critical Biodiversity Areas (CBA) and Ecological Support Areas (ESA) in the planning. CBA areas were defined by Cape Nature and are used to support land-use planning and to show priorities for conservation, especially for eco-diversity and connectivity of natural areas (SANBI, 2018). Drawing on the CBA and ESA, the report emphasised the need to maintain the river systems as ecological corridors, excluding the steep slope areas (1 in 4) as much as possible, and excluding 100-year flood areas. The SDF mapping for KwaNonqaba is depicting in Figure 8 below. Clearly visible in the mapping is the expansion of the urban development areas, and a significant reduction in the green open space as mapped in the 2018 SDF. This reflects the radical change to the area brought about by informal settlement, and the resultant mapped loss of the ecological corridors during this time period.

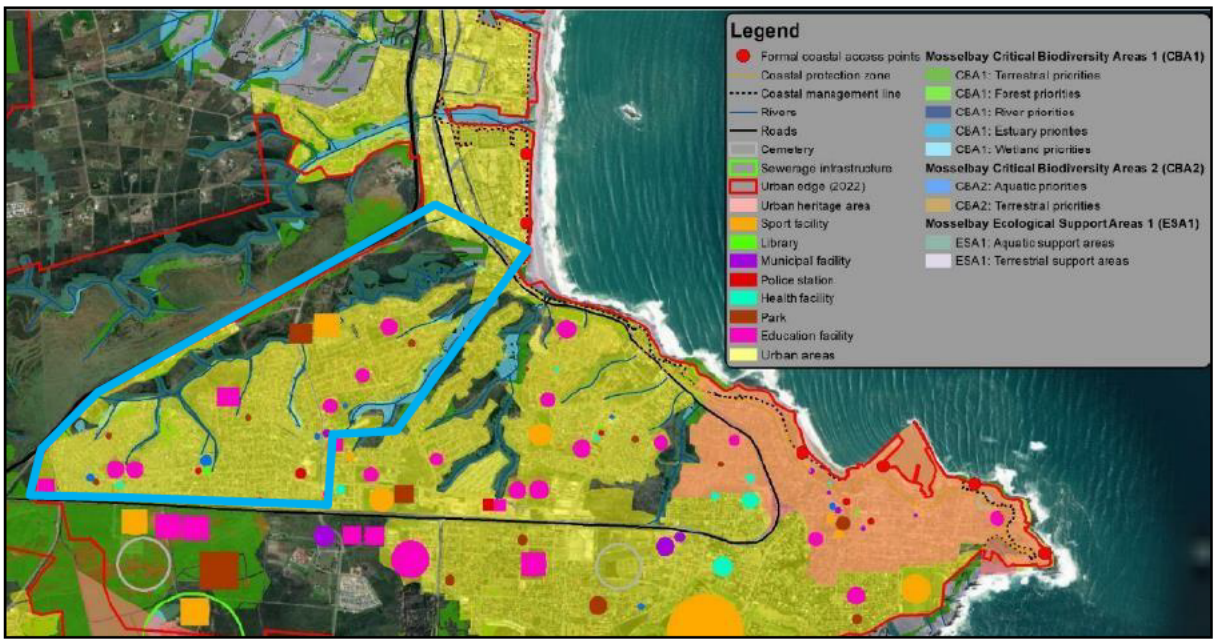


Figure 8. Extract from Mossel Bay 2022 SDF with the KwaNonqaba study area identified as the light blue polygon. (Source: Mossel Bay Municipality, 2022)

A visual analysis of the three maps (2006 ecological baseline, the 2018 SDF and the 2022 SDF) indicates that much of the area that could have been incorporated as an ecological corridor has gradually been redefined as urban in the SDF mapping. The 2022 SDF mapping of urban areas differs significantly from the 2018 SDF, with the significant influx of 2021 informal settlement into the ecological corridor not mapped/ identified as Urban Areas in the 2022 SDF.

3.3.3 Evolving 2021 informal settlement mapping

With the stalling of the UISP program in 2017 due to insufficient space to accommodate the informal settlements, in conjunction with inability of the Mossel Bay Municipalities to retain the areas identified for new development free from land invasion, a significant increase in informal settlement took place from 2017. Figure 9 below maps how KwaNonqaba informal settlement has expanded into ecological corridors from 2006 to 2021, with intensification of the 'land invasion' from 2016 rendering unbuilt or green spaces—ecological commons—inaccessible both for community members and for emergency and other municipal services along the smaller tributaries.

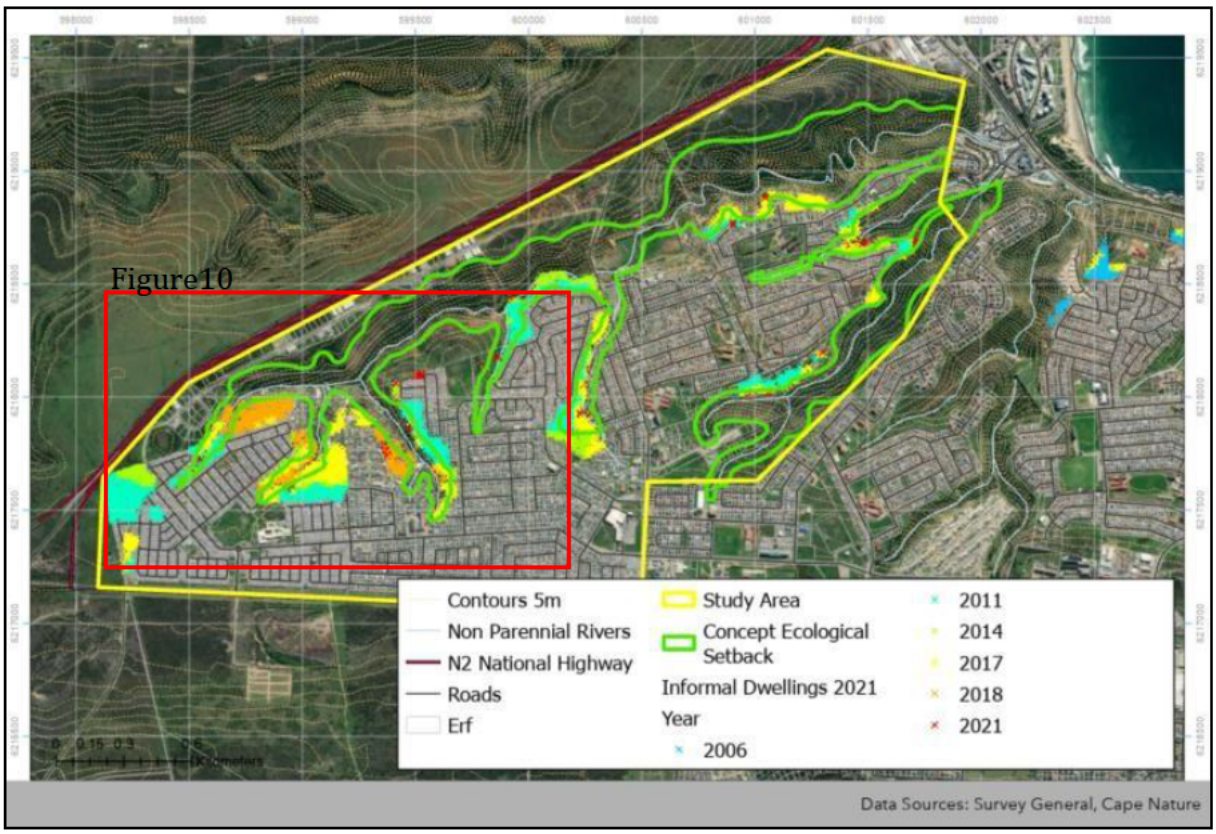


Figure 9. KwaNonqaba 2021 Informal Settlement distribution mapped by the author overlaid onto Google Earth satellite imagery and Survey General cadastral areas. (Source: ESRI South Africa, 2022; Survey General, 2022)

Figure 10 depicts a zoomed in view of how the settlement has resulted in ingress into the PoS, and the flood zones. The light blue areas show the settlement in 2006. The turquoise (2011), green (2014), yellow (2017) and orange (2018) areas show the progressive expansion, closer and closer to the rivers, with the period 2017 to 2021 depicting the main expansion into the PoS. Post-2018, it is evident that natural spaces are being lost, despite there being a clear planning directive from the Mossel Bay 2018 SDF that the ecological corridors along the river systems need to be retained. Though there is still some access to ecological commons areas in KwaNonqaba, it seems more thanprobable that these areas will soon be informally settled, as there is no formalizedplanning intervention to address this current trend. Also, clearly visible on the map, are the close proximity of the informal structure to the drainage line, with many of this riverine area falling below the 1 in 50-year flood line.

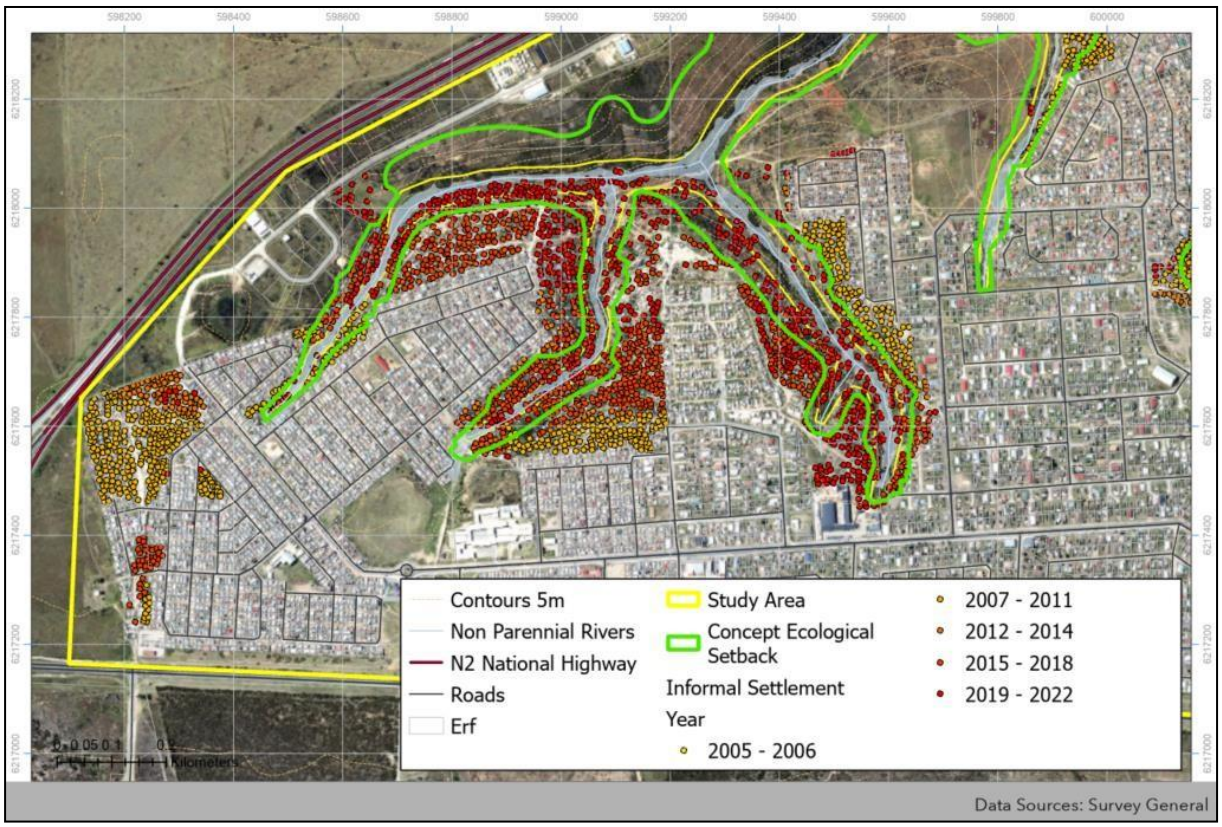


Figure 10. Focus area map of the 2021 informal settlement dwelling overlay onto the broad-brush ecological setback areas, the 1 in 4 Slopes and 100-Year Flood Zone Map. (Source: ESRI South Africa, 2022; Survey General, 2022)

3.4 Discussion

The findings of the paper are that firstly, effective management the ecological areas as PoS are failing, despite being clearly defined in local planning and recognition of the important ecological corridors are having recreational value. Secondly, in the evolving landscape mapping, the planning and management practices defined to sustain ecological corridors contrast quite markedly with what has taken place. And finally, based on the progressive loss of the ecological corridors due to the increasingly rapid growth of informal settlement in the area, the capacity of local governance to effectively manage informal settlement over the time study time period, appears to be limited.

Extrapolating the above findings to the larger context of the southern Cape and the Garden Route region where there are numerous riverine areas and significant ecological areas within the urban and peri-urban context, suggests that this loss of riverine ecology and recreational space should be recognised as a significant risk, requiring reflection on the planning for informality within this geography. To address this risk, the questions raised are firstly: What is the framework by which a balance can be achieved between

development, and the clear loss of biodiversity that is taking place in urban areas throughout South Africa due to unmanaged informal settlement? And secondly: What is the socio-ecological framing that needs to be incorporated to ensure that we can create more social and ecologically sustainable landscapes that are required in the Southern Cape WUI context? Attaining socio-ecologically appropriate land-use in KwaNonqaba requires a design mind- shift that embraces moving away from formalised, single residential styled, big project framing, and with it the required high levels engineering and 'three decimal point' type of

design that is currently the requirement for UISP or RDP housing schemes. The following points form the basis for discussion in this section:

- Design for peopled places using urban green infrastructure systems thinking.
- Enhance knowledge and capacity of the value of ecological commons for citizens and governance.
- Adoption of faster, phased approaches to addressing informal settlement, embracing informality as the initial process toward formalized settlement over time.

3.4.1 Design for peopled places using urban green infrastructure systems thinking

The international organization GreenSurge identifies a wide range of ecosystem services that are provided by natural systems if diverse natural areas can be effectively managed as an interconnected whole through Urban Green Infrastructure planning (Hansen et al. 2017). These provisioning services include those related to grazing for animals, medicinal resources and raw materials (Andersson et al. 2015). A key factorlimiting management of ecological corridors adjacent to low-cost housing projects and/ or UISP programs, is placement of erven on both sides of the road to maximise the numberof units per length of road. While this obviously makes sense from a purely economic perspective, looking to maximise service delivery at the least cost, this design brief createslonger term problems and costs for future management of the ecological corridor.

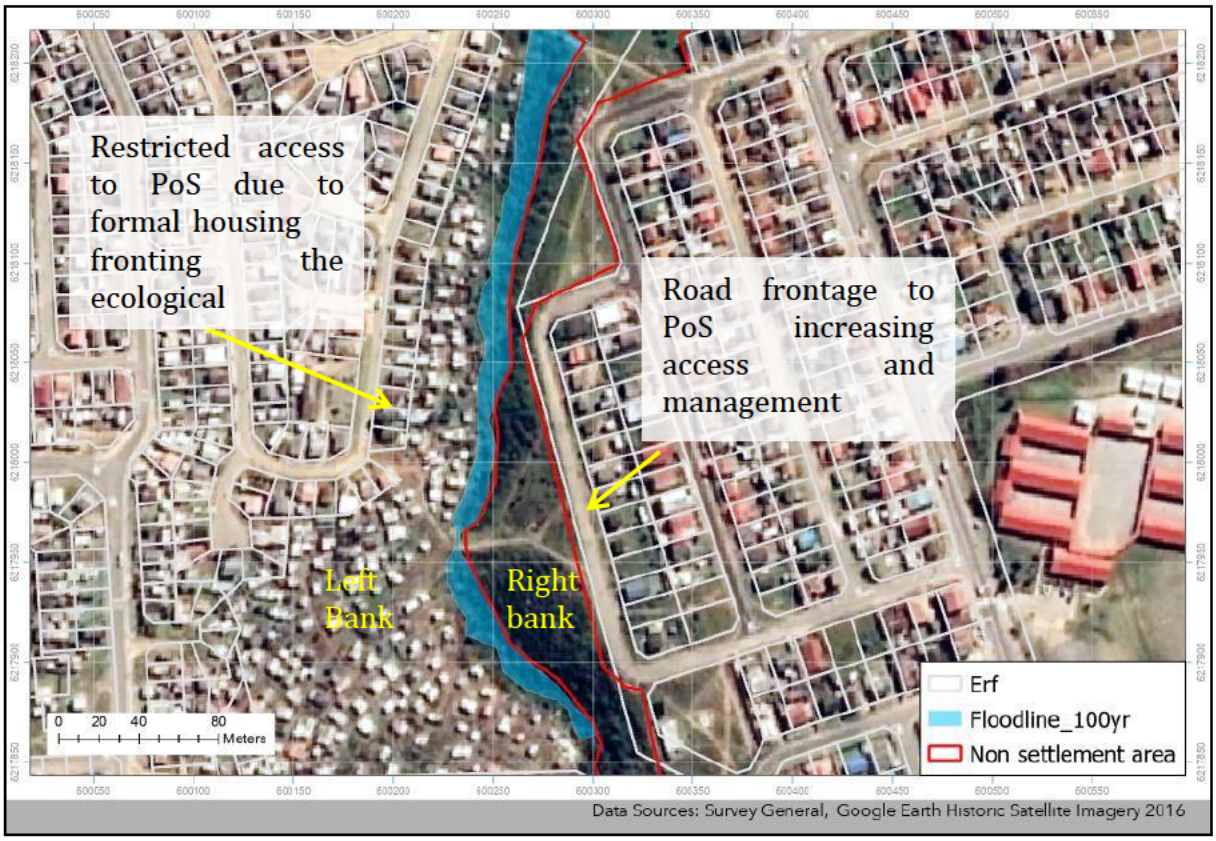


Figure 11. Google Earth 2016 Satellite image depicting two areas of KwaNonqaba depicting a riverine area with and without road access with different outcomes regarding informal settlement growth. (Source: Google Earth, 2016; Survey General, 2022)

As depicted in Figure 11 above, this is a key factor influencing informal settlement growth nodesin KwaNonqaba. Placing a row of dwellings overlooking river areas creates linear restriction to the river areas as a recreation resource and creates unseen areas where 'illegal' shelters can become established outside of the planned domain. In hidden areas 'behind' or 'on the river side of' the formal houses, this is a much higher probability that more informal structures will be constructure so that they can be rented out based on access to electricity and water provided by the formal housing. As depicted on the map, it is clearly noticeable that where a road separates the urban-nature interface on the right bank, new informal settlement nodes have not taken place, thus allowing access to the PoS for the greater community. On the left bank of the stream, where there were houses fronting the PoS, informal settlement filled the PoS, thereby restricting access for the greater community to the PoS.It is likely that as a result of the road along the ecological corridor allowing municipality access to the ecological corridor, the area could function as PoS. However, even with theroad access, due to the likely laissez faire approach by the Mossel Bay Municipality with regards to management of this PoS, this space was

informally occupied by March 2017, asshown in the satellite imagery. This indicates the road separating urban from ecological areas as a stand-alone mitigation, in isolation from a municipal directive to protect the area as a PoS, is likely to fail. The question remains, if this area had been designated a park or recreations status, with resources to add value to the local communities and a local municipality management plan, would this portion of the ecological corridor have become settled?

