MAPUTALAND EFTEON LANDSCAPE

(Quaternary Catchment W70A)

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With substantive inputs from an additional 47 people

Appendix A contains the list of collaborators supporting the proposal

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Photographer: Prof Chris Appleton

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

amsl	Above mean sea level
AD	Anno Domini
ADCP	Acoustic Doppler Current Profiler
ARC	Agricultural Research Council
BP	Before Present
BZ	boundary zone
CBA	Critical Biodiversity Areas
CEH	Centre for Ecology and Hydrology
CEO	chief executive officer
CGS	Council for Geoscience
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station data
CO_2	carbon dioxide
CP	Cathedral Peak
CS	Core site
CSIR	Council for Scientific and Industrial Research
CWRR	Center for Water Resources Research
DAARD	KwazuluNatal Agriculture and Rural Development
DDT	Dichlorodiphenyltrichloroethane
DWS	Department of Water and Sanitation
EC	electrical conductivity
EFTEON	Expanded Freshwater and Terrestrial Environmental Observation Network
EIA	Environmental Impact Assessment
EKZNW	Ezemvelo KZN Wildlife
ENSO	El Niño-Southern Oscillation
ES	Earth System
IDP	Integrated Development Plans
IGRAC	International Groundwater resource assessment Center
IOCBB	Indian Ocean Coastal Belt Biome
IOD	Indian Ocean Dipole
iSimangaliso	iSimangaliso Wetland Park
ITB	Ingonyama Trust Board
IWHP	iSimangaliso World Heritage Park
KZN	KwaZulu Natal
LS	Lake Sibaya
LSCDT	Lake Sibaya Conservation and Development Trust
LULCC	land use land cover change
LULC	land use land cover
NBA	National Biodiversity Assessment
NGA	National Groundwater Archive
NGO	Non-Governmental Organisation
NO	National Office
NWRS	National Water Resource Strategy
ORI	Oceanographic Research Institute
PA	Protected Area
PID	Partners in Development
RI	Research Infrastructure
RSA	Republic of South Africa
RU	Rhodes University
SA	South Africa
SAEON	South African Environmental Observations Network
SAM	Southern Annular Mode
SANBI	South African National Biodiversity Institute
SANLC	South African National Landcover

SASRI	South African Sugarcane Research Institute
SAWS	South African Weather Service
SBRUV	Stereo-Baited remote underwater video
SDF	Spatial Development Framework
SDG	Sustainable Development Goal
SFRA	Streamflow Reduction Activity
SIOD	Subtropical Indian Ocean Dipole
SMCRI	Shallow Marine and Coastal Research Infrastructure
SWSA	Strategic Water Source Area
SWASA-gw	Groundwater Strategic Water Source Area
TA	Traditional Authority
TTT	Tropical-Temperate Troughs
UCT	University of Cape Town
UJ	University of Johannesburg
UK	United Kingdom
UKDM	uMkhanyakude District Municipality
UKZN	University of KwaZulu Natal
ULM	Umhlabuyalingana Local Municipality
UN	United Nations
UNIZULU	University of Zululand
UTR	Underwater Temperature Recorder
WITS	University of the Witwatersrand
WMA	Water Management Area
WMS	Water Management System
WRC	Water Research Commission

1 IN A NUTSHELL

Maputaland, within the Indian Ocean Coastal Belt Biome (Figure 1), is a landscape of international and national significance, characterised by extraordinary biodiversity interlinked with a unique hydrological system. It represents the biogeographical transition zone of tropical to subtropical ecosystems. Beset with typical challenges centered on water security and economic development, the tensions between and codependencies of environmental and human needs are escalating. The proposed Maputaland EFTEON Landscape which typifies this context is catchment W70A, in the north-east of the KwaZulu-Natal Province, bordering Mozambique (Figure 2). A unique feature of catchment W70A is that it is almost exclusively a rainfall-fed groundwater system with closely dependent terrestrial-aquatic ecosystems. This interconnected landscape provides an ideal context for investigating how water resources are influenced by shifts in land use and land cover and a changing climate, and how these impact human well-being and ecosystem integrity. Understanding the global change drivers of the water resource functions and the socio-ecological consequences of this, is the primary motivation behind proposing the area as an EFTEON landscape. Additional attributes of the region substantively add to its merit for achieving the objectives of all the EFTEON program themes including (but are not limited to): 1) wetland ecosystems with some of the highest carbon storage capacities in the country; 2) a diverse mosaic of open- and closed-canopied vegetation types which, together with diverse fauna, form the Maputaland centre of endemism; 3) strong links between terrestrial, aquatic and marine ecosystems including freshwater, estuarine and marine systems almost exclusively influenced by non-surface freshwaters (Figure 2) - a unique setting in the South African context; 4) tight connections between human well-being, socio-economic activity and ecosystem integrity moderated by the water resource; 5) its location at the southern margin of the Afrotropical region and the extralimital margin for critical coastal/marine habitats (e.g. coral reefs, mangroves); and 6) a number of paleo archives of environmental change within the landscape against which change and the impacts thereof can be contextualised.

The area, positioned squarely in the face of change in a border region (Mozambique) of South Africa, offers a rich natural template for globally relevant research. Rapid but unequal socio-economic growth, strategic policy reform and infrastructural investment by the government, and a steady increase in settlement densities and human activities, give rise to various and increasing anthropogenic pressures influencing diverse environmental functioning and the water resource. This is expected to accelerate significantly with the recent completion of a tar road connecting Maputo to the region, facilitating cross-border trade, population influx, land transformation and tourism. Typified by low agricultural potential, economic imperatives in the proposed landscape are leading to persistent land cover change through the afforestation of grassy ecosystems with *Eucalyptus* woodlots and the transformation of wetlands for commercial food production. Climate change is predicted to exacerbate water stress on the Maputaland Coastal Plain, with projections of significant temperature rises, higher evaporation rates, more frequent heat waves and potentially lower rainfall. Allied with this are anticipated shifts in major weather systems, including contradictory projections of northwards or southwards shifts in tropical cyclone activity. Changing the frequency of occasional large rainfall events is likely to have important implications for recharging the groundwater system with knock-on effects throughout the greater ecosystem, including effects on ecosystem services and dependent livelihoods. Close linkages between livelihoods and environmental function lend the landscape to socio-ecological studies, and indeed these studies are required to inform proactive management responses. The proposed Maputaland EFTEON Landscape would also allow for the establishment of an integrated terrestrial-aquatic-marine Research

Infrastructure platform, due to it being spatially aligned both with the Oceanographic Research Institute's (ORI) long-term reef observation sites and the Shallow Marine and Coastal Research Infrastructure (SMCRI) at Sodwana Bay. A major strength of this proposal is that it has been developed collaboratively not only with researchers, but also the land custodians and local communities who fully support the initiative, with Inkosi K.T.H Nxumalo of the Mabasa Traditional Authority offering to host the core site.

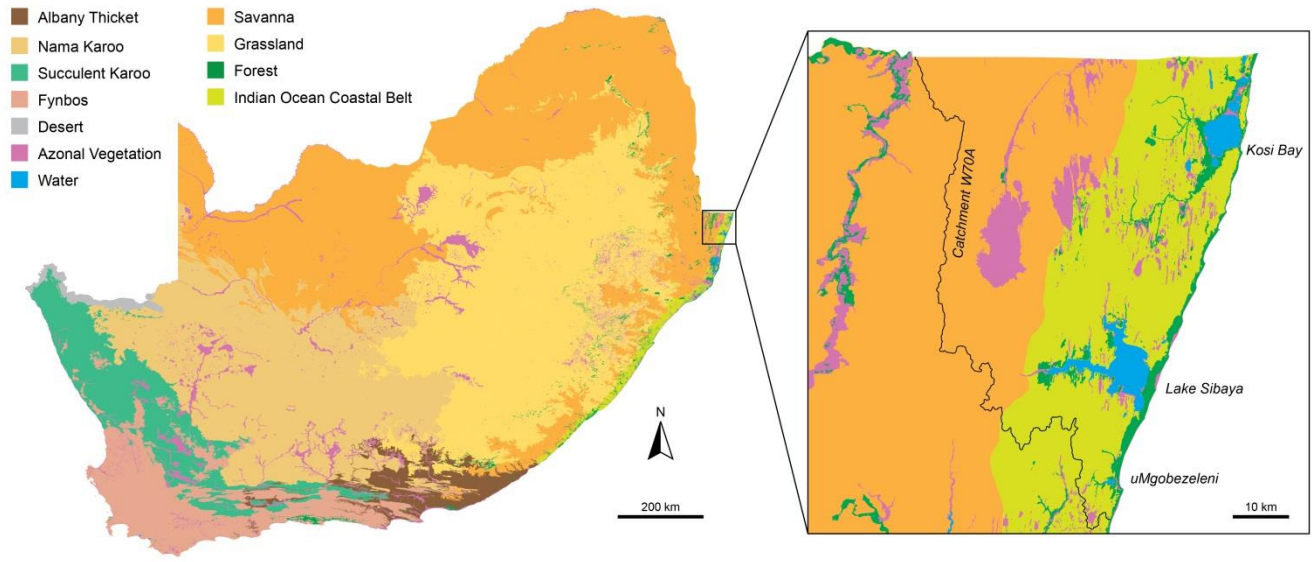

Figure 1: Biome distribution in South Africa following the National Vegetation Map 2012. Inset shows the biomes in the Maputaland region, with the proposed Maputaland EFTEON Landscape delimited by the boundary of quaternary catchment W70A.

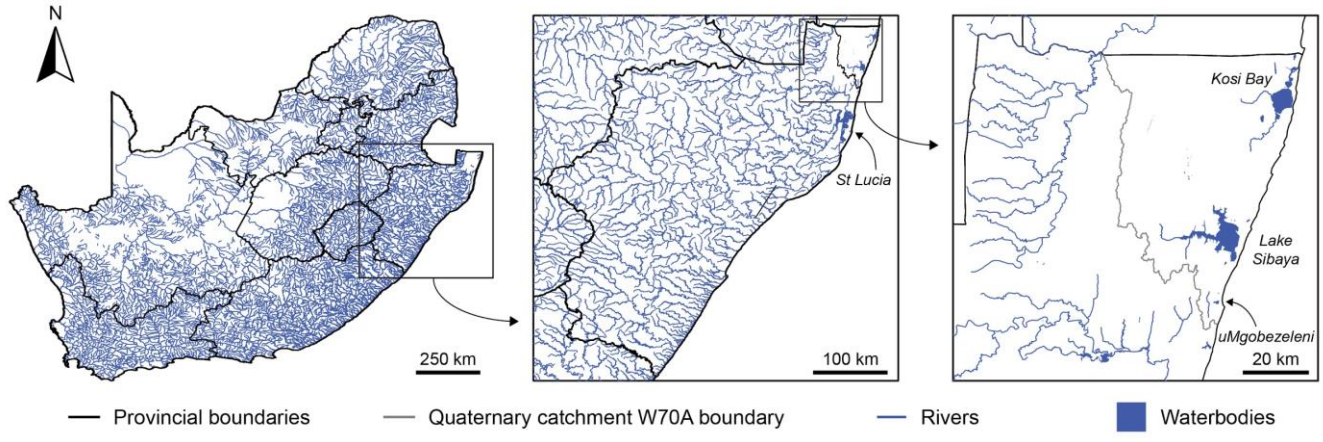

Figure 2: The surface rivers of South Africa showing the location of catchment W70A as a discrete coherent hydrological unit and the lake-estuarine water bodies within the W70A catchment (note the absence of perennial rivers).

2 DEFINING THE MAPUTALAND EFTEON LANDSCAPE COGENERATIVELY

2.1 An accessible landscape open for research

We achieved consensus on the Maputaland EFTEON Landscape through several engagement processes with stakeholders, researchers and land custodians. The need and desirability for the selection of this landscape is strongly supported by collaborators representing a diversity of organisations and a wide array of disciplines, as evident in the co-authorship, as well as the significant number of collaborators (88) supporting this proposal. A survey to solicit inputs for the proposal yielded rich information so, where relevant, links to the raw answers are provided for reference.

The needs of land custodians, academic collaborators' research questions and the EFTEON objectives are very well aligned. Collaborators have indicated a number of landscape opportunities that provide a basis for a conceptual design framework that interlinks these. Consequently, land custodians strongly support the proposal, providing ***assurances of long-term access*** for EFTEON and associated collaborator research activities. Current and past research activities within the landscape also ***demonstrate accessibility of the landscape to researchers.*** Established processes are in place to vet, enable and coordinate project registration, to which EFTEON can align.

Academic collaborators will make use of the Maputaland EFTEON infrastructure, which is also likely to enable most researchers to leverage additional funding for their research. Some recommendations on context relevant variables have also been provided. As a collective, there is a desire and willingness to provide expert input to the optimal design for the standard EFTEON observations, as well as to guide what contextually relevant priority long-term observations would be appropriate within the proposed location aligned to EFTEON themes. Several collaborators would thus be willing to serve on the local EFTEON steering committee, as would land custodian representatives. As with the spirit in which this proposal was developed, we would advise using co-creation approaches to generating knowledge that enables transformative learning across all stakeholder and research groups (see Burt et al., 2019).

The interconnected nature of the system is naturally facilitating novel interdisciplinary approaches that are authentically dissolving barriers across traditional research-policy-action silos. This is particularly important in catchment W70A, where, as Dr Taylor emphasises, a systems approach is required to understand the components within it. The very nature of the landscape necessitates a "Critical Zone Observatory'' approach to understanding the impacts of environmental and anthropogenic change. This is not only feasible, building on existing initiatives (Department of Water and Sanitation (DWS), Agricultural Research Council (ARC), South African Weather Service (SAWS), Shallow Marine and Coastal Research Infrastructure (SMCRI), Oceanographic Research Institute (ORI), Ezemvelo KZN Wildlife (EKZNW) and South African Environmental Observation Network (SAEON)), but also makes for a formidable Global Change Research Infrastructure that ***functionally and institutionally links the terrestrial, aquatic, marine and atmospheric systems***.

2.2 A coherent landscape extent

The Maputaland Coastal Plain (MCP) represents a low-lying coastal system located within the tropical to subtropical climate transition zone. A broad stakeholder network is interested in, and active on, the entire MCP (Figure 3). EFTEON, however, requires a spatially focused approach, and thus stakeholders were engaged to identify a "coherent landscape" that will optimally catalyze science activities as a National Research

Infrastructure platform. The most functional landscape of "coherence" was identified as quaternary catchment W70A (Figure 2), within the Pongola-Mtamvuna Water Management Area. This falls within the Umhlabuyalingana Local Municipality (ULM) (Figure 4). The area experiences a humid-subtropical, summer rainfall climate (Smithers et al., 2017). Catchment W70A ***is a connected hydrological unit*** where the groundwater aquifer is the only available water resource for people and a diversity of groundwater-dependent ecosystems that typify the area. The proposed landscape encapsulates three ***aquifer-linked*** coastal lake systems (Figure 5): Lake Sibaya (a relic estuary, now endorheic freshwater coastal lake), the Kosi Lake System (with a permanently open estuary), and the uMgobezeleni Estuary (a temporary open/closed estuary system). These systems have interconnected yet distinguishable groundwater catchment recharge zones at local scales (Figure 6) that shift depending on the level of the groundwater table (Bate et al., 2016; Kelbe, 2020). The conceptual design harnesses this opportunity, as observations can contrast local scale impacts across the three sites, while gaining an understanding of the connected aquifer at larger spatial scales through observation over space and time. There are differences between the groundwater and surface catchment boundaries in this region that are important to consider when observing environmental and anthropogenic change as impacts may fall outside of the topographical catchment but within the groundwater catchment (Bate et al., 2016; Kelbe, 2020). Within quaternary catchment W70A, we propose the Lake Sibaya groundwater catchment as the primary “core focus” area, with the adjacent connected groundwater catchment areas (Kosi and uMgobezeleni) as satellite sites (Figure 5). Each of these areas includes near-natural sites in and outside of protected areas and modified land uses.

A major advantage for the proposed landscape extent lies in series of recently completed studies on the ecology and hydrodynamics (uMbgobezeleni, Bate et al., 2016), as well as the ecological water requirements determinations and yield assessments (Kosi Bay and Lake Sibaya; DWS, 2015a-d; 2016 a&b; Groundtruth, 2020, Keble, 2020). These all provide a solid foundation from which to springboard EFTEON long-term observations.

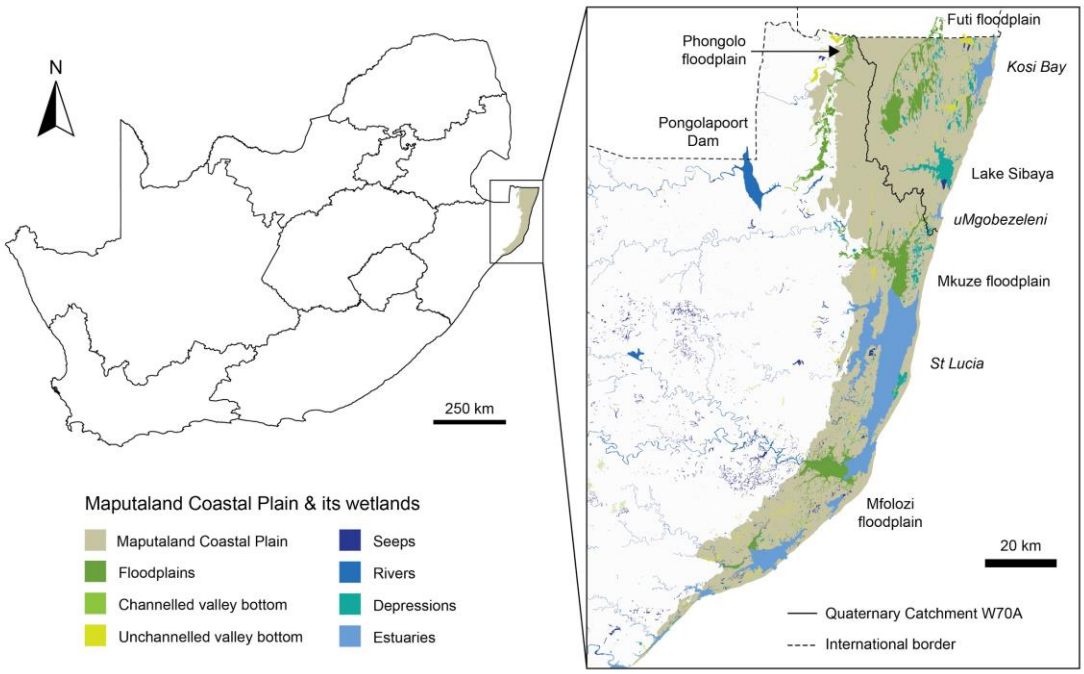

Figure 3: The Maputaland Coastal Plain within the KwaZulu-Natal Province, South Africa. Catchment W70A (black line; inset) is situated in the far north and is characterised by a diverse array of wetland types.

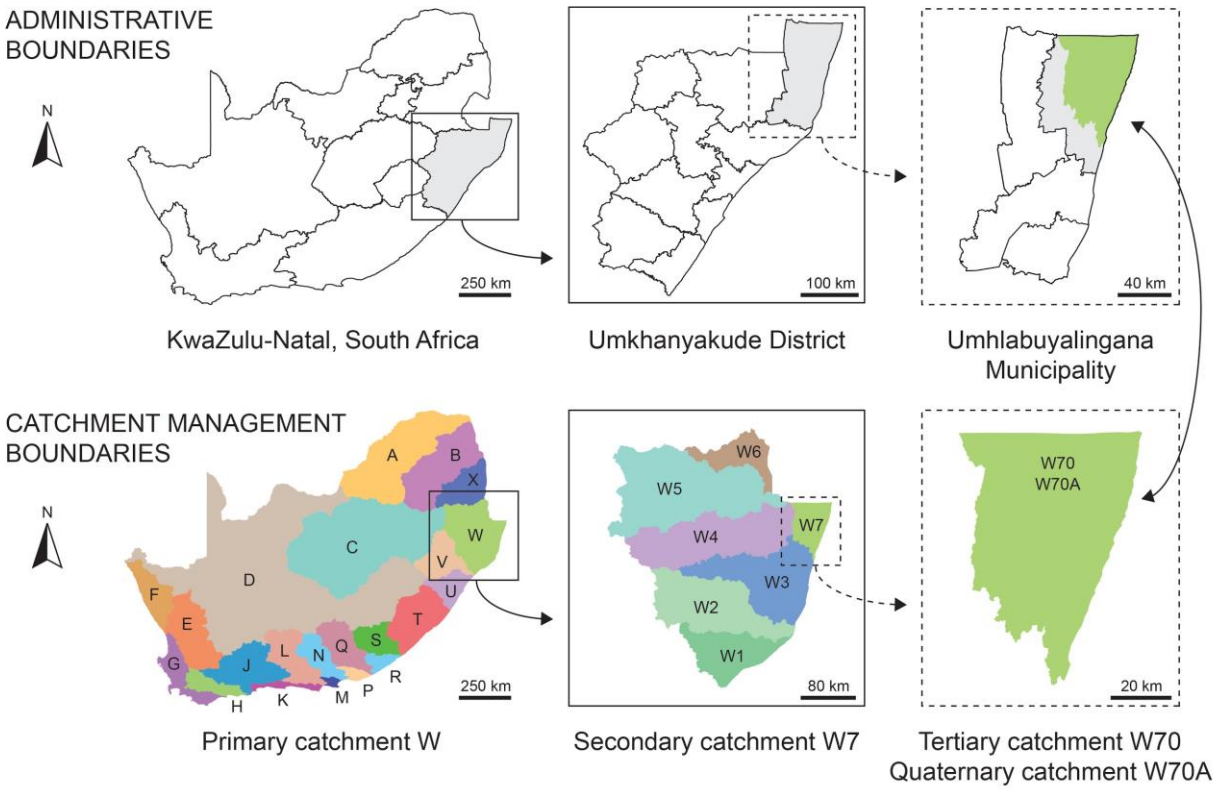

Figure 4: Maps showing the administrative and catchment boundaries relevant to the proposed Maputaland EFTEON Landscape. Quaternary catchment W70A within the Umhlabuyalingana Local Municipality forms the boundary of the proposed landscape.

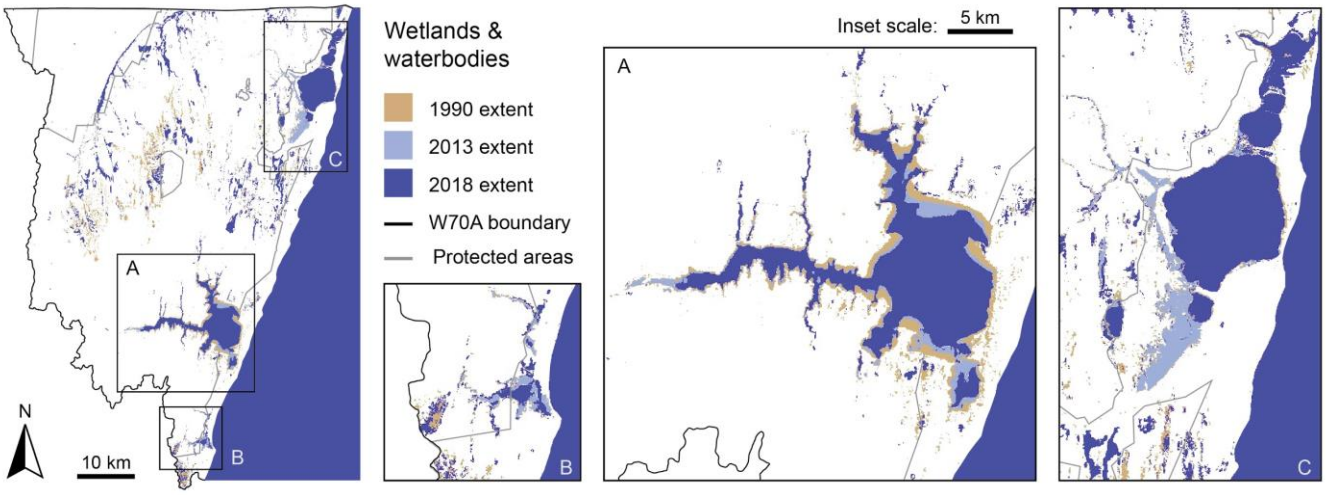

Figure 5: The proposed focus areas, with (A) Lake Sibaya as the core site and (B) uMgobezeleni to the south and (C) Kosi Bay to the north as the two satellite sites. This figure also indicates the temporal change that the three sites have undergone over the past 20 years. Specifically note declining water levels over time in Lake Sibaya, resulting in the current separation into two lakes.

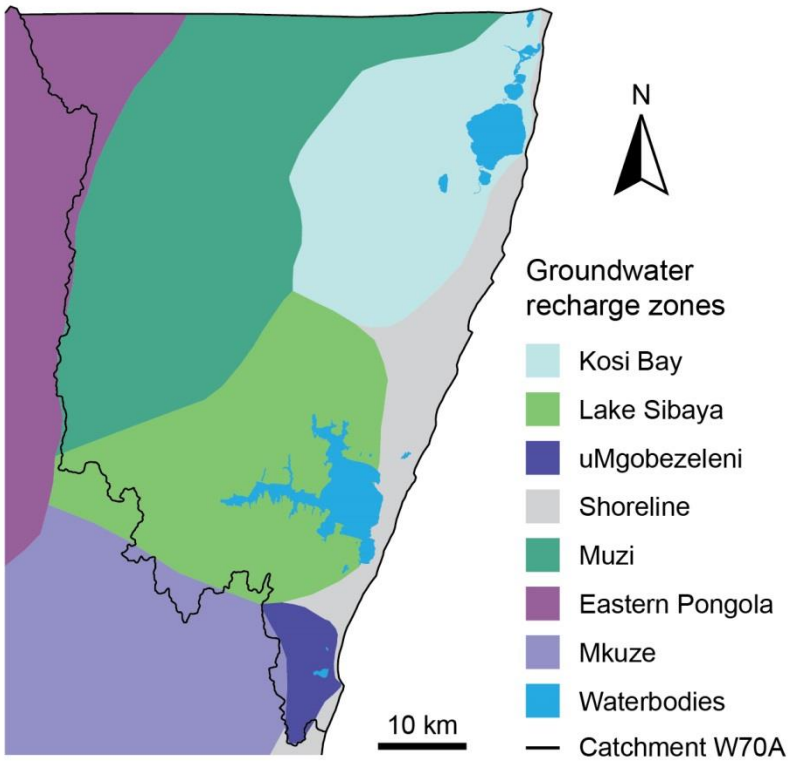

Figure 6: Groundwater recharge zones pers. comm. Bruce Kelbe indicating groundwater catchment boundaries.

2.3 Developmentally relevant land uses and land cover types within the landscape

The dominant land tenure systems within the proposed extent are state-protected conservation areas and Ingonyama Trust Board (ITB) land. This is an ***important development context*** within South Africa as ITB landscapes represent large sections of untransformed land, which are rapidly undergoing land use change, affecting environmental goods and services provision. Change, often driven by external players, precipitates tensions between local communities and conservation objectives and potentially degrades ecosystems services. Land use decision made now within the proposed Maputaland EFTEON landscape will directly affect the adaptive capacity of communities living in the region to anticipated climate change impacts.