The continuation of the design practice of building dwellings fronting onto ecological areas in UISP development scenarios, creates a continuous linear development, or 'walling-off' of the ecological corridor and subsequently restricts access to the area increasing the probability of future 'add-on' informal settlement taking place. In areas of steep slope or where the ecological corridor has high biomass vegetation that is prone to burning, the limited access of fire services to informal settlements, places these communities at risk. Other than increased fire risk, the line of housing on the riverine side of the road will increase solid waste pollution due to limited access for municipal services to remove waste discarded down the bank, further degrading the local landscape and increasing the likelihood of water pollution. Also, as clearly illustrated by the photograph taken in KwaNonqaba Mossel Bay in Plate 3 below, these communities arewithin the 100-year flood line and, as for all informal settlements in South Africa located in low lying areas adjacent to river areas, this places the informal settlement residents atsignificant risk from flooding.

Plate 3. Photograph of KwaNonqaba informal settlements located below the 1 in 50-year flood line.

In RDP/ UISP designs, not placing dwellings fronting onto river areas (i.e., a double row of houses on either side of the road where there is no road access to the ecological corridor) will be more expensive in the short term as the road would not be able to service dwellings on either side of the road. It is for this reason that this practice is not supported. However, it is very likely that future costs from not adequately addressing the urban-nature interface by design will be much higher in terms of health and wellbeing, with losses in ecosystem services return on investment (Andersson et al. 2015). Pollution costs will be higher due to limited access to collect and remove dumping from dwellings located next to river systems. Municipal services, such as waste removal and emergencypersonnel and vehicles, cannot access informal settlement located within the river system.

Interestingly, the 2018 version of the Mossel Bay SDF indicates that development on both sides of a road along ecological corridors is not supported, stating that future development along the valley areas "should as far as possible face onto single sided roads lining the valley tops" (Mossel Bay Municipality, 2018, p. 445). However, this statement has been excluded from the 2022 Mossel Bay SDF (Draft Final 1). As such, without effective planning management, new informal settlements will likely be located on more difficult terrain, more inaccessible, and likely to be significantly more costly with more risk of wildfire and flood. There is likely to be further losses of biodiversity and lossof access to public open spaces for the greater community.

The loss of ecological commons is likely to be costly in the long term, in terms of emergency costs in the event of unmanageable fires or floods, and a reduced opportunity for climate change mitigation by NCS/ NBS (Griscom et al. 2017a). As highlighted by Creutzig et al. (2016), studies analyzing driving factors of GHG emissions in new urbanizing areas in Asia, the Middle East and Africa suggest that modifying emerging urbanization, in terms of factors of GHG emissions in urban settlements, could reduce future urban energy use by 20–25% until 2050.

3.4.2 Capacity to enhance collective understanding of value in public open space

Part of the problem of insufficient management of access to PoS is that communities and authorities may both fail to see value in public open space. Land use management legislation protecting ecological commons is sometimes perceived as reinvigorating apartheid-era land economy, where space for White-only nature reserves and White-only public parks and financially exclusive green corridors, such as golf courses, took priority

overblack needs for both housing space and public open space (Berrisford and Kihato, 2008).In communities where the pressing need for housing is often seen to supersede problemsof biodiversity and, in the immediate emergency of having nowhere to live, future floodingor fire emergencies can seem to be of low priority. Consequently, poor people will settle in inappropriate areas and, as informal residents without access to municipal services, are likely to dump solid waste into the river system, down steep slopes, resulting in biodiversity loss and landscape degradation.

Communities in the Mossel Bay Municipality—especially those informal settlements along ecological corridors—should have access to PoS areas for recreational purposes. A key component to attaining this vision is progressive planning based on cooperative governance and an informed dialogue around integrated landscape assessment as a basis upon which designers, politician and the communities act. The lack of effective co-ordination between national governmental and local municipalities with respect to informal settlement is highlighted in the 2021 State of South Africa Cities Report compiled by the South Africa Cities Network (SACN), wherein it is stated that this creates a challenge for longer-term planning for improvements and formalisation within informal settlements (Maharaj et al. 2021). The report emphasizes the significance of cross-cutting management and enhanced intergovernmental relations to effectively integrate implementation and operational planning among diverse actors. This collaborative approach, from both governmental and non-governmental organizations, is crucial for enhancing safety in urban areas.

3.4.3 Faster, phased approach: Informality as initial process of formalisation

Rapid urbanisation is a settlement phenomenon that is likely to be a key characteristic of development in Africa, with the SACN citing Smit (2018) and Moretto et al. (2018) to claim that Africa is the most rapidly urbanising region of the world and, as such, faces immense urban challenges relating to the growth of unmanaged informality, poverty and inequality, as well as fragmented governance capacities (Maharaj et al. 2021). This point of view is vindicated in the current research on the KwaNonqaba ecological corridor, where planned PoS has been lost to informal urban sprawl over a relatively short time period. Attaining socio-ecologically appropriate land-use in KwaNonqaba requires a new approach to planning for informal settlement along ecological corridors. The following suggestions are put forward for discussion.

Firstly, planning for KwaNonqaba public open space requires an unequivocal visual distinction between built areas and nature areas, and a clear mandate from governance to protect the land for PoS purposes. This unequivocal land use distinction needs to be recognised by the community, and by the municipality in their open space planning. Given the growing risks from climate change induced wildfires, a fundamental health and safety design feature of future urban development is that there needs to be an access road separating urban development from public open space, and from river corridors and natural vegetation areas. Such access roads, defining an Urban Green Infrastructure connectivity system—settlement vs nature—allow for enhanced service delivery, and access to long-term recreational benefits. Given that there is clear evidence in the KwaNonqaba landscape context of loss of PoS, and that without intervention informal settlement will expand into river systems, areas that have ecological or recreational value need to be identified early in the planning process, and a management plan implemented such that these resources can be retained. Secondly, there is a need to move away from looking at planning through the lens of over- engineered, 'three-decimal-places' development based on single residential planning typologies designed around vehicles. While detail design is critical to long-term planning outcomes, this over-engineered process requires long time periods, is beyond the budgetof most municipalities, and as such is not meeting rapid urbanisation demands.

The proposal is that a 'hybrid' approach to development is utilised, enabling a flexible approach to UISP development that allows for rapid implementation of informal settlement areas, but on a rudimentary infrastructure skeleton, but aligned with a long-term structured plan that allows for the planned evolution of the settlement into the required higher density, formalised development at a future point in time. While this approach embodying flexibility may appear chaotic, the existing top-down, heavily engineered and prohibitively expensive option is clearly not managing to address the backlog. An example of a rapid planning strategy plan is the Rapid Planning Toolkit generated by the Princes Foundation. The document highlights that, as planning for rapid urbanisation is an inter-disciplinary exercise, it is essential to coordinate departmental representatives and other key stakeholders "towards the collective effort of creating a framework plan" (Princes Foundation, 2020, p. 11). Furtherwork on this theme needs to be implemented and tested to see if it could be effective in the South African planning context.

3.5 Conclusion

There appears to be a planning mismatch between the goal of providing shelter to informal settlers and sustaining urban public open spaces and ecological corridors. In this paper it is argued that increased speed and flexibility in planning processes is neededto address rapid urbanization, and a review of how informal settlement is planned and implemented. With future rapid urbanisation likely to be a dominant urban settlement theme in the Garden Route, and in South Africa more broadly, the urban- wildlands interface will become vigorously contested and the resultant land use and land-use change needs to be evaluated against a long-term monitoring and evaluation platformto ensure that ecological and recreational resources within PoS areas are not lost.

A central finding of Clark and Harley's research is that sustainable development can realistically only be pursued through an iterative process, where the interventions are considered as experiments, being open to making changes based on new information, and having the courage to quickly abandon them if they do not go as planned (Clark and Harley, 2020). Throughout the Southern Cape, there are multiple examples that show that the restricted access to ecological corridors located in front of linear planned, single residential developments, has resulted in, and is likely to continue resulting in, the ecological corridors being utilised for informal settlement, or subject to ecological degradation to the extent that the integrity of public open spaces and ecological corridors are compromised. The location of informal settlement in these natural areas places these communities at risk from flood and wildfire and other human wellbeing factors, such as emergency health penetration. A better understanding of the costs/ benefits of this design approach need to be undertaken, to see if there are reduced costs from economic efficiency that would out way the increased cost of this design. With the implementation of any of the UGI concepts, this iterative process would need to be followed, evaluated and then abandoned in deemed to be unsuccessful. As with the UGI, the rapid planning that has been mooted as a possible solution, would also need to be subject to the same evaluation. Specifically, providing a better understanding of what a rapid planning scenario look like within the South Africa context, and what laws would need to be modified to accommodate this process would need to be undertaken.

Failing to plan proactively for rapid informal settlement will place a long-term financial burden on future citizens, but will also be costly in terms of social, mental, physical, and

economic wellbeing of informal settlement residents, and will result in long-term socio-ecological deprivation. Given the risks from these inappropriately located settlements, without rapid planning interventions, the communities will always be locked into cycles of poverty due to the increased risks they face and the temporal status of their abodes, and a spatially embedded inability to transition into the formal housing structure and economy.

CHAPTER 4

Proactive planning requirements for reduced wildfire threat to informal settlements in the Garden Route, Western Cape Province

Abstract

With the reality of rapid urbanisation in Sub Saharan Africa and South Africa, it is apposite to ask how can informal settlement encroachment into public open spaces (PoS) be more effectively managed, such that climate change induced wildfire risk to these communities is reduced? This paper explores the examples of White Location and Smutsville in the Western Cape Province, South Africa, with reference to wildfire risks to unplanned informal settlements. The paper builds on the findings of the 16-year time series analysis of informal settlement growth in KwaNonqaba, Mossel Bay, with the conclusions that unplanned informal settlement in the Southern Cape is increasingly taking place in ecological corridors and areas planned as wildfire buffers adjacent to formalised urban settlement.

This paper postulates that, as there is a strong trend towards further informal settlement development of ecological corridors, better management of ecological corridors framed as a 'commons', with more adaptive governance management strategies, should be introduced to address growing climate change wildfire risk. However, as low-income development methodologies in South Africa are well established (Charlton, 2008), changing the status quo approaches to planning for informal settlement could require 'informed agitation' (Clark and Harley, 2020) to ensure that more sustainable development outcomes are achieved.

Keywords: wildfire, ecological corridors, rapid urbanisation, informal settlement, adaptive governance, informed agitation.

4.1 Introduction

The Knysna wildfire of 2017 highlighted the vulnerability of informal settlements in the Garden Route region (South Africa) with much of informal settlement around White Location razed and eight lives lost (VWM, 2017). Without effective land use management for containing informal settlement expansion into ecological corridors where there are known wildfire risk areas, further loss to life is to be expected with climate change induced risk from drying biomass (Jolly et al. 2015). The emphasis in this paper is to highlight, via two study areas, that the risk areas have been apparent since the 2017 Knysna wildfire, and, secondly, that insufficient governance of the wildlands-urban interface (WUI) is being applied, with the potential for dire results for the informal settlements that are increasingly located in the Garden Route WUI.

The spatial analysis of the Mossel Bay informal settlement KwaNonqaba from 2006 to 2021 suggests that the potential problems could be mediated through proactive community engagement and planning, based on urban green infrastructure principles. Access roads, of various sizes, along the ecological corridors separating the informal settlements from the riverine areas, can facilitate greater community access to parks and recreation facilities incorporated into the planning for the public open space but, critically, also allow emergency services access to respond effectively in cases of threat from flooding or wildfire. Such access means that municipalities can remove the solidwaste that is increasingly becoming a major problem along rivers, polluting both these ecological corridors and nearby beaches. The KwaNonqaba study found that contemporary designs for UISP and spatial planning tended to place rows of dwellings/ site and service platforms adjacent ecological corridors, there-by resulting in a loss of access to the PoS and a continuation of the informal settlement footprint into the ecological area.

Chaffin et al. (2014) note that, given the uncertainties arising from global environmental change, climate change and land use changes, governance systems need to become highly adaptive. The authors note that there is a need, therefore, to champion new approaches to environmental governance that allow for effective management of landscape-scale problems in a way that is both flexible enough to address highly contextualized socio-ecological systems (SESs), and responsive enough to adjust to complex, unpredictable feedbacks between social and ecological system components (Chaffin et al. 2014). The approach taken in this paper draws on the framing provided by Clark and Harley (2020).

Their findings are, firstly, that present governance arrangementsglobally, are inadequate to guide the rapidly intensifying and intricate dynamics of the Anthropocene toward more sustainable development pathways. Secondly, they argue that improved governance capacity is required to support collective action for sustainabledevelopment. And, thirdly, they argue that sustainable development needs to be considered as an iterative strategy, requiring a collaborative approach to the design of research-informed interventions addressing the required technologies, policies, and visions.

Contemporary development pathways are deeply intertwined with the prevailing arrangement of states, markets, firms and other influencing entities, creating reluctance among powerful socio-political forces to pay attention to the warning signs associated with conventional 'business-as-usual' approaches to development (Clark and Harley, 2020). Clark and Harley elaborate on the idea of informed agitation, where agitation is required to challenge the powerful entrenched interests that disproportionately benefit a few people at the cost of impoverishing the prospects of the many. However, the proposed agitation needs to be informed by better understanding of sustainability science, so as not to "blunder blindly forward pushing development down even more destructivepathways" (Clark and Harley, 2020, p. 23).

4.1.1 Inequality in planning of South African informal settlement

South African land use management draws on a tradition of British town planning activities that respond to the impacts of the industrial revolution to urban areas, specifically with regard to improving health and safety (Charlton, 2008). The assumptions inherent in colonial era British town planning were that the majority of economically active people in urban areas would be formally employed. Residences were placed at a distant from working environments, assuming the support of good transport systems. In conjunction with the British land use planning models, apartheid urban planning furthered racist objectives of segregation (Charlton, 2008). Between the 1960s and 1980s, South African local government was focused on implementing control measures on commons land use to ensure modernist planning outcomes while reinforcing the Group Areas Act intentions to separate citizens into racially defined areas.

The relevance of Charlton's findings, are that our current planning for informality in settlement, is embedded into a land use management system that that is still likely to reflect the near-history risks flagged as: complexity, fragmentation, dualistic in approach

to informality, with the overall framing being a cumbersome procedure with a confusing approach (Charlton, 2008). A consequence of this dualism in land use management is that an unevenness in the enforcement of land use regulations is likely to prevail. As noted by Charlton, people who live in areas that are not well-planned or lack basic services often face challenges when public systems fail or are insufficient. This situation is particularly true for informal settlements located in wildfire-prone areas, who have little financial or other capacity to negotiate the private provisionof defensive landscaping. According to Vulcan Wildfire Management (VWM,2017), it is important for these settlements to implement measures such as maintaining homes, usingfire-resistant strategies, adopting defensive landscaping, and installing home-specific measures such as sprinklers, water tanks, and firefighting equipment.

As a consequence of the heritage of apartheid planning, the bulk of present-day low cost and informal urban settlement in South Africa takes place where land is cheap on the outskirts of sprawling cities, usually to the detriment of these poorer communities (Bernstein, 2020). Bernstein notes that due to the fixed policies of providing free-standing RDP housing for all South Africans earning less than R3500 per month, large urban informal settlement program housing developments have limited choice in land they can acquire, usually on the urban perimeter. Within the Garden Route context however, where strongly undulating terrain with steep slopes and large critical biodiversity areas are often located in close proximity to urban areas, tracks of land suitable for large scale RDP housing are often limited or constrained by expensive builds on unsuitable topography. As a result of the complexity and increased cost, a large backlog in the supply of low-cost housing has developed, tending to perpetuate the cycles of poverty, where poor people are forced to seek alternative, informal housing opportunities closer to employment opportunities and water provision. As mapped in KwaNonqaba, Mossel Bay, this has resulted in unplanned settlement ingress into ecological areas, or areas that were planned as PoS.

4.1.2 White Location Wildfire

The 2017 Knysna fire is evidence of how vulnerable informal settlements are to wildfires in the WUI, with the Situational Analysis of the 2017 Knysna Fires report recording eight documented fatalities, 1059 formal dwellings destroyed, 385 informal dwelling destroyed or damaged, and financial loss estimated at billions of Rands. With reference to informal settlements, the report states that informal settlement homes near White Location were

lost due to “direct heat and flame exposure, structure-to-structure ignition and ember attack” (VWM, 2017, p. 116).

A key factor highlighted by VWM is for landowners and municipalities to review the wildland-urban interface from a broader perspective, with a focus on creating buffer zones that can reduce the impact risk on communities. The report defines the Wildlands Urban Interface (WUI) as a zone of transition or area between unoccupied land and human development. A key function of the WUI is that the homeowner can implement defensive landscaping where ember-resistant strategies can be adopted as part of a suite of firefighting defensive actions (VWM, 2017). Management of the WUI becomes important in the light of increasing trends for informal settlement and vulnerable communities opportunistically seeking settlement within this zone, especially where there is no formal access provided to these areas. Making use of Google Earth historic satellite imagery, Figure 12 identifies the approximate number of informal dwellings razed during the 2017 fire, all of which were located within the WUI on a planned buffer zone to protect formal cadastral erven, where there was limited formal road access to municipal fire services.

Figure 12. White Location informal dwellings burnt by the 2017 wildfire. (Source: Google Earth, 2017; Survey General, 2022)

The study methods and findings described below are informed by the idea that informality is in, and of itself, acceptable and necessary, though its effects in occupying

important ecological corridors/ wildfire buffers should be mitigated through better, more proactive planning methods, within the adaptive governance framework. Environmental governance is defined by Chaffin et al. (2014) as "the system of institutions, including rules, laws, regulations, policies, and social norms, and organizations involved in governing environmental resource use and/or protection, and there are a variety of different approaches". An emergent approach that falls within environmental governance is that of adaptive governance (AG), stemming from a need for new approaches to environmental governance capable of addressing landscape-scale problems in a "manner both flexible enough to address highly contextualized SES and dynamic and responsive enough to adjust to complex, unpredictable feedbacks between social and ecological system components" (Chaffin et al. 2014, p. 54). Drawing on a synthesis of research on AG, Chaffin et al. note that the authors who defined AG, also define what AG should do—namely:

- Provide information (science and local knowledge)
- Deal with conflict
- Induce rule compliance
- Provide infrastructure; and
- Be prepared for change.

Chaffin et al. (2014) note that a different group of scholars have adopted AG to explain governmental changes in policy relating to the emergence of community-based natural resource management (CBNRM). Citing Brunner et al. who offer AG as a practical application to address legal and political gridlock in resource governance, where AG can be used as framework for adapting policy decisions for people on the ground. However, citing Brosius et al. and Brunner et al., Chaffin et al. note that scholars have indicated that lack of governing authority, legitimacy, funding that can lead to an inadequate flow of knowledge, and resources that are required to sustain community leadership. The authors note that AG has the potential to address failures of CBNRM by bridging locally oriented resource management initiatives with government interests for development that can lead to improved environmental governance policies (Chaffin, et al, 2014).

4.2 Methods

The area of study is broadly defined as the Garden Route Biosphere (GRBR), proclaimed by the UNESCO as a Biosphere Reserve in 2016 (Garden Route Biosphere Reserve, 2016) in respect of the broad-brush landscape context of where informal settlement is taking

place, but with specific attention placed on White Location/ Xoleni (Knysna) and Smutsville (Sedgefield), both in the Western Cape Province. Both townships were historically areas designated for those classified as 'non-white' during apartheid. Apparent from the Garden Route Biosphere Reserve mapping of the Core, Buffer and Transition Zones as mapped in Figure 13 below, is the fragmented nature of the development within the 'transition zones', surrounded by vegetation dense 'buffer zones' that create a long WUI edge.

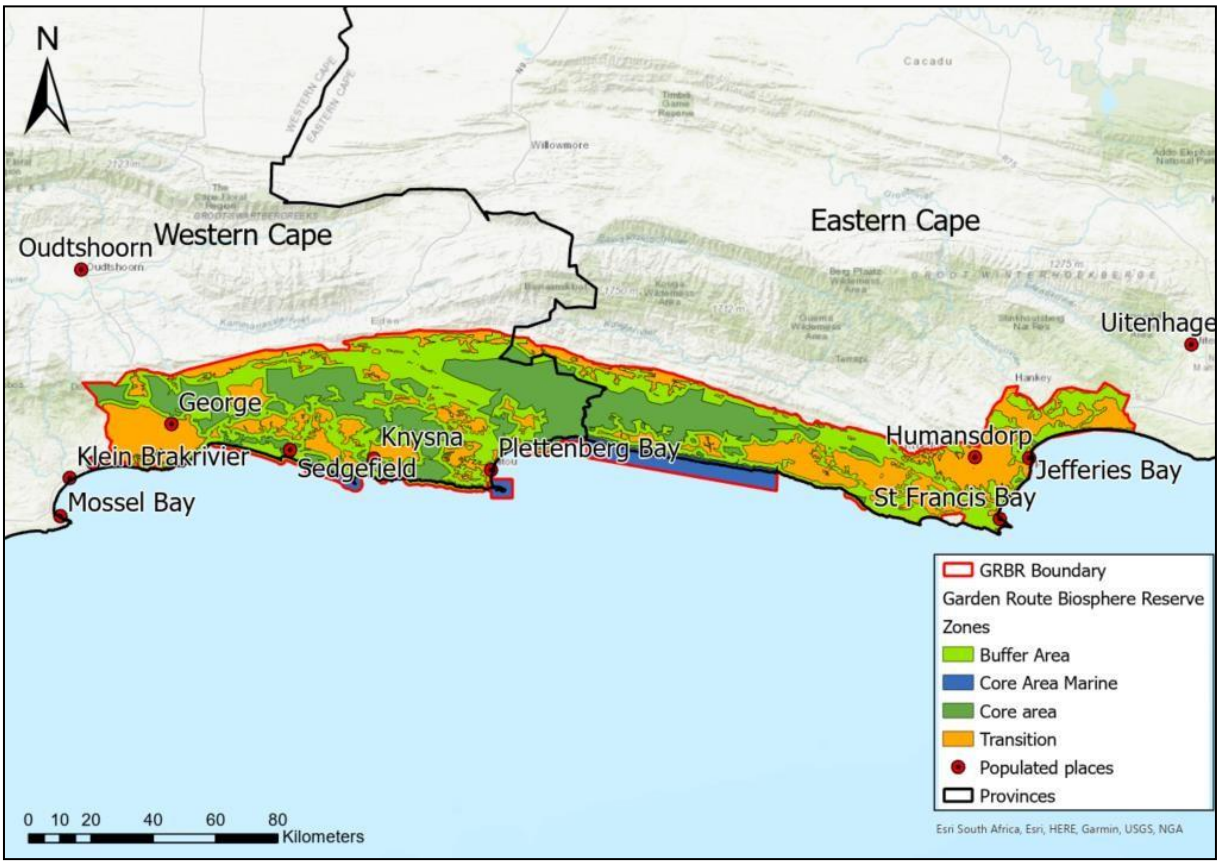


Figure 13. Buffer around the Transition Areas that represent the Wildlands-urban interface in the locality of Knysna & Sedgefield, Garden Route Biosphere Reserve. (Source: ESRI South Africa, 2022; Garden Route Biosphere, 2016)

Key to assessing future expansion of informal settlements and subsequent wildfire risk dynamics is steep slopes. Steep slopes are less suitable for informal shelter due to increased labour and build costs required to stabilise development platforms and are a key factor influencing increased wildfire risk. Manzello (2020) states the following: "Terrain and slope have a broad range of impacts in relation to wildfire and theWUI… Advances in digitization of terrain and slope have enabled the spatialization of many landscape processes, including wildfire". Manzello, (2020) states that theseadvances have enabled local and broadscale management to mitigate wildfire risks and that international and

local efforts are continuing to be made to increase accuracy and resolution. Manzello defines terrain as the "vertical and horizontal dimensions of landscape" and slopes as the "change in elevation over a distance in the same direction". Citing McArthur (1967), Manzello states that the core issue to wildfire is that "a head fire'srate of spread doubles for every ten degrees increase of slopes" (Manzello 2020, p.919, 921).

The study method involves the capture of an informal settlement dataset in ArcGIS Pro Geographic Information System, using data from Google Earth historic satellite imagery from the period 2016 to 2021. The location of the informal settlements in the area were on-screen digitised, with a point location assigned to each informal dwelling. Informal dwellings located within the existing cadastral areas (infill) were not captured. Focusing on the White Location region, a triangulated irregular network (TIN) was generated using Survey General 5m contours. From the TIN, a slope percentage layer was generated as a raster feature, from which the steeper slopes (1in 4m and 1 in 10m) could be identified as they, firstly, broadly define the higher risk area for wildfire and, identify an area less suitable for informal developments. As steep slopes areas have historically been less developed, these areas are more vegetated and more likely to add value as Climate Change mitigation through reforestation. A three-year time series mapping determined if any planning to manage informal settlement growth was implemented, namely 2018 and 2021, when the follow-up mapping took place.

4.3 Limitations

Limitations of the mapping exercise include the lack of a record of the specific time when the informal structure was constructed, and the inconsistencies in when historic satellite imagery data were available. Densification modelling was not used in the thematic mapping but could well provide useful insight into the nature of informal settlement growth in the future, should the database continue to be updated. The study focuses on unplanned informal settlement within, or adjacent to, public open space/ nature areas that form the WUI that are outside of a defined cadastral erf defined as residential and as such does not refer to 'backyard' informal structures.

Further limitations to the study were the lack of investigation of the local authority processes for decision-making, of consultation with the community and of interaction with provincial and national governments. While critically important to addressing the 'bigger picture' of effective management of informality in rapid urbanisation, these

dialogues were beyond the scope of this paper, but would need to be flagged as important dimensions of future work aimed at better understanding the nature of informal settlement.

4.4 Results

The time series mapping and slopes analysis for White Location and Xoleni (Knysna) and Smutsville (Sedgefield) found that expansion in the WUI around the formal cadastral areas is increasingly taking place with exposure to steep slope vegetated areas that fall within defined CBA areas. In both locations, unless there is an intervention, it is likely that unplanned informal settlement will continue into areas that are in close proximity to vegetated areas, exposing the community to increased wildfire risk and loss of CBA vegetation This is exacerbated apartheid planning. In Sedgefield, apartheid urban planning placed what was then a residential area only for those classified as 'non-white' in a small valley to keep it from view of economically and spatially privileged suburbs for those classified as 'white.' In the post-apartheid context, the result is that the small valley is extremely overcrowded (see Figure 14 below).

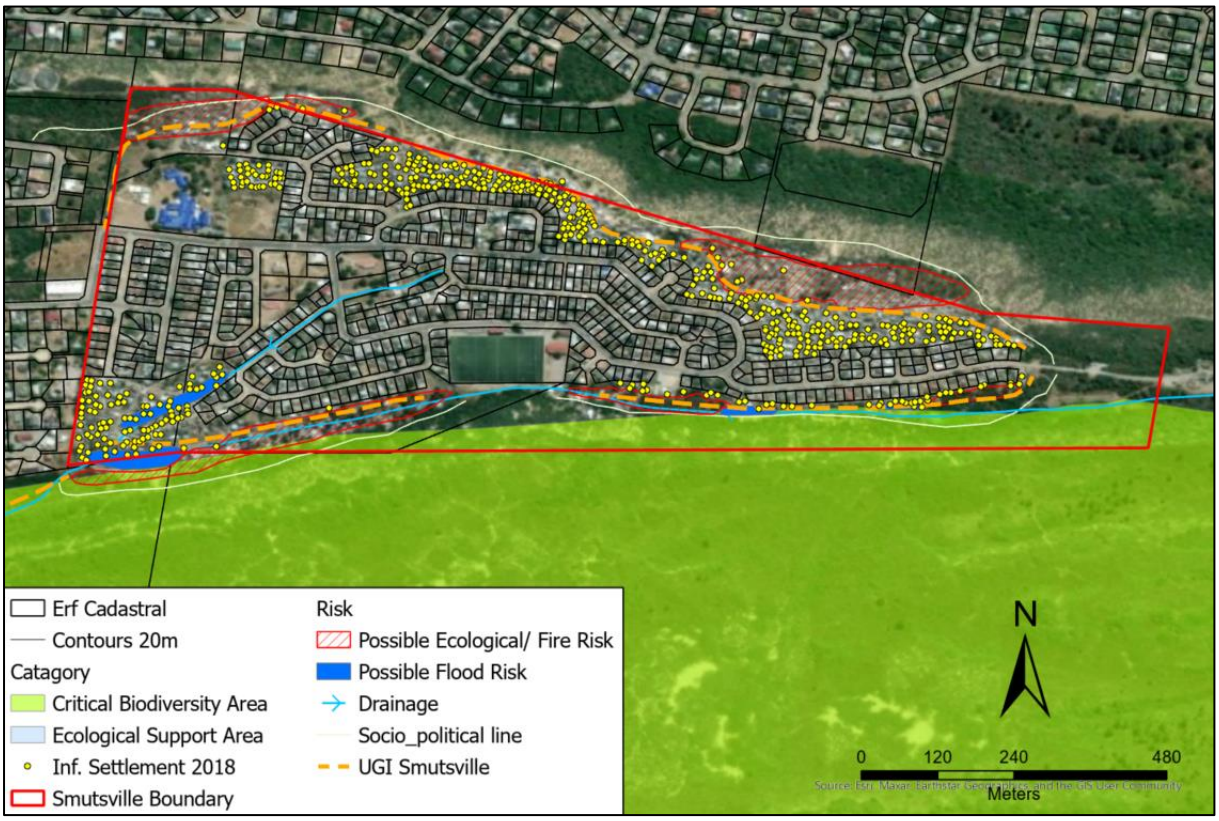


Figure 14. Map depicting the informal settlement on the fringe of Smutsville in 2018. (Source: ESRI South Africa, 2022; Garden Route Biosphere, 2016; SANBI, 2019)

With the need for further accommodation requirements within the locality, there is a push into the northern Knysna Sand Fynbos (Mucina et al. 2006), that are dry, north facing with steep slopes that are likely to exacerbate wildfire risk in this area.

While this may be the expedient response to allowing access to land for previously disadvantage poor, as an unplanned settlement trend it could result in incremental losses to the Critical Biodiversity Areas that characterise much of the Garden Route and places the informal settlements near to fynbos related vegetated, steep slopes, both factors predisposing the communities to wildfire risk. The buffer between the surrounding Knysna Sand Fynbos vegetation and the residential areas is a requirement to protect the community from periodic fires that are anecessary to maintain the integrity of the fynbos biome and to provide a firebreak area. However, the increase of the social footprint into the buffer areas increases the risk of wildfire loss to people and property. The fact that the informal settlement is outside of formal access routes where fire protection services can not get to the locality, is a factor that further compromises the community safety.