Falling within the Indian Ocean Coastal Belt Biome (IOCBB), the landscape includes a diverse template of terrestrial and aquatic vegetation types (see Figure 7). Large tracts of "near-natural" sites are found in formally protected conservation areas (Figure 8) including Sileza (EKZNW), Tembe Elephant Park (EKZNW), iSimangaliso Wetland Park World Heritage Site (iSimangaliso), Manguzi Forest Reserve as well as in some extensive communal grazing lands and indigenous forests managed by the Traditional Authorities (TA's) (Figure 9). Adjacent to the coast is an offshore Marine Protected Area (MPA). The diverse tourism sector is an important economic driver and within in the region, where its full potential has likely not yet been achieved. There are portions of land outside the protected areas considered "irreplaceable" or "optimal" for achieving biodiversity targets (Figure 8). Overuse and associated degradation are evident in some areas both inside and outside of the protected area network. Resource harvesting takes place in the terrestrial (e.g. Lala Palm tapping for wine) and aquatic systems (e.g. fishing from both legal catches in community fish traps, as well as from illegal gill nets). The interaction between tourism and other economic benefits accruing to local communities and the status of biodiversity assets are intertwined and ***nationally relevant*** with respect to the countries intention to

focused on Ecosystems Based Adaptation as a strategy to increase resilience and reduce vulnerability to climate change impacts (DEA and SANBI, 2016).

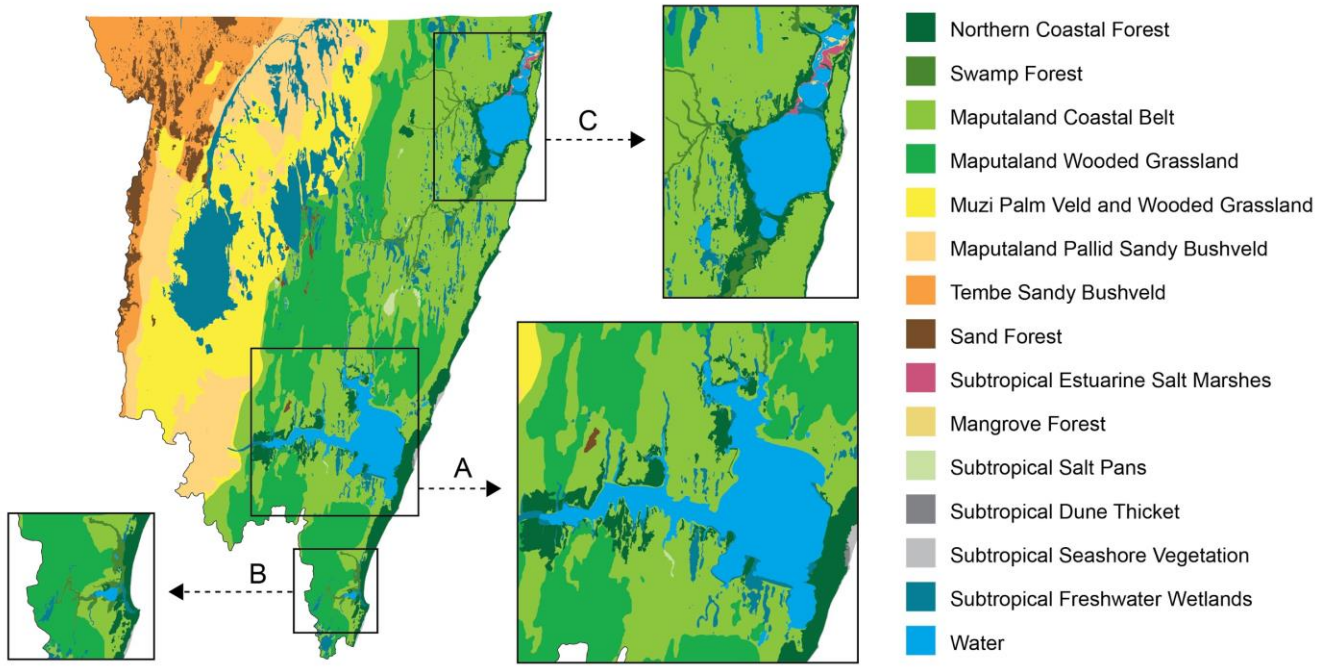

Figure 7: Vegetation type distributions in the proposed Maputaland EFTEON Landscape following the National Vegetation Map 2012. Insets show the core site at Lake Sibaya (A) and satellite sites at uMgobezeleni (B) and Kosi Bay (C).

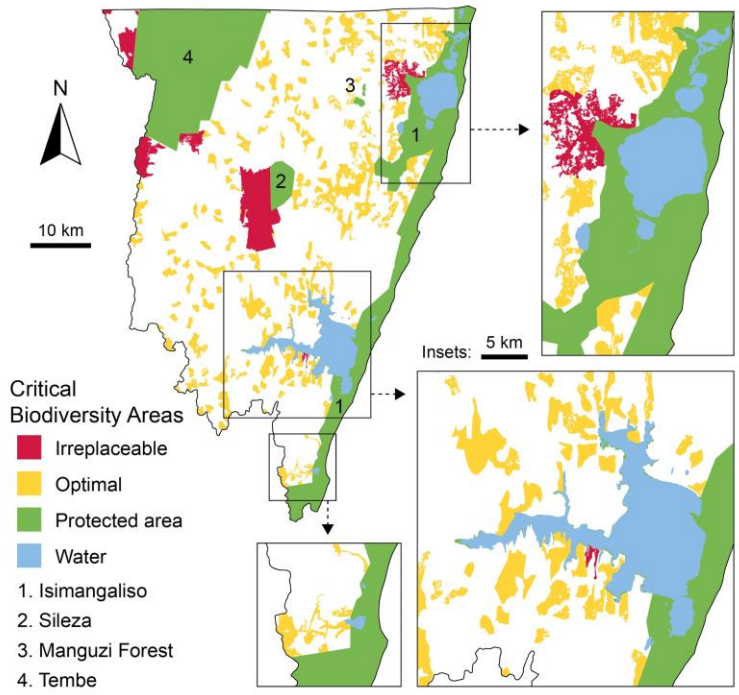

Figure 8: Protected areas network in relation to proposed focused areas, also indicating critical biodiversity areas (CBA) outside of the Protected Area network as per EKZNW CBAs. These areas also reflect "intact" areas outside of the PA system, some of which are rapidly transforming

The largest extent of modified land use on the terrestrial system is commercial *Pinus* and *Eucalyptus* plantations initiated in the 1950s (Figure 9) (Allanson, 1979). Forestry extent in the region has at least doubled since 1985 (Manish et al., in press). Recent trends are a switch from pine to fast-growing, higher water consumptive *Eucalyptus* (Everson et al., 2018) and an increasing number of small grower *Eucalyptus* woodlots. ***This is an important developmentally relevant land use*** as forestry is seen as economically important but is also a Stream Flow Reduction Activity (SFRA) and South Africa's water resources are in "crises", potentially heading for a 17% water deficit by 2030 (DWS, 2018). This is in a context where historically unequally access to water resources (for both agriculture and human use) has not been adequately addressed and is thus emphasised as a key focus area in the current National Water and Sanitation Master Plan (DWS, 2018). Further south, on the MCP, multinational commercial forestry companies have enjoyed the use of the MCP for their operations over a long period and are still reaping this benefit. The declining water situation on the MCP has however resulted in an effective moratorium on "new" forestry activities within the region, just at a time when reform programs aim to empower previously disadvantaged communities through forestry operations within the proposed Maputaland EFTEON Landscape. Resolving tensions with respect to licensing and compliance of SFRAs, which are pitted against conflicting economic imperatives, socio-economic justice, human need and ecological requirements, necessities not only an understanding of relative LULCC impacts on the water resources under a changing climate, but the system as a whole. The proposed Maputaland EFTEON Landscape thus epitomises a developmentally relevant social-ecological system where land use decisions impact directly on ecosystem services and ecological and economic resilience.

In addition to forestry, there is a commercial scale cashew nut orchard within the Lake Sibaya ground water catchment. *Macadamia* trials are currently also underway within old forestry compartments, with plans to expand such operations by switching *Eucalyptus* compartments to *Macadamia* orchards. These land uses provide an ***experimental opportunity*** to contrast water use across commercially important species and indigenous flora. The area is earmarked as national priority for improving agricultural production. However, the nutrient status of the soils is poor other than in wetland areas (Atkinson and Barichievy, 2014), thus large-scale commercial agriculture is limited. Fruit, vegetables, peanuts, cashews, maize and sugar cane are grown in a subsistence or semi-commercial manner both on dry land, as well as within nutrient rich, yet critical and sensitive aquatic systems, such as swamp forests and wetlands which have become over exploited (Atkinson and Barichievy, 2014). Improvement in agriculture potential is possible, but requires innovation and careful management (Atkinson and Barichievy, 2014).

Settlement patterns include the rapidly expanding "urban" centres of Manguzi (a border town), Mbazwana, and, to a lesser extent, Mseleni and Sodwana Bay (Figure 9). Within ITB land there are designated areas for cattle grazing, natural resource use and homesteads managed by the Traditional Authorities. In some areas designated for development, there is increasingly rapid densification of homesteads, road infrastructure and fencing within the rural areas from a near-natural baseline, however a number of extensive traditional cattle grazing areas remain intact and some are in very good condition, for example in the Mabasa TA (Figure 9, "sustainable resource area"). The recently completed tar road and Maputo–Katembe bridge linking Maputaland to southern Mozambique is likely to lead to an influx of tourists and increased cross-border trade, further fueling economic growth and associated pressures on natural resources in the region. See Figure 25 in the Appendix B for change over time.

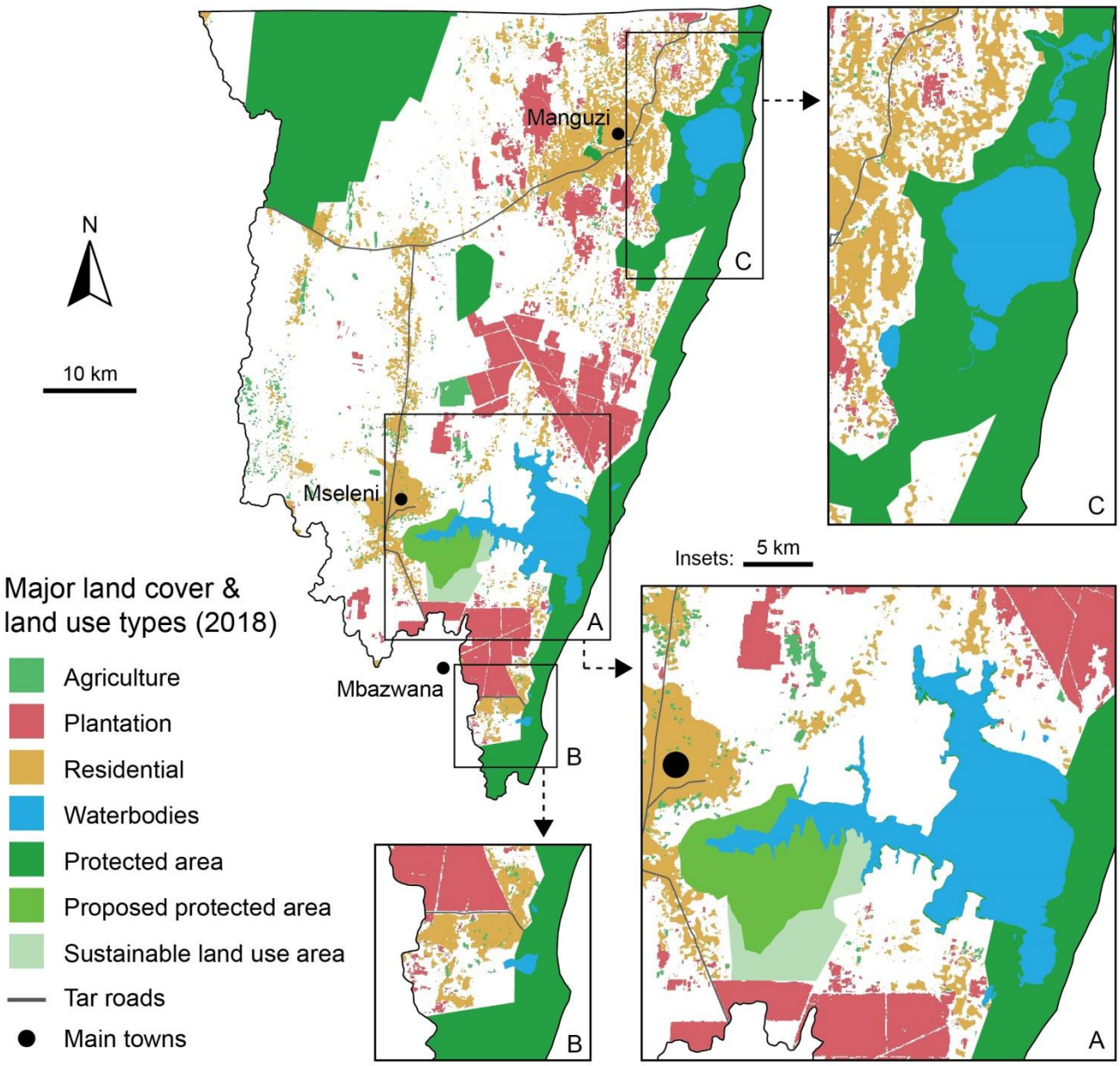

Figure 9: Major land cover types and protected area boundaries within the proposed EFTEON landscape in quaternary catchment W70A. The proposed Lake Sibaya (A) core site and uMgobezeleni (B) and Kosi Bay (C) satellite sites shown in insets. Land cover was mapped from the South African National Land-Cover 2018 (SANLC 2018) dataset. Note protected areas (near-natural vegetation) and white areas outside of the PA's (largely "near-natural"), as well as proposed protected area and "Sustainable land use zone" (Mabasa TA grazing lands).

2.4 Proposed landscape array: A scaled approach

Catchment W70A is embedded within the MCP which is a functionally interconnected region resulting from a unique geological and evolutionary history where the large coastal water bodies were created during Mio-Pliocene glacial still-stands (Wright et al., 2000). We thus propose a spatially scaled approach to observations, which will realistically reflect the functional processes observed within this interconnected landscape. The Lake

Sibaya groundwater catchment area, as a proxy for the larger MCP area, is proposed here as the ideal near-natural focus area for micrometeorological observations and detailed hydrological and biological surveys (terrestrial and aquatic). It provides an opportunity to observe the flux dynamics (carbon, water and energy) in a natural coastal grassland system within the catchment area of a relic estuary, but now a coastal freshwater lake, Lake Sibaya. This lake had, in the geological past (7000-5000 BP), direct connectivity to the marine environment (Miller, 1998; 2001) and consequently supports unique relict estuarine faunal communities (invertebrates and fish, Whitfield et al., 2017). The recent past has seen drought and land use changes influence lake water levels to the extent that it has separated into two distinct basins (Figure 5) (Kelbe, 2020). The location, therefore, provides an excellent natural system where extreme events (cyclonic influences, extreme temperatures, mega droughts/flooding events) may be observed and studied in the future, while paleo studies can hindcast similar events.

The nature of the landscape, in conjunction with existing SAEON and DWS infrastructure, makes it cost-effective for EFTEON to expand the meteorological, hydrological and biological observations to the "satellite" groundwater catchments of Kosi and uMgobezeleni for a feasible and powerful EFTEON aquatic design. Cost-effective methods for measuring soil respiration fluxes from different wetland types under varying degrees of drying are available and can be used as complementary measurements in both the core and satellite sites. Different land use land cover (LULC) types within each of the three connected groundwater catchment areas (Figures 7 & 9) provide opportunities for biodiversity and ecosystem function observations under contrasting conditions and across various gradients. Biological studies on vegetation (within the IOCBB) and biome shifts (IOCBB and savanna) can harness the aridity and soil fertility gradient from east to west, through each of the groundwater catchments and extending further inland where appropriate. Socio-ecological studies are logistically feasible in at least three Traditional Authority areas adjacent to the Lake Sibaya (Tembe TA, Mbila TA and Mabasa TA) (Figure 10), with two of these also linking to the Kosi (Tembe TA) and uMgobezeleni systems (Mbila TA) with the potential addition of a 4th, Mashabane (TA) which has no "open water" access. Remote sensing studies can utilise the core and satellite sites as calibration points for detecting changes in systems at the MCP scale. The full gradient of natural aquatic systems from coastal freshwaters, through estuarine lakes, and estuaries and into the nearshore marine environment is covered. Locating the Maputaland EFTEON Landscape within this particular catchment achieves spatial alignment with the Oceanographic Research Institute's (ORI) long-term reef observation sites and the Shallow Marine and Coastal Research Infrastructure (SMCRI) at Sodwana Bay. This provides the additional significant benefit of creating a truly integrated terrestrial-aquatic-marine Research Infrastructure Platform that is functionally connected and discrete enough to enable meaningful Global Change research.

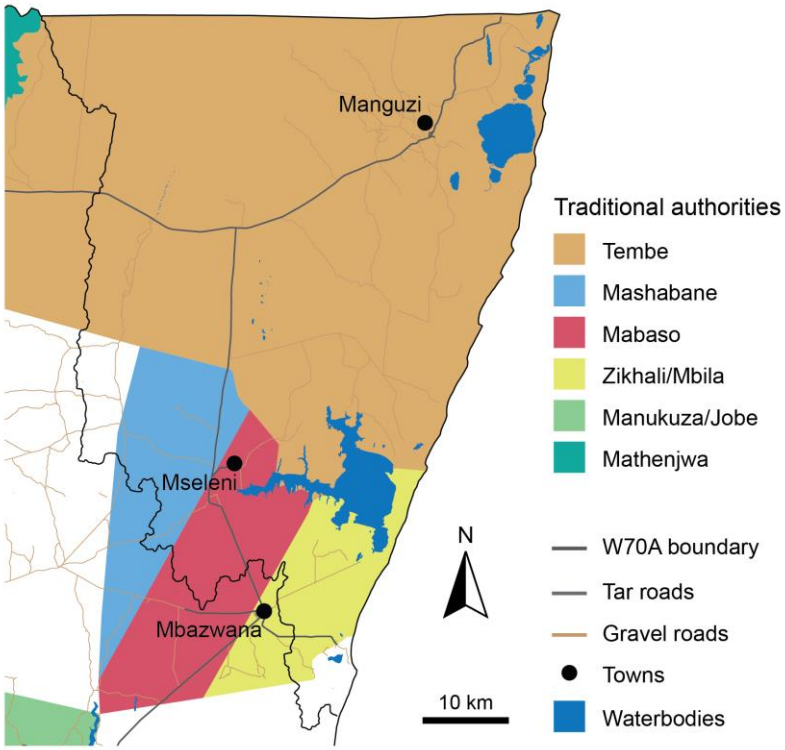

Figure 10: Traditional authorities within the Maputaland region. Four tribal authorities are represented within the W70A quaternary catchment, namely the Tembe, Mashabane, Mabasa and Zikhali/Mbila TA's.

3 THE MAPUTALAND EFTEON LANDSCAPE IS IDEAL FOR OBSERVING CHANGE

Collaborators confirmed this is a landscape of national and international relevance with significant features and opportunities for observing global change processes and addressing critical knowledge gaps. Below is an overview of some of the most important and relevant opportunities for EFTEON. Detailed inputs are in Appendix B.

3.1 A landscape of international significance

The proposed Maputaland EFTEON Landscape is of international conservation significance as encapsulated by the iSimangaliso World Heritage Park (IWHP; http://www.isimangaliso.com/) and three RAMSAR sites (Kosi Bay, Lake Sibaya and the Pondoland Coast turtle beaches). Likewise, the water resources of the region are of international significance as part of the transboundary Coastal Sedimentary Basin VI / Coastal Plain Sedimentary Basin Aquifer (Figure 11), shared between South Africa and Mozambique. This triggers a number of requirements linked to international obligations and ratified bilateral agreements aimed at promoting cooperation and sustainable utilization of transboundary water resources and includes contributions to Sustainable Development Goals (SDG Indicator 6.5.2; IncoMaputo, 2002). Strategically incorporating these features into the Maputaland EFTEON Landscape provides the opportunity to ensure the relevance and profiling of the EFTEON program internationally. Cost efficiencies for national and international reporting obligations can also be realised.

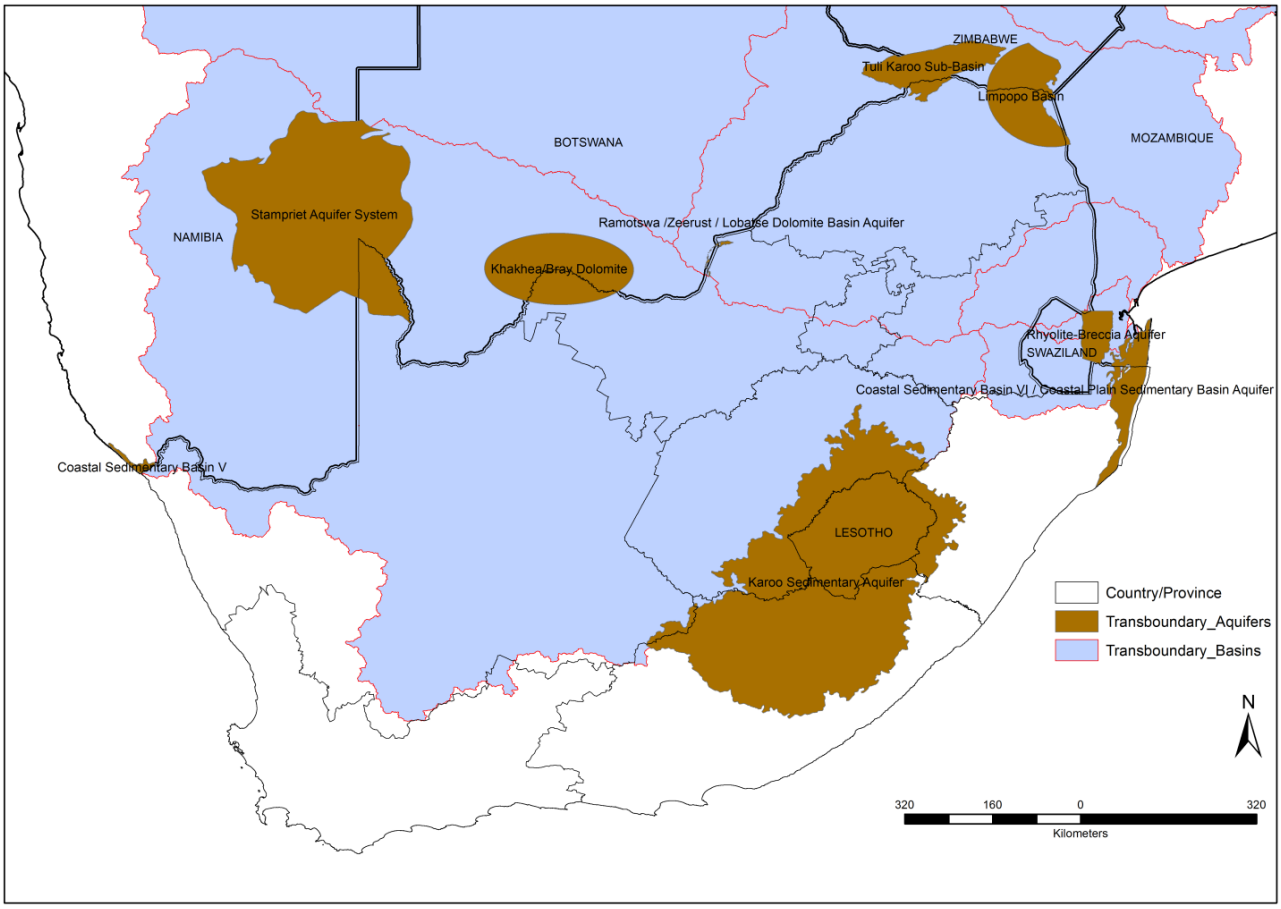

Figure 11: Transboundary aquifer map of Southern Africa (IGRAC, 2015).

3.2 A Strategic Water Source Area

The proposed Maputaland EFTEON Landscape (core and satellite areas) covers 59% of a nationally important Zululand Coastal Plain groundwater Strategic Water Source Area (SWSA-gw; Le Maitre et al., 2018; see Figure 12). These areas are of particular importance for water provision, especially during intensified and prolonged drought periods expected to result from climate change (Kirtman et al., 2013; Pohl et al., 2017; Nangombe et al., 2018; Naumann et al., 2018). Evident changes in this water resource are highlighted throughout this proposal and provide the key "response variable" in understanding the relative impacts of different global change processes (land use change, carbon dioxide (CO_2) fertilisation, climate shifts etc). Noteworthy is that much of the work informing Streamflow Reduction Activity (SFRA) licensing in the National Water Act (RSA, 1998) (e.g. impacts of commercial forestry on streamflow) has been undertaken in surface water driven landscapes. From a science-policy perspective, understanding the impacts of different land uses, such as commercial forestry, in an interconnected sandy aquifer groundwater driven system would be valuable for informing the water use licensing of SFRAs in such systems.

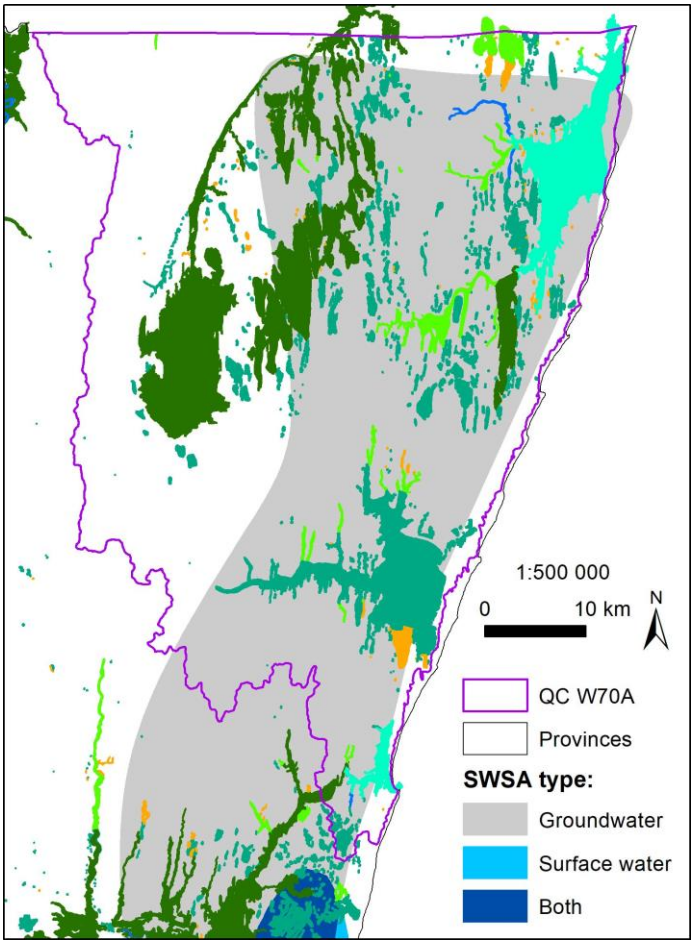

Figure 12: The extent of the Zululand Coastal Plain groundwater Strategic Water Source Area (Le Maitre et al., 2018) against the proposed Maputaland EFTEON Landscape (W70A).

The geology of the Maputaland EFTEON Landscape is relatively simple (aeolian sand deposits on a Cretaceous basement), ***with little input of water or sediment from beyond the catchment boundary***. Therefore, recharge responses across the three lake systems provide an exciting opportunity to tease out the relative impacts of land use and land cover change (LULCC) and regional scale climate changes at the catchment scale. The largest wetland feature is Lake Sibaya, which is a rare example of a clear, oligotrophic system in South Africa. As an endorheic system, it essentially acts as an integrating 'sink' for various inputs reaching it and impacting on lake water quality while also reflecting the net impact of land uses and climate influences on the groundwater table, that themselves reflect in lake level change. For example, electrical conductivity of Lake Sibaya has increased from early records of 584-598 $\mu S.cm^{-1}$ (Allanson and van Wyk, 1969), to a later 626 $\mu S.cm^{-1}$ (Humphries and Benitez-Nelson (2013) with the latest SAEON data indicating an increasing trend from 723 $\mu S.cm^{-1}$ in 2018 to 879 $\mu S.cm^{-1}$ in 2020. Changes in the lake level and water quality thus offer a valuable proxy, together with the peatlands and coastal swamp forests, as barometers of the health of the Zululand Coastal Plain SWSA-gw and are thus ideal observatories for achieving an integrated measure of change as envisaged by EFTEON.