In White Location, historically located outside of the views of the main urban areas of Knysna, a similar picture emerged. However, as this area is not contained by the natural constraint of a closed valley topography, as Smutsville in Sedgefield is, the development has taken place in a buffer area separating the formally proclaimed erven from surrounding forested areas. Previously analysis undertaken by the author in KwaNonqaba, Mossel Bay, suggest that, once started, informal settlement is likely to expand outward until a physical or natural restriction is encountered, or a planned intervention restricts the expansion. In in suburb of the town of Mossel Bay, therewas a gradual expansion over 15 years into riverine areas, effectively cutting off access for flood, fire and waste management, reflecting a pattern of informal settlement expansion that is predictable (ibid), and without governmental intervention could exposure these communities to flood and wildfire risk, as well as degraded living landscapes. Without planning intervention, this informal settlement expansion can also be expected in the White Location settlements. To better understand the spatial dynamics of informal settlement expansion, theinformal settlements of White Location and Xoleni (Knysna) were overlaid onto a map ofthe derived steep slopes for the area, as depicted in Figure 15 and Figure 16 on the following page.

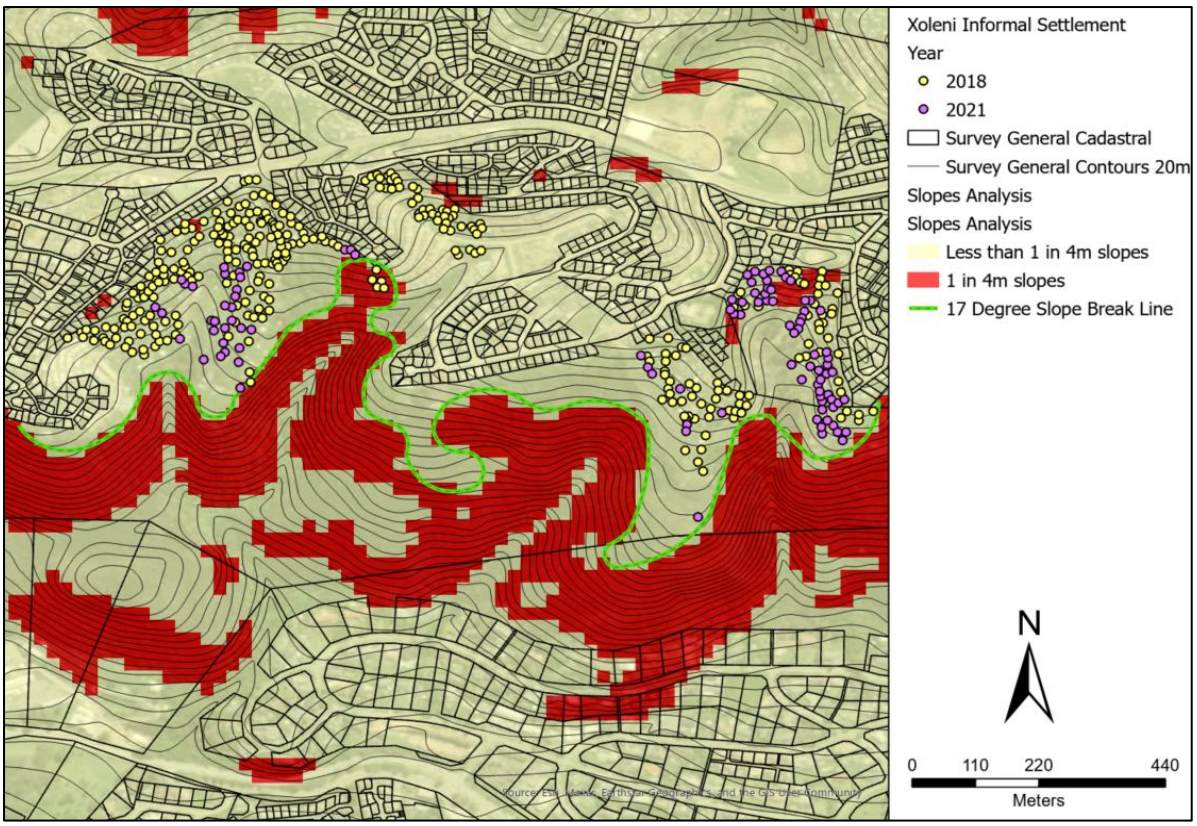


Figure 15. Steep slopes analysis map with2018-2021 informal settlement depicted. (Source: ESRI South Africa, 2022; Survey General, 2022)

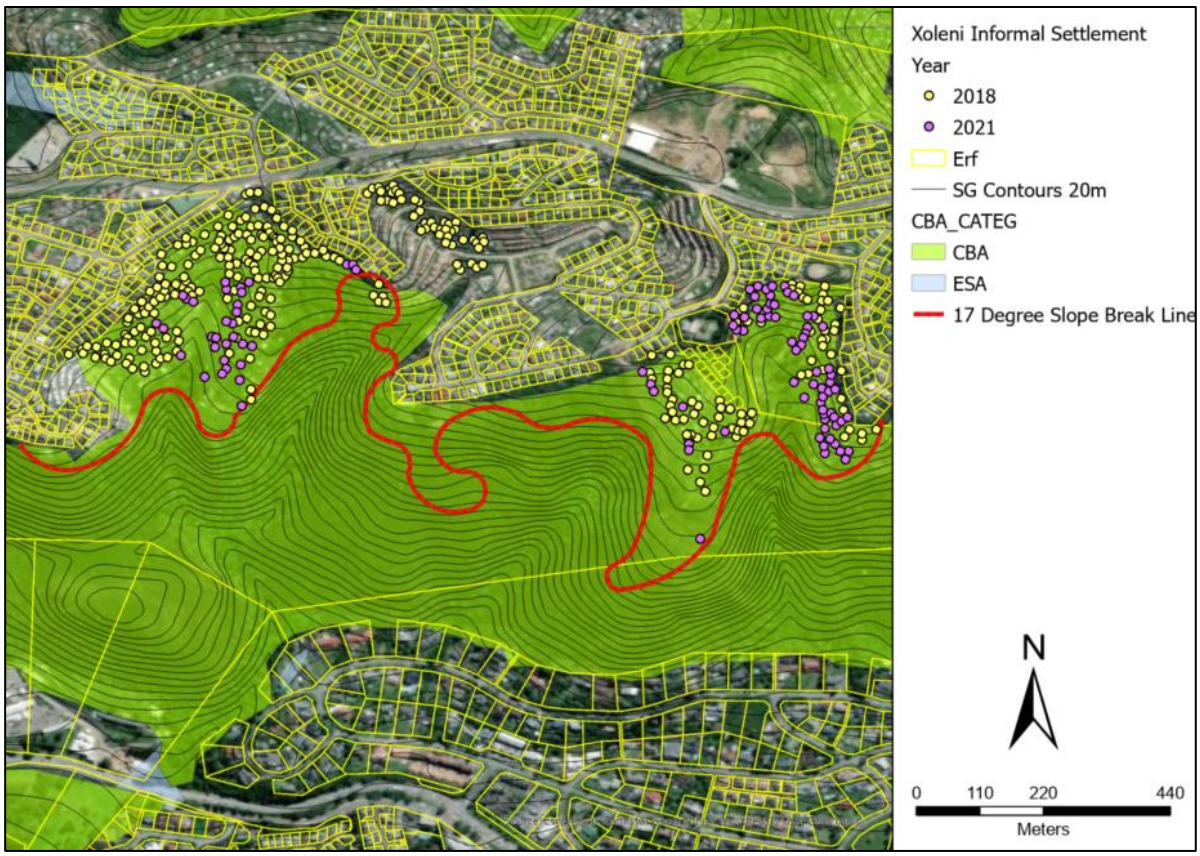


Figure 16. Critical biodiversity areas and mapped informal settlement. (Source: ESRI South Africa, 2022; Survey General, 2022; SANBI, 2019)

As depicted by Figure 15, most of the informal settlements were located on areas of lessthan 17.6 degrees slope gradient. While there were some dwellings located on steeper ground, this could be a variance of the 5m contour data used to generate the slopes analysis, or the necessity of locating dwellings close to formal residences where there is rental access to water or electricity. Time series mapping shows that there is an expansion towards the southern steep slope areas. Mapping in Figure 16 identifies the previously defined 17-degree break line where informal settlement was taking place at the time of research, overlaid on the South African National Parks CBAs defined for George and Knysna regions mapped by Holness Bradshaw and Brown (2010) as part of the biodiversity assessment for the Garden Route. The assessment was designed to identify key ecological areas, in as small as possible vegetation areas, that allow for the targets for conserving the underlying biodiversity features to be met. The report was generated to serve as a common reference for all multi-sectoral planning procedures in order to provide improved decision making on which areas can be lost to development, and which areas of critical biodiversity and associated support zones should be protected against any impact. The report also states that "land-use guidelines have been development for each CBA category and correspond to land-use planning categories commonly used in SDFs" (Holness Bradshaw and Brown, 2010 p.5). The defined desired management objective of CBA areas are listed below.

- Maintain natural land.
- Rehabilitate degraded to natural or near natural and manage for no further degradation.

Without planned intervention, it is highly likely that informal settlement will continue to expand until a natural constraint is encountered. This hypothetical (red) line is depictedin the maps in Figure 17 below, as the Socio-Political Expansion line where it is predicted that the building of informal structures will expand until construction of dwellings become constrained due to the southern steep slope areas.

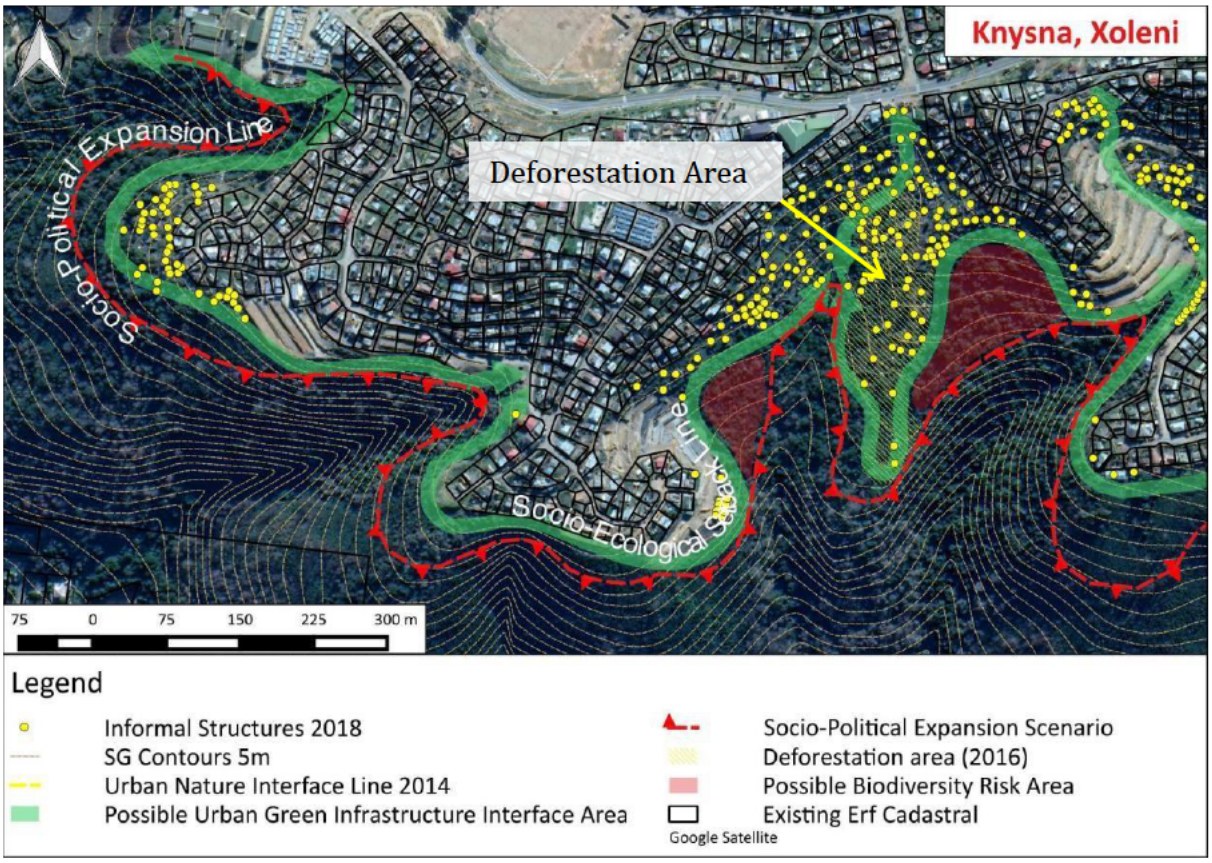


Figure 17. Xoleni informal settlement area with proposed socio-political expansion scenario overlay against possible urban green infrastructure interface management buffer map. (Source: ESRI South Africa, 2022; Survey General, 2022)

As there is an established imperative to protect biodiversity for NBS/ NCS and wellbeing (Griscom et al. 2017), and to create a buffer between the steep slopes areas and informal settlement area with access provided for fire suppression services, a hypothetical urban green infrastructure (UGI) corridor was proposed by the author In Figure 17, the green line represents a possible access routing for facilitating increased municipal governance of the ecological/ wildfire buffer area. This would allow some degree of formal road access for the community to access their dwellings more effectively, and for the municipality to remove solid waste, provide access for emergency fire services, and for municipality monitoring of the ecological commons. Also depicted in Figure 17 is the four-hectare deforested area and possible future biodiversity loss areas that could be subjected to deforestation or utilised for PoS.

Figure 18 shows a similar mapped spatial analysis of informal settlement for Smutsville inSedgefield. In the case of Smutsville, gradient is important to managing and predicting human settlement expansion into green open areas. The Smutsville area includes low-

gradient drainage, so a broad-brush flood risk area was defined using the criteria of low-lying lands within 2m of a drainage line. As indicated in the bottom left ofthe map in Figure 18, the south-eastern parts of Smutsville informal settlement are likely to be flooded unless an intervention is set in place.

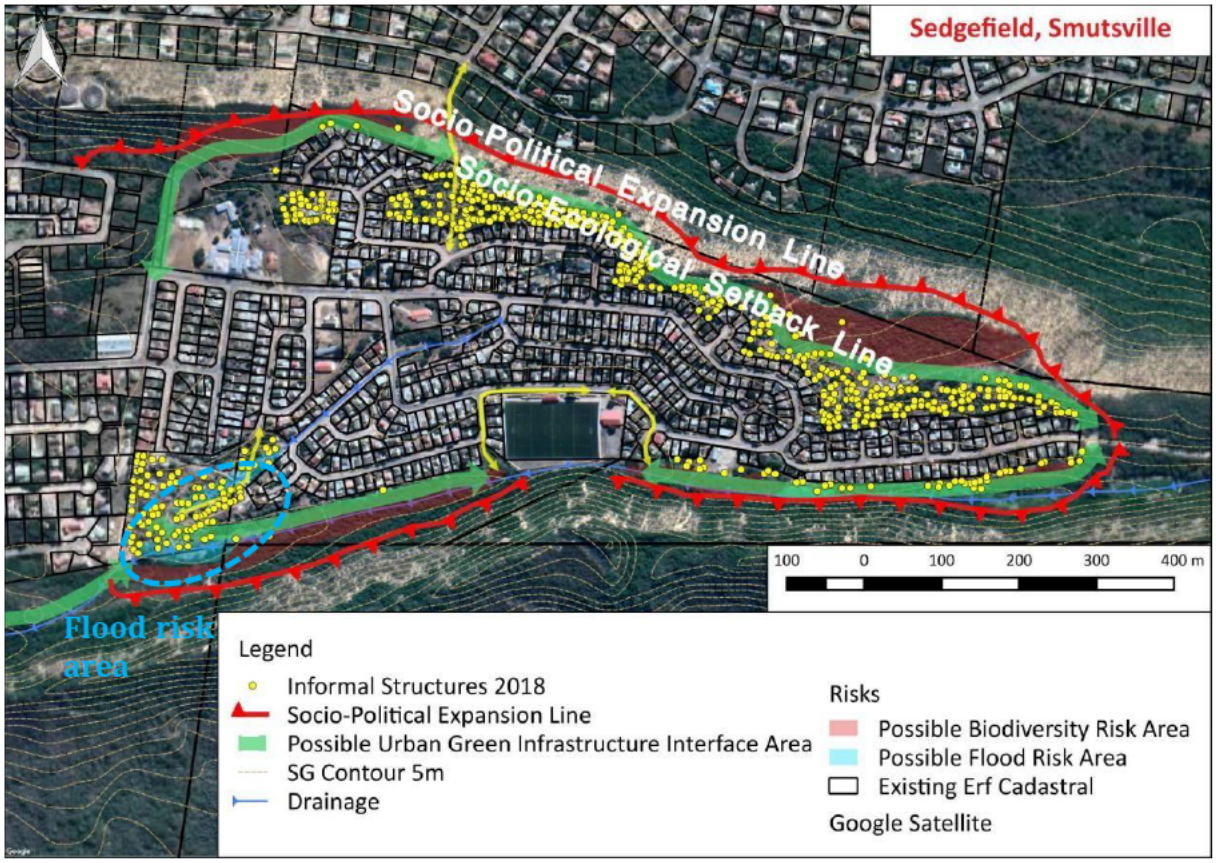


Figure 18. Sedgefield-Smutsville socio-political expansion scenario overlay against possible urbangreen infrastructure interface. (Source: ESRI South Africa, 2022; Survey General, 2022)

It is important to note that White Location and Smutsville are only two of many more informal settlements in the region, with many of the settlements likely to be facing similar WUI wildfire and biodiversity loss risks. Regional screening found 79 informal settlements, located in urban, peri-urban and rural landscapes (see Figure 19). The limited scope of the research restrained further investigation of these IS nodes, but it must be noted that many of these communities will increasingly be subject to wildfire risk and, due to circumstances related to poverty, critical biodiversity loss is likely to ensue. As depicted in the time series mapping for White Location (Knysna) and Smutsville (Sedgefield), and well as previous analysis of informal expansion in KwaNonqaba (Mossel Bay), further research into these nodes needs to be undertaken for the future protection of people and ecology in the Garden Route Biosphere Reserve.

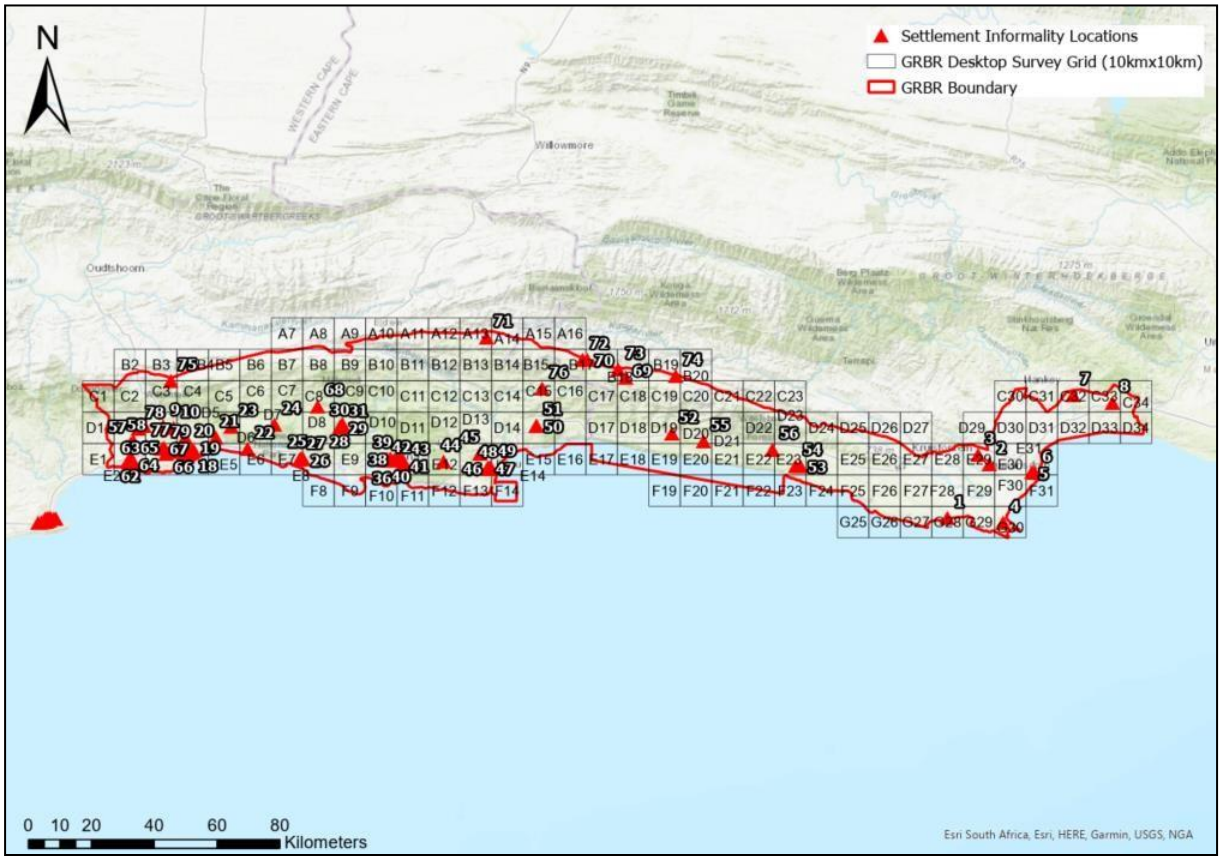


Figure 19. Informal settlements within the Garden Route Biosphere Reserve. (Source: ESRI South Africa, 2022)

4.5 Discussion

In both White Location and Smutsville, the problem is clear: the continued building of informal settlements in the CBA areas, will result in loss of critical biodiversity and will increase the future risk to the community to steep slope exacerbated wildfire. The findings of the assessment of informal settlement expansion in KwaNonqaba, Mossel Bay, was that attaining socio-ecological informed land-uses in KwaNonqaba could require a design mind-shift that embracesmoving away from formalised, single residential styled, big project framing—as argued elsewhere (Marie et al. 2019). Critically, as informality in settlement is likely to continue to be a more common settlement typology in the context of rapid urbanisation scenarios in the Garden Route, a more informed approach needs to be established to better manage the WUI and assist the poor in securing their basic needs.

As the WUI wildfire risk has been clearly visible since the 2017 Knysna fire, the question is raised as to why a governance intervention has not been implemented? As a possible answer, firstly, this information is not readily available to stakeholders in communities

and in local authorities. Secondly, where such information is available there is often conceptual and systemic blind spots that make acting in a timeous way to avoid unplanned informal settlement difficult. Finally, given the high costs and long development times of UISP projects, financial constrain is also likely to be a core component of this complex problem. To overcome the complexity of this socio-ecological issue, Yasmin et al. (2019) advocate that adaptive governance has emerged as a "normative, conceptual and analytical approach to address the inherent complexities of socio-ecological systems" (Yasmin, et al. 2019, p. 1, 16) to better manage natural resources and promote sustainable development. Recognising the complexity of the system, they motivate for an enabling process requiring broad participation and collaboration, across scales that embrace reflexivity and the development of actor- networks.

Progress with this concept is being made in South Africa, with the SACN making reference to the 'all of society' approach (Maharaj et al. 2021) advocated by the Integrated Urban Development Framework, a policy initiative of the Department of Cooperative Governance and Traditional Affairs. In the 2021 State of South Africa Cities Report, under the heading 'Stacking' the levers: Governance and economic levers', it is stated that the Integrated Urban Development Framework views local government as an all-of-society approach to social and economic development, with multiple actors coming together to collaborate around economic levels. While this only refers to the economy, this principle is key to facilitating a more inclusive approach to addressing these complex problems, and the seeking of innovative sustainable land use management solutions. In the White Location and Smutsville WUI scenarios, there is an opportunity to test broad interventions as part of a wider, 'all-of-society', adaptive governance framing, where at risk informal settlement communities work with civil society and local government to define an intervention strategy, for small scale implementation as part of a pilot study for evaluation. However, as this may not align with the existing 'large project' status quo approaches to low-cost housing development, resistance to a broader framing of adaptive governance—that is, inclusion of civil society into the governance space—could be resisted.

This research has identified that 79 already-existing informal settlements located within the GRBR, many in wildfire risk areas. This underlines the critical need for planners to become more proactive in response to wildfirerisk in the WUI. As evident in the mapping, White Location and Smutsville, a clear governmental intervention is not apparent in many

instances, with likely dire consequences for the informal settlement residents and biodiversity. Clark and Harley (2020) reflect on the growing concern many scientists are experiencing with regard to how transformation of natural systems by humans is taking place at unsustainable levels. As indicated in their research, there is growing concern that this trajectory, accompanied by increasing poverty and inequality, will destroy the natural resource base that underpins human wellbeing. Within the local Garden Route landscape context, the loss of natural resource areas predisposes many communities to wildfire and flood risks, and a loss of future PoS that could be used for recreational purposes. Rapid planning is proposed as a possible adaptive co-management solution (Princes Foundation, 2020). The problem, as outlined by the authors, often lies in the unwillingness of the incumbent socio-political forces to heed the distress signals brought about be the continuation of 'business-as-usual' approaches to development that are expensive with long development timeframes.

Clark and Harley (2020) maintain that undoing such blockages is likely to require a radical restructuring of the political status quo if society is to enable a serious pursuit of sustainability. They further elaborate on the idea of 'informed agitation'. If a better understanding of sustainability is to be achieved, agitation is required to challenge the powerful entrenched interests that disproportionately benefit a few people at the cost of impoverishing the prospects of the many. However, the proposed agitation needs tobe informed by better understanding of sustainability science, so as not to "blunder blindly forward pushing development down even more destructive pathways" (Clark andHarley, 2020, p. 23). Successful strategies for the mobilization of informed agitation strategies usually involve enhanced citizen participation that encourages other forms of collective resistance (Clark and Harley, 2020).

Clark and Harley motivate that organisations can assist in enabling capacity, measure sustainable development, promote equity, and link knowledge with action, which will allow communities to adapt to shocksand surprises and to transform the system onto more sustainable development pathways. The authors indicate that many opportunities exist for research that would be useful in improving the governance of resources for sustainability.

- Creating more and better databases that capture the relevant governance arrangements that are in place and their success in the pursuit of sustainability.
- Making wealth metrics used to guide the design of integrative governance

arrangements more practical and usable than those that focus only on individual sectors and resources; and

- Promoting the use of network analysis and modelling approaches based on complex adaptive systems to assess and evaluate proposed governance arrangements (ibid).

These concepts are encapsulated in this research, where GIS databases and spatial analysis are utilised to highlight risk areas, as well as the critical need to proactively engage in integrative governance arrangement, as well as provide a concept document that could lead to GIS modelling approaches that assist governance with proactive planning for informal settlement expansion into wildfire risk areas, with increasingly devastating loss of life and property. While rapid planning has been mooted as a possible solution, the question that also needs to be raised, is what would a rapid planning scenario look like within the South Africa context, and what laws would need to be modified to accommodate this process? Further research in the nature of this concept as a possible solution needs to be undertaken.

CHAPTER 5

5.1 Summary, Conclusions and Future Work

The 2017 Knysna wildfire with loss of eight lives, 1059 formal dwelling destroyed or damage, 385 informal dwelling destroyed or damage and final losses of estimated at billions of Rands (Vulcan Wildfire Management, 2017), highlights the risk of the WUI to wildfire in the GardenRoute. Well established in research (Manzello, 2020), indicated that the likelihood that this risk will become exacerbated with climate change (Jolly et al. 2015). Against this backdrop, the research highlighted in this thesis emphasises that there is a clear imperative to protect biodiversity for NBS/ NCS and wellbeing (Griscom et al. 2017), and to create a buffer between the steep slopes areas and informal settlements with access provided for fire suppression services (Vulcan Wildfire Management, 2017). In addition, research is also highlighting the potential benefits of introducing of UGI systems thinking (Anderson, 2015) as a method of facilitating increased municipal access and governance of the ecological/ wildfire buffer areas. The spatial data analysis on the expansion of informal settlement over time, also finds that there is ingress into areas identified and mapped as CBA areas. The spatial data collected during this study, compared against the spatial development framework planning, also infers that a more proactive and 'rapid planning' approach is required if these types of rapid urbanization scenarios are to be more effectively managed. However, it is important to consider whether these are the correct approaches to follow and, if they are, how they can be implemented, given thewell-entrenched modus operandi of the existing low-cost housing programme that essentially maintains the status quo.

A central finding of Clark and Harley's research is that sustainable development can realistically only be pursued through an iterative process, where the interventions are considered as experiments, being open to making changes based on new information, and having the courage to quickly abandon them if they do not go as planned (Clark and Harley, 2020). With the implementation of any of the UGI concepts, this iterative process would need to be followed, evaluated and then abandoned in deemed to be unsuccessful. As with the UGI, the rapid planning that has been mooted as a possible solution, would also need to be subject to the same evaluation. Specifically, providing a better understanding of what a rapid planning scenario look like within the South Africa context, and what laws would need to be modified to accommodate this process would need to be undertaken.

In the case of White Location and Smutsville, mapping slopes in relation to informal settlement expansion over time, allows for a broad brush understanding of where informal settlement is likely to expand to, where there is increased possibility of wildfire risk *and* loss of biodiversity. This type of spatial analysis could provide insight into the type of buffering design required for less risk-prone development, and thus provide some insight into the nature of the adaptive co-management strategies that need to be undertaken to reduce the risk. As highlighted in the evaluation of the planning for informal settlement in the KwaNonqaba area, Mossel Bay, failing to plan proactively for rapid informal settlement will place a long-term financial burden on future citizens, but will also be costly in terms of social, mental, physical, and economic wellbeing of informal settlement residents, and will result in long-term socio- ecological deprivation. Given the risks from these inappropriately located settlements, without rapid planning interventions, the communities will always be locked into cycles of poverty due to the increased risks they face and the temporal status of their abodes, and a spatially embedded inabilityto transition into the formal housing structure and economy.

This thesis argues for more rapid, adaptive planning measures for increased unplanned informal settlement, which would prioritise equitable access to natural resources, defusing social tension in a situation of deeply rooted—and likely increasing—inequity. This paper also highlights the need for civil society organisations to engage in the governance space to ensure that more timeous, and less costly, approaches to management of informal settlement along the many ecological corridors in the Garden Route takes place. An adaptive planning approach could be an alternative to the current adherence to the current top-down type governance, historically embedded to colonial and apartheid-inspired settlement patterns, further exacerbated by short-term planning that is overly engineered and, thus, costly and lengthy. To continue with a management system that is already impacting poorly on ecological corridors, with knock-on effects of increase fire and flood exposure, is likely to result in the long-term loss of recreational spaces for these communities, and a loss of ecological integrity of the urbanriverine areas within the Garden Route.

While this thesis does not provide definitive solutions to the problems of WUI wildfire management, it does highlight the risks of maintaining the status quo in terms of addressing informal settlement in areas with critical biodiversity/ drying biomass. Within

the South African land use management context, sustainability science framing calls for the need to address capacities for addressing (in)equality, and (in)equity for sustainable development (Clark and Harley, 2020). Failure to apply proactive, transformative land management—namely, one embracing a more informed and participatory understanding of sustainable development that does not degrade the natural systems that stabilise earth systems—could result in increased urban / rural landuse conflict, and subsequent informal settlement 'spill over' into the critical biodiversity areas.

The key consideration for achieving future socio-ecological sustainability within the Garden Route WUI, which has significant ecological and landscape resources, should be related to how policy and planning can achieve integrated landscape-scale planning that allows for the sustainable utilisation of non-renewable resources, such that the derived eco-systems goods and services (provisioning and other) continue to support the nutritional and wellbeing requirements of a rapidly growing, and urbanising population. Unfortunately, within the South Africa historic planning framework, spatial inequalities inherited from the apartheid planning policies have segregated society on racial and, increasingly, on economic grounds (SACN, 2016; Bernstein, 2020). Due to the long-time required for UISP / RDP houses, the significant costs, and the limited areas for low-cost development areas, poor communities are increasingly likely to seek more informal settlement solutions by necessity. The findings of both papers indicate that informal settlement is trending towards expansion into public open spaces along river systems that are not effectively managed by local government, increasing community risk to wildfire and flood, and increasing the cost for possible future relocation/ or formalisation. Thus, planning for ecological corridors requires an improved adaptive management structure, and incorporation of UGI systems thinking to create recreational spaces that incorporate within the design, an unequivocal visual distinction between the built areas and the nature areas. The distinction is necessary to safeguard future ecosystem goods and services and associated community wellbeing, and effective municipal access to maintain service delivery and solid waste removal, and to provide a physical buffer between urban development and the increasing likelihood of climate change related wildfires. This unequivocal land use distinction needs to be clearly recognised as a benefit to the local community, and by the relevant municipality, where it becomes obvious to all concerned that informal settlement has taken place in the incorrect area, to the loss of the greater community wellbeing.

The question as to how to productively engage in the informal settlement design space is addressed in Chapter 3 /Paper 1. The recommendation is for planners to embrace more adaptive governance systems that allow for proactive climate-change adaption by design, incorporating appropriate densification, and allowing urban green infrastructuresystems thinking. This is to ensure that resilience is embedded into settlement by design,such that the collective challenges of climate-change and rapid urbanisation can beaddressed and the resultant, socially just, living landscapes in the Garden Route allow for social and ecological cohesion as an expression of collective prosperity. While the costs of building a road next to the river valley, servicing a single row of houses, will be greater in the short term, as future costs from not adequately addressing the urban-nature interface by design are likely to be higher. Pollution costs will be higher due to limited access for collection and removal of solid waste from dwellings located next to river systems. What are the secondary costs from water pollution to the communities? Located outside of the 'visible' spaces, informal structures will be opportunistically located adjacent to the RDP/ UISP dwelling, usually located on more difficult terrain and will be more inaccessible and likely to be significantly more costly to relocated as a result. The loss of this land to 'forced' informal development, results in further losses of PoS for the greater community, which as highlighted by Andersson et al. (2015), is also linked to avoided costs due to economic efficiency. Without intervention, unplanned loss of PoS has the potential to incur higher costs to society in the long term, due to continuously incurred costs from land degradation from pollution, water pollution, costs to the community for the continuous rebuild after flood and wildfire.