3.3 Uniquely strong coupling between terrestrial, aquatic and marine environments

The proposed Maputaland landscape represents a unique and fragile coastal landscape in South Africa. A defining characteristic of catchment W70A, resulting from its geohydrology, is the strong linkage between terrestrial and aquatic ecosystems, with influences on an adjacent marine system through a coastal interface.

The primary aquifer consists of variably weathered deep sands that overlie the impermeable cretaceous layer (Botha, 2015). Rainfall infiltrates the sandy system and percolates vertically downwards to recharge the groundwater table. Groundwater flows from recharge areas down the groundwater gradient towards discharge boundaries, such as the wetland and lake systems, which intersect the groundwater table. Most landscape features are thus aquifer-dependent ecosystems (Colvin, 2007; Taylor et al., 2008; Botha, 2015). These connect to the marine ecosystem through subsurface flows moving through the eastern dune corden into the sea (Kelbe et al., 2016; Kelbe, 2020). The localised influence of aquitards beneath the coastal lakes represents an important controlling factor influencing freshwater discharge beneath the coastal barrier dune to the marine littoral zone. Lake Sibaya, perched approximately 20 m above mean sea level (amsl) when "full", has a considerable hydrological head and contributes a significant amount (~1 x 10^6 m^3 per annum) of fresh water to the adjacent marine environment via groundwater seepage (Pitman, 1980). Groundwater inputs from the terrestrial system have influences on marine ecology, for example cues for turtle nesting (Hughes 1974; Hughes, 1989; Brazier, 2012) and nutrient fluxes influencing soft corals (Porter et al., 2018).

Anthropogenic activities and LULCC affect the terrestrial, freshwater and marine systems in the area. For example, commercial forestry has a significant impact on drawing down the groundwater table (Kelbe et al., 1995; Weitz & Demlie, 2014; DWS, 2015; Bates et al., 2016; Smithers et al., 2017; Everson et al., 2018; Kelbe, 2020). Water quality is also being impacted by increased nutrient input from land (Bate et al., 2016, Humphries and Benitez-Nelson, 2013). The low soil nutrient status combined with the oligotrophic status of Lake Sibaya, which is a continuously well-mixed system (Allanson and Van Wyk, 1969), provides a unique opportunity to observe potential ***nutrient enrichment and atmospheric deposition trends*** and the impact of these on terrestrial and freshwater ecosystem functioning. Detailed limnological assessments, combined with phytoplankton and ***productivity studies*** from the 1960s and 1970s (Allanson, 1969; Allanson and Van Wyk, 1969, Allanson and Hart, 1975; Hart and Hart, 1977) provide sound baseline data from which to observe such change. In addition, recently analyzed cores provide a 250-year record against which nutrient changes can be assessed (Humphries and Benitez-Nelson, 2013). While the system is still considered relatively unpolluted from a nutrient perspective (Humphries and Benitez-Nelson, 2013), it is contaminated with the highest concentrations of Dichlorodiphenyltrichloroethane (DDT) reported for South Africa (Humphries, 2013) which might also be impacting on the marine environment through groundwater seepage. One of the oldest long-term coral reef monitoring sites in the world, on Nine-mile Reef directly opposite Lake Sibaya, records temporal dynamics in coral cover and seawater temperature (Porter & Schleyer, 2017) with the aim of detecting potential climate change impacts on the reef (Schleyer et al., 2008). Noting the elevated DDT levels found in Lake Sibaya (Humphries, 2013), when consistent declines in soft coral were observed, despite *in situ* temperatures having remained relatively stable, the potential role of terrestrial sources of pollutants and pesticides were investigated (Porter et al., 2017, 2018). Some of the highest concentrations of organochlorine pesticides, including DDT, were thus also detected in coral reef organisms in the near-shore marine environment adjacent to Lake Sibaya (Porter et al., 2018). This could partly explain the significant amount of variation in coral community composition associated with distance from the shore (Porter & Schleyer, 2019).

The fluvial outflows from uMgobezeleni Estuary and Kosi Estuary are low compared to those on other parts of the coast (Berry, 1980). As such, the marine environment is characterised by low concentrations of suspended inorganic sediments and terrestrial particulate organic matter from river plumes (Porter et al., 2014; Porter et al., 2017). However, these outflows, as conduits and offering biological cues, are biologically significant along this stretch of coast with the limited number of estuary connections. These surface flows provide the

mechanisms for catadromous organisms such as anguillid eels and invertebrates such as the freshwater crab *Varuna litterata* to enter the marine environment to breed. Outflowing freshwaters are a primary determinant of estuary mouth status and marine-estuarine-freshwater connectivity, also providing the cues for returning larvae and juveniles to enter nursery habitats in the aquatic systems of the coastal plain and access to important feeding grounds as adults. Changes in these, and other related ecosystem dynamics, are thus likely to have ***trophic implications*** spanning the terrestrial, aquatic and marine systems with knock on effects for livelihoods.

As water availability decreases and the demand for groundwater increases in the future, the possibility of ***salt-water intrusion*** into coastal aquifers rises. In addition to rendering the groundwater non-potable, saltwater intrusion can cause ion exchange and other reactions to occur which enrich fluids in nutrients and pollutants. Such changes have been documented on a worldwide scale and demonstrate how vulnerable coastal aquifers are to over-pumping (Ferguson & Gleeson, 2012). The impacts of groundwater pumping are likely to be magnified by climate change and rising sea levels, which have the potential to ***alter tidal ranges, groundwater salinity, nutrient cycling and ultimately, the productivity and biodiversity of coastal ecosystems***. This coupled with potentially increased aridity (Ndlovu and Demlie, 2020) which enhances the risk of dune blowouts compromising the protective function of the dune barrier (Both, 2015), is of particular concern.

The connected terrestrial-aquatic-marine system within the proposed landscape provides a unique model for assessing how natural processes influence ecosystem functioning across these domains through groundwater flows. Furthermore, the hydrogeological characteristics particular to this landscape are ideal for observing how climate forcing and anthropogenic impacts emanating from the terrestrial environment impact the ecological, hydrological and biogeochemical functioning and associated ecosystem services of the coastal wetlands, aquatic and marine ecosystems, and *vice versa*.

3.4 Significant and diverse wetlands

The closely coupled terrestrial and aquatic systems manifest in the wetland diversity within the proposed landscape. As early as the mid-1500s (Perestrelo, 1564; 1576) the area was noted for its swamps and marshlands. Today, the MCP remains an area with an exceptional density and diversity of wetland and aquatic systems (See Aitiken and Gale, 1921; Kramer 2003; Grundling et al., 2013; Grundling 2014; Pretorius et al., 2016; Gabriel et al., 2017; 2018; Grundling et al., 2018). Sieben et al. (2014) note that the MCP "seems to be one of the richest areas of wetlands in the country". Within the proposed Maputaland EFTEON Landscape, the peneplain not only supports Lake Sibaya (southern African's largest natural freshwater lake), the Kosi Bay Lake system and the uMgobezeleni Estuarine system, but a diversity of wetland and lentic systems that are rare and unique on a national scale. Peatlands (wetlands containing accumulated deposits of organic matter) are locally common on the MCP, accounting for 60% of all South Africa's peat resources (Grundling et al., 1998). Within the Maputaland EFTEON Landscape there are many actively accumulating peatlands (Neal, 2001; Venter, 2003; Grobler, 2009; Pretorius et al., 2016). The sustained groundwater supply has kept them permanently wet and facilitated anoxic soil conditions (Mitsch & Gosselink, 2000). These peatlands are important archives of paleo-environmental conditions and change (Humphries et al., 2019). The fresh and estuarine lake/wetland systems are interconnected and co-influenced by an almost complete dependence on groundwater, with biogeochemical cycles that are distinct to those in flowing systems. EFTEON presents an opportunity to consider these connected ecosystems ***holistically***, for the first time in a local context.

Wetlands, particularly peatlands and swamp forests, in catchment W70A provide essential functions including water storage and retention during drought periods, and carbon sequestration and storage, and in particular in this area, have high teal carbon values. The role of peatlands, wetlands, coastal swamp forests, salt marshes and estuarine mangroves in carbon storage and sequestration, and consequences of their altered function, begs quantification in relation to environmental and anthropogenic change. Recently, higher-lying peatlands within the proposed focus area have dried out and several have burnt. Given the conditions under which peat remains intact (permanently wet) and the known age (Elshehawi et.al., 2019) of these now burnt peatlands (The Vasi North peatland, for example, was initiated > 7000 years ago), it is clear that a significant shift in system state is underway, potentially indicating a wetland system collapse.

As wetlands have dried out, previously inundated areas have become more accessible, with wetland-dependent agricultural activity shifting to lower lying portions of the landscape, some of which are within iSimangaliso. Coastal swamp and riparian forests in wetlands and estuaries are thus increasingly modified through slash-and-burn operations. There is also an apparent increased rate of modification, potentially representing a switch from subsistence to commercial crop production on the MCP (Grundling et al., 1998; Janse van Rensburg, 2019). Activity within these wetland systems degrades their function, leading to the loss of water retention, faster desiccation and the loss of carbon storage function and potentially increased greenhouse gas emissions (Jewitt, 2018; Janse van Rensburg, 2019; Van Deventer et al,. in prep). This perpetuating cycle epitomises the linkages between climate, terrestrial land use activities, wetland systems and the aquatic environment including escalating conflict between communities and conservation authorities (Janse van Rensburg, 2019). These synergistic influences are ideal for long-term observations to quantify and characterise linked and cascading global change impacts on hydrological-biogeochemical cycles and livelihoods. Such knowledge is needed to inform management interventions, not only in identifying alternative sustainable livelihoods, but also to inform restoration and rehabilitation initiatives. The rate of degradation against recovery is currently unknown and opportunities in the landscape exist to test restoration efforts against rates of natural recovery and loss. This has relevance given the United Nations (UN) General Assembly declaration of 2021–2030 as the “UN Decade on Ecosystem Restoration” and how appropriate investment opportunities are sensibly identified for local ecological and social contexts.

3.5 A global biodiversity hotspot

The “Maputaland Centre”, part of the Maputaland-Pondoland-Albany hotspot, is one of Africa's most important biodiversity hotspots and centres of endemism (Van Wyk & Smith, 2001; Smith et al., 2008). The high numbers of endemic faunal (Perera et al., 2018) and floral (Matthews et al., 1999) taxa are likely related, with peaks in endemic vertebrate diversity corresponding to floristic endemism (Perera et al., (2018). Terrestrial diversity is extremely rich with >2500 vascular plant species (Moll, 1980, Van Wyk & Smith, 2001) occurring in a mosaic of ecosystems and ecological zones (See Figure 7). These are defined by variations of dune ridge sequence, abrupt changes in the soil catena, soil fertility, drainage and seasonal water stress, climate, rainfall gradients and the influence of fire (Moll, 1980, Matthews et al., 2001; Van Wyk & Smith, 2001; Botha, 2015; Kelbe et al., 2016). The diverse species complex is characterized by ‘neo-endemics’ resulting from active biological speciation (Van Wyk and Smith 2001) with many endemics reflecting recent diversification. There is still much to be learned about the diversity assets of the region, and scaled long-term surveys across the diversity of terrestrial and aquatic systems will enhance the knowledge base and enable more in-depth status assessments of change against improved baseline information.

3.6 A tropical-subtropical transition zone

The Maputaland Centre is located at the southern end of the African tropics, where many plant and animal species reach the ***southernmost limit of their distributional ranges***. Most of the flora and fauna are thus of Afrotropical origin. This area is a ***biotic transition zone*** and commonly described as the mixing point between biota from the subtropical and temperate south and west, and the tropical north (Aitiken & Gale, 1921; Lawrence, 1947; Bruton and Cooper, 1980; Perera et al., 2018). The uMgobezeleni and Kosi estuarine systems have recently been categorised as South Africa's only tropical estuaries, with systems immediately to the south identified as being subtropical (Van Niekerk et al., 2020). The marine environment adjacent to the landscape lies at the south-western limits of the tropical Western Indian Ocean marine province, in what is referred to as the Delagoa Bioregion (Spalding et al., 2007; Porter et al., 2013). The region marks the southern limits of the tropical Indo-West Pacific seaweed flora, the southern limits for many tropical coral species and comprises a significantly high proportion of tropical ichthyofauna (Bolton et al., 2004; Turpie et al., 2000; Floros et al., 2012; Schleyer et al., 2018). The marine environment is also inhabited by several species of tropical reptile, such as the critically endangered hawksbill turtle (*Eretmochelys imbricata*) (Haagner, 1994). Consequently, the marine biodiversity also exhibits a mix of tropical and subtropical species with phyto- and zoogeographic tropical affinities. The location thus provides a unique opportunity to observe changes relating to the range limits of tropical/subtropical species across the terrestrial, freshwater and marine systems. Long-term observations across these systems will provide neat "systems-level" insights into the responses, relative resilience and potential interdependencies of responses in relation to Global Change impacts and the trophic implications of these dynamics.

3.7 Vegetation shifts and plant traits in a nutrient poor region

The core and satellite sites in the proposed landscape incorporate ***boundary zones*** between wetlands, forest and grassy ecosystems ***within*** the IOCBB (Figures 7 & 13), as well as various estuarine and coastal vegetation types. This considerable biological diversity is further enhanced in the west of the proposed landscape, where the ***IOCBB transitions into savanna ecosystems*** that include sandy bushveld vegetation types, and which also features large patches of sand forest and freshwater wetland vegetation types. This wide diversity of open- and closed-vegetation types, with varying soil moisture requirements, presents an ideal natural template for studying vegetation responses to shifts in CO_2, temperature and rainfall under climate change. Jewitt et al. (2015), using "climate-dynamic environmental domains" demonstrate that the projected magnitude of change for the IOCBB environmental domain under climate change, particularly within the proposed Maputaland EFTEON Landscape, is potentially high. The relatively simple, nutrient poor and sandy soils in the landscape facilitate comparisons throughout the region, enhancing the potential for isolating the effects of other key drivers. Furthermore, the generally low soil nutrient status provides ***an opportunity to perform nutrient addition experiments***, while remaining within the range of nutrient levels observed in ecosystems with more fertile soils. The research potential of the landscape is further enhanced ***by a rainfall gradient from the coast (1100 mm.yr^{-1}) to the west of catchment W70A (700 mm.yr^{-1})***, providing an opportunity for space-for-time studies, or mesocosm-type studies that represent conditions in other parts of South Africa and beyond (e.g. high rainfall, sandy and low nutrient Miombo ecosystems).

The landscape is also well-suited to studying the consequences of shifts in fire and herbivory regimes for plant community assembly processes. The widespread distribution of forest vegetation types across the landscape attests to the climate-potential for closed-canopy ecosystems (Bond et al., 2005), while ***a range of plant traits***

in the open-canopied vegetation types clearly indicate the role of both fire (e.g. thick-barked trees, geoxylic suffritices and grasses with high biomass ratios, crown depths and leaf sheath packing) and herbivores (e.g. spines, megaherbivore-dispersed fruits and grazing lawns) in the evolution of these ecosystems (Charles-Dominique et al., 2015; Archibald et al., 2019). Closed-canopy and fire- and herbivore-maintained open vegetation types occur widely ***across protected areas and high- and low-intensity communal grazing areas*** in the region, providing a diverse array of contexts to explore the ***consequences of shifts in the consumer regime*** (i.e. fire and herbivores) for ecosystem dynamics and consequent implications for the well-being and livelihoods of people who rely on these systems. An important consideration in this landscape context is the role of hygrophilous coastal grasslands, which are associated with waterbodies, in potentially "drought proofing" the region with respect to cattle and how changes in land use may alter this resilience feature.

The high prevalence of 'underground trees' in the Maputaland Coastal Belt is a particularly interesting component of the regional flora. These geoxylic suffrutices are an indication of fire-maintained mesic savannas and grasslands, and have a growth form that positions most of their permanent woody structures belowground (Maurin et al., 2014). Rising CO_2-concentration levels are suspected to be enhancing the growth rates of underground trees, similar to the rapid clonal growth observed in 'root suckering' trees and shrubs, which has resulted in woody encroachment in many parts of the country (Stevens et al., 2016). If this indeed is the case, ***underground trees*** are likely to be acting as an ***important carbon sink*** in the system, with the added benefit of the majority of their carbon-dense structures not being exposed to fire. The Maputaland Coastal Belt thus provides an excellent opportunity to conduct research on ***the productivity, stoichiometry and carbon flux implications of these growth forms***, aided by sandy soils that make working on underground plant structures much more feasible than in other systems. The impacts of atmospheric deposition in this context should also be determined. A further belowground research opportunity is presented by the ***spatially varying depth of the water table***, as well as changes that occur over time, which allow for an assessment of the ***effects of groundwater-level changes for different vegetation types***. Given the chemistry of the system, deep-rooted species with high water use may also alter hydrogeochemical processes, an important consideration given the rapid rate of increase in the extent of *Eucalyptus* plantations (Manish et al., in press). In general, the region thus provides an excellent opportunity to explore the belowground dynamics of plants, providing a window into the ***carbon sequestration and water use properties of different communities and growth forms***, thus informing their conservation and management in this region and beyond. The combined effects of climate change and ***shifts in disturbance regimes*** are likely to have profound consequences for local communities, many of whose livelihoods are at least in part closely linked to intact ecosystem function. For example, land custodians (Mabasa TA) have voiced concern over the perceived increase in natural woody vegetation (bush encroachment) in the area, and the impacts this has on the availability of cattle grazing area and water resources. The ***different levels of intactness*** of terrestrial vegetation and wetland types, from ***near-natural to severely degraded***, provide a wealth of research and observation design options across the landscape. Added to this are the contrasts among the Sibaya, uMgobezeleni and Kosi lake systems, which are closed, partially open and open to the ocean respectively. Comparing different land uses (commercial forestry, woodlots, bush encroached areas, *Macadamia*, new crop trials etc.) to natural vegetation states within this context, and the relative impact of these in relation to climatic drivers, is the subject of ongoing research which would benefit from the EFTEON array. ***Experiments on rehabilitation*** techniques are also beginning. The opportunity therefore exists to observe ecosystem function responses to change over time from various "baseline" starting points and across ***multiple environmental gradients***, land uses and vegetation units within a coherent hydrological unit. Importantly, at a national-level, land transformation rates in the IOCBB are the highest

recorded over recent years, and it is one of the least protected biomes (Jewitt 2018; Skowno et al., 2019). The consequences of change in this landscape thus urgently need to be understood, yet it is also ideal for long-term observation on ***ecosystem processes*** and ***boundary shifts***.

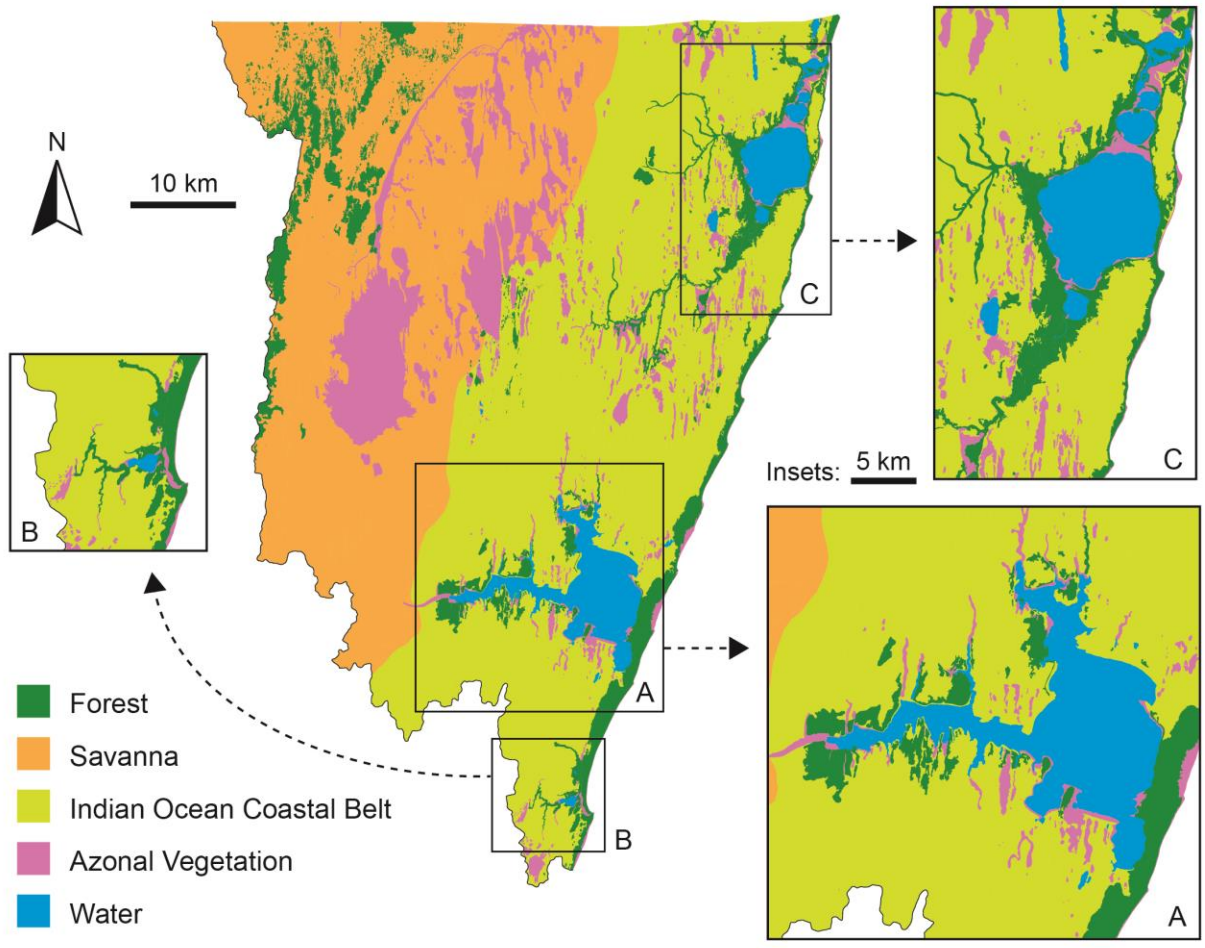

Figure 13: Biome distribution in quaternary catchment W70A following the National Vegetation Map 2012. Insets show the proposed core site near Lake Sibaya (A), and the proposed uMgobezeleni (B) and Kosi Bay (C) satellite sites.

3.8 Ideal for observing climate shifts and their impacts in a climate-sensitive region

The geographic advantage this specific location offers for observing coupled Earth System (ES) processes across the terrestrial, aquatic, marine and atmospheric systems can significantly advance South Africa's Global Change science programs. Importantly, localised impacts of variability and change in these ES processes can be feasibly measured and interpreted due to the particular characteristics of the landscape. Contrasting Lake Sibaya, Kosi and uMgobezeleni groundwater catchment areas provide a ***uniquely ideal model for differentiating climatic processes (operating at local, meso and global scales) and local scale LULCC impacts***. A number of climate change impacts are anticipated for this region (see Figure 14).

Catchment W70A is located within a climate-sensitive region that is strongly influenced by both regional oceanic and remote forcing. The region experiences a predominantly summer rainfall regime. The most

important rain-producing weather systems for the region are cloud bands (or tropical-temperate troughs (TTTs)) (Hart et al., 2010, 2013), tropical lows (and occasionally tropical cyclones), cut-off lows (Singleton and Reason, 2007), ridging anticyclones and mesoscale convective systems (Blamey and Reason, 2009, 2013). Regional circulation systems such as the South Indian Ocean High, the Mozambique Channel Trough, the Angola Low, the mid-level Botswana High and the South Atlantic High are likely to influence the tracks, frequency and intensity of these systems. In turn, these systems will be influenced by large scale climate modes such as the El Niño-Southern Oscillation (ENSO), the Southern Annular Mode (SAM), the Indian Ocean Dipole (IOD) and the Subtropical Indian Ocean Dipole (SIOD) as well as by long-term climate change (Reason et al., 2000; Washington and Preston, 2006; Morioka et al., 2010; Malherbe et al., 2016). The impacts of variability in these circulation patterns and weather systems over the region (e.g in terms of groundwater recharge and availability, wetland water availability) has, however, not been well quantified and is currently the subject of research being conducted within the Oceanography Department at the University of Cape Town, as well as the SAEON Egagasini node. Paleo evidence (Botha, 2015; Humphries et al., 2019) however provides an indication that ***Maputaland is susceptible to extreme variations in precipitation*** and may be ***particularly vulnerable to climate change*** given the nature of geomorphological processes that may emerge under increasing aridity (e.g. dune blowouts; Botha, 2015).

An increase in the frequency and intensity of drought is often considered one of the most severe impacts projected under anthropogenic-induced climate change across southern Africa (Kirtman et al., 2013; Pohl et al., 2017; Nangombe et al., 2018; Naumann et al., 2018). Episodes of severe drought within the MCP region appear to be closely tied to El Niño conditions (Blamey et al., 2018), which are expected to develop more frequently under present climate change projections (Abram et al., 2008). ***The 2015/16 period is the driest summer on record (1950-2016) for the region*** (Blamey et al., 2018; Ndlovu and Demlie, 2020) and a recent analysis indicates that droughts within the KZN province are indeed becoming more intense and frequent (Ndlovu and Demlie, 2020). An early "raw" record for Manguzi (1915-1972) provided by Pitman and Hutchinson (1975) indicates a mean annual precipitation (MAP) of 932.6 $mm.yr^{-1}$, where as an analysis for the 1987–2017 period (Ndlovu and Demlie, 2020) has a MAP of 827.9 $mm.yr^{-1}$ for the same area indicating a potential declining trend in precipitation. The MAP for Mabazwane for the period 1970–2017 is 839.1 $mm.yr^{-1}$ (Ndlovu and Demlie, 2020). The region is typically described as having a rainfall gradient from east (1100 $mm.yr^{-1}$) to the west of catchment W70A (700 $mm.yr^{-1}$) which is largely based on an analysis done by Pitman and Hutchinson (1975) with patchy data from short time periods. A revision of this pattern is an active topic of change detection research to which the EFTEON array would add value.

Located within the ***tropical to subtropical transition climate zone***, the region lies to the south of the typical landfall location of tropical cyclones/storms in central Mozambique, but north of the coastal region that typically gets significant rainfall from onshore flow associated with ridging anticyclones, and thus represents an interesting transition zone. Occasionally though the region does experience significant tropical cyclone rainfall input. Equally concerning therefore is the projected decrease in the occurrence of tropical systems (cyclones, depressions and lows) originating from the southwest Indian Ocean making landfall over the southern African subcontinent (Malherbe et al., 2012). As these are responsible for widespread heavy rainfall events (Malherbe et al., 2012), they likely play a vital role in recharging groundwater resources. However, contradicting studies indicate a southwards shift of the cyclone belt (Fitchett & Grab, 2014), highlighting the need for more observations and research to resolve conflicting projections. In the South West Indian Ocean, there is evidence that severe tropical cyclones (categories 3-5) are becoming more common but not cyclones in general (Malan

et al., 2013; Mawren and Reason, 2017). Extreme flooding events have historically been associated with wet cycles in combination with tropical rainfall (e.g. Cyclone Leone-Eline in 2000). Wet periods within the catchment (1909-1922; 1954-1967; 1971-1984 and 1989-2000) largely match up with those over subtropical southern Africa as a whole, and have been related to ENSO-like decadal patterns (Reason and Rouault, 2002), low frequency variability in the Southern Annular Mode (Malherbe et al., 2014) or in the Botswana High (Reason, 2016; 2019). The role of cyclonic rainfall in recharging the coastal aquifer in relation to "normal" rainfall is not clear and currently the subject of research by UKZN and SAEON within the area. When full, the lake level is ~21 m amsl and 40 m deep at its deepest point. Historically, the lowest measured water level for Lake Sibaya was in 1970 at ~18 m amsl (Hill, 1979; DWS, 2015; Smithers et al., 2017). Cyclone Leone-Eline was the last time significant cyclonic rainfall reached the system. The decline in lake levels over the past two decades is unprecedented with levels currently ~14.5 m amsl (SAEON data).

The Maputaland landscape is thus well-positioned to contribute to an improved understanding of climate change impacts in general and, specifically, the drivers of rainfall extremes over southern Africa and their relationship with recharge processes under past, current and future climates. It also sits on one of the flattest coastal areas, vulnerable to sea level changes (section 3.3). Understanding change in this context is crucial for informing water management policies and climate resilient development in a region where ***water, food security, and livelihoods are inextricably linked*** and is of relevance for the entire coastal plain extending into Mozambique. The location also provides an extreme contrast against mesic-temperate high altitude landscapes (such as the Drakensberg grasslands) and arid warm sites and nutrient rich summer rainfall sites.

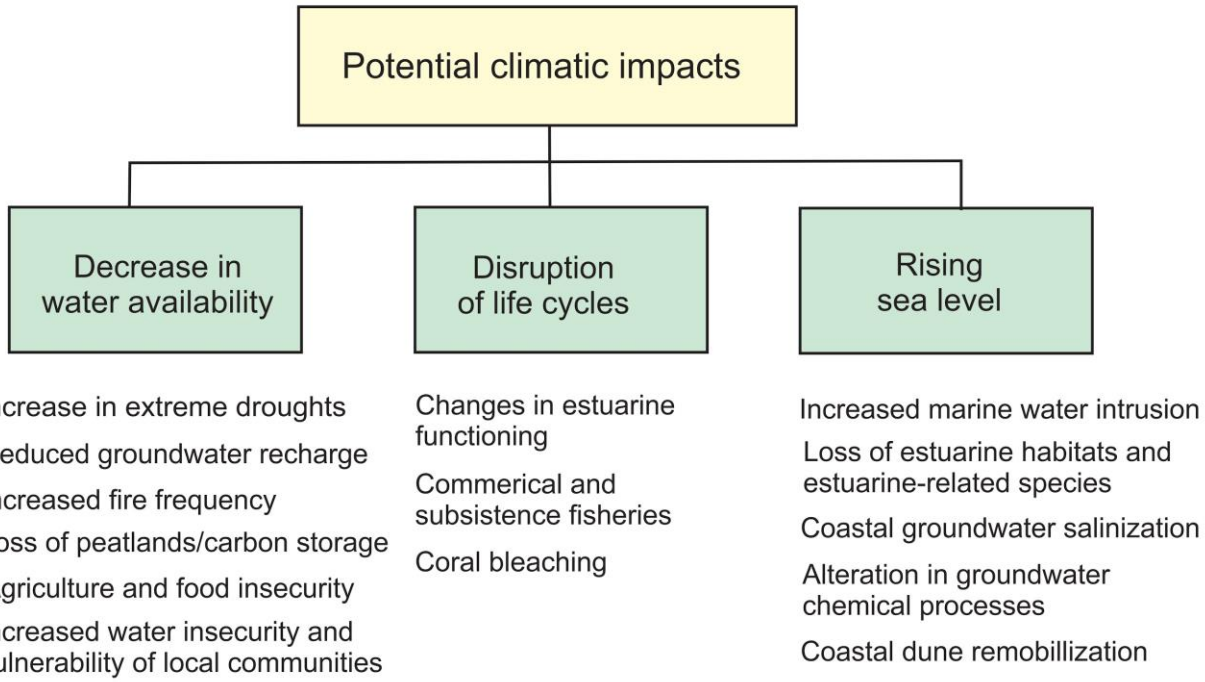

Figure 14: Potential biophysical and socio-ecological consequences of climate change in Maputaland.

3.9 Looking to the past to understand the future

The geological processes and coupled paleo-climatic history of the region are closely associated. Current surface features are a reflection of the late Pleistocene to Holocene period (Porat & Botha, 2008). The sequence of dune mobilisation phases linked to long-term global environmental change and sea-level fluctuations that influenced groundwater table level and vegetation cover provide a paleo-environmental change template (Botha et al., 2016). The contrast between deeply pre-weathered dune sediment and pulses of marine-linked coastal sedimentation result in significant differences in silt and clay content of surficial sediments/soils, soil fertility and associated trace elements across the area and act as important markers to interpret longer-term changes in the region. The landscape offers a unique chance to understand the current status of the coastal wetland catchments relative to similar "interglacial" periods over the past 400,000 years and the climatic, groundwater and vegetation threshold conditions that resulted in regional remobilisation of aeolian cover sands (Botha et al., 2003).

The sensitivity of the Maputaland landscape to extreme and often rapid changes in climate is evident in palaeoclimate records spanning the past 7000 years (Humphries et al., 2019). Such reconstructions are not only useful in the development of climate models, but critical for assessing the sensitivity of ecosystems to present and future drivers of climate change.

Recently discovered archaeological evidence, exposed by receding lake levels, date back to the stone age (period still to be resolved). To the west in the Lebombo mountains, Border Cave also provides a phenomenal archaeological record dating back at least 200 000 years with evidence of different periods of human occupation in the region (Beaumont et al., 1978; Villa et al., 2012; Backwell et al., 2018). Evidence of early African farmers, possibly the earliest in KwaZulu-Natal (~300 AD), has also recently been found around Lake Sibaya and is being investigated by the KwaZulu-Natal Museum (Whitelaw & Janse van Rensburg, 2020).

Collectively, the available data on dune structures and sequence and age (Miller, 2001; Porat & Botha, 2008; Botha et al., 2016), paleo cores from sediments and peat (Grundling et al., 1998, Humphries et al., 2019), palynology (Walther & Neuman, 2011), as well as recent archaeological findings, provide useful foundations to contrast the historical socio-ecological context to current dynamics (see Botha et al., 2016).

3.10 A Socio-ecological system embedded in a nationally significant development context

Quaternary catchment W70A falls within the Umhlabuyalingana Local Municipality (ULM) and uMkhanyakude District Municipality (UKDM) (Figure 3). Of the four local municipalities within the UKDM, ULM is the poorest (44.9% of households with no source of income; high dependence on social grants) (ULM IDP2018/19), most vulnerable and most in need of evidence-based development. High levels of unemployment and low adaptive capacity typify the region (Fairer-Wessels, 2017; ULM IDP 2018/19). Integrated Development Plans (IDP) and Spatial Development Frameworks (SDF) are in place for the UKDM and the ULM. The majority of the proposed landscape outside of the protected area network falls within a “priority 1” zone for “Provincial Spatial Economic Development'' (ULM IDP 2018/2019) (Figure 15). Given its early developmental stages, it offers high potential for science to impact meaningfully on the development trajectory.

The socio-political history of the area is nationally relevant and known to be complex (Owen, 1833; Carruthers 1988; Mthethwa, 2002; Guyot, 2002; Kloppers, 2003; Hazel, 2008 Fairer-Wessels, 2017; Mathebula, 2017). Historical legacies are still influential in contemporary relationships (Mthethwa, 2002) and of relevance to

observing and understanding the current socio-ecological system. All the land outside of the protected areas is Ingonyama Trust Board land, with some areas within iSimangaliso subject to land claim settlements. There are three Tribal Authorities (Tembe, Mbila, Mabasa; Figure 10) adjacent to Lake Sibaya, each having distinct origins. Understanding the relationships people have with the landscapes within this context, and how and why these are changing, is important with respect to the social-ecological objectives of EFTEON.

Options for economic activity are perceived as being limited, with a strong focus on forestry, which is a water-depleting activity (Weitz & Demlie, 2013; Bates *et al.,* 2016; Smithers et al., 2017, Everson et al., 2018). The water resource for socio-economic and environmental use is exclusively the aquifer as there is no bulk water supply to the area nor import of water from upper catchment rivers. Changes to the available water resource are responses climate and extreme events, over which there is limited immediate control; and LULCC, over which there is much more control. Due to systems' high dependence on localised rainfall for recharge***, climate change impacts that affect rainfall are accentuated within this catchment area***. Historically there was a high dependency on natural resources for human livelihoods (Hazel, 2008), however this may be changing for some (Arndt, 2014) with a switch to commercialisation of produce (e.g. bananas); whereas the most vulnerable are likely still closely dependent on natural resources from the natural environment. The closely coupled terrestrial-aquatic system means that land management choices impact on the water resource, which in turn feeds back on environmental and economic outcomes. Land use and economic development choices can have either negative or mitigating outcomes. Climatic extremes, which will escalate with climate change, are likely to accentuate these linkages and their consequences for environmental and human well-being when poor land use choices are made. For example, high water use economic activity (such as *Eucalyptus* plantations), combined with increasing aridity will lead to net negative outcomes. EFTEON presents the opportunity to understand system-wide responses of the combined impacts of changes in climate and LULCC on the hydrological resources within the landscape, with ensuing feedback. This feedback refers to the effects the hydrological changes have on the livelihoods of people and on land use decisions in a continuous loop.

This landscape offers potential for contrasting the patterns of land use change in a relatively undeveloped rural context, which is now rapidly changing, with influx evident, relative to those in other rural landscapes in South Africa, some of which are experiencing attrition to urban centres (pers. comm. Dr Shakelton). Contrasting such patterns across rural landscapes to develop a holistic understanding of patterns and drivers of change across different environmental and socio-economic contexts within South Africa will be informative in assessing policy intervention imperatives relative to environmental and social drivers of change. Intentionally designing the social ecological component aspects undertaken in the Maputaland EFTEON to interpret the social ecological system in a manner that is comparable to other EFTEON sites selected would be beneficial.

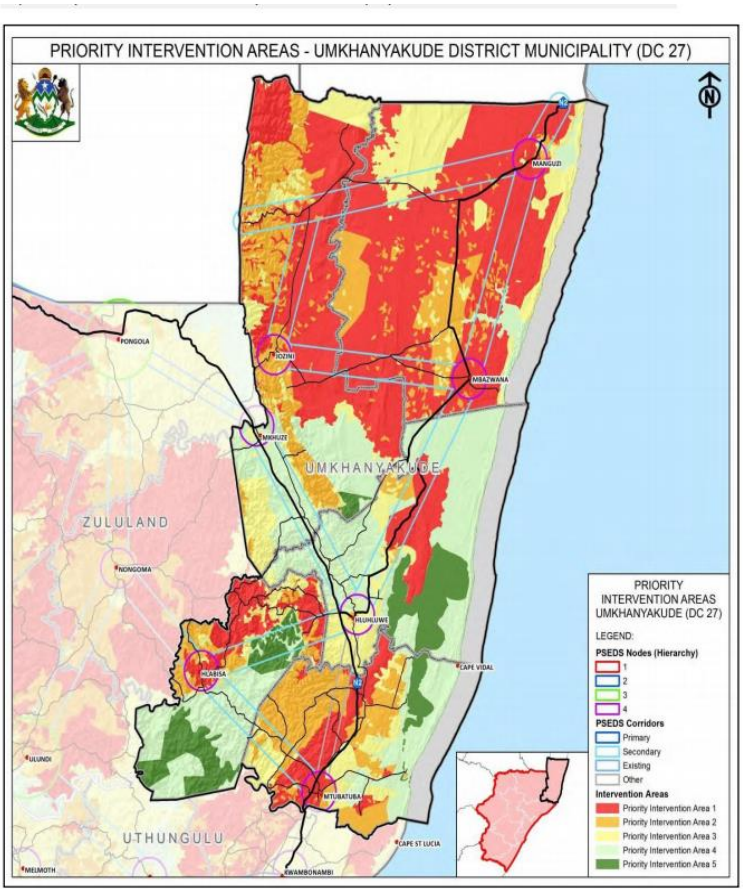

Figure 15: Economic development priority zones, taken from ULM IDP 2018/2019

3.11 Significant global changes processes are evident and increasing

Historically the MCP has been a relatively sparsely populated area, but recently there has been a significant rise in population numbers (Bate et al., 2016; Malherbe, 2018). Linked socio-economic land use changes include: 1) a switch from a subsistence livelihood to a money-based livelihood, 2) increased land use intensity and resource use, 3) new areas becoming accessible for farming as a result of receding water levels, where increased rates of use are likely to outpace the ability of these systems to recover, 4) increased forestry activity (Figure 16), 5) changes in agroforestry species being planted which impact differently on the water resource, 6) increase in population density around towns/villages with associated degradation of land and water quality. Superimposed in these is climate change, with evidence of increasing drought severity and frequency (Nldovu and Demlie, 2020) and significant temperature increases 1.6-2^0 C (1961-2010), with projections of further warming of 4-6^0 C in the 21st century (Engelbrecht et al., 2015).

Commercial-scale plantation forestry (*Pinus* and *Eucalyptus* species) is being driven as a land reform-economic stimulus program within the region. A large-scale forestry operation within the region (TMM Forestry) is owned by the three Traditional Authorities within the Maputaland EFTEON Landscape (Tembe TA, Mabasa TA and Mbila TA). TMM Forestry has a proven track record of enabling researchers and is interested in exploring alternatives to *Eucalyptus* plantations. SAEON is currently working with TMM to compare the water use of *Macadamia* to other LULCs. TMM Forestry also supports the Maputaland EFTEON proposal, with the assurance they will ***support the deployment of research infrastructure related to the EFTEON program and would like to be involved*** in the project if this landscape is successful. Their operations and quest for water sustainable systems provides for scaled experimental designs as their compartments straddle all three groundwater

catchments. ***Opportunities exist, with a proof of concept through their work with SAEON, for the use of experiments and manipulations to observe environmental processes.*** There are also an increasing number of "small grower" woodlots within the region. Large-scale commercial forestry operations (TMM Forestry) can thus be contrasted to "small grower" woodlots as an alternative management regime. There are plans to convert some *Eucalyptus* compartments to *Macadamia*, providing further ***landscape-level "experimental" templates***. The Coastal Cashews farm (Figure 31) currently has extensive groves of cashew plantations, providing for another useful contrast. They have openly welcomed SAEON activities on their farm and permitted the deployment of research equipment and long-term observations on the farm. They are also interested in exploring economical viable alternatives, providing further experimental opportunities and are supportive of EFTEON operations within the area and on the farm (pers comm. Fanie Vermaak).

Changes in the groundwater table will lead to changes in the spatial extent and the ecological function of water-related ecosystems that people use (e.g. wetlands, lakes, peatlands, swamp forests, estuaries and mangroves), and consequently the water retention capacity of these systems. Changes in water quality are also likely to have knock on effects with respect to tropic impacts. An increase in invasive species is likely to be facilitated by accelerated slash and burn agriculture in terrestrial systems and by aquatic invasives in ecosystems that have undergone stable state shifts (e.g. *Tarebia granifera* snail proliferation in KZN estuaries, including Kosi Estuary and Lake Sibaya). The loss of connectivity of aquatic habitats with increased drought cycles and a fundamental change to the underlying aquifer is likely. As ecosystems become increasingly degraded, the ability to sustain livelihoods equitably is diminished. Extreme rainfall events/cyclone landfall may help water-dependent ecosystems recover, but flooding of cropping areas results in shocks to food security and livelihoods. All these impacts are interlinked.

Social dynamics around land and tenure are likely to become accentuated within the next two decades. The implementation of economic development initiatives, as well as external pressures, such as cross border influx if conditions (socio-economic, political and/or environmental) further north deteriorate, and how externally driven development initiatives are regulated (or not), will be influential in determining future resilience trajectories. Increased demand for water for domestic use, land uses such as forestry, irrigated agricultural developments at the expense of ecological function is likely.

The links between human and environmental health are an important aspect deserving of attention given the low nutritional status of the soils, disease vectors (malaria, bilharzia etc), environmental contamination and shifts in dietary patterns from subsistence to commercially available food. There are a number of lifestyle-based health diseases (e.g. diabetes, obesity) potentially on the rise within the region (pers. com. Dr Fredlund). The links between these trends and the shifts from a subsistence-based economy to a commercial one, need to be quantified.

High dependency on natural systems reflects rich indigenous knowledge systems, however these may be changing in terms of skill attrition, intent and practice. There is significant opportunity to develop a more in-depth understanding of indigenous knowledge systems, relationships with the natural environment and if these are changing. The high potential for action-based research is strength of this landscape as highlighted collaborators. Ultimately, the program and associated researchers can play a role in democratizing science and empowering informed choices (see Burt et al., 2019) in relation to projected futures where the net costs and benefits of both the environment and livelihoods are understood. For example, SAEON, ASSET, UKZN and UCT, are working together to understand the linkages between climate, hydrology and economics in the area within

a resource economics framework, working with sector partners (TMM) and local communities.

The site is thus in an area ***already experiencing significant global changes processes***, in terms of growth in settlement, development, economic activity and associated land use changes, as well as climate change impacts associated with sea level rise, rainfall and temperature changes. There are thus many opportunities for long-term observations on the synergistic links and levers between economic, social, ecological aspects in relation to land use and climate dynamics. For example, observing and understanding wetland farming practices, and how these are changing, offers a lens to the multiple terrestrial and climate change drivers of change within the socio-ecological system. Because of its topography, hydrology and location at a tropical/subtropical interface, and societal reliance on natural ecosystem goods and services, ***consequences of climate change can be expected to be disproportionate in this area***.

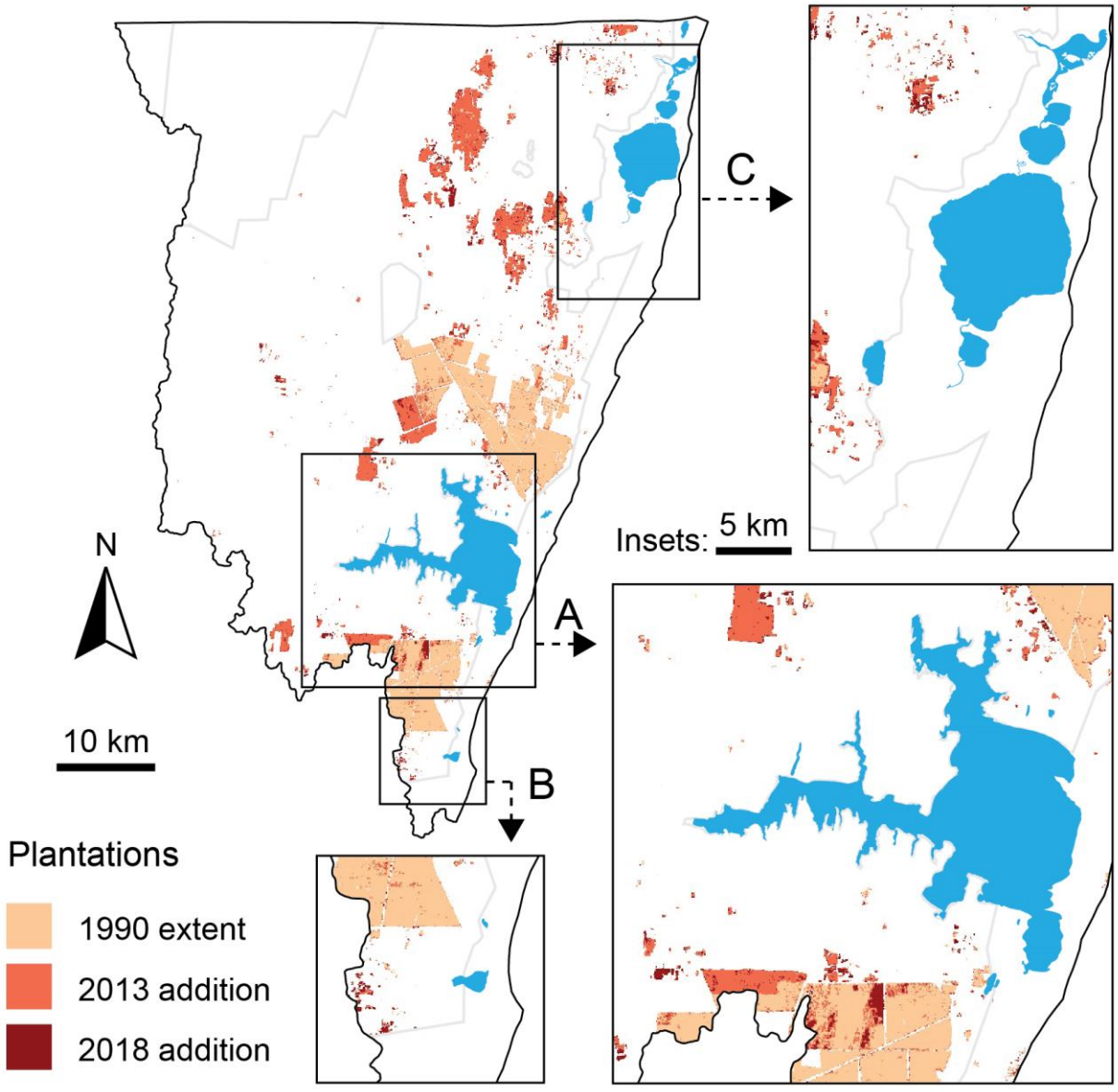

Figure 16: Change in forestry plantation extent from 1990 to 2018. Data for 2018 were obtained from the South African National Landcover 2018 (SANLC) data set, with 2013 and 1990 extents derived from the SANLC 2013/14 and 2018.

4 LOGISTICAL AND OPERATIONAL SUITABILITY OF THE CORE AND ASSOCIATED SITES

4.1 Existing research infrastructure and facilities for hydrological observations

Due to the absence of perennial rivers, the primary means for hydrological observation within this system is monitoring groundwater level using boreholes or piezometers. There are existing facilities for both meteorological and hydrological measurements within the system, some of which are currently collecting data. SAEON is actively monitoring 27 boreholes (+7 in St Lucia) within the Lake Sibaya, uMgobezeleni and Kosi Bay groundwater catchment areas as well as stream flow discharge in Sihadhla steam. In addition to these there are a substantial number of DWS monitoring and municipal production wells within the landscape, as well as community boreholes that are currently not monitored but are optimally placed (Figure 17) and could be (re)commissioned for groundwater level monitoring by EFTEON in a cost effective manner. Where strategic observation locations are identified by EFTEON that do not have existing infrastructures, the estimated cost of drilling a paired wells (one deep and one shallow) is approximately R150 000 (or cheaper depending on depth and casing required).

DWS recently completed a national strategic assessment and implementation plan of their hydrological infrastructure with recommendations of long-term observations which EFTEON can align to. A summary of these relevant to catchment W70A is provided by DWS in their inventory submission. This includes all available infrastructure, the current variables being monitored, spatial distribution and density, frequency of observation and available metadata and other data integrity information available for the networks. Monitoring of infrastructure is linked to various sources: National Groundwater Archive (NGA), DWS's HYDSTRA system, and the DWS's chemical Water Management System (WMS). The spatial coverage of infrastructure is synthesised in Figure 17. Spatial distributions and other information related to historical data for sites can also be provided.

There are several opportunities for the deployment of observation systems for measuring discharge from groundwater fed streams entering the three lake systems. These range from citizen science tools (velocity plank), routine measurements using a flow meter (SAEON has a flow meter) and loggers of various kinds that can make use of existing culverts. There is infrastructure in place at uMgobezeleni for measuring the lake level that EFTEON can instrument. SAEON is currently monitoring lake level in the main basin for Lake Sibaya. Innovative solutions are required for determining lake levels of the south basin. SAEON has also worked with DWS to place survey points around Lake Sibaya for reference to enable any further survey of new points into mean sea level.

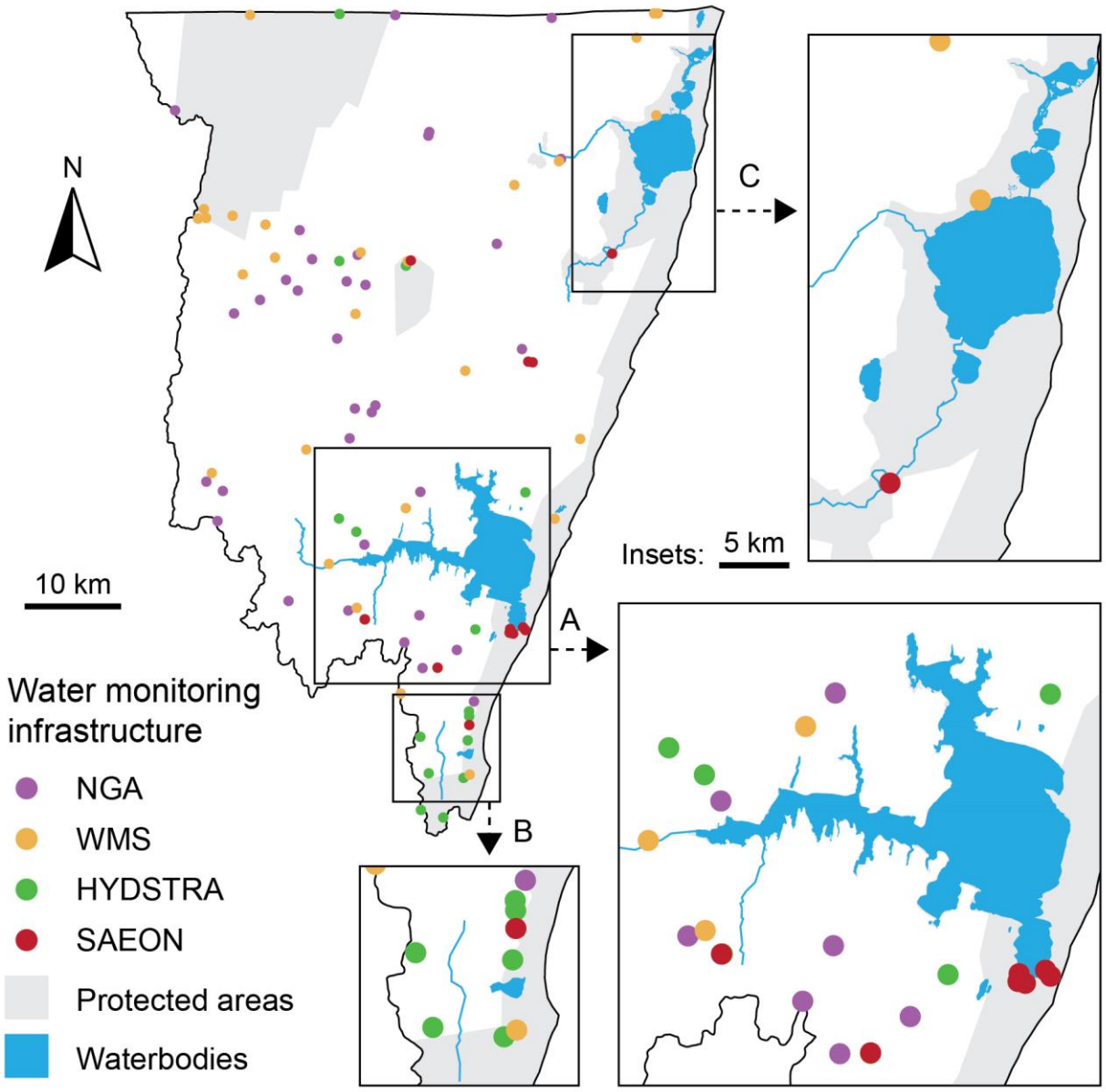

Figure 17: Monitoring infrastructure available in catchment W70A, including the National Groundwater Archive (NGA), the DWS's Water Management System (WMS) and HYDSTRA monitoring points, and SAEON groundwater monitoring infrastructure. Insets show the proposed Lake Sibaya (A), uMgobezeleni (B) and Kosi Bay (C) sites.