Drawing on field research, policy analysis and satellite mapping in the Garden Route Biosphere Reserve—specifically focusing on Mossel Bay, Sedgefield and Knysna—in the Southern Cape, South Africa, this dissertation argues for more adaptive governance in land use management of WUI. Proactive planning for alleviating the experience of poverty, through provision of basic services and access to public open space, calls for a more rapid, inclusive and community-informed dialogue on adaptive co-management of the wildlands-urban interface.

5.2 The way forward: Preliminary Recommendations

Clark and Harley (2020) argue that social movements and political mobilization are important components of enhanced governance capacity to promote equity, emphasising that social movements work by spreading values of micro-level activists and agitators to

the institutions, with the potential to challenge the rules, norms, values, and beliefs of incumbent regimes. Through this process, the authors assert that organisations can assistin enabling capacity, measure sustainable development, promote equity, and link knowledge with action, which will allow communities to adapt to shocks and surprises and to transform the system onto more sustainable development pathways.

The intention of the thesis is to create a foundation of sustainability science knowledge, from which to 'agitate' for a review of the current planning status quo for informal settlement in the WUI areas, however, mindful of Clark and Harley's (2020) emphasis that agitation needs to be informed by research, the proposed agitation needs to be guided by better understanding of sustainability science. To be a part of an inclusive solution to a complex problem, the author has assisted in setting up a non-profit company to start a dialogue, centred around the development of capacity to engage in sustainability science. The organisation, Sustainability Forum (SF), piloted in George in the Garden Route, with the broad objective to increase dialogue and governance capacity to address sustainability risks to increasinglycomplex, socio-ecological systems. While the continuation of the non-profit company in its current form is questionable due to capacity and funding constraints, the setting up ofa civil society 'WebGIS', an online spatial database for raising and tracking socio-ecological issues, has demonstrated value that this type of platform in creating a dialogue around sustainability issues, and engaging with governance to address issues raised (refer to Annexure C).

The Figures reflect several slides, presented to the Overstrand Environmental Conference 16 February 2023. Figure 25 depicts the organisation structure and provides a diagram depicting the focus of organisation towards Good Governance, Social and Ecological Wellbeing and the need to work towards a Green Economy. Figure 26 outlines the necessity for a sustainability science framing and the need for 'Informed Agitation' as proposed by Clark and Harley (2020). Figure 27 is a screen capture of the front-end of the WebGIS Issue Logging Portal, showing three of the issues logged, with Figure 28 a list of the Issues logged or raised by the Sustainability Forum during the three years of operation. Figures 29 and 30 are thematic maps of the locations of the logged issues, withthe former a subjective appraisal of the social risk to persons/ communities in relation tothe activity, and the latter the ecological risk of the activity. Figures 31 and 32 are overview maps of the flagged risks, where the subjective appraisal has flagged a high risk for both Social and Ecological categories. The final map highlights the logged issues in relation to a Risk Champion status,

where there are/ not community organisations working within the environment to address the risk. Two areas are highlighted as they depict areas of high socio-ecological risk without a champion.

Due to the lack of capacity to engage in the process (with all directors working pro bono), and limited funds to create a more functional platform, risks within the platform were apparent. One of the risks that was highlighted in the WebGIS process, was the lackof inclusiveness in the dialogue, with the platform mainly linked to middle-income issues,that has the potential to shape the dialogue towards protection of white-minority interests. Should any new evolutions of the organisation and the 'WebGIS' take place, theplatform would need to address these and other risks and recognised the financialcosts of building a more user-friendly interface. However, the preliminary experiment undertaken by SF does indicate value in the empowering of civil society with the means to spatially log socio-ecological risks, engage in an inclusive dialogue around sustainable science framing for sustainable development, and track persistent socio-ecological risks such that governance is held accountable.

Further work that would need to be addressed is, after SACN, setting up all-of-society platforms (Maharaj et al. 2021) to start to engage productively in the informal settlement management space at inter- and intra-disciplinary levels. This needs to be done from the ground-up, with populating of the initial informal settlement spatial database to define the faces and names behind the places. While individual databases of informal settlements are available, these are local governance area specific and unlikely to 'talk' to each other. These databases are outside of the view of civil society. While densification modelling was not used in the thematic mapping of this study, it could well provide useful insight into the nature of informal settlement growth in the future, as partof further research into informal settlement management. While this analysis could provide a better understanding of the spatial nature of informal settlement growth, it is the engagement with the communities that is key. Only through collective engagement with the informal settlement communities on the ground, and the institutions governing these areas, can a more inclusive understanding of the ecological commons be established. Further research into systems thinking and NAS approaches to land use management are required, as this would be the foundational framing for ensuring a just, sustainable development outcome.

5.3 Conclusion

As has been emphasised in this thesis, climate change is contextual, but acts as an additional stressor and threat multiplier to existing problems. Research by Rigaud*et al.*, 2018 indicate that urbanisation of the continent of Africa is going to be one of the defining characteristics, and a major source of GHG emission mitigations if not successfully managed. Critically, a better understanding of urbanisation, located within a sustainability science framing is required.

There is a need to understand the expansion of informal settlement into PoS areas, in the context of open spaces as a 'commons. This opens the opportunity for adoption of tools for work in adaptive governance and adaptive planning spaces. Both the papers give examples of the influences of lack of proactive management of informal settlement on the ground, and provide motivation for the need to move towards more adaptive planning practices located within an adaptive governmental framework, to ensure that wilderness areas, within and surrounding urban areas, are preserved as functional spaces for civil society, and as a legacy for future generations where these ecosystems do not collapse into a 'tragedy of the commons' through over extraction and destruction by unplanned land use change.

A central finding of Clark and Harley's research is that sustainable development can realistically only be pursued through an iterative process, where the interventions are considered as experiments, being open to making changes based on new information, and having the courage to quickly abandon them if they do not go as planned (Clark and Harley, 2020). Throughout the Southern Cape, there are multiple examples that show that the restricted access to ecological corridors located in front of linear planned, single residential developments, has resulted in, and are likely to continue resulting in, these ecological corridors transformed into unplanned informal settlement, or subject to ecological degradation to the extent that the integrity of public open spaces and ecological corridors are compromised. The location of informal settlement in these natural areas places these communities at risk from flood and wildfire and other human wellbeing factors, such as emergency health penetration. A better understanding of the costs/ benefits of this design approach need to be undertaken, to see if there are avoided costs from economic efficiency that would out way the increased cost of this design. With the implementation of any of the UGI concepts, this iterative process would need to be followed, evaluated and then abandoned in deemed to be unsuccessful. As with the UGI, the rapid planning that has

been mooted as a possible solution, would also need to be subject to the same evaluation. Specifically, providing a better understanding of what a rapid planning scenario would look like within the South Africa context, and what laws would need to be modified to accommodate this process, would also need to be evaluated. Further research in the framing of ecological corridors within urban areas as an ecological commons, would also need to be tested, engaging with all stakeholders to define the rules of engagement for effective commons governance.

Finally, there is a need to review the legal mechanisms for ensuring informal settlement does not take place in area of high flood or wildfire risk. Of relevance to addressing this risk, a review of the Prevention of Illegal Eviction from and Unlawful Occupation of Land Act 19 of 1998 (PIEA) (RSA, 1998) is proposed. While the provision for legal relocation from at-risk locations is contained within the Act, the reality of the complicated and costly procedures faced by local municipalities required to relocate settlements to safer lands, which are notnecessary readily available, creates a scenario that limits action. While this legal quandary is outside the brief of this thesis, it is highlighted as an urgent risk that needs to be addressed if more sustainable land use management in riverine areas is to be achieved, without increased risk of loss of life and property.

As highlighted in the review of the long-term planning for informal settlement in the KwaNonqaba area, Mossel Bay, failing to plan proactively for rapid informal settlement will place a long-term financial burden on future citizens, but will also be costly in terms of social, mental, physical, and economic wellbeing of informal settlement residents. Given the risks from these often inappropriately located settlements, without rapid planning interventions, these communities will always be locked into cycles of poverty due to the increased risks they face and the temporal status of their abodes, and a spatially embedded inability to transition into the formal housing structure and economy.

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ANNEXURES

Annexure A: DEA&DP Authorisation Letter Regarding the Mossel Bay Precinct 2 UISP.

Figure 20. DEA&DP Authorisation letter regarding the Upgrading of Informal SettlementsProgram - For Precinct 2, Mossel Bay.

Western Cape Government
Environmental Affairs and Development Planning

DIRECTORATE: ENVIRONMENTAL GOVERNANCE
SUB-DIRECTORATE: RECTIFICATION

REFERENCE NUMBER: 14/2/4/2/3/D6/26/0008/18
ENQUIRIES: Jamie-Lee van Zyl

BY REGISTERED MAIL

The Municipal Mayor
Mossel Bay Municipality
Private Bag X29
MOSSEL BAY
6500

Tel: (044) 606 5013
Fax: (044) 606 5062
Email: jvanzyl@mosselbay.gov.za

Attention: Mr Johan van Zyl

Dear Sir

APPLICATION IN TERMS OF SECTION 24G OF THE *NATIONAL ENVIRONMENTAL MANAGEMENT ACT, 1998 (ACT 107 OF 1998)* ("NEMA"): UNLAWFUL COMMENCEMENT OF A LISTED ACTIVITIES: THE UPGRADING OF INFORMAL SETTLEMENTS PROGRAM (UISP)- PRECINCT 2, MOSSEL BAY

With reference to your application dated 31 May 2018 and environmental assessment of September 2018 in terms of section 24G of the NEMA for the consequences of unlawful commencement of listed activities identified in terms of the NEMA, find below the decision in respect of your application.

ENVIRONMENTAL AUTHORISATION

A. DECISION

By virtue of the powers conferred by section 24G of the NEMA and the *Environmental Impact Assessment Regulations, 2014* ("EIA Regulations, 2014") (as amended), the competent authority herewith **grants environmental authorisation** to the applicant to continue with the listed activities specified in Section C below in accordance with the

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tel: +27 483 8347 fax: +27 21 483 4033 www.westerncape.gov.za/eadp

Figure 21. DEA&DP authorisation letter outlining loss of indigenous vegetation of which 17.65Ha is located on land zoned Public Open Space.

more than 10 cubic metres from a watercourse.	
Government Notice No. 983 of 4 December 2014 - **Activity Number: 27** Activity Description: *The clearance of an area of 1 hectares or more, but less than 20 hectares of indigenous vegetation.*	An approximate total area of ±17.65ha of indigenous vegetation has been cleared (brownfields – informal houses established) across all the aforementioned erven, but less than 20ha on each individual erf.
Government Notice No. 985 of 4 December 2014 - **Activity Number: 12** Activity Description: *The clearance of an area of 300 square metres or more of indigenous vegetation except where such clearance of indigenous vegetation is required for maintenance purposes undertaken in accordance with a maintenance management plan. (i) Western Cape: (ii) Within critical biodiversity areas identified in bioregional plans; & (iv) On land, where, at the time of the coming into effect of this Notice or thereafter such land was zoned open space, conservation or had an equivalent zoning.*	Erven 1704, 5184 & RE Pt 249 of Farm 220: More than 300 square metres of indigenous vegetation has been cleared on areas indicated as CBA and on land zoned Public Open Space.
Government Notice No. 985 of 4 December 2014 - ***Activity Number: 14*** *Activity Description: The development of– (ii) infrastructure or structures with a physical footprint of 10 square metres or more; Where such development occurs –*	Informal housing structures with a footprint greater than 10 square metres have been constructed at various locations throughout the site and are located within CBAs.

Figure 22. DEA&DP authorisation letter stating that the Visual Impact Assessment findings must be incorporated into final layout design.

PART VII

Activity/ Development Specific Conditions

15. Should any heritage remains be exposed during excavations or any other actions on the site, these must immediately be reported to the Provincial Heritage Resources Authority of the Western Cape, Heritage Western Cape. Heritage remains uncovered or disturbed during earthworks must not be further disturbed until the necessary approval has been obtained from Heritage Western Cape.

    Heritage remains include: meteorites, archaeological and/or paleontological remains (including fossil shells and trace fossils); coins; indigenous and/or colonial ceramics; any articles of value or antiquity; marine shell heaps; stone artefacts and bone remains; structures and other built features with heritage significance; rock art and rock engravings; and/or graves or unmarked human burials including grave goods and/or associated burial material.

16. A qualified archaeologist and/or palaeontologist must be contracted where necessary (at the expense of the holder) to remove any heritage remains. Heritage remains can only be disturbed by a suitably qualified heritage specialist working under a directive from the relevant heritage resources authority.

17. The recommendations made in the Freshwater Impact Assessment compiled by BlueScience of January 2018 must be implemented.

18. The recommendations made in the Botanical Assessment compiled by Regalis Environmental Services CC of March 2018 must be implemented.

19. The recommendations made in the Visual Statement compiled by Visual Resource Management Africa CC dated 30 August 2018 must be implemented

20. The recommendations made in the Traffic Impact Assessment compiled by SMEC of February 2018 must be implemented.

21. The recommendations made in the Stormwater Strategy compiled by Aurecon (Pty) Ltd dated 4 September 2018 must be implemented.

Figure 23. Record of Visual Impact Assessment findings recorded in the DEA&DP authorisation letter.

Mitigation proposed: All the existing informal houses should be removed from the ESA1 (water drainage) areas; retaining heathy vegetation and reducing soil erosion along the water drainage lines; reducing (or ideally remove) grazing pressure by domestic stock from the entire Kwanonqaba area; Establish paved pedestrian access routes at key points between neighbouring areas; removing alien vegetation and clearing the litter from water drainage lines regularly.

Operational Phase

No impacts were identified by botanist for the operational phase.

3.6. Visual / Sense of Place

The Visual Statement received as part of the application notes that the proposed development is highly likely to result in the significant degradation of an important urban 'green lung'. It is expected that the development will result in a high negative visual impact. This is due to urban sprawl into the river valleys, restricted access of the community to Public Open Space as a result of to ribbon development along the river valley edge, as well as insufficient space adjacent to CBA/flood zones areas to allow for Urban Green Infrastructure connectivity routes.

Mitigations relating to visual impacts are addressed during the design phase and are reflected in the site layout as far as practically possible.

3.7. Traffic Impacts

According to the assessment, the implementation of the UISP will have a major impact on the current Kwanonqaba road network. Even though the construction of a new link road between Louis Fourie and Grunter Road is imminent, there are in reality very few major ingress/egress points in to the greater Kwanonqaba area. The housing development will therefore place additional strain on these nodes which will require intersection upgrading to mitigate the impact. Various additional traffic mitigation measures have been identified in the Traffic Impact Assessment report.

3.8. Heritage / Archaeological / Built Environment Aspects

Virtually the entire study area has been transformed through various urban-related land uses, including densely populated informal residential structures, agriculture (e.g. pig farming, goats) cultivation and grazing. Dumping of

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Annexure B: Extract from the VRMA Mossel Bay 2 & 3 UISP Upgrade Visual Statement

Figure 24. Extract from the Visual Resource Management Africa Draft Final Visual Statement regarding the Mossel Bay Precinct 2 & 3 UISP upgrade.

1 INTRODUCTION

Visual Resource Management Africa CC (VRMA) was appointed by Aurecon South Africa (Pty) Ltd to undertake a ***Visual Baseline Assessment*** for the proposed Mossel Bay Precinct 2 Upgrading of Informal Settlements Programme (UISP) on behalf of Mossel Bay Municipality. The scope of the study is for a baseline assessment only and does not include impacts. This visual statement pertains to the revised layouts informed by botanical, hydrological and visual /landscape resources specialists input. This statement needs to be read in conjunction with the Precinct 2 Visual Baseline. The updated layout plans are provided as a separate PDF document of the A3 scans. As digital copies of the layout could not be provided, comments were made onto the drawing by hand.