4.2 Suitable sites for the deployment of micrometeorological observations

A number of "core sites" have been explored for the deployment of micrometeorological equipment in relation to the three lake-system catchment areas proposed within the landscape. The entire catchment is relatively flat and low lying with the highest point being on coastal dunes which range from 64-172 m amsl. **Note that the sites included in the assessment were restricted *to near-natural (unmodified)* Indian Ocean Coastal Belt Grasslands, *where the location is least likely or unlikely to change in land use within the foreseeable future (>20 years)***. Six potential sites have thus far been identified (Figure 18). In selecting sites we prioritised locations that would be ideal in terms of ensuring stable atmospheric conditions, that are flat/gently sloping,

and those having relatively homogeneous vegetation in near-natural condition for an extent equivalent to or beyond the expected footprint. It was assumed that the height of the equipment would be 6 m, given the varying height of the vegetation (~2 m). Using the commonly accepted 1:100 rule of thumb a rough fetch area of 600 m was used. Note, there are other near-natural vegetation types (e.g. various forest types) available in the landscape, as potential sites for micrometeorological observations, which have not been included in this assessment as the proposed focus is on the coastal grasslands.

Table 1: Potential flux tower sites within the proposed Maputaland EFTEON Landscape.

Groundwater catchment: Map code	Land custodian	Accessibility	Site evaluation
Lake Sibaya core site (LS_CS1) (Note this falls within the sustainable resource zone as showing in Figure 9	Mabasa TA: Strong desire to host the core site and will provide security of tenure (ensuring land use will not change) and assurance of access for the related activities A community game reserves is currently being negotiated adjacent to this, which is primarily indigenous forest	Easily accessed via the tarred R22 and a relatively short jeep track to site, < 16 km from Mbazwana	Ideal near-natural core site. Good condition uniform lala palm grasslands for a 1 km radius around central point (2 km diameter). >4.5 km from the closest point to the lake Relatively flat. Indigenous forest to north, Savanna to the west, grassland to east (Figure 18) Plantations to the south. Within Lake Sibaya Groundwater water catchment.
Lake Sibaya (LS_CS2)	Tembe TA: Would need to be negotiated	58 km from Mbazwana via west of lake or 36 km via east along dune cordon, jeep tracks	Cattle grazing grassland area with encroaching woodlots. Site is not as easily accessible as LS_CS1 and the uniformity footprint is slightly smaller. There is a borehole in the near vicinity Slightly more hilly then LS_CS1. Manzengwenya forest station to the north and east, drainage zones to the west and woodlots in the surrounding area. Edge of Sibaya ground water catchment recharge zone.
Kosi Bay (KS_CS1)	iSimangaliso	Access from Manguzi town is via an initial section of tar road, with gravel and sand tracks thereafter (6 km)	Stable land use (within PA). 1.2 km south west of third lake. Grassy plains stretch from the forest (see Figure 18) flanking the lake to iSimangaliso border. Manguzi town lies approximately 5 km north west of this site. Within Kosi groundwater water catchment
Kosi Bay (KS_CS2)	iSimangaliso	Accessed from Manguzi town by approximately 12 km of gravel road and 3-10 km of sand track depending on the	Stable land use (within PA) Gently undulating grassy dunes between Bhanga Neck and Black Rock Boundary of Kosi Recharge zone and Shoreline Recharge zone.

		exact site chosen	
uMgobezeleni	iSimangaliso / Mbilia TA	Easily accessed	No suitable safe sites in grasslands Does provide the opportunity to conduct campaigns over swamp forest undergoing rapid transformation using alternative flux techniques (respiration chambers)
Boundary zone Kosi system (BZ_CS1)	EKZNW (Sileza)	Access arranged via EKZNW, 55 km from Mbazwana, 20 km from Manguzi	Smaller area of uniformity then LS_CS1. Being encroached with curry bush, low grazing densities Outside of main groundwater catchment areas for Lake Sibaya and Kosi Potentially better security being inside a PA, Sites on boundary zone of Kosi groundwater recharge area (important to monitor for hydrological component). Long-term vegetation data available.
Boundary zone Lake Sibaya BZ_CS2)	Tembe / TMM	Via R22 then down good road and short distance along jeep track 38 km from Mbazwana	Grassland but being encroached with *Dichrostachys*, heavily grazed, Increase conversion close to the area for *Macadamia* SAEON has established a tower at this site for surface renewal measurements. Flat to very gently undulating. Forestry to east cashew to south (as well as charcoal making industry). Wetland areas to west and grassland to north. Sites on boundary zone of Lake Sibaya groundwater catchment recharge zone

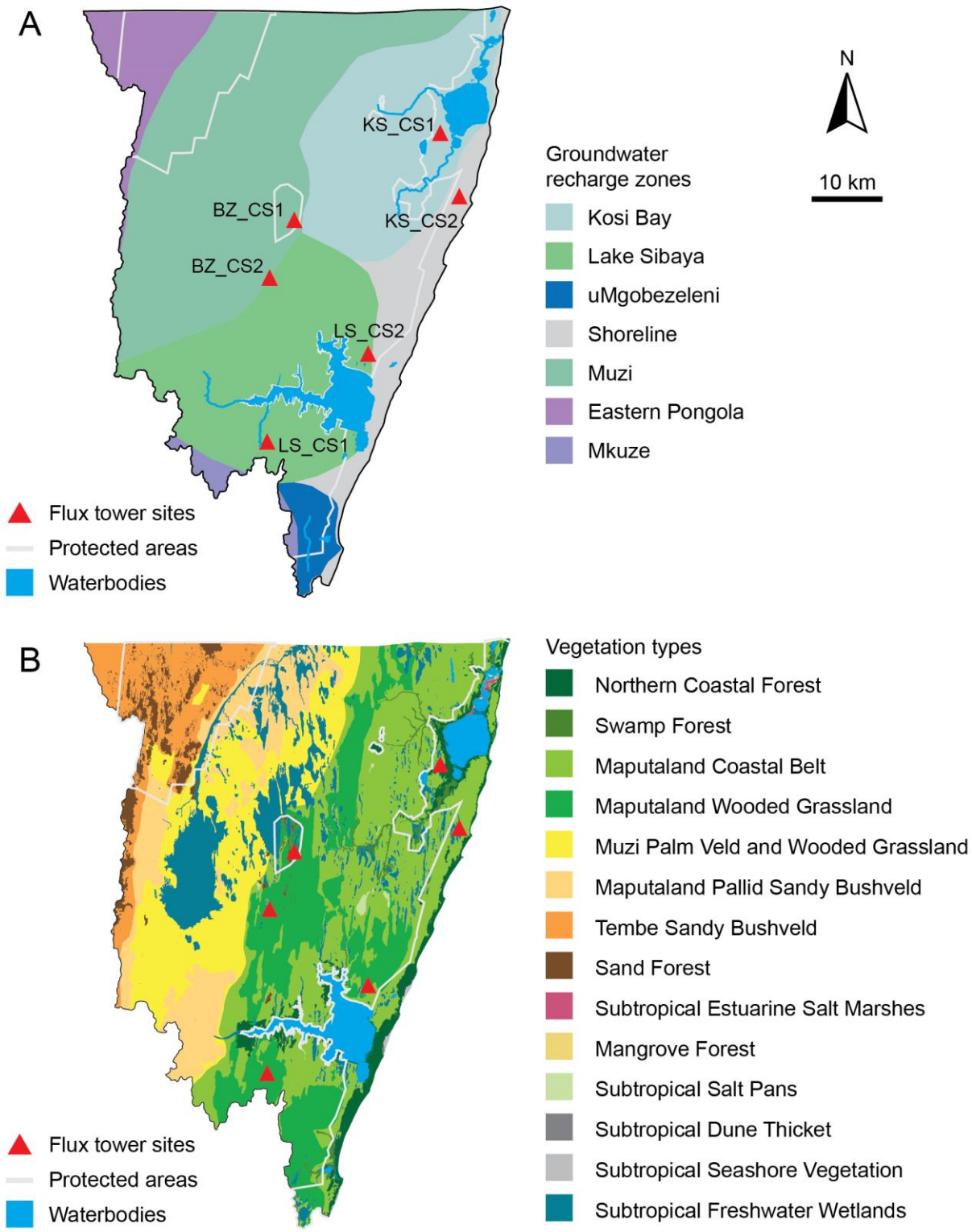

Figure 18: Proposed flux tower sites in Indian Ocean Coastal Belt Biome grassland, in relation to groundwater recharge zones (A) and vegetation types (B). The flux tower site labels in (A) correspond to the labels in Table 1 and the text. Groundwater recharge zones were mapped following Bruce Kelbe (pers comm), and vegetation types follow the National Vegetation Map 2012.

The Lake Sibaya groundwater catchment area has an ideal core site within the Mabasa Communal grazing area/sustainable use zone (LS_CS1, Figure 18a). Wetland areas within the Lake Sibaya western arm Mseleni floodplain are cultivated (banana, spinach, amadumbe etc.), shifting downslope as the water level declines. Fishing takes place within the lake and there is some level of natural resource use within the forest, grassland and wetland areas for timber, Lala Palm wine and Ncema grass harvesting, respectively. There are active citizen science programs measuring inflow from the Mseleni stream into the lake.

Natural vegetation assemblages in the Kosi system include coastal forest, swamp forest, mangroves, savanna, grassland and peatland communities. The range of land uses outside iSimangaliso in the vicinity include large *Eucalyptus* plantations and small-scale woodlots, small-scale agriculture in peatlands (e.g. bananas, amadumbe, sugar cane), while Manguzi town is experiencing rapid growth and rates of urbanization. The Kosi lake system is experiencing an intensification of fishing, while it is also likely that the influx of various pollutants from Manguzi is increasing. The optimal site within this system with respect to access is KS_CS1 (Figure 18a).

While only one of these sites 7 sites will be selected for micrometeorological investigations by EFTEON, all should be considered for auxiliary measurements such as groundwater level and rainfall where these measurements are not already in place.

4.3 Current research activities, existing long-term observations and historical datasets

A large body of relevant research is available for the proposed landscape, which includes unique detailed baselines from which to observe and understand change dynamics. These cover a wide range of disciplines and all the EFTEON themes. The Rhodes Freshwater Research Unit was active in the region in the 1960s and 70s. As noted by Bruton (1975), scientists working in and around the lake at this time had the "rare opportunity" of conducting research on what they described as essentially a "pristine" system. The products from this initiative provide a holistic historical baseline on lake limnology with detailed information on lake water quality dynamics including temperature profiling, water chemistry, abundance of planktonic algae, zooplankton and fish, as well as terrestrial vegetation, general lake faunal and floral suites, and cultural history including the historical development trends within the area and anticipated changes. A synthesis of these studies is documented in Allanson (1979) which also includes a detailed bibliography up until that period. SAEON has been securing all literature and historical reports for the region to update the bibliography produced in 1979. Bruton and Cooper (1980) provide an additional synthesis covering the greater Maputaland region. There are also publications on Kosi Bay and Maputaland generally from this time (e.g. Allanson, 1969; Breen and Hill, 1969; Bruton and Appleton, 1975). A vision for the proposed Maputaland EFTEON Landscape may be firstly to revise the status of knowledge gained subsequent to these large bodies of work, followed at a later stage by a detailed assessment of system change in relation to historical baselines using the data emanating from EFTEON and associated collaborator projects. SAEON has also initiated a detailed assessment of historic vegetation surveys conducted within the proposed landscape, assessing feasibility of repeating these and has also secured and digitized historic rainfall records for the area. All this information is available to EFTEON and the collaborators performing research in the area as an easy "start up" to enable effective knowledge sharing. Photographic records for the area, donated by Prof. Chris Appleton, have been digitized captured will be upload up onto the rephotosa website.

The location also allows EFTEON to link to at least five long-term observation programs: SAEON Grasslands Node Maputaland Platform (Figure 19), SAEON Elwandle Node's Acoustic Doppler Current Profiler (ADCP)

program, ORI's long-term reef monitoring program (Figure 20), EKZNW's long-term coral reef monitoring and turtle monitoring program and the SMCRI. The ORI long-term coral reef monitoring program constitutes one of the oldest reef dynamics and temperature time series on the east coast of Africa. Nine-mile reef, directly opposite Lake Sibaya, has been monitored since 1993 (UTRs since 1994). SAEON-Elwandle has ADCP data (water currents and temperature) since 2018; EKZNW have long-term coral reef and temperature monitoring at Saxon, Two-mile and Leadsman reefs since 2008; and SAEON-Grasslands has been collecting groundwater data since 2015, and has expanded its array over this time to include meteorological measurements as well as ecohydrological studies on vegetation water use relations and Lake Sibaya water temperature. Ezemvelo KZN Wildlife has been monitoring turtle nesting activity on the shore of iSimangaliso Wetland Park since 1963 as part of one of the world's longest running and most successful marine turtle conservation programmes. Part of the success of this programme has been ***the involvement of local coastal communities*** with significant job creation.

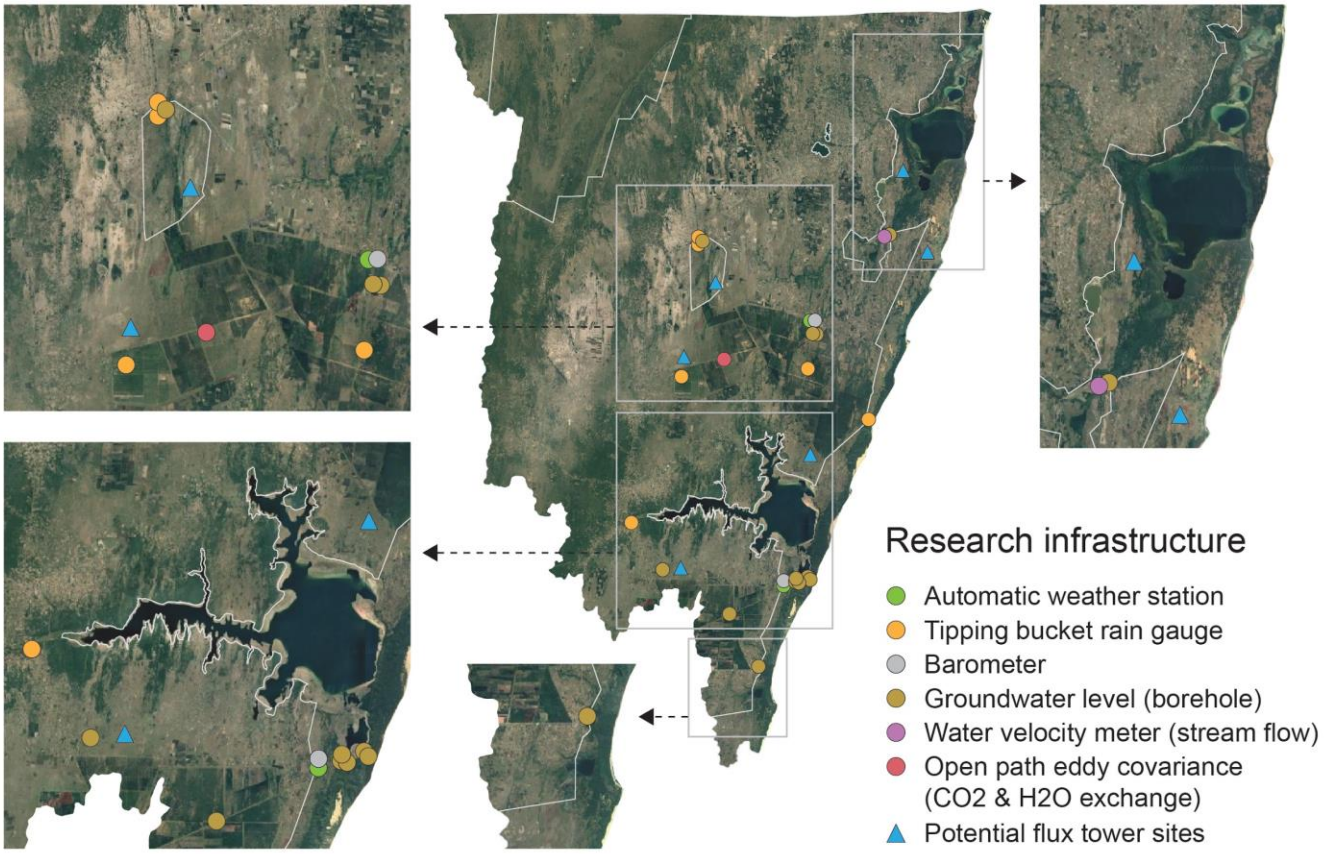

Figure 19: SAEON research infrastructure also indicating potential flux sites within the landscape.

Research infrastructure (RI) and measurements from SAEON and SMCRI will contribute directly to the EFTEON array and help to facilitate collaborator's projects. Existing RI includes: monitoring of 27 boreholes, six tipping bucket rain gauges, two weather stations, surface renewal systems, OTT flow pro meter, two thermistor strings with *in situ* temperature recorders in Lake Sibaya, periodic Lake Sibaya water quality data, handheld electrical conductivity (EC) measurements, and two trip cameras. SAEON also conducts manual water level monitoring on an array of Piezometers on the Coastal Cashews farm (Figure 31 and Figure 32). Planned RI includes: additional temperature and salinity recorders for the estuaries, additional water quality multi-probe with

handheld display and 50 m cable, soil water Diviner tubes installed at several sites representing different vegetation types, a 4.8 m 6 pax "estuarine" boat for wet boat work and additional ecohydrological measurements, as well as selected long-term vegetation surveys. EKZNW currently has automatic weather stations in Sileza Nature Reserve and Tembe Elephant Park. SAWS has a weather station at Mbazwana (−27.5000; 32.6000, 55 m amsl) that falls in the boundary area between Lake Sibaya and uMbgobezeleni as well as one at Manguzi (−26.9830; 32.7329, 69 m amsl). SAEON has a full weather station on the northern side of the main Lake Sibaya basin and on the southern extreme of the south basin. A high-end meteorological station on the western arm, associated with the proposed flux site in the Mabasa TA sustainable use zone (LS-CS1; Figure 18), would be ideal. Additional rainfall stations envisaged by EFTEON could be placed in east west transects in the southern uMbgobezeleni and northern Kosi Ground water catchments to augmented current stations for an optimised meteorological design.

Current research activities relevant to EFTEON include the SAEON-Grasslands work on understanding the relative impacts of LULCC and climate change on the ecosystem services provided by the landscape, which is well aligned to EFTEON objectives with a willingness to collaborate. Studies on hydrodynamics, land use change and plant water use are being undertaken by SAEON in collaboration with UKZN and ***UNIZULU***. UKZN is conducting research on the hydrological and water quality components of Lake Sibaya; UCT-Oceanography Department and SAEON-Egagasini are working on climate systems; the ARC have initiated work to investigate peatland rehabilitation techniques in the area, with logistical support from SAEON; the CSIR is currently testing the capabilities of the European Space Agency Sentinel satellite sensors for potential monitoring of wetland ecosystems at the scale of the MCP and RU is assessing the value of sacred forests in biodiversity conservation. Planned research includes work on the links between climate hydrology and resource economics (collaboration between SAEON, UCT, UKZN and ASSET), and on the water use of different crops with potential to improve livelihood in the landscape (SAEON, UKZN, RU and ***UNIZULU***). Regarding the potential for quantifying gas fluxes from the wetlands in the area, international standards have been developed for reporting on greenhouse gas emissions for wetland ecosystems. International collaborators who have experience implementing these methods would like to initiate this within the Maputaland EFTEON Landscape. The KZN Department of Agriculture and Rural development have done soil and vegetation surveys within the Catchment W70A (Figure 30) including a detailed study within the uMbgobezeleni, which provides good soils information in relation to agricultural potential (see Atkinson and Barichievy, 2014).

Historic and recent studies provide sound conceptual understanding, with associated hydrological models, for the linked terrestrial and aquatic environment (Pitman & Hutchinson 1975, Bruton 1980; Bate et al., 2016, DWS 2015; Weits & Demlie, 2014, PID 2020, Kelbe, 2020). These in conjunction with offered input from sector partners (JG Afrika & PID), who have in depth knowledge of the aquifer dynamics through experience gained in assessing schemes in the area, can be used to guide what the optimal design framework for EFTEON should be to achieve its particular scientific objectives. PID have agreed to share the relevant information and data they have with the EFTEON program through SAEON should this landscape be successful. There are also a number of WRC reports and commissioned reports available for the area as well as relevant datasets on which to build the Maputaland EFTEON Landscape. Furthermore, the "Resource Quality Objectives" designed for the area by DWS (DWSb, 2017) provides a policy-relevant basis against which change in the system can be observed and assessed. DWS strongly supports the nomination of this particular landscape (co-authorship and survey responses), where EFTEON will bring focused to identified research needs within the catchment for mutual benefit while retaining the integrity of respective mandates.

The opportunity exists to contrast observations within this coastal tropical/subtropical landscape to a high-altitude temperate system, the Cathedral Peak (CP) SAEON platform, where comparative measurements are already being undertaken between the two sites (the CP SAEON platform falls within the proposed Northern Drakensberg EFTEON Landscape).

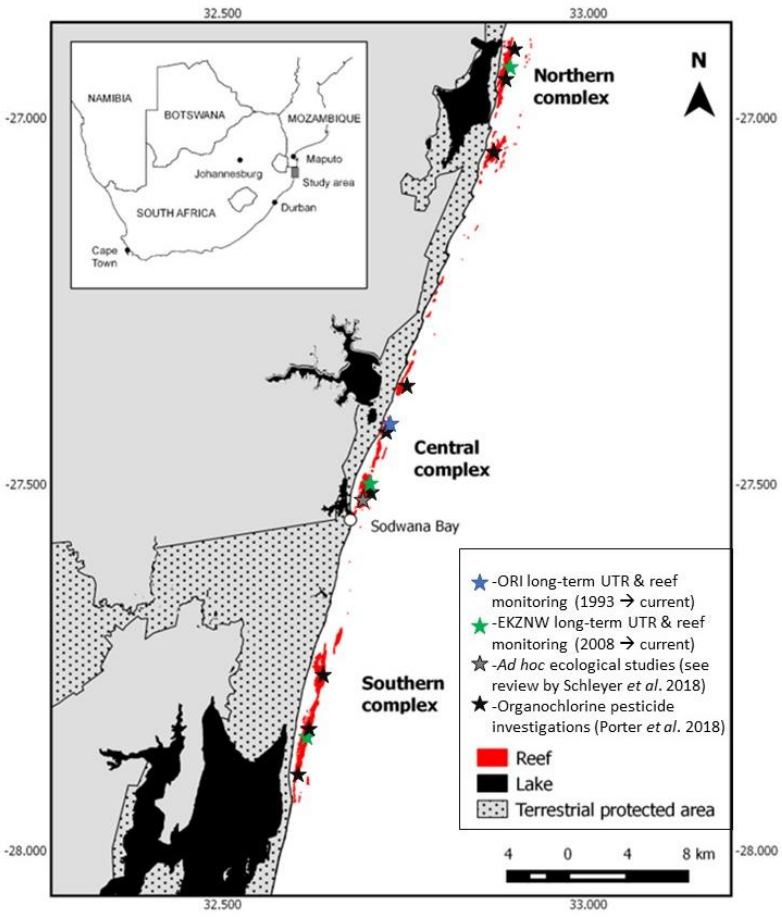

Figure 20: Overview of various long-term coral monitoring and underwater temperature recorder locations (UTR) as well as ad hoc reef ecology studies and organochlorine pesticide investigations.

4.4 Access and facilities are available for staff and guest researchers

Access to catchment W70A is easily accessible by road (6.5 hrs from JHB; 3.5 hrs from Durban). As highlighted in our stakeholder survey ***the location is ideal as a field site for universities in Gauteng and Kwazulu-Natal***. Richards Bay is the closest major airport, but there are also airstrips in Manzengwenya, Mbazwana and Manguzi which service the tourism destination status of the area. A new airstrip is currently being completed at Mkuzi for cargo and tourism (pers. comm. Russel Tembe). The area also offers direct access to Mozambique, with a border approximately 18 km northeast of Manguzi town. There is a road network providing access to the three lake catchment areas proposed within this landscape. The landscape is also close enough to the Kruger National Park (only 370 km away from the Malelane Gate and 434 km away from Skukuza Camp (via eSwatini), and therefore provides an additional opportunity for international scientists visiting Kruger to visit a highly attractive and academically interesting contrasting landscape.

It is envisaged that EFTEON staff will be located **within** the proposed Maputaland (W70A) EFTEON landscape, which is supported by the towns of Manguzi, Mabazwana, Mseleni and Sodwana Bay where groceries and hardware supplies are readily available. From Mseleni as the central point to Mbazwana/Sodwana is 16 km, and to Manguzi is 60 km. Jozini town, which now boasts a new mall offering all major banking groups, clothing stores, furniture shops and grocery stores, is only 60 km away from Mbazwana. Hluhluwe town is 82 km away and Mkuzi is 72 km away. There is internet connectivity within all the site location towns and most surrounding areas. A few of the more remote areas have limited connectivity. Fibre is being installed within the area. Office space, if required, can be rented in Manguzi or Mbazwana at affordable rates. The Mabasa TA has also undertaken to assist with sourcing suitable facilities for office (as a house) and accommodation for permanent EFTEON staff if required within Mseleni.

Accessibility to all the proposed research areas from these centers is available via tar and jeep tracks and all fall within 100 km of each other. For example, the entire SAEON instrument array, which extends from the uMgobezeleni catchment (Sodwana Bay) in the south to Sihadhla stream in the north (which feeds Kosi Bay), can be serviced within two and a half days (including all downloads and routine maintenance). This is made easier by the fact that there is a circular road around Lake Sibaya that makes for efficient routing to service a distributed network.

There are various options available for EFTEON staff accommodation in each of the above-mentioned towns as well as the areas around them, including affordable rentals and long land lease agreements. By way of example, within Sodwana there is an opportunity for a cluster of three independent houses available for rental (~R3500-R4700 per month per house, boat storage could be built on this premise). There are two hospitals servicing the area in Mseleni and Manguzi, with additional facilities available at Richards Bay. The tourism industry provides opportunities for employment as do the hospitals. A number of primary schools are available within the area and in Hluhluwe town (90 km away), and very good high schools (e.g Grantleigh) are available in Richards Bay with weekend transport to and from the area. The area offers significant attractions to family members, as prime diving (Sodwana Bay, M'bibi, Kosi Bay) and tourism destinations surrounded by reserves such as Phinda Game Reserve, Tembe Elephant Park, Hluhluwe-iMfolozi Park and iSimangaliso all within reach of less than 100 km.

There is a wide range of accommodation options available for catering for students and large groups to international visiting scientists. Accommodation is currently readily available around Sodwana Bay, Manguzi-Kosi Bay and M'bibi and surrounding areas ranging from very affordable backpackers to luxury beach lodges. Camping facilities are available at uMgobezeleni (EKZNW) and Kosi Bay. There is currently a simple laboratory at Triton Dive charters (Peter Timm science lab). ***Research facilities run by EKZNW are available at Manzengwenya and Tembe Elephant Park***. A ***conference facility*** is available in the north on Lake Shengeza (Hippo Lodge) and co-owner, Russel Tembe, has personally confirmed this could be utilised for research related conferences. It is suitable for up to 60 delegates.

There are plans to develop a fully-fledged research facility, with wet and clean labs, workshop space, group facilities and communal areas within the Mabasa TA that EFTEON could consider partnering in developing. This would provide central access to all three areas and the proposed core area in the Lake Sibaya catchment, while also facilitating advantages for the local community who would run the facility at affordable rates slightly above a cost recovery basis. The proliferation of high-end integrated studies that took place in the 1960s and

1970s due to the presence of the Rhodes Fresh Water Unit Research station provides proof of concept of the value of a field research station in this location. Reinstating research facilities on site is strongly supported by the stakeholder group, epitomised in a letter of support from a prior resident researcher, Prof Rob Hart. Such facilities (e.g. Hluhluwe Research Centre) in "remote" locations are known for producing leading science and scientists through enabling the gathering of minds across disciplines in an immersive creative space away from daily distractions. Such a facility will also help to ensure closer connections with the land custodians and communities within the area. Investment models in which EFTEON could partner are currently being explored by SAEON and the Lake Sibaya Conservation and Development Trust (LSCDT) and are supported by iSimangaliso.

4.5 Strong links to research and educational partner institutions

Academic

The number of universities and academic institutions involved in this proposal reflects the potential use of the site as a training ground for the academic pipeline. In particular, UNIZULU has expressed a strong desire for long-term involvement with the Maputaland EFTEON Landscape, given the universities extensive experience in the MCP in the thematic areas aligned to the EFTEON program, as well as the potential this landscape holds for capacity development of their students. Proof of concept on how a program like EFTEON can facilitate capacity development is evident in the SAEON program. By enabling a long-term relationship within the area, SAEON has managed to facilitate a number of student projects already from Honours to PhD level and provide logistical assistance to students affiliated with the ARC as well. The Center for Water Resources Research (CWRR), UKZN, currently has 1 PhD student, 1 MSc student and 2 Honours students who are undertaking their studies on the system. This ***demonstrates the feasibility of the landscape as a living laboratory***. The EFTEON program has the potential to unblock key research infrastructure constraints in this landscape that will have a catalytic effect on science and capacity development opportunities, leading to significantly greater transformative impact compared to others that have well established facilities.

A number of collaborators have confirmed their intention to utilise this landscape for postgraduate training, highlighting the value EFTEON could play in enabling capacity development and the significant interest in using this landscape for such purposes. This includes the value and intent to use the landscape for data sharing, field schools, post graduate students, action-based research with communities, and running workshops for students in the field. "*What makes it attractive is that there is still a lot we don't know about how the ecology functions in this World Heritage Site*."

The location is also ideally located to connect to other research facilities enabling cross exchange and capacity training opportunities across systems. The Hluhluwe Research Center in Hluhluwe-iMfolozi Park is less than 100 km away, and there are research facilities in Tembe Elephant Park, Mkhuze Game Reserve and Ithala Game Reserve. Within eSwatini there is also the Mbuluzi Savanna Research Centre which would be a convenient stop over to the Kruger National Park, which has an active research station and has links to the Organization for Tropical Studies (OTS) and Nsasani Trust. Both OTS and Nsasani Trust have confirmed their strong support for and interest in running human capital development programmes in the proposed Maputaland EFTEON Landscape, noting it is a unique region to work within, providing ideal contrast to the savanna systems of the Kruger National Park. Additionally, OTS and Nsasani Trust would contribute to collecting long-term data as part of their education efforts, thereby adding to EFTEON Observations. Importantly, SMCRI has provided a letter of

support for this program and have committed some research equipment, through SAEON-Grasslands, to facilitate the cross exchange between the aquatic and marine environments. Collectively, these networks will enable cross exchange between research and capacity building activities across these landscapes offering unrivaled training opportunities.

Citizen science groups, leaners and local government engagement

There are several known initiatives focusing on local learner science development, citizen science programs and community development NGOs, which endorse and strongly support this EFTEON landscape, who have indicated they are willing and keen to be involved in the program. The Christoph Meyer Maths and Science Centre supports the program and offers links into their science centre which is focused on improving maths and science outcomes in the region. This network can be used to engage learners in local science projects and citizen science programs.

The Lake Sibaya Conservation and Development Trust was established by Inkosi K.T.H Nxumalo of Mabasa Traditional Council. The Founder established the Trust in order to ensure the conservation and environmental restoration of wetlands, nature within the area of Mabasa Community, and to the Lake in particular. The key objectives of the Trust are to create awareness and promotion of:

- Conservation of Ecosystems (Natural Habitat, Water Quantity and Quality)
- Saving our planet by protecting nature and community education about biodiversity
- Development of Ecotourism Opportunities
- Poverty Eradication through Creation of Employment Opportunities

LSCDT strongly support the Maputaland EFTEON Landscape and provide an exciting conduit for knowledge sharing and local impact. They would like to explore a number of opportunities with EFTEON, including the joint development of research facilities within the area (western arm of Lake Sibaya). SAEON already has strong links with this organisation and is willing to facilitate discussion with EFTEON.

SAEON has initiated a pilot community citizen science program through the LSCDT, drawing from tools and training from Groundtruth. These activities are aimed at ***democratising science and improving water stewardship***. SAEON has had requests from local residents to expand this program into other areas. Working together with EFTEON, these programs can be fully developed and will help to ensure communities are involved with the science programs and are included in the knowledge generation process. In addition, SAEON is already working with several schools in the area where weather stations and citizen science tools have been provided and are being used for improving maths and science literacy. The is high interest from other schools in also doing this.

An existing network of community health workers, who work closely with all the communities in the region, presents a opportunity to link into to facilitate social ecological surveys. In partnering with them, clear links can be drawn with human health, economic well-being and the environment health with respect to water security and environmental contamination and nutrition. We recommend that surveys capture information on contemporary patterns of land use, yields, crop types, herbicide-pesticide management, markets, water access ans use and consumer data in addition to planned EFTEON standards. Survey interactions should be accompanied with awareness on climate change, which is not well understood in the region (pers. comm. Mabasa Nduna's). Ecological infrastructure mapping (by communities) that captures perceptions on where assets were in the landscape historically, now, and moving forward would be powerful. Building a narrative of

change, that is locally owned and developed, with scientists as willing "learners", should be considered as a transformative learning process where co-learning is developed as an integral part of the research program, reflecting a truly social- ecological systems approach.

The UKDM strongly supports the Maputaland EFTEON Landscape and is happy to facilitate knowledge exchange within the municipal structures related to the program.

All these networks can facilitate knowledge exchange and the action-based research envisaged by collaborators, while also acting as a conduit for EFTEON to make meaningful contributions to capacity development at various entry points into the communities in the region as well as through government structures.

4.6 Potential security considerations for the site

There are well-designed, vandal-proof security systems available (Figure 21) to secure instrument deployments requiring solar systems and battery power. Locking cap solutions also exist for borehole related instrument deployments for both pipe and "flat" infrastructures. These in conjunction with community engagement processes can mitigate security threats. SAEON has demonstrated that by deploying instrument sets with land custodian consent and with the appropriate locking and security systems, continuous measurements are feasible. Importantly, land custodians from the Traditional Authority to the Ndunas and their Amaphoyisa (messengers) must be informed of activities, and where possible, these engagements should be used as knowledge exchange opportunities. If this landscape is selected, SAEON undertakes to facilitate the appropriate connections to these networks, and to provide guidance on appropriate security measures required.

A number of locations are available for the secure deployment of equipment. For example, Sileza Nature Reserve and Tembe Elephant Park have existing boreholes within the protected areas that can be instrumented by EFTEON and would provide reference points on groundwater level in the boundary zone between the Lake Sibaya and Kosi Bay catchments and the inland Muzi groundwater catchment. The Mabasa TA has one office (S-27,475578; E32,493698) close to the proposed Lake Sibaya Core site (LS_CS1) that provides an ideal location for the secure deployment of equipment. SAEON already has a rain gauge on the premises and it is ideal for ***atmospheric deposition and other meteorological equipment.*** They have a second office further inland (S-27,362908; E32,536042) on a more arid site which is secure. In addition to these, there multiple safe and accessible locations within each of the three ground water catchment areas proposed both in and outside of protected areas. These include field ranger camps within iSimangaliso, schools, the Tembe and Mbila tribal courts, the Coastal Cashews farm (Figure 31 and Figure 32), TMM Forestry fenced trials, Manguzi hospital, Mseleni hospital to mention a few, where equipment can be safely and optimally positioned to meet the needs of the EFTEON design.

Fire protection of equipment must be considered. SAEON has significant experience and operating procedures in this regard. With respect to deployments within Lake Sibaya, due to the depth and size of the system, illegal activity is confined to the near shore. SAEON has two thermistor strings in the main lake (12m and 34m) which have been in place for over a year without incident. While much of the meteorological equipment can be placed in secure locations, some borehole monitoring systems may require deployment in existing infrastructure in more remote areas and will require secure locking caps. iSimangaliso has indicated the

presence of a high tower at Manzengwenya field station, on top of the dune cordon, that could conceivably be used for novel meteorological and measurements, at different heights, to understand wind flow patterns between the terrestrial and marine system. This is of high value to climate and oceanography modelers. The tower could also be used for atmospheric measurements. This site also provides a very secure location on the eastern edge of the proposed landscape. Likewise, there is an evidently unused tall tower on the Coastal Cashews farm, near the residential home, which is secure and can be utilised for stratified atmospheric instrument measurement.

Figure 21: Example of vandal-proof solar and battery security system for an Eddy Covariance deployment currently over Macadamia trials in the Maputaland landscape.

5 STAKEHOLDER ANALYSIS

From inception, the aim in developing the Maputaland EFTEON Landscape proposal was to be as inclusive as possible. Various engagement processes identified relevant stakeholders and solicited input to ensure that what is proposed meets EFTEON criteria while optimally serving the aspirations of the research community, land custodians and the communities in which these activities will take place. 57 people have actively contributed to developing the proposal. A total of 46 "organisations" are represented on the collaborator list, including land custodians, local NGOs, science centres, a broad range of academic institutions, government departments, conservation agencies and sector partners. Support is demonstrated in responses to the survey sent out, contributions to this proposal, though survey inputs received, stakeholder engagement meeting outcomes and letters of support (21 received).

5.1 Strong support from stakeholders, land custodians, local authorities and communities

The Umkhanyakude District Municipality (UKDM) is the primary government authority in charge of this region. The Municipal manager has provided a very strong letter of support, indicating the value that the program will bring to this region in particular and ***requests to be involved*** if this landscape is successful. Land custodians within the proposed landscape include Conservation authorities (iSimangaliso and EKZNW); Ingonyama Trust Board (ITB) land managed by Traditional Authorities (TAs) within the area and large-scale local forestry industry operating over a significant extent of the ITB land (TMM forestry). Through engagement, it became clear that

the planned EFTEON scientific objectives closely match critical knowledge needs as identified by land custodians relating particularly to water, climate resilience and projected social economic development trajectories in a vulnerable cross border coastal region. As such, land custodians have expressed strong support for the proposed W70A catchment as the Maputaland EFTEON Landscape.

Local residents (community members) from Mabasa TA through the Lake Sibaya Conservation and Development Trust (LSCDT) have been engaged. During a field visit (23th August 2020), an ideal site for micrometeorological instrumentation/measurements/observations was identified by them with SAEON in a Lala Palm grassland south of the western arm of Lake Sibaya. The LSCDT, representing the Mabasa community, firmly supports this proposal and will help with community engagement.

The Mabasa TA has been involved in the development of this proposal from inception. Importantly, Inkosi Nxumalo, the King within the Mabasa TA, attended the EFTEON stakeholder engagement meeting (16th of July) and is ***a co-author of this proposal***. A site meeting was held on 25th August 2020 with Inkosi Nxumalo to discuss the final proposal content. He confirmed the Mabasa Traditional Council's support for this proposal, and expressed his strong desire ***to host the core site within the Mabasa TA*** area in the grassland area south of the western arm of the lake (See Figure 9). He has provided assurance for stable land tenure, long-term accessibility and deployment of instruments within this area. This is in line with their zonation plan (Figure 9; "Proposed protected area" and "Sustainable land use zone") as an important biodiversity and cattle grazing area for the TA. The expressed desire is that if successful, the EFTEON program shares knowledge that will help the TA in understanding the system and how it is changing, so that they can keep informed and try by all means to halt degradation and build a more resilient economy with the area.

Relevant representatives from EKZNW have assisted with the development of this proposal. EKZNW, District Ecologist uMkhanyakude has expressed full support for the Maputaland EFTEON Landscape and outlined several long-term datasets available for relevant reserves (Tembe & Sileza) that would be of value to the EFTEON program and noted that "*The envisaged research infrastructure and survey observations EFTEON plans to conduct will be a major enabler to a number of interested research groups operating within this landscape*". The ***availability of Tembe's Research facility to provide logistical support for research projects and data collection in the area was emphasised***. In addition, this proposal enjoys the firm support of EKZNW at the highest level, with an undertaking to ***provide relevant data and favorable reviews of permit applications***.

Engagement with the iSimangaliso Wetland Park Authority was from the initial nomination of this landscape. They attended the EFTEON Maputaland stakeholder (16th July 2020) and were directly engaged by SAEON (3rd of September 2020) to explain the program in more detail and address any questions and concerns. Approval in principle was given, with a request to work closely with the program, if the landscape is selected, to see how best to align the EFTEON design with Park knowledge needs. iSimangaliso supports the Maputaland landscape and has established protocols for facilitating research within the park. The letter emphasised support for the proposed Maputaland EFTEON Landscape based on the particular challenges to catchment W70A and its potential to stimulate a "science hub" and capacity development within the region. Furthermore, iSimangaliso reiterated that are committed to a science-based approach to enable the effective management of their biological assets, thus demonstrating a commitment to facilitating science based activities within the area.

TMM Forestry is a major land custodian within the landscape and has a track record of enabling research activities. Involved from the onset of the nomination TMM have support the proposal. The Chair of TMM

Forestry, Mr Russel Tembe, confirmed full support at a meeting. As a member of the regional development committee and he has offered to help to facilitate exchange between regional development initiatives and the EFTEON program. TMM's support for EFTEON activities in their area of operation ensures ***access to modified landscapes for the deployment of equipment and research activities as well as the potential to engage regarding experiment trials and alternative commercial forestry crops***.

Local residence from Coastal Cashews farm (Figure 31) have been engaged regarding this project and are very supportive. They have allowed SAEON to undertake long-term observations on the farm and have indicated they will support the EFTEON activities as well (pers. comm. Fanie Vermaak).

5.2 Strong and broad support from academic institutions

Academic support is from a broad section of the scientific community. Twelve people were involved in compiling this proposal including the Mabasa Traditional Authority, DWS, CSIR, ORI, SAEON, SANBI, SMCRI, UCT, WITS, UKZN, GroundTruth and ***UNIZULU***. A further 45 individuals provided substantive input in support of the proposal. Notably ***eight universities***, including the ***University of Zululand,*** are represented. Collaborator expertise represents multiple disciplines spanning the ***full range of themes within EFTEON*** and many have indicated their research interest in anticipated changes in this landscape. In addition to support secured through the survey, letters of support highlight how EFTEON will bolster current ***cross disciplinary research*** in the area (ASSET), the value the research infrastructure for this region in particular (PID) and the intention the platform for ***research and training*** (University of Johannesburg (UJ), CWRR-UKZN; UNIZULU. Support from the KZN Museum, emphasises the ***cultural importance*** of the area. Compelling support from Prof Rob Hart, who lived and worked from the Rhodes Freshwater Research Institute field station at Lake Sibaya, highlights the ***value of the integrated approach*** outlined in the proposal and the ***value of the site as a field based research facility***. Likewise, Dr Ricky Taylor, whose work provides some of the foundation for EFTEON to build on, emphasises the ***coherence*** of proposed landscape. ***International support*** for the platform from Prof Chris Evans, indicates an intention to contribute to the activities through implementing greenhouse gas measurements within the wetlands systems in collaboration with UJ. Representatives from DEFF support this landscape, highlighting their long-term research involvement and willingness to be involved with EFTEON program. SANBI also strongly supports this landscape, wishes to collaborate on data sharing and is willing to be part of the landscape committee. The collaborator groups welcome the opportunity to provide expert input into the final design concept for the area.

The majority of respondents to the survey conducted indicated measurements EFTEON intends to undertake would be valuable baseline information to enhance their research objectives. A total of 76% of respondents indicated the initiative was likely to enable them to leverage extra funding for their research.

Given the overlap between SAEON Grasslands node long-term research observations in the region and the EFTEON core themes, the SAEON Grasslands node offers to co-host the EFTEON instrument array where observations can be aligned for optimising a cost-effective design. Logistical support for the platform is already operational and this can be drawn on, in particular where SAEON can enable collaborator use of the platform, as node resources permit. Cost efficiencies can be realised for both parties and benefits shared in terms of skills sharing, particularly in light of SAEON Grasslands node's extensive experience in micrometeorological observations.

In summary, local residents, schools, community leaders, industry sectors, government departments and academics all see value in and support this landscape as an optimal location for observing Global Change processes. The location and characteristics of Catchment W70A lend the landscape to an integrated systems approach, with EFTEON as part of the social ecological system, thereby contributing to transformative science approaches within a vulnerable and scientifically fascinating region. The tension between economic livelihoods, ecological function and climate change is a “typical” and relevant development context in South Africa. The proposed landscape’s unique characteristics, however mean that these dynamics can feasibility be observed within in a coherent and closely coupled terrestrial-aquatic system with the added advantage of strong links to the marine environment.

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APPENDIX A: LIST OF COLLABORATORS

Table 2: Stakeholder list supporting the landscape

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APPENDIX B: SCORING CRITERIA, RELEVANT LINKS AND SUPPLEMENTARY INFORMATION

The information below is supplementary material in relation to *scoring criteria*. Where possible, links to relevant sections in the document are provided as well as additional information (e.g. survey results) as further "evidence" of statements made within the proposal.

Stage 1

Does the proposed core site offer long- term (>20 years) accessibility?

YES, with strong support from land custodians. Letter of support and offer to host the core site from Mabasa Traditional Authority, with assurance of security of tenure.

Would access to the site be available for external researchers, and for deployment of additional long and short term research infrastructure (with agreement based on submitted research proposals)?

YES, with strong support from lands custodians

- Current and past research activities demonstrate proof of concept for research activity in the landscape
- Letter of support from the District Municipality (UKDM) (support and enabling environment within municipal structures)
- Letter of support from EKZNW (provides access to "near-natural" landuse)
- Letter of support from iSimangaliso (provides access to "near-natural" landuse)
- Letter of support from TMM (provide access to experimental options and alternative land uses)
- Letter of support from Mabasa TA (access to proposed core site)

Table 2: Research needs identified by land custodians

Organisation	How they would use/ like to benefit from EFTEON	Specific requirements/ opportunities
iSimangaliso	Require scientific information for guiding conservation management Build science hub capacity in the region that can inform conservation management Ensure iSimangaliso can help guide research question of priority for the park and be kept informed of research outcomes	uMgobezeleni, - Impact of swamp destruction - Opportunities for restoration - Alternative socio-economic opportunities Lake Sibaya - Understanding of hydrological dynamics - Drivers of change - Impact on the lake from catchment area outside of the lake Kosi system - Understand external influence on the system and its potential to change the stable gradient of conditions from mouth to Lake Amanzimnyama - Resource use General: - Improved climate data for the region
TMM	Land use impacts water resources	How alternative land use and productions systems impact on the water resources Consequences of changed from *Eucalyptus* to other species on the water table Alternative crops.

EKZNW	There needs to be a strong link between management of the biophysical features of the reserves and research and monitoring conducted both inside and outside the reserve. Opportunities exist for EFTEON programs to be structured to observe and assess if current management initiatives are effective in ensuring that the reserve objectives are being Met. In this regard EFTEON program would help to bolster limited capacity with EKZNW towards understanding the impact of management on ecosystem function in relation to desired outcomes Key Elements of concern for the protected areas and special features of biodiversity inside and outside of the protected areas, given the close link between biodiversity and the hydrological system, includes resource use and includes water usage inside and outside the reserve but it also includes the protection of riparian vegetation and wetlands. The research and monitoring should focus on resilience defined by Brian Walker as "the capacity of a system to absorb disturbance and reorganize so as to retain essentially the same function, structure, and feedbacks to be able to cope with shocks and keep functioning in much the same kind of way".	- Long-term resource use datasets from Kosi: need to be continued, opportunity for EFTEON to pick up on this - Long-term resource use and climatic datasets available for Tembe Elephant Park, and these need to be continued (automatic weather station in place, as well as boreholes), DWS monitoring borehole on the western boundary - Long-term climatic data available for Sileza Nature Reserve, needs to be continued, DWS monitoring borehole in the protected area Sileza & Tembe - Understanding of hydrological dynamics - Drivers of change – impacts of other groundwater users on quantity and quality - Resource use (Tembe) – and socio-economic alternatives to this - Impact of fires in peatlands - Restoration of peatlands
Mabasa Tribal Council	Seeking knowledge to protect their natural resources system and guide sustainable development Build capacity in the area (science engagement) Share knowledge Host the core site micro met site Want to develop a research centre to facilitate EFTEON operations if resources can be secured	Climate change impacts in the area Land degradation and what is driving this Impact of bush encroachment on the water table and grazing lands Socio-economic alternatives to practices that are causing land degradation Climatic data is useful What species are present in the area and what is their status
DWS	Enhanced climatic and hydrological data for the region	Global indicators from a water perspective: Change in water quantity in aquifers and lakes. Setting of threshold limits for groundwater and lake levels. Measurement of effectiveness of international agreements (shared transboundary aquifer). Water quality: Setting of threshold limits for EC, ph, and sulphate. Biodiversity limits.
UKDM	Scientific information and science capacity Can facilitate knowledge sharing through municipal structures	Extreme events Improved climatic and hydrological data Enhance citizen science (community science) programs.

(Back)

Stage 2

Site location in the face of change

Does the proposed landscape provide the opportunity to observe global change processes in a landscape of particular significance?

The proposed Maputaland EFTEON Landscape is in an area already experiencing significant global changes impacts with a number of anticipated changes. It is of national and international significance and classified nationally as Strategic Water Source Area. The location is of international conservation significance including several RAMSAR sites and a World Heritage site, falls within a significant biodiversity hotspot and represents a unique and fragile coastal landscape in the IOCBB of South Africa. The density and diversity of wetlands within this landscape is significant and includes carbon rich peatlands and swamp forest. The close coupling between the terrestrial and aquatic environment, with connections to the marine system, make it an ideal location for understanding the relative impacts of different global change drivers on strongly linked ecological, biogeochemical and social-ecological processes. Paleo data from several sources, provides a useful context for interpreting change and anticipating the impacts of these changes.

Supplementary information

Of the 2500 plant species, at least 225 species or infraspecific taxa are endemic or near-endemic (Van Wyk & Smith, 2001). More than 472 bird species (almost 60% of South Africa's total bird population) are found in the Maputaland Centre, of which 4 species and 43 subspecies are endemic or near-endemic. (Van Wyk, 1996). Species richness in mammals is also high, with 14 endemic or near-endemic species and infraspecific taxa (Van Wyk, 1996). Amphibians and reptiles are also diverse and support some endemic species (Van Wyk, 1996). There are 67 freshwater fish species, of which 8 species are endemic or near-endemic. The Holocene evolution of the lakes and estuaries within the area provides an explanation of some of the species patterns observed (Whitfield et al., 2017).

Survey responses to the following question: EFTEON Objectives: What components of this landscape are useful for understanding global change processes of **national and international relevance**? What are the **significant features** (e.g. biodiversity, water provision, biogeochemical cycles, transition zones) and opportunities that this landscape offers to observe global change processes and address critical knowledge gaps?

- Strategic water source area
- Swamps that currently accumulate peat, or have done so in the past. These could indicate changes in groundwater hydrology.
- Nutrient levels, and related microalgal levels, in the freshwater lakes. These will indicate pollution.
- Grasslands which may be encroached with woody plants. These may be indicators of overgrazing, altered fire regime, altered groundwater levels, altered CO_2 levels etc."
- Global indicators from a water perspective: Change in water quantity in aquifers and lakes. Setting of threshold limits for groundwater and lake levels. Measurement of effectiveness of international agreements (shared transboundary aquifer). Water quality: Setting of threshold limits for EC, ph, and sulphate. Biodiversity limits.
- Active interaction between global climate change and local scale forcing in driving local water availability in a hydrologically simple system (groundwater dominated)
- 1. Impacts of future climate change and Indian Ocean dynamics on summer rainfall over eastern SA and impacts on freshwater resources and biodiversity. 2. Connectivity between terrestrial and marine ecosystems (nutrient flows, pollutants) and impacts on productivity and ecological processes
- This landscape is linked to the adjacent coastal environment. It would therefore be an important location for assessing changes in biogeochemical cycles across different realms and transition zones eg. terrestrial, wetland, reef and submarine canyon with national and international relevance.
- It is imperative that anthropogenic impacts north of the border as far as Maputo Bay be considered and compared with those south of the border, bearing in mind that much of the demarcated area falls within a World Heritage Site. The area is a tropical/subtropical abstraction zone where biodiversity is being lost and the hydrodynamics are being hugely changed.

- Climate change: The area makes an exceptionally good case study to understand climate change in coastal areas.
- Water and water resources (e.g. peatlands) in a time of water scarcity
- Communities: understanding access to, use of, management of, perspectives of and relationship with the natural environment"
- The synergistic influence of rapid rural and suburban sprawl and impact of global climate change on critical ecosystem resources (e.g. water, limited cropping area and grazing land) make this system and it's rich biodiversity particularly vulnerable to drastic change.
- groundwater and water supply
- Different land use types.
- 1. Mapping the extent of wetland types (alike to SDG target sub-indicator 6.6.1a; 2. Defining their hydrological regimes; and 3. Monitoring changes in these. This would facilitate the ability to see how climate and global change impacts the wetland types.
- Groundwater dependence of ecological, social, and economic activities.
- The uniqueness of the system by being groundwater-dependent, dominated by wetlands and freshwater lakes. With human livelihood (i.e. domestic water consumption, subsistence farming, timber, etc) mainly dependent on these water sources, the system is particularly vulnerable to drought- and land-use-induced water scarcity. Furthermore, water shortages have direct impacts on other ecosystem features such as biodiversity and biogeochemical cycles. In addition, continued water shortages will likely result in conflict within the area. This brings about the need to address issues related to land use and land management in the face of increasingly extreme and unpredictable effects of climate change, particularly from a water resources management perspective.
- biodiversity, land use-lake-coastal ocean surface contrasts and gradients between them
- Sequence of dune mobilisation phases linked to long-term global environmental change and sea-level fluctuations that influenced groundwater table level and vegetation cover. The contrast between deeply pre-weathered dune sediment and pulses of marine linked coastal sedimentation result in significant differences in silt and clay content of surficial sediments/soils, soil fertility and associated trace elements across the area.
- There is a need to understand the current status of the coastal wetland catchments relative to similar "interglacial" periods over the past 400,000 years and the climatic, groundwater and vegetation threshold conditions that resulted in regional remobilisation of aeolian cover sands. "
- The local water cycle is most important, and the close dependencies of humans with the natural environment supported by water. Being groundwater dependent, the water cycle (supported ecosystems and the services they provide) are sensitive to increasing anthropogenic pressure and climate change. Biogeochemical cycles are different to those in flowing systems. There are unique biological assemblages associated with the peneplain aquatic habitats, with varying connectivity, through estuarine lakes and estuaries, to nearshore marine habitats.
- Water Services - water supply/resilience/balance/accounting; water quality; recreational benefits, biodiversity. Land based-activities near water systems. Ecological Infrastructures e.g. mapping of wetlands /peat-lands, strategic water source areas etc.
- While not a 'landscape' per se, Lake Sibaya itself is the most critical component for study - based on its functional role as integrator of socio-ecological impacts.
- The Maputaland Coastal Plain extends into Mozambique. Comparing the two countries (e.g. different governance structures and land use activities) are the impact on the natural resources the same?
- This section of the peneplain supports a diversity of aquatic ecosystems; a relict estuary (Sibaya) that is now a coastal lake which still supports relict estuarine fauna (some endemic), a linked-lake estuarine system (Kosi), a small estuarine lake (uMgobezeleni), smaller freshwater lakes (Lakes Bhangazi N & S), various wetlands and lentic systems that are are rare and unique on a national scale and are interconnected and co-influenced by an almost complete dependency on groundwater. To date not a single study has considered these ecosystems as a whole, and indeed what are the mutual dependencies of the Maputaland socio-ecological system on this water source and the changing ecological benefits and services with an ingression of communities into the area and a changing climate.
- This catchment seems to be specifically significantly affected by climate change (reduction in rainfall and cyclones) and the rainfall fed-groundwater catchment is isolated from neighboring catchments in terms of water supply. This makes this catchment critically important in terms of water management for people residing in the catchment but also to prevent sea water ingress.
- Looking at the flux dynamics of a drying lake, carbon, water and energy, would be very interesting locally; and I think this is not a parochial case, it potentially significant for any region experiencing water body dry down.
- Water provision

- It's quite likely that this (EFTEON landscape) would serve as an example for a significant portion of the south east African coastal plain. Mostly similar vegetation, climate, soils and various land use pressures.