2 MOTIVATION

The UN-HABITAT State of the World's Cities 2012/2-13 report states that "never before has humankind as a whole faced cascading crises of all types as have affected it since 2008, from financial to economic to environmental to social to political. Soaring unemployment, food shortages and attendant price rises, strains on financial institutions, insecurity and political instability, among other crises" (UN-HABITAT 2012, Pg 10). The United Nations Conference of Housing and Sustainable Urban Development adopted the Habitat III New Urban Agenda in 2016. The agenda notes that urbanization will be "one of the 21st century's most transformative trends" with the world urban population expected to nearly double by 2050 (United Nations 2016, Pg 3). Thus, the complexity of the growing informal settlement landuse pattern, against the background of apartheid planning and the need for social justice, has to be recognised as a critical issue that needs to be addressed in South Africa. The lack of proactive planning catering for the influx of lower income groups is evident in the marginal areas where informal settlement has manifested in the Garden Route. As a result, there is an increasing (and often violent) expression of anger against the continued marginalisation of the urban poor. We critically need to relook at the issue of landuse and land-use change against the backdrop of rapid urbanisation and climate change, to ensure that we come up with new approaches to achieve socially just, living landscapes in the greater Garden Route.

The Habitat III New Urban Agenda emphasises the opportunities of new urbanism as having the potential to "adopt and implement disaster risk reduction and management, reduce vulnerability, build resilience and responsiveness to natural and man-made hazards, and foster mitigation and adaptation to climate change" (United Nations, 2016. Pg 4). With regard to addressing global sustainability threats, the agenda emphasises the need for futures cities to "protect, conserve, restore, and *promote their ecosystems,* water, natural habitats, and biodiversity, minimize their environmental impact, and change to sustainable consumption and production patterns" (United Nations, 2016). In terms of managing the risks of climate change adaption, the Intergovernmental Panel on Climate Change (IPCC) emphasise the need for enhanced Ecosystem management approaches which include "Maintaining wetlands & urban green spaces; Coastal afforestation; Watershed & reservoir management; Reduction of other stressors on ecosystems & of habitat fragmentation; Maintenance of genetic diversity; Manipulation of disturbance regimes; Community-based natural resource management" (IPCC 2014. Pg 44).

However, with low income communities often faced with limited choices and a pressing economic imperative to obtain residential rights as close as possible to economic opportunity, communities have, and increasingly will, force the issue of urban land availability for low cost development. For this reason, it is critical to ensure that adequate planning is set in place to ensure that the long-term value can be obtained from the multitude of ecosystems located within our urban landscapes. As such, the planning for this *Kwanoqaba Public Open Space (PoS) requires an unequivocal visual distinction between the built areas and the nature areas*, which are necessary to derive future ecosystem goods and services and associated community well-bing, effective municipal access to maintain service delivery and solid waste removal, as well as provide a physical buffer between urban development and the increasing likelihood of climate change related wild-fires. This unequivocal landuse distinction needs to be clearly recognised by the community, as well as by the Municipality, where it becomes blatantly obvious to all concerned, when informal settlement has taken place in the incorrect area. As such, it is fundamental to the successful design of this urban development, that a road access separates the urban-nature divide, becoming the Urban Green Infrastructure connectivity system and allowing for enhanced service delivery, and ecosystem services, for this needy community.

It is plainly visible *from the existing Kwanoqaba landscape patterning*, that once a patch of land along the river is boxed in by erven to the extent that visual monitoring cannot take place (Figure 1, left insert), that informal settlement has take place. As can be seen from the extract map from the Prencinct 2 layout, a very similar 'boxed-in' design is proposed.

Figure 1. Google Earth clip of erven boxed in river system where informal settlement has taken place and the extract for the Prencinct 2 layout indicates where informal settlement is very likely to occur due to similar enclosed PoS by design.

Due to the lack of access by municipal services to remove solid waste from these boxed-in communities, *dumping into the river system over the steep slopes will take place*. Dumping and degradation of the river valley *will attract social ills*, enhancing crime and further reducing the viability of this landscape to function as a recreation area. Conversely, it is also plainly visible from the existing landuse patterning, where a road separates the urban-nature interface, that new informal settlement nodes have not taken place. These easily accessed areas allow municipal service delivery to the area, the areas are less polluted, and thus offer stable landscapes for building recreation and enhanced well-being to the community.

The recent 2017 Knysna fire has clearly shown how susceptible urban-fringe informal settlements are to climate change induced wild-fires. This eventuality is very likely to re-occur as the Garden Route that is located in a temperate climate zone area, and due to our

settlements being located in close proximity to natural areas that have a high biomass. The Knysna fire exposed the Xoleni informal settlement community to severe fire risk, with many informal dwellings located on the forest edge razed to the ground. Once again the informal settlement in Xoleni took place in an 'out of sight' areas between a formalised cadastral layout and natural areas. The increased fire risk to settlements in this area once again re-emphasises the need for proactive planning, which includes ensuring that a suitable road buffer seperates communities (especially low income communities) from fynbos biome areas which are required to be burnt to ensure regeneration, as well as facilitating access for rapid response emergency services to aleviate the fire risk. The extract map below, for the Prencinct 3 Gentswana B & C layout (Figure 3), indicates where ribbon development along the PoS will restrict community access to the PoS, increase informal settlement risk below the row of houses, increase pollution due to limited access for municipal services to remove solid waster, as well as increase the community to fire risk due to location of the settlement next to a fynbos vegetation on a steep slope.

Figure 2. The extract for the Prencinct 3 Gentswana B & C layout indicates where communities will be exposure to increase risk and restricted PoS by design.

While the costs of building a road next to the river valley (servicing only a single row of houses) will be more expensive in the short term, it is very likely that future costs from not adequately addressing the urban-nature interface by design, will be much higher. Pollution costs will be higher due to limited access to collect and remove dumping from dwellings located next to river systems. These new informal settlements will be located on more difficult terrain, will be more inaccessible and likely to be significantly more costly as a result. The loss of this land to 'forced' development, results in further losses of PoS for the greater community, which in the long run is likely to cost more in terms of mental and physical health, through limited nature-based well-being opportunities. The following extract from a GREENSURGE document titled Infrastructure Ecosystem Services into Real Economics (Andersson et al, 2015), looks at the value of Urban Green Infrastructure (UGI) in poverty eradication, inclusiveness and public spaces:

> "It has been shown that greener public spaces attract more people and are used more by residents (Kuo et al., 1998). The same study also showed that residents

> closer to green public spaces enjoyed more social activities, had more visitors, knew more of their neighbours, and had stronger feelings of belonging. Greening public spaces contribute to greater community cohesion and social integration (Gobster, 1998; e.g. Kweon et al., 1998), factors that not only have positive effects on physical and mental health but also on economic resilience and productivity (Putnam,1993). This relationship seems to be particularly strong for disadvantaged people, as community cohesion and social inclusion are linked (O'Connor and Sauer, 2006). Studies show that socioeconomically deprived groups tend to live in areas with poorer access to green space, which also relates to health deprivation (Dai, 2011; Gill et al., 2007; Wolch et al., 2014). Cities can counteract these problems by increasing the supply of urban green space in socio-economically deprived neighbourhoods, including using economic incentives to revitalize such areas (Wolch et al., 2014). Properly designed UGI can help achieve both environmental and social objectives, including poverty alleviation and inclusiveness, as demonstrated by multiple case studies (such as the Green Bronx Machine combining urban farming with workforce development, initiated by school teacher Stephen Ritz, and other greening projects undertaken in underprivileged communities by local leaders such as Majora Carter) and systematic studies (Dunn, 2010)." (Andersson et al. 2015,Pg 11),

The value of the river valley as Public Open Space cannot only be viewed from a purely aesthetic perspective (while this is intrinsically true). The international organization GREENSURGE identifies a wide range of ecosystem services that are provided by natural systems if these diverse natural area can be effectively managed as a interconnected whole through Urban Green Infrastructure planning. These ecosystem services include provisioning services in terms of grazing for animals, medicinal resources as well as raw materials. The ecosystems provide regulating services for local climate control and improved air quality, carbon sequestration and storage, as well as moderation and physical buffering of extreme weather events. These areas can also provide cultural services in the form of recreation, physical and mental health, tourism as well as have spiritual benefit from the natural sense of place.

Throughout the Garden Route, there are multiple examples that clearly show that low cost housing adjacent to natural areas has resulted, and is likely to result, in an expansion of an informal settlement landuse pattern. Not addressing this causal informal development pattern by design has a significant cost to our collective biodiversity heritage. We need to plan differently to ensure that we can all benefit from the long-term ecosystem goods and services derived from these nature areas, which are the critical natural features that define these landscapes as the *Garden* Route. As such, it is of great importance for the greater Kwanoqaba and Mossel Bay areas, that the river valley systems in these areas (and in the greater Garden Route) are defined and operated as well-managed, functional, Public Open Space systems as part of a greater Urban Green Infrastructure network. We need to embrace planned systems that allow for ***proactive climate-change adaption by design***, incorporating appropriate densification, nature base solutions and urban green infrastructure systems thinking to ensure we create the resilient society required to overcome our collective challenges of the future and create a socially just, living landscapes in the Garden Route.

Annexure C: Extractions from the Sustainability Forum Presentation to the Overstrand Environmental Conference 16 February 2023.

Figure 25. Extract from Overstrand Environmental Conference: Sustainability Forum. Who we are.

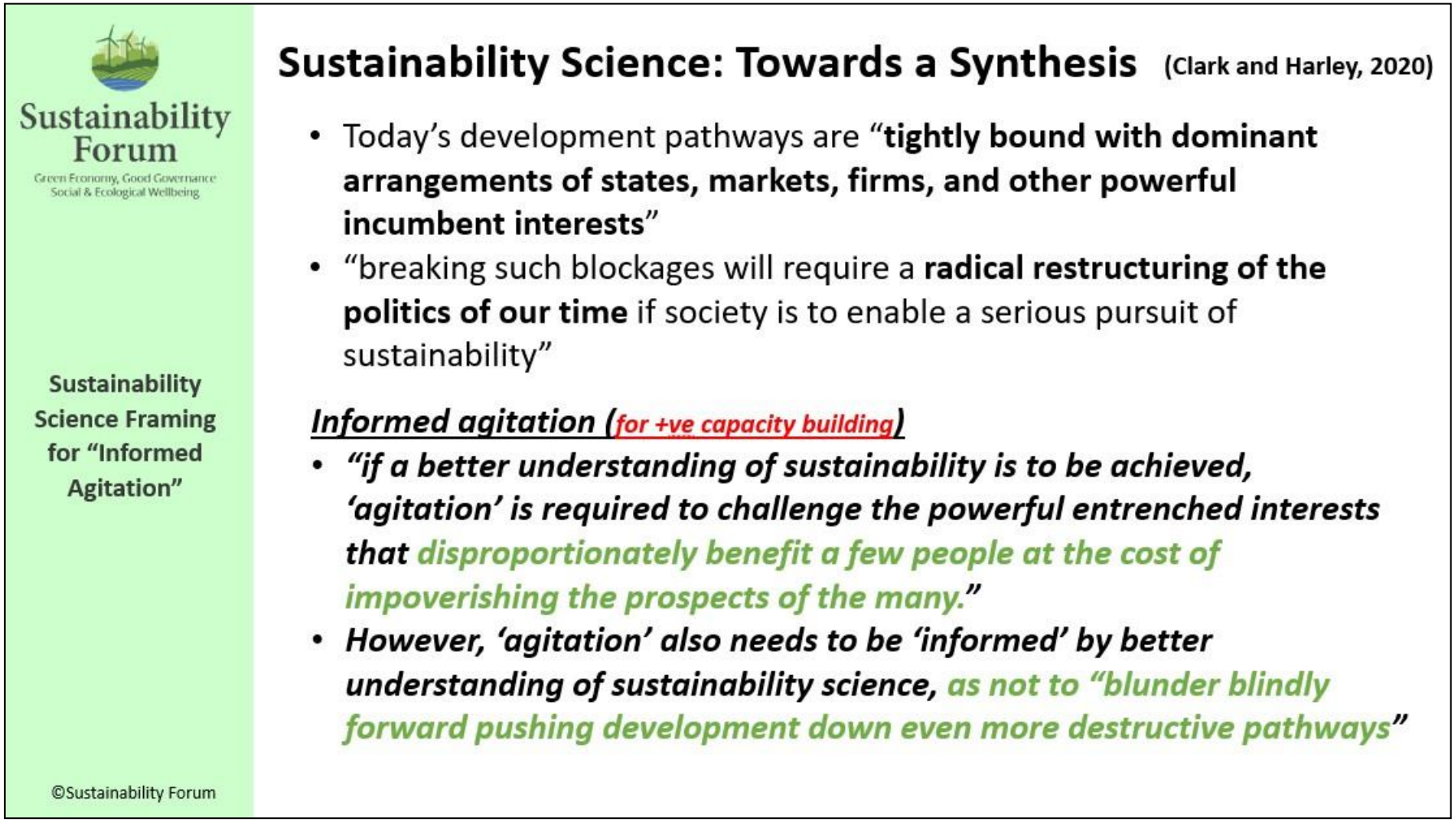
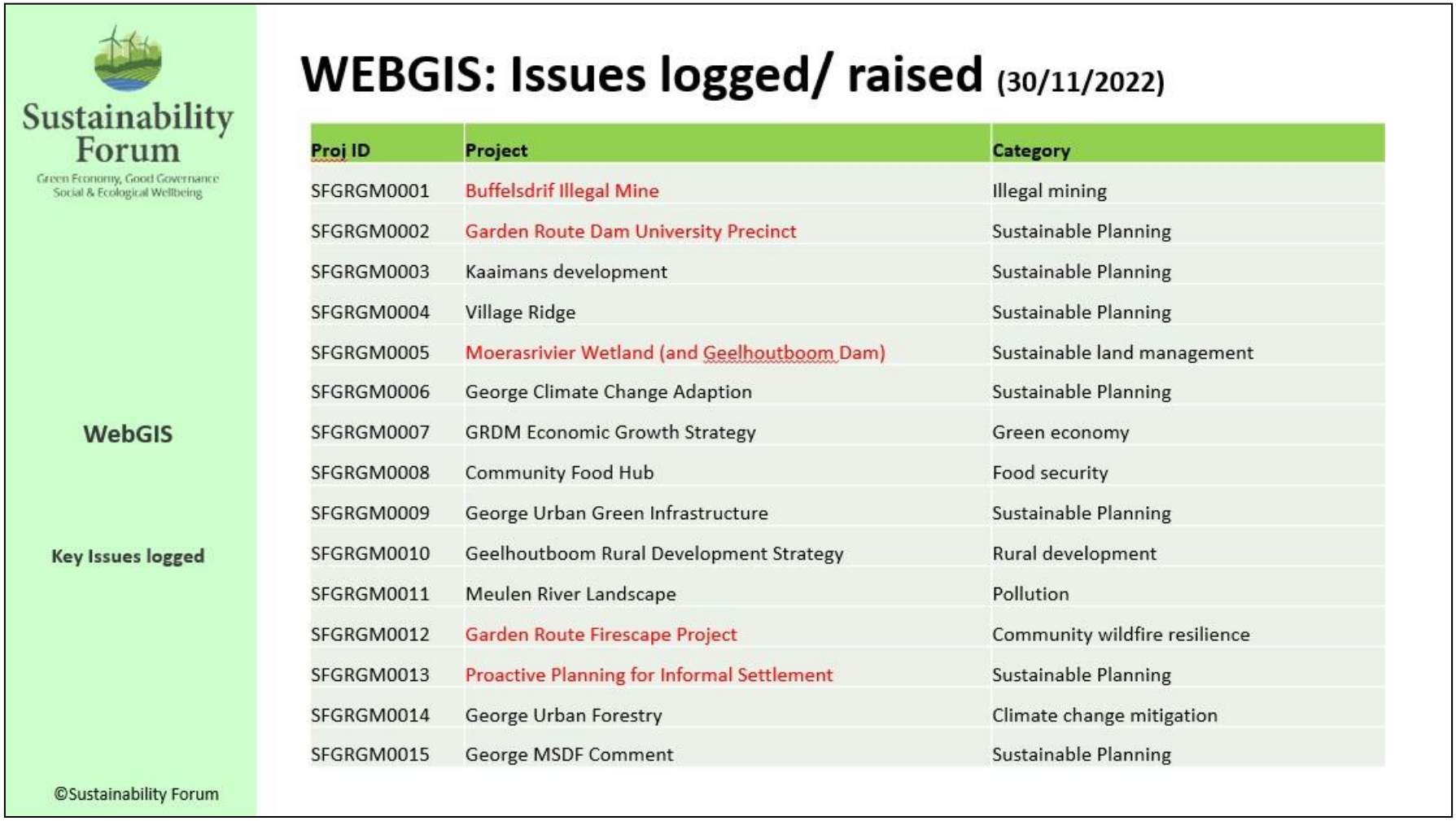


Figure 26. Extract from Overstrand Environmental Conference: Sustainability Science Framing for Informed Agitation.

Figure 27. Extract from Overstrand Environmental Conference: WebGIS Issue Logging Page.