(Back)

Within the landscape is there potential for observing a stable near-natural land use, such as conservation or extensive rangeland agriculture?

Ideal opportunities are available to observe stable near-natural land use, in both conservation and good condition communal rangelands. See Figures 7; 8 and 9; See also section 2.3 and section 4.2

Figure 22: Example of good condition grasslands in Mabasa TA cattle grazing area. (Back)

Survey responses to the following question: Based on your interests, expertise and knowledge of the landscape, as well as the research questions proposed in Section 3, which near-natural land location(s) are best suited as possible core sites and why?

- Satellite site in woody encroached
- Proposed Mabasa game reserve/sustainable use zone next to Lake Sibaya
- Mbazwana - access and security
- Link core sites to monitoring of Resource Quality Objectives and Reserve Requirements
- I would think Lake Sibaya would be a good core site. This site offers numerous strategic advantages in understanding key questions such as links between freshwater and marine ecosystems, impact of climate change on key water resources, utilization of natural resources by communities, human health concerns....
- First choice would be Lake Sibaya, because it lies in the centre of the proposed landscape, its near-natural, its easily accessible from Sodwana Bay, it encompasses both freshwater and terrestrial systems and directly adjacent to it in the marine environment lies Nine-mile Reef where long-term coral and temperature monitoring as been conducted since the early 1990s.
- Lake Sibaya, Kosi estuary
- Area around Sibaya Lake/Manzengwenya - SAEON's core activities and access to roads, towns, hospital and other infrastructure. Community willing to engage
- Manzengwenya grassland; Sileza Nature Reserve; Tshanini Nature Reserve; Tembe Elephant Park (will have issue of elephants and warthog digging up equipment but maybe a lesser theft impact) - somewhere not heavily impacted by herbivores and associated bush encroachment (would be nice to contrast encroached area - note that most of the south of Tembe has been heavily impacted by high herbivore densities (plus low rainfall) associated with a number of factors - a number of tree species and elements of grassland diversity have been extirpated). May be risky though to partner too strongly with Ezemvelo instead of community based authorities - going through the latter would be more sensible.
- Too many to highlight

- Manzengwenya plantation. Changing of land use
- I don't have specific preferences. It would be good to have in-field sites to monitor changes, including both intact, pristine areas, several sites representing various degrees of degradation and areas where rehabilitation will take place. This could inform on the ecological condition of wetlands and terrestrial areas, and the effectiveness of interventions.
- Kosi and Sibaya catchments as they are essential socio-economic resources and they are criticality dependent on the groundwater.
- I have not spent enough time in the area to answer this question with great confidence.
- Somewhere as far as possible from potentially interfering influences such as plantations, other agriculture, settlements or other built infrastructure
- An expanded network of groundwater monitoring boreholes
- Lake Sibaya, Kosi, other sites to be selected
- I can't think of one at this stage
- The main basin of Lake Sibaya, with its associated historical and moderately long-term data
- Will send you my answer.
- Kosi Lakes, Sibaya. Importance as threatened and unique aquatic ecosystems and link to the terrestrial landscape and marine ecosystems
- Unsure
- I cannot comment on this with authority, because I am not familiar with the landscape. I would look at the area between Lake Sibaya and the coastal belt margin in the east.
- "Sibhayi lake, uMgobezeleni due to their wetland farming proximity and the sourcing of water for community supply"
- Conceivably, on the E-W axis from Sodwana to the Lebombos - because a significant value of the project will be through exposure to the public, politicians, researchers etc.. (I think long-term data takes years to accrue value? and Sodwana is close); and you will have located your monitoring stations etc.. on a primary moisture gradient therefore you would be able to use that gradient as primary measure of change...?
- Lake Sibaya area, Due to the recent continuous decline in surface lake levels.

Does the landscape represent a transition between biomes, an altitude, or climate gradient?

Yes. Several of significance that offer a distinct geographic competitive advantage for advancing South Africa's Global Change and Earth System Science programs ***across the terrestrial, aquatic marine and atmospheric systems***. Located at the ***southernmost limit of the eastern African coastal plain***, there are significant opportunities to observe global change processes at the ***southern extreme of the African tropics***. The landscape represents an area where many plant and animal species reach the ***southernmost limit of their distributional ranges*** across the ***terrestrial aquatic and marine environments***. This includes two tropical estuarine systems, not only an artifact of increased resolution, but contributed to by tropical species distribution range extensions (van Niekerk et al., 2020). Incorporated in the landscape are transition areas between Biomes (IOCBB, savanna and Forest) and different vegetation communities within the IOCBB, with the unique opportunity to observe vegetation shifts and plant traits in a ***nutrient poor region***. There is also and ***east-west rainfall and fertility gradient***. As a low-lying coastal system, it is ideal for observing the ***terrestrial-aquatic-marine interface,*** linking to long-term RI and measurements undertaken by EKZNW, ORI and SMCRI. Located within ***the tropical to subtropical climate transition zone***, the region lies to the south of the typical landfall location of tropical ***cyclones*** (but with period cyclonic input) but north of the coastal region that typically gets significant rainfall from onshore flow associated with ridging anticyclones and thus represents an ***interesting climatic transition zone***.

Does the landscape offer the potential for observing environmental function in the face of differing land uses

There are developmentally relevant and conflicting landuses within the proposed landscape where economic reform objectives (forestry) are pitted against ecosystem-based adaptations (tourism) imperatives. Different land management regimes within the landscape (e.g. commercial forestry versus woodlots, subsistence wetland agriculture versus commercial) and the potential for landscape level experiments and key landowner experimentation with different land uses (TMM, Coastal Cashews). The switch of species being utilised in forestry blocks (*Pinus* to *Eucalyptus* and the inclusion of *Macadamia* among other new test crops offers major potential for land use impact comparisons. In addition, the use of wetlands and the impacts on these, with the potential for testing restoration techniques is significant.

The nature of the hydrological system and the distinguishable impacts of the terrestrial land uses on this offers the unique potential for observing environmental function in the face of differing land uses due to the tight coupling between the terrestrial-aquatic-marine system. The relatively simple geology of the system, coupled with **limited influence** from beyond the W70A catchment boundary, makes it an ***ideal model for discerning climatic and LULCC impacts on biological, hydrological and biogeochemical processes***. Important Biome boundaries and vegetation types occur within the landscape for observing vegetation shifts.

Figure 23: Vasi Pan Peatlands (>7000 years old) burning in 2017 (Back) (Photo supplied by S Janse van Rensburg)

(Back)

Figure 24: Swamp forest in previously inundated inaccessible areas being slashed and burnt to clear the way for agriculture (Back) (Photo supplies by S Janse van Rensburg).

Does the landscape provide opportunities for observing and understanding the social-ecological systems within the landscape?

The water resource for environmental and human well-being is a central link that "locks" the social ecological system together. The region reflects one of the poorest areas in the country, facing significant development challenges which could be translated into significant transformational opportunities. There is well documented information on this and the number of anticipated and evident changes were highlighted by collaborators (summarized in Section 3.11) as a basis for a powerful social ecological model for understanding change. Collaborators have highlighted a number of strengths of this landscape as a social ecological system. There is also significant collaborator interest in addressing questions pertaining to the social ecological system.

Responses to survey question: EFTEON will prioritize linked freshwater-terrestrial systems that also provide the opportunity to observe and understand the coupled ecological-social systems, with a focus on ecosystem services and land use decision making processes within this ecological context. Given this prerequisite, what are the **strengths and opportunities** the proposed landscape provides that should be highlighted in the proposal?

- Unique groundwater driven system
- As the geology of the site is relatively simple (aeolian sand deposits on a Cretaceous basement) and as there is little input from beyond the catchment boundary of water or clay/silt the basics of the system are fairly simple. This leads to ecological processes that are fairly easy to understand. Similarly the ecological-social systems are fairly straightforward and not too complex. The above all make this an achievable study.
- The strong linkage of the Maputaland area to ecological-social aspects. It is critical to highlight that without sustenance from the local lakes and groundwater, that the livelihoods of communities are at threat.
- Simplicity' of the hydrology system compared to other catchments; presence of Lake which can serve as 'gigantic rain gauge'
- Clear link in both aspects. 1. strong connectivity between the coastal plain aquifer and the ocean, but little is known about the significance of the flows mediated through this pathway. Important potential impacts on ocean biogeochemistry, coral reef and coastal communities. 2. strong existing connection between people and their dependence on the local environment for natural resources.
- The linkage between the freshwater-terrestrial environs and the adjacent coastal environment should not be neglected. Investigating/monitoring the freshwater-terrestrial environment will have benefits for investigating/monitoring the adjacent marine environments and coral reefs and understanding interactions between the land and sea.
- This should extend to terrestrial-freshwater- estuarine systems
- Humans, biodiversity and ecosystem functioning are highly dependent on and have a synergistic influence on ground water resources in the study area.
- We have an opportunity to better monitor changes in wetland vegetation with the new, freely available Sentinel-1 and -2 sensors, at a higher spatial and temporal resolution. This ability will strengthen more timeous decision making.
- This area covers much of the largest primary aquifer in south Africa, nearly all socio-economic activities are critically dependent on the fresh water, little is known about the groundwater dependence of the terrestrial environment
- Water availability (and quality?) has a direct effect on human livelihood in the area. Beyond domestic consumption and agricultural demand, water resources sustain the local economy through tourism, which is enhanced by the area's unique biodiversity. This interdependence between humans, water and the environment provides an opportunity to unpack the complexities related to this social-ecological system in order to develop strategies to resist, absorb and adapt to the effects of change.
- Unique biodiversity and geography
- The Kosi lakes and Lake Sibaya have similar geological substrates but have developed along contrasting pathways over the past 8,000 years resulting in a closed system with marine remnants in Sibaya whereas the Kosi lakes maintain a tidal influence that influences biota. There is demonstrable freshwater discharge beneath the coastal barrier dune from Sibaya whereas this factor has not been shown from the Kosi system.
- There are very strong dependencies between local people, natural resources (which still provide immediate basic needs of food, water and shelter. These natural resources in turn are highly dependent on a very localized water cycle.

- State of ecological (ecological infrastructures & ecosystem services) and social-technological attributes (i.e. infrastructure, operations, etc.) and water system services. Costs & benefits of changes in aquatic ecosystem services in the catchment.
- The role of L. Sibaya as an integrating 'sink' for various inputs reaching the water body.
- The proposal provides an opportunity to investigate links and feedback loops that may not be apparent for now. For instance, elucidating the long-term benefits of natural goods and services to communities (including food security and mitigation against climate change) may be limited by the opportunities being taken now to conduct multiple small-scale subsistence agriculture.
- The landscape has unique groundwater fed lakes, peatlands, wetlands and estuaries that have important social functions and which need urgent attention.
- Wetland farming
- Unless land use (i.e. commercial) issues are addressed, outside of protected area networks there will be no freshwater-terrestrial systems to monitor. So I suggest you consider the triad i.e. commercial - ecological - social.
- land use needs to underpin the whole idea here - you might be in a position to measure the effects of land use on these 'systems' but that is kind of redundant information unless there are clear commercial proposals on offer to test your models with. Don't forget - commercial land uses are usually strengthened if they correspond with 'social-ecological' processes.

(Back)

Responses to the following Question: EFTEON Objectives: A core objective of EFTEON will be to observe and understand change – what are the evident, planned and anticipated changes in this landscape?

- The main changes will be related to increased human activities - progressing beyond a subsistence livelihood to a money-based livelihood. From small-scale impacts to commercial-level impacts. In the next few decades this impact will be orders of magnitude larger than climate-change impacts.
- Huge climate change factor. Since the area totally relies on groundwater recharge for sustainability. Consideration to the impact of lack of tropical cyclones linkage to groundwater recharge and therefore an incessant threat to biodiversity and water-supply.
- Water availability change- evident; increased water use anticipated
- Effect of climate change drivers (ENSO/more frequent drought, sea-level rise) on the coastal zone and freshwater resources.
- The water in the adjacent marine area is anticipated to warm and increase in acidity. Atmospheric temperatures and CO_2 levels are likely to rise and this may affect cloud cover and solar radiation.
- There have been enormous population changes in the Maputaland area in the last 50 years. What is the anticipated population trend and how will this affect the area? A socio-economic prospect with highly significant environmental significance.
- Climate
- Water resources
- Community (expansion/tensions/land use)
- External pressures (influx of people from Moz, developers, etc)"
- Land use intensity and cover is increasing. Disappearance of pristine natural areas, their biodiversity and the environmental resources and functions these provide. Changes in rainfall and temperature regimes. Changes in primary productivity. Lowering of the water table and drastic reduction of surface water. Degradation of peatlands. Increase in invasive plants and animal species - out-competing endemic species. Woody plant invasion. Increase in slash and burn agriculture and associated invasion by alien species. Wood harvesting decimating sand forest. Local extirpation of medicinal species and plants used for various construction activities. Due to the shortage and decline of available surface water, associated ecosystems and their biodiversity are extremely vulnerable under increasing pressure from humans.
- Limited change
- Crop change. Reduce the planting of *Eucalyptus* trees.
- 1. Evident: 1.1. loss of swamp forests - nearly 50% of a cluster west of Maphelane was lost between 2002 and 2010. Losses need to be quantified elsewhere too, and particularly in W70A. 1.2. Increase in the number of peatlands becoming desiccated and burning on the Maputaland Coastal Plain. 2. Planned - I don't know. 3. Anticipated - increasing droughts and water shortages is certain; the return of tropical cyclones are uncertain.
- Declining groundwater reserves

- It is evident, from the drop in Lake Sibaya water levels, that the area is water-stressed. This is due to the combined effects of low average rainfall over the last decade, growing population and domestic demand and the long-term effects of timber water use. Climate change is a widely-accepted phenomenon, therefore, extreme rainfall (both low and high) patterns are expected to increase, necessitating the need to understand the effects of such changes on water resources, biodiversity and human livelihood.
- land use and rural population change, changes in demand on local resources by various user groups, local response to large scale global climate and environmental change
- Seasonal and longer-term changes on rainfall and the impact on groundwater table and seepage contributions to the stream channels feeding coastal water bodies. The localised influence of aquitards beneath the coastal lakes also represents an important controlling factor influencing freshwater discharge beneath the coastal barrier dune to the marine littoral zone.
- Climate change impacts: Changes to water budgets and how they move through the compartments (groundwater/surface water), drought cycles. Sea level rise (high sensitivity in flat peneplain area. Land use changes, increased agriculture and forestry is particularly important (impacts on groundwater levels). Alien invasive species (aquatic).
- Probably the change in the spatial extent of water-related ecosystems over time e.g. wetlands, lakes, peat lands, estuaries & mangroves etc.
- Increasing anthropogenic influences, including water extraction, and the related vulnerability of the diminishing water-body to absorb/process human inputs.
- Evident changes are the removal of critical and sensitive ecosystem types (swamp forest, wetlands, peatlands) for subsistence agriculture. Climate change will likely have large-scale effects on this ecosystem being in the tropical/subtropical biogeographical zone. Anticipated changes will include potential tropicalisation of species and loss of habitats with sea level rise, the loss of connectivity of habitats with increased drought cycles and a fundamental change to the underlying aquifer.
- Yes, it is important in order to understand how to adapt management in the area.
- None that I know of.
- Economic development

Response to the following question: Your research objectives - Change opportunities: Given that a core objective of EFTEON will be to observe and understand change, are there any ongoing or foreseen anthropogenic changes in the area that might have relevance to your research interests?

- Focus on cattle management systems. These are so very important to the local people. There are very high quality cattle in the area. Develop a tourism industry around this - focussing on South Africans who have been displaced from the land into urban areas - and now want to learn about their heritage. Research is needed to unlock this
- Commercial forestry threat
- Change in vegetation dynamics as the result of may be climate and change in land use because of economic drivers
- Yes - impact of pollutants on ecosystems, organisms and people. These include endocrine disruptors, agri-chemicals and microplastic associated chemicals.
- Climate change impacts and potential coastal developments on adjacent coral reef systems
- People and their activities generate water demands - the entire area requires development of a water budget
- See answer of four questions back
- See question above.
- Yes, continued slash and burn operations in swamp forests.
- Changing ground water levels, rainfall, evaporation, and rooting depth of forests.
- Commercial timber, subsistence timber, other agricultural land use activities (e.g. *Macadamia* and cashews).
- Changes in local population and demand on water resources, land cover changes
- The preservation of human settlements on sand platforms that are normally submerged around the margins of Lake Sibaya indicate the likely fluctuation of lake levels. The scope of cultural evidence and its chronology must be described and dated to provide a cultural link to long-term climate change in the system.
- Population growth, land use change, forestry, fisheries
- Extent of land cover types in and surrounding water related ecosystems especially in wetlands/peatlands and the extent of land ownership within the catchment e.g. private, gov etc.
- Land cover/land use change, population increases, increased potable water use from local supply
- The impact and benefit of plantations on households and available water.
- As far as I know, which is not a lot for this region, no.

- Drastically reduced water level in lake sibhayi (Back)

Survey responses to the following question: Your research objectives - Socio-economic/natural resource management links: Are there ways in which your research might contribute to improving the socio-economic status of local communities? Could your research feed into improved management of natural resources in the region? Please describe these links.

- Understand how hygrophilous grasslands 'drought-proof' the cattle economy. These possibly provide increased grazing during dry periods than there is available in wet periods.
- Use of an Aquifer Management Plan to feed into the Catchment Management Strategy
- Potential links to human health (exposure to chemicals through diet)
- Provide information that will support comprehensive monitoring of coral reefs which are the backbone of the marine dive tourism industry. The research would certainly improve management of the local corals reefs in the region.
- Yes, potentially. Action research can help grow and develop awareness and knowledge together with scientists. For more info see list of research Qs that will be sent separately
- Understanding the environmental limits of extant biodiversity is the first step towards preserving ecosystem biodiversity and functioning. Then improving the understanding of how these ecosystems are used (in natural and communal/commercial scenarios) management can be improved and also informed by the biodiversity assessment.
- The output could inform communities where restoration should be done.
- Changing groundwater levels impact directly on the natural resources of the local communities. The loss of Vasi pan is an example.
- My research aims to investigate the viability of adopting alternate land use activities to replace timber (e.g. *Macadamia* nuts) from a hydrological perspective. Monitoring the water use of *Macadamia* trees and/or any other potential land use activities will help establish the water footprint of these land use activities to compare with the water use of timber. This will then be combined with the comparisons with the economic benefits of these land uses to help the stakeholders in their decision-making to select the most suitable land use(s) to sustain (or even improve) human livelihood with minimum effects on the integrity of water resources.
- I do not see any way in which my type of aquatic environmental research would contribute to improving the socio-economic status of local communities. Nobody is going to show or demonstrate "improved management of natural resources" - this type of statement is a fallacy. At absolute best there might be some control of those human activities that impinge on natural resources such that utilisation is sustainable. The expansion of forestry in the area and increasing fishing levels in the Kosi estuary both demonstrate a lack of appreciation of cause and effect.
- Better understanding of rainfall variability / change and local hydrology will help alleviate rural poverty by improving sustainable agriculture and forestry
- The infrastructure development needs of the communities in this area are limited by the lack of hard rock that can serve as a source of coarse aggregates necessary for construction. Methods of utilising the abundant fine aggregate (ie sand) for use in construction must be developed.
- The impact of the regional aeolian sand and associated poorly developed soils that lack trace elements and have poor water retention characteristics have always impacted seasonal crop agricultural production forcing the community to focus on using wetland margins for agriculture.
- The deep geological structure beneath the southern edge of Lake Sibaya represents a zone of high heat flow in the earth's crust that could be investigated for developing geothermal energy. This could reduce the dependence on trees from threatened forests in the area for domestic energy. "
- Surface waters, the degree to which they connect, and the habitats they support are strongly linked to groundwater. Groundwater is an increasingly exploited resource and is likely to remain so, strongly tied to current socio-economic activity. Peneplain fishes are an excellent indicator of this link, and water quantity and quality in general. They comprise a wide range of species with different dependencies on water quantity and quality, and which include species with strong habitat affinities. These habitats include botanic elements (reed bends, mangroves, swamp forest) that are harvested and used by local people.
- In the Department of Water and Sanitation we do collaborate with community based organizations / citizen science initiatives as part of stakeholder engagement or awareness campaigns as far as water resource management is concerned.
- Indirectly yes through climate change mitigation and directly in that the aquatic habitats are the nurseries of important fisheries (vertebrate and invertebrate species) that are targeted by these communities.

- As indicated we don't have research proposed for the area. However understanding the value of plantations and the acknowledged impact it has on the economics of the area and on water resources might assist in water resources decisions. Alternative economic activities need to be found for the area.
- There is no direct link at this stage. The changes in sensible and latent heat fluxes and precipitation, if we can establish them, may help guide land management and climate change adaptation strategies.
- Management of wetlands and water sources

Assessment of current land uses, maps or other evidence highlighting core sites and land use / climatic/ biome gradients

- Refer to Sections 2.3, 3.6; 3.7; 3.8; and 4.3,
- See List of Figures Pg. iii
- The following plans and research publications provide background information to past current and planned land uses and developments as well as status of biodiversity assets within the landscape and are available on the Google drive evidence file
    - The EKZNW Umkhanyakude Biodiversity Sector plan (2014) provides details in from on the area within the context of the district municipality o the region as a whole
    - Umhlabuyalingana Local Municipality (ULM Integrated development plan 2018/19
    - ULM 2017 Integrated Spatial Development Framework
    - ULM IDP 2017-2022
- See reference list for papers cited and in particular:
    - Grundling, A.T., Van den Berg, E.C. and Price, J.S., 2013. Assessing the distribution of wetlands over wet and dry periods and land-use change on the Maputaland Coastal Plain, north-eastern KwaZulu-Natal, South Africa. South African Journal of Geomatics, 2(2), pp.120-138.
    - Jewitt, D., 2018. Vegetation type conservation targets, status and level of protection in KwaZulu-Natal in 2016', Bothalia – African Biodiversity & Conservation 48(1):a2294. DOI: https://doi.org/10.4102/abc.v48i1.2294.
    - Jewitt, D., Erasmus, B.F., Goodman, P.S., O'Connor, T.G., Hargrove, W.W., Maddalena, D.M. and Witkowski, E.T., 2015. Climate-induced change of environmentally defined floristic domains: A conservation based vulnerability framework. Applied Geography, 63, pp.33-42.
    - Ramjeawon MR, Demlie M, Toucher ML and Janse van Rensburg S. 2020. Analysis of three decades of land cover changes in the Maputaland Coastal Plain, South Africa. KOEDOE (In Press)
    - Blamey, R.C., S.R. Kolusu, P. Mahlalela, M.C. Todd and C.J.C. Reason, 2018. The role of regional circulation features in regulating El Nino climate impacts over southern Africa: a comparison of the 2015/2016 drought with previous events. Int. J. Climatol., 38, 4276-4295, doi.org/10.1002/joc.5668
    - Fitchett, J.M. and Grab, S.W., 2014. A 66-year tropical cyclone record for south-east Africa: temporal trends in a global context. International Journal of Climatology, 34(13), pp.3604-3615.
    - Malherbe, J., Landman, W.A. and Engelbrecht, F.A., 2014. The bi-decadal rainfall cycle, Southern Annular Mode and tropical cyclones over the Limpopo River Basin, southern Africa. Climate dynamics, 42(11-12), pp.3121-3138.
    - Matthews, W., van Wyk, A. and van Rooyen, N. 1999. Vegetation of the Sileza Nature Reserve and neighbouring areas, South Africa, and its importance in conserving the woody grasslands of the Maputaland Centre of Endemism. Bothalia 29:151–167.
- See DWS Portfolio

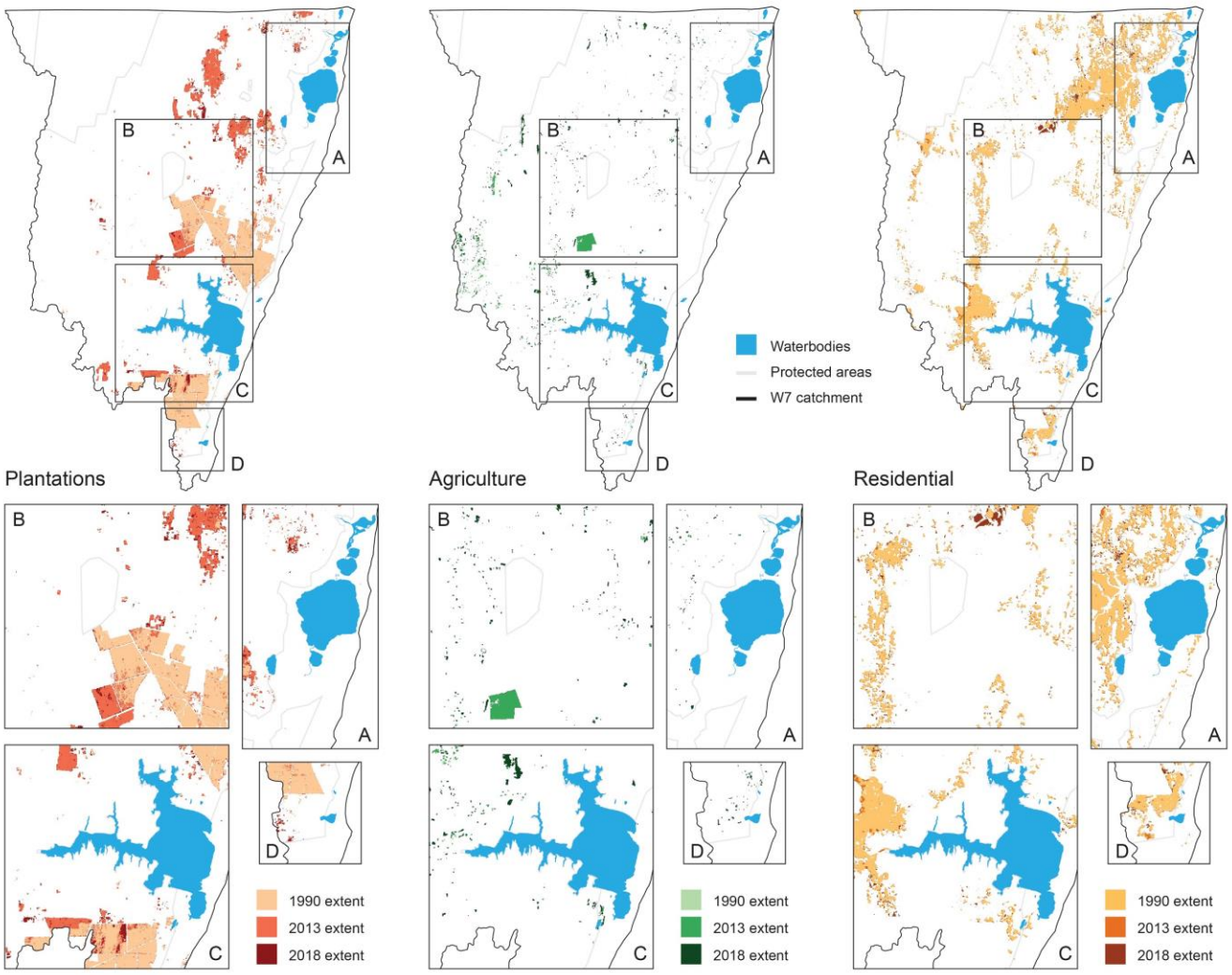


Figure 25: Land cover change in quaternary catchment W70A showing the extent of plantation, agricultural and residential areas in 1990, 2013 and 2018. Data for 2018 were obtained from the South African National Landcover 2018 (SANLC) data set, with 2013 and 1990 extents derived from the SANLC 2013/14 and 2018 Change Assessment and SANLC 1990 and 2018 Change Assessment data sets respectively. Plantation, agriculture and residential categories follow those used in the SANLC 2018 Change Assessment report. (Back)

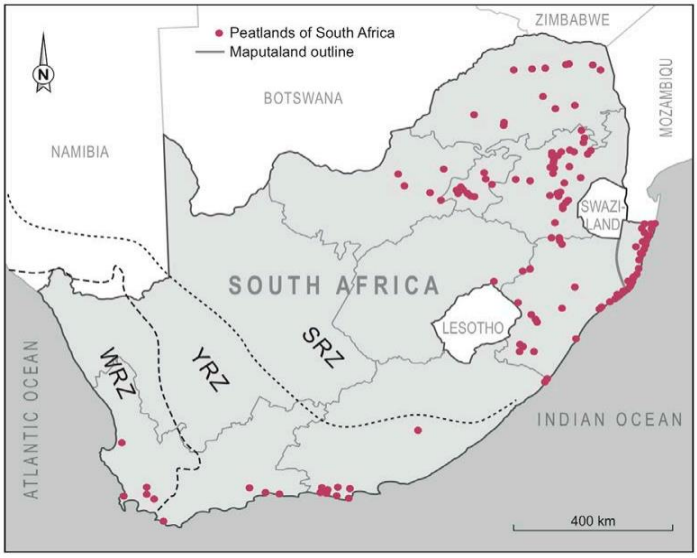


Figure 1. Peatland distribution in South Africa, SRZ: summer rainfall zone; YRZ: year-round rainfall zone; WRZ: winter rainfall zone (adapted from Grundling *et al.* 2017).