WEBGIS: Issues logged/ raised (30/11/2022)

Proj ID	Project	Category
SFGRGM0001	Buffelsdrif Illegal Mine	Illegal mining
SFGRGM0002	Garden Route Dam University Precinct	Sustainable Planning
SFGRGM0003	Kaaimans development	Sustainable Planning
SFGRGM0004	Village Ridge	Sustainable Planning
SFGRGM0005	Moerasrivier Wetland (and Geelhoutboom Dam)	Sustainable land management
SFGRGM0006	George Climate Change Adaption	Sustainable Planning
SFGRGM0007	GRDM Economic Growth Strategy	Green economy
SFGRGM0008	Community Food Hub	Food security
SFGRGM0009	George Urban Green Infrastructure	Sustainable Planning
SFGRGM0010	Geelhoutboom Rural Development Strategy	Rural development
SFGRGM0011	Meulen River Landscape	Pollution
SFGRGM0012	Garden Route Firescape Project	Community wildfire resilience
SFGRGM0013	Proactive Planning for Informal Settlement	Sustainable Planning
SFGRGM0014	George Urban Forestry	Climate change mitigation
SFGRGM0015	George MSDF Comment	Sustainable Planning

Figure 28. Extract from Overstrand Environmental Conference: WebGIS Issue Logged and Raised.

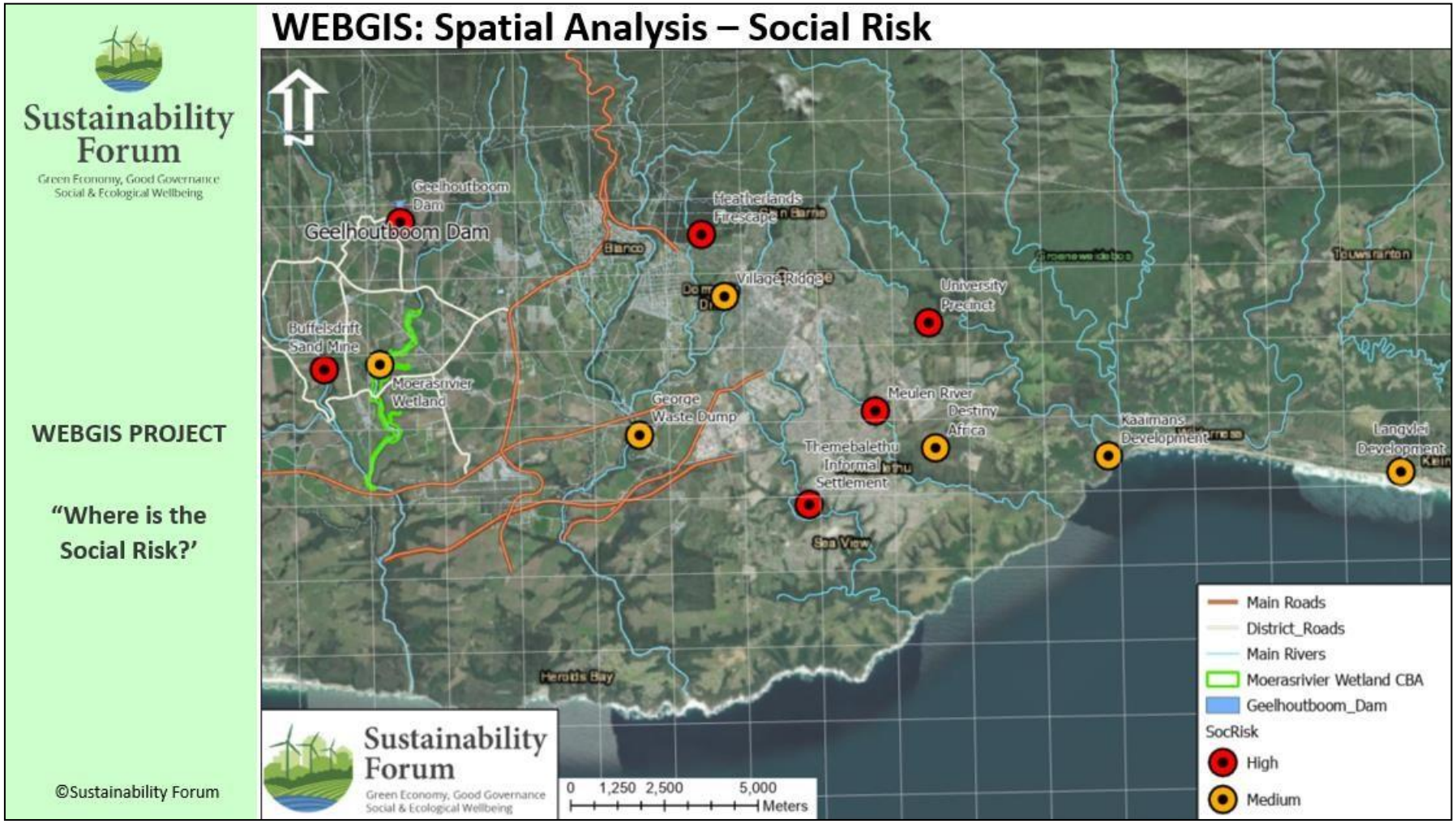


Figure 29. Extract from Overstrand Environmental Conference: Mapping of Social Risk for Issues Logged and Raised.

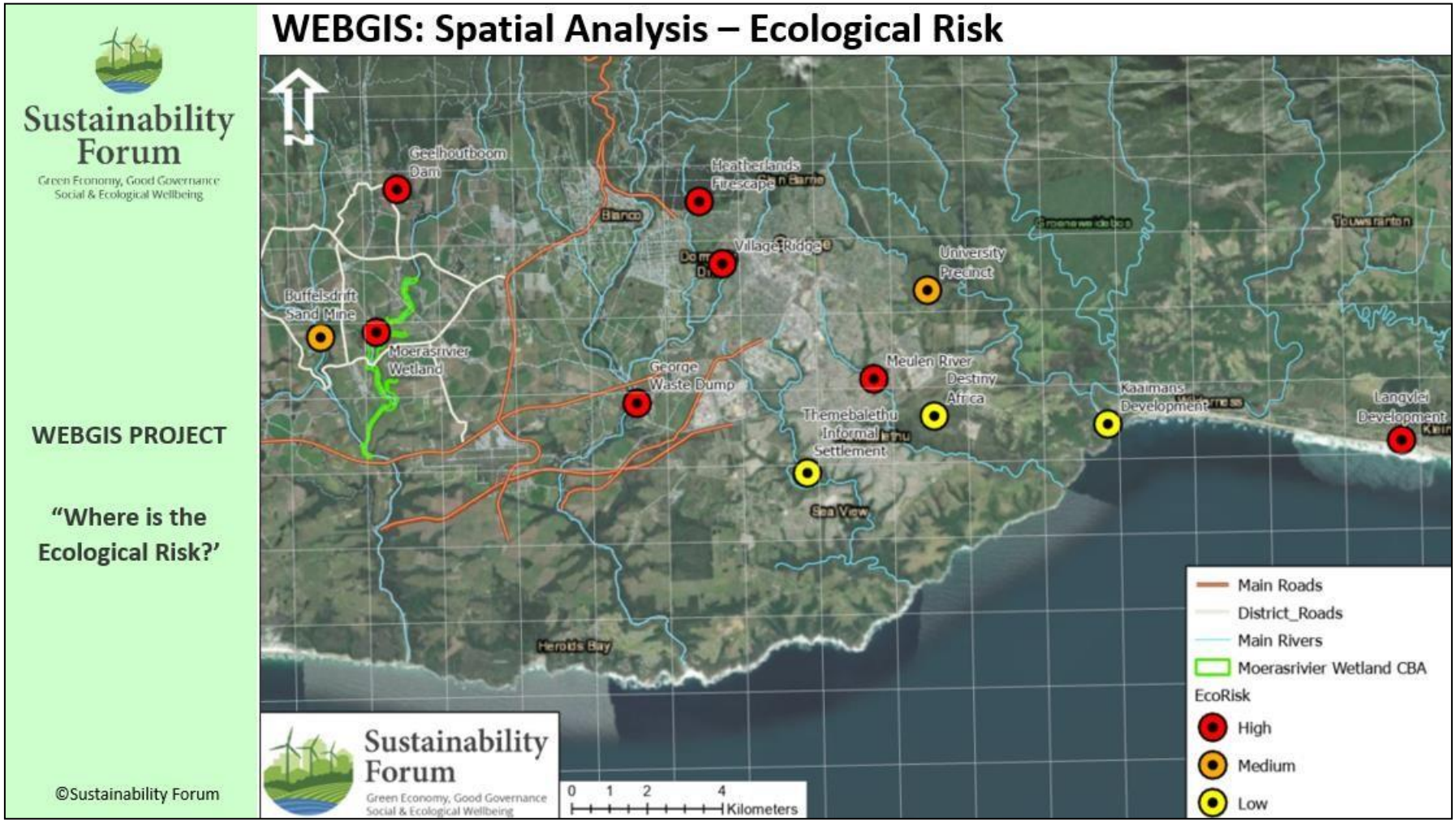


Figure 30. Extract from Overstrand Environmental Conference: Mapping of Ecological Risk for Issues Logged and Raised.

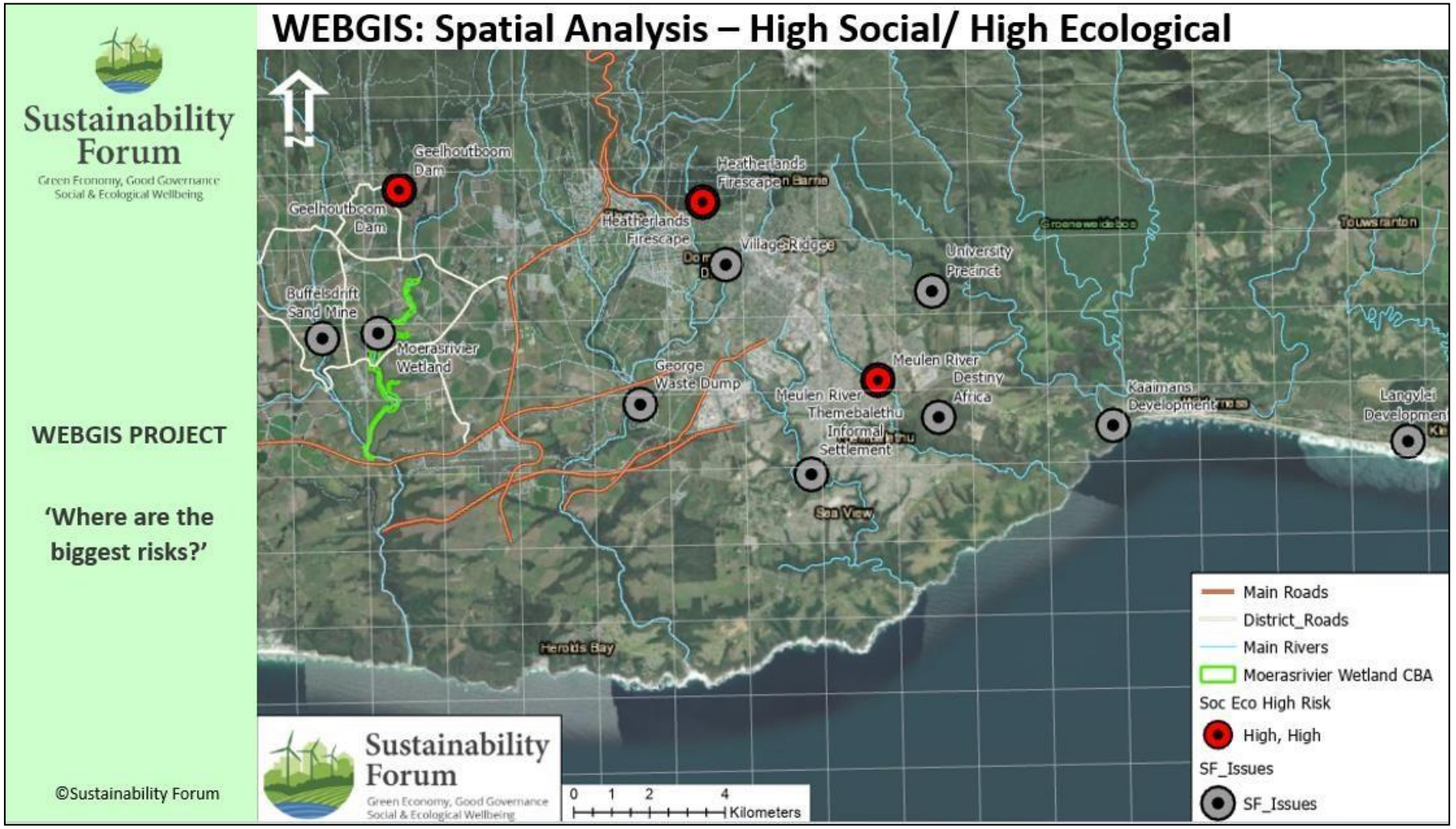


Figure 31. Extract from Overstrand Environmental Conference: Mapping of 'broad brush' Socio-Ecological Risk for Issues Logged and Raised.

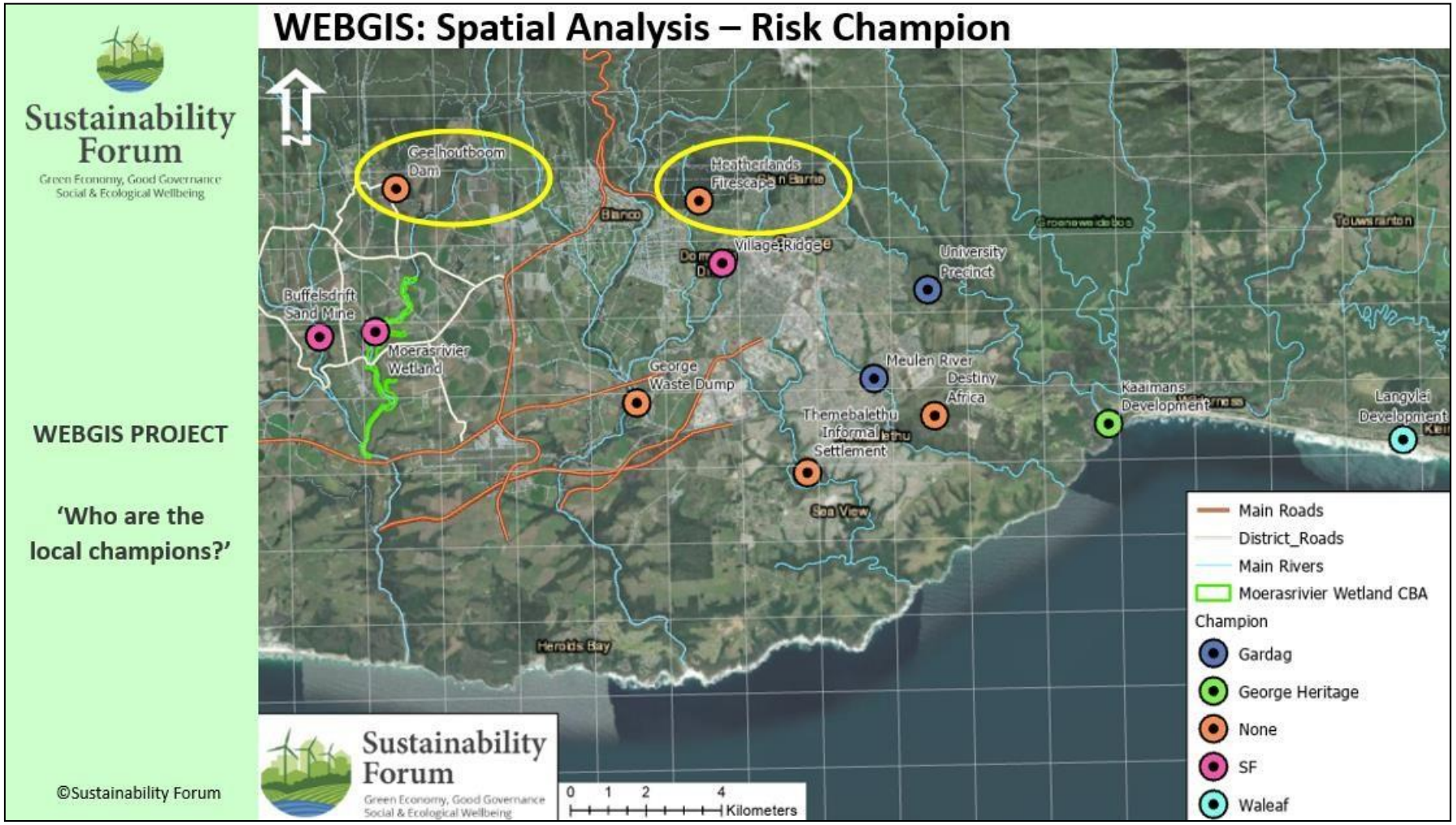


Figure 32. Extract from Overstrand Environmental Conference: Gaps analysis for Risk Champion in relation to Socio-Ecological Risk for Issues Logged and Raised.