Figure 26: Taken from Elshehawi et al., (2019), demonstrating the density of peatlands within the MCP

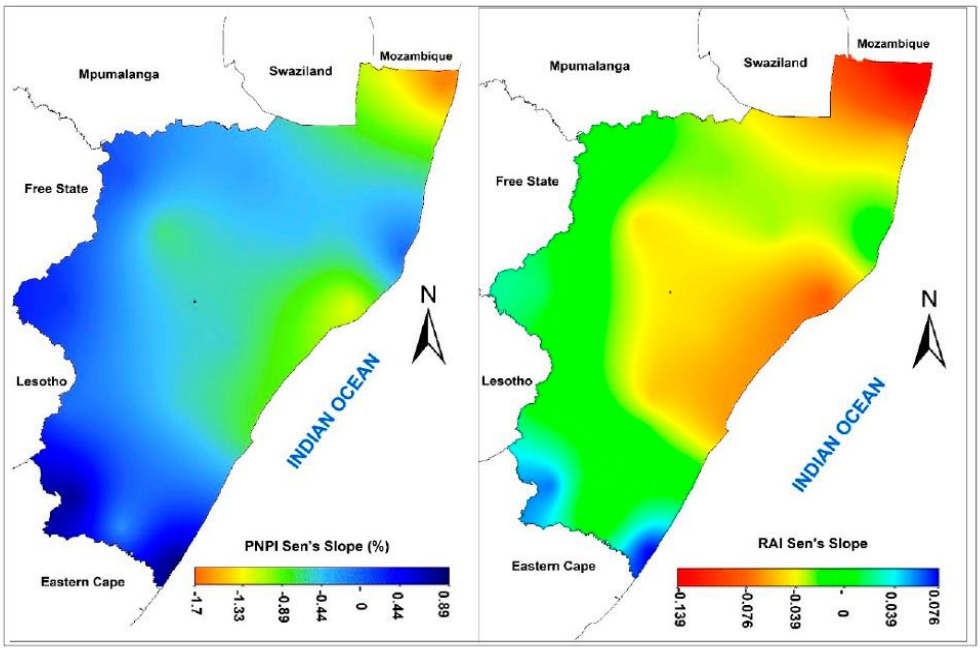


Figure 6. Spatial distribution of Sen's slope for (a) PNPI and (b) RAI for the period from 1970 to 2017.

Figure 27: From Ndlovu and Demlie (2020) demonstrating increased aridity in northern KZN.

Logistical and operational site suitability

Is there physical infrastructure available and functional for continuous hydrological measurements, i.e. gauging weirs, groundwater testing boreholes, etc.?

YES, physical infrastructure is available for continuous hydrological measurements. Several boreholes around the region in each of three ground water catchment can be recommissioned. Existing structures available for the deployment of water level monitoring instruments are highly suitable. Some may require reconditioning. A major advantage is that SAEON has established a number of surveyed control points with DWS to enable surveying of any current (not yet surveyed) or new monitoring points to meters above mean seal level and has surveyed several of sites currently being monitored. This is a vital measurement for accurate hydrological monitoring. SAEON has developed workflows for the processing and checking of groundwater level data.

Is the core site of the proposed landscape conducive for deployment of micrometeorological instrumentation (i.e. local assumptions of horizontal heterogeneity and steady state conditions)?

YES: Several potential sites that are conducive for deployment of micrometeorological instrumentation were assessed within the proposed core focal area (Lake Sibaya groundwater catchment), as well as in other locations within the landscape. The proposed Flux site is within a good condition cattle-grazing area with long-term assurance of stable land use. It falls within a buffer area of a section of the ITB land that may soon be designated game reserve status. The uniformity footprint of this site from a vegetation perspective stretches a 2km diameter from the central point and thus provides the leeway for a higher tower above the required height of current vegetation if deemed necessary.

Figure 28: Example of typical grassland and terrain in the sites assessed. Note the high forb diversity, sufferitecs and flat terrain. (Photo supplied by S Janse van Rensburg)

Are there existing observational data or experimental sites at, or associated with the landscape?

YES. There are existing observational data and experimental opportunities as well as historical and long-term data records from the area that provide a sound conceptual basis and understanding of the system as a basis

from which change can be understood. PID will also make their data available through SAEON, DWS data is freely available and SAEON data is open access. A Sound conceptual framework for observing the functional linkages between the terrestrial and aquatic systems and global change impacts on these over the long-term has been developed (Groundtruth, 2020, Kelbe, 2020).

Meteorological data for the region extends back to 1914 (Figure 24), with a range of sources available. SAEON has been compiling historical data that is in the public domain. There was a scarcity of rainfall stations within the Lake Sibaya catchment, this has been somewhat addressed by SAEON's rain gauge network.

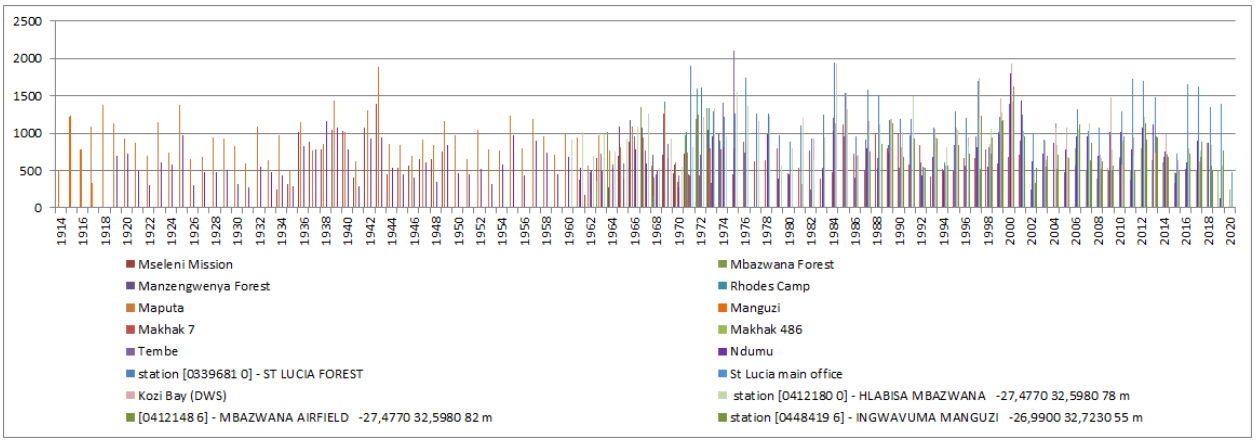


Figure 29: Rainfall records compiled by SAEON available for the region.

Commissioned reports that provide detailed hydrological and ecological assessments include:

- PID 2013 MSELENI COMMUNITY WATER SUPPLY SCHEME, Report on the Status Quo of the, scheme, January 2013
- PID, 2016. Lake Sibhayi Hydrological Study: Modelling and Yield Analysis. Commissioned by Partners in Development (Pty) Ltd, carried out by Terratest (Pty) Ltd
- Kelbe 2020, Lake Sibayi Groundwater and Lake Water Balance Models for sustainable water use analysis and management. IN Lake Sibayi Geohydrology: DRAFT Report (2) 2020 (available on request)
- Revised ecological reserve (GroundTruth 2020) (Available on request)
- Lake Sibaya Intermediate EWR – Volume 1 - Ecoclassification Report.
- Lake Sibaya – Volume 2 - Intermediate EWR Assessment Report.
- Lake Sibaya EWR – Volume 3 - Specialist Reports.
- Lake Sibaya – Volume 4 - EcoSpecs and monitoring programme.
- Kosi Estuary Rapid Environmental Water Requirements Determination, Volume 1 - EWR Report.
- Kosi Estuary Rapid Environmental Water Requirements Determination, Volume 2 – Specialist Reports.
- DWSb. 2017. The preliminary reserve determination and ecological categorisation of the rivers, estuaries, lakes and wetlands in the Usuthu to Mhlatuze Water Management Area. Department of Water and Sanitation

A number of WRC projects conducted within the area include:

- Everson, C.S., Scott-Shaw B.C, Kelbe, B.E, Starke, A, Pearton T, Geldenhuys, C, Vather, T, Maguire, M. 2018. Water-efficient Production Methods And Systems In Agroforestry, Woodlands And Forestry Plantations.Final Report Directed Research Project: Water Research Commission, Project: K5/2554.
- Everson, C.S., 2019. Quantifying The Water-use Of Dominant Land Uses In The Maputaland Coastal Plain (WRC PROJECT K5/2554).
- Bate, G., Kelbe, B.E. & Taylor, R., 2016, Mgobezeleni: The linkages between hydrological and ecological drivers. Water Research Commission (WRC) Report No. 2259/1/16, WRC, Pretoria, South Africa.
- Grundling, P.L., Grundling, A.T. and Pretorius, L., 2017. South African Peatlands: Ecohydrological Characteristics and Socio-economic Value: Report to the Water Research Commission. Water Research Commission.

- Malherbe, W., Ferrreira, M., van Vuren, J.H.J., Wepener, V. and Smit, N.J., 2017. The Aquatic Biodiversity and Tourism Value of Selected South African Ramsar Wetlands. Water Research Commission Report. Water Research Commission, Pretoria, pp. TT732/17.
- Meyer, R., Talma, A.S., Duvenhage, A.W.A., Eglington, B.M., Taljaard, J., Botha, J.P., Verwey, J. and Van der Voort, I., 2001. Geohydrological investigation and evaluation of the Zululand coastal aquifer. Water Research Commission Report, 221(1), p.01.

Datasets and research products available include (but are not limited to):

- SAEON data (groundwater, lake temperature and climatic data; Table 3)
- SAEON and IDP abstraction records from Lake Sibaya
- SAEON/DWS survey control points
- PID data
- PID have recently completed a yield assessment for Lake Sibaya which they will make available
- Historical data from Rhodes research unit (SAEON is currently securing what is available)
- Historical data regarding the planting of *Eucalyptus* is available form DWS (compartment registers)
- Department Water and Sanitation lake level and groundwater records (includes some physiochem)
- The National Groundwater Archive (NGA)
- Umkhanyakude district municipality records.
- iNaturalist species records
- SAWS weather data
- ARC weather station data
- SASRI weather station data
- CHIRPS rainfall, ERA5 and satellite products such as TRMM
- StatsSA
- ORI long-term coral reef monitoring at Nine-mile Reef since 1993 (UTRs since 1994) (this constitutes one of the oldest reef dynamics and temperature time series on the east coast of Africa)
- SAEON ADCP (currents and temperature) data since 2018
- EKZNW climatic data has been collected for Tembe Elephant Park (Tembe) since 1959
- EKZNW, Climatic data Sileza Nature Reserve since 1919.
- EKZNW, harvesting of natural resources from Tembe has been recorded since 1989.
- EKZNW Data on water collected from the boreholes in Tembe has been recorded since 2006
- EKZNW Underwater Temperature Recorders (UTRs) at Saxon, Two-mile and Leadsman reefs.
- EKZNW long-term coral reef temperature monitoring at Saxon, Two-mile and Leadsmans reefs since 2008
- EKZNW long-term turtle observation (1964 to date)
- CGS has bathymetry data for Lake Sibaya as does Terraset who have shared their report and are willing to make the data available (in hand with SAEON).
- EKZNW land use land cover data (2017)
- EKZNW Vegetation map and wetland layers
- NBA wetlands layers
- EKZNW Critical Biodiversity Areas
- EKZNW Ecological support areasKZN Veg map
- EKZNW Bird hippo and croc census data
- EKZNW Game counts
- EKZNW: long-term resource use (Fish Kosi)
- EKZNW long-term vegetation data
- EFTEON supported PhD research on land use land cover change (in press data will be made available)
- Verified lake level records (SAEON supported MSc project in progress, (data will be made available)
- DAARD soils data
- Vegetation studies
    - Vegetation of the Sileza Nature Reserve and neighbouring areas, South Africa, and its importance in conserving the woody grasslands of the Maputaland Centre of Endemism, 1999, Matthews, W.S, van Wyk, A.E and van Rooyen, N

- Vegetation of the Tembe Elephant Park, Maputaland, South Africa. 2001. Matthews, W.S, van Wyk, A.E, van Rooyen, N and Botha, G.A.
- The vegetation of Tshanini Game Reserve and a comparison with equivalent units in the Tembe Elephant Park in Maputaland, South Africa. 2004. Gaugris, J.Y, Matthews, W.S, van Rooysen, M.W and Bothma, J.du P.
- Growth rate of selected woody species in Northern Maputaland, KwaZulu-Natal, South Africa. 2008. Gaugris, J.Y, van Rooysen, M.W and Bothma, J.du
- Seed bank dynamics of selected vegetation types in Maputaland, South Africa. 2004. Kellerman, M.J.S and van Rooyen, M.W.
- The extended occurrence of Maputaland Woody Grassland further south in KwaZulu-Natal, South Africa. 2011. Siebert, S.J, Siebert, F and du Toit, M.J
- The impact of elephants on the plants and their community variables in South Africa's Maputaland. 2007. Guldemond, R and van Aarde, R
- The coastal grasslands of Maputaland, South Africa: Effects of fire and grazing on vegetation structure, diversity and composition. 2007. Dalton, B,P,A
- The ecology and species richness of the different plant communities within selected wetlands on the Maputaland Coastal Plain, South Africa. 2014. Pretorius, M.L, Brown, L.R, Bredenkamp, G.L, van Huyssteen, C.W.
- Effects of water dependence on the utilization pattern of woody vegetation by elephants in the Tembe Elephant Park, Maputaland, South Africa. 2009. Gaugris, J.Y and van Rooysen, M.W
- Woody vegetation structure in conserved versus communal land in a biodiversity hotspot: A case study in Maputaland, South Africa. 2010. Gaugris, J.Y and van Rooysen, M.W

(**Back**)

Table 3: List of SAEON equipment (some not indicated on the map provided)

Type	Lat	Long	Alt
Barometric pressure	-27,42	32,69	
Barometric pressure	-27,16	32,71	
EC system	-27,20	32,63	
Flow discharge (cumecs) stream profile	-27,08	32,79	
Groundwater level	-28,27	32,48	
Groundwater level	-28,17	32,52	
Groundwater level	-28,12	32,51	
Groundwater level	-28,17	32,54	
Groundwater level	-28,22	32,49	
Groundwater level	-28,14	32,51	
Groundwater level	-28,18	32,51	
Groundwater level	-27,45	32,63	
Groundwater level	-27,41	32,57	
Groundwater level	-27,42	32,71	
Groundwater level	-27,42	32,70	
Groundwater level	-27,42	32,70	
Groundwater level	-27,30	32,71	41,176
Groundwater level	-27,30	32,71	41,176
Groundwater level	-27,42	32,67	34,488
Groundwater level	-27,42	32,70	
Groundwater level	-27,09	32,60	
Groundwater level	-27,50	32,66	
Groundwater level	-27,18	32,72	
Groundwater level	-27,18	32,72	51,263
Groundwater level	-27,16	32,71	64,809
Groundwater level	-27,18	32,71	51,056
Groundwater level	-27,18	32,70	52,185
Groundwater level	-27,18	32,72	53,98
Groundwater level	-27,18	32,72	50,778
Groundwater level	-27,18	32,72	51,466
Groundwater level	-27,16	32,71	56,979
Groundwater level	-27,18	32,71	
Groundwater level	-27,33	32,71	15,267

Groundwater level	-27,42	32,71	
Groundwater level	-27,08	32,79	
Precipitation	-28,38	32,41	
Precipitation	-27,26	32,77	
Precipitation	-27,09	32,60	
Precipitation	-27,08	32,60	
Precipitation	-27,21	32,71	
Precipitation	-27,22	32,59	
Precipitation	-27,36	32,54	
Water temperature profile	-27,34	32,69	
Water temperature profile	-27,37	32,70	
AWS	-27,16	32,71	
AWS	-27,42	32,69	

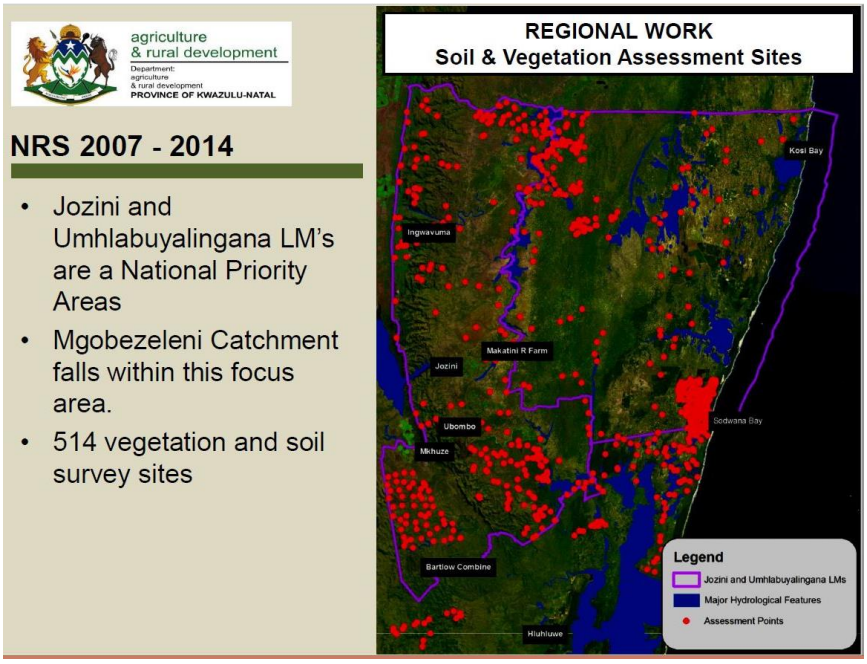


Figure 30: Taken from DAARD internal presentation showing vegetation and soil sampling assessments points.

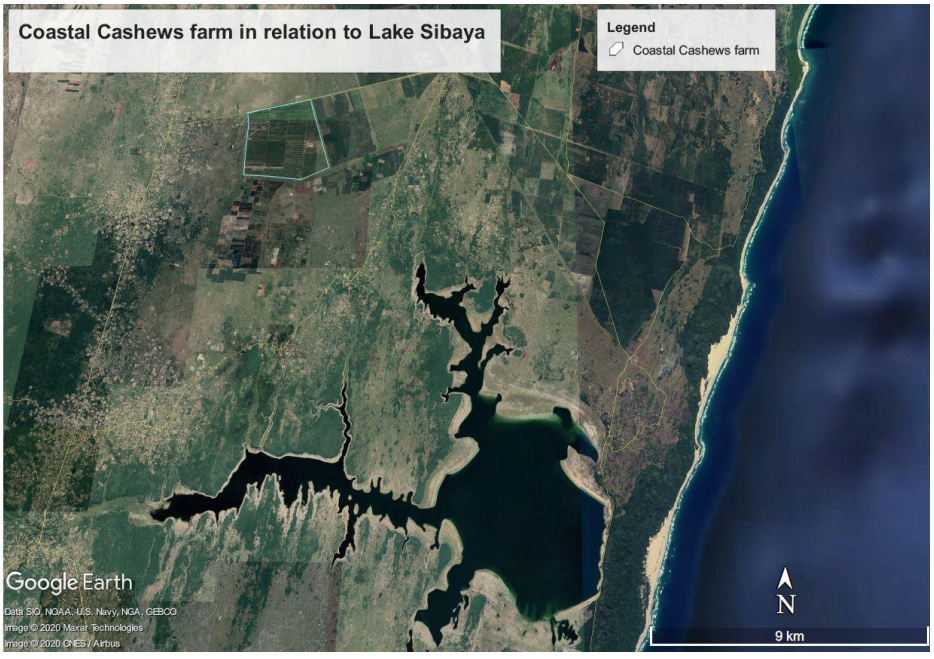


Figure 31: Location of Coastal Cashews farm in relation to Lake Sibaya (blue polygon)

Figure 32: Groundwater level monitoring points within Coastal Cashews farm manually monitored by SAEON

(**Back**)

Table 4: From Humphries and Benitez-Nelson (2013) indicating changes in lake chemistry in relation to prior studies.

Table 3. Historical water chemistry data for Lake Sibaya and its catchment (mg L^{-1})
– = not measured; ND = not detected; * = refer to Fig. 2 for location

Year	Location	pH	Ca	K	Mg	Na	Si	Cl	NO_3	SO_4	PO_4	Reference
1967	Lake water	8.3	28	7	9	86	7.5	135	0.02–0.03	24	<0.1	Allanson (1979)
1979	Lake water	8.3	7	6	13	–	–	142	0.05	–	<0.1	Allanson (1979)
1988	Lake water	–	23	7	9	81	–	110	ND	10	–	Meyer and Godfrey (2003)
1989	Lake water	–	23	9	9	83	–	113	ND	9	–	Meyer and Godfrey (2003)
1990	Lake water	–	23	7	9	78	–	111	ND	9	–	Meyer and Godfrey (2003)
2011	SIB 1*	6.0	2.2	1.2	1.6	21	–	36	0.53	0.99	–	DWAF (2012)
2011	SIB 2*	7.5	35	4.8	10	30	–	46	0.22	2.6	–	DWAF (2012)

Additional plans that have been provided for this proposal/ can inform EFTEON operations include

- EKZNW Biodiversity Spatial plan where the terms and process document provides detailed information on available data
- TMM forestry business plan for their forestry operations
- DWS has a "Review, Evaluation And Optimisation Of The South African Water Resources Monitoring Network Implementation Strategy.
- iSimangaliso is currently going through a review of the Integrated management plan
- UKDM Biodiversity Sector Plan (EKZNW, 2014)

Does the proposed core site offer security for infrastructure and instrumentation? (it is understood that in many instances this is a risk that can be managed by the selection of the microsite or building protective infrastructure for the observations)?

SAEON has demonstrated that the security for infrastructure and instrumentation can be appropriately managed. In addition, the fact that the tribal authority has provided support, this will be communicated through their structures to ensure the community is aware of what the intention is.

Are there available support facilities for site operations within a 100km radius or 1 hour drive of the site, (for EFTEON site offices (10 persons, including students and visiting scientists) workshops/ laboratories and staff and student accommodation)?

YES: Suitable support facilities for site operations ***are embedded within*** and available around the landscape, with significant opportunities to enhance an *in situ* research hub. Several opportunities have also been identified by collaborators, some of which can be further developed if the landscape is successful.

Responses to the following question: What are your recommendations or suggestions on existing/developing infrastructures (e.g. accommodation, laboratories, office space etc.) to strengthen the logistical requirements criteria for the proposal?

- Ability to participate and contribute to the experimental design.
- Several satellite camps with basic infrastructure (Solar charger, solar water heating, borehole, basic accommodation, cellphone communication. This will allow scientists to access the full area, and encourage local groups (schools, traditional leadership groups etc) to have easy access (with limited transport needed.)
- Link in with the DWS KZN logistics if possible
- It would be extremely beneficial if the core site had a basic laboratory and could accommodate researchers and small groups of students.
- I think that local existing accommodation should be supported in the region where possible. I generally do not support developing new infrastructures as this may be an unnecessary expense and is hugely costly to maintain and ensure security of. Any development in a World Heritage Site is subject to an EIA and long process etc. With regards to laboratory space there may be potential at Triton Dive Camp. The late Peter Timm, who was a citizen scientist, built such a space for visiting scientists and students, but im not sure if this was ever realized and used, or what the current status is of that space.
- Secure accommodation
- 1. I think we need to engage with Mr Bukhosini about using the science centre as a lab. Perhaps in time, when funding is available, accommodation can be erected around the science centre. 2. We need to think how we can make EKZNW's accommodation work for this purpose. 3. Options in Sodwana - coming to some type of arrangement at a backpackers place to rent their facilities, but once again - funding. 4. If funding is available to erect accommodation I think we'll be able to get land quite easily in the Mabasa area
- African Insight accommodation facilities, in the north of the study site, may be an option for developing a base. There are also some pristine grasslands in their vicinity (last time I visited).
- We will definitely benefit from accommodation and laboratory space in the study area. This may include a drying oven, safe and dry storage space for samples, fridges and a dark room, if possible.
- Secure data loggers which are routinely monitored and reliable communication of data to remote servers
- The Baya Campsite on Lake Sibaya or the Amanzengwenya infrastructure could be upgraded to serve as research accommodation and infrastructure.
- I suggest that partnership with Ezemvelo KZN Wildlife be explored. There may be opportunity to use the accommodation and office space that they have. They could also house a few small boats/vehicles for use. The possibility of a Research Station at Lake Sibaya should be investigated.
- None at this stage
- At least one research station (with full facilities) for monitoring expeditions is imperative. The old research station at Sibaya gave birth to some of the most formative studies of this region (which haven't been much improved on since the 1960s). Facilities such as these are also well suited for visiting university groups for conducting field practical exercises etc.

- unsure
- Consultations with the traditional council

Is the landscape suitable for use in Human Capital development? (including but not limited to; school groups, University groups at both the post graduate and undergraduate level, post graduate research projects, citizen science groups, community engagement and the transfer of indigenous knowledge).

The landscape is ***highly suitable*** for use in Human Capital development across the range from local learners, community citizen scientists groups and NGOs to graduate and postgraduate groups as well as across sectors (municipal, TA's researchers, conservation organisations, industry, government institutions). The potential for bottom up driven co-generated knowledge and information sharing for better outcomes is high.

Responses to survey in relation to the following question: What are your current or planned interests in using the area with regards to human capital development, and what would make it attractive as a platform where training/engagement could occur?

- Availability of data; pooling of expertise to allow for cross-disciplinary training
- Community citizen science projects
- Broaden the studies global footprint
- High interest for MSc and PhD training
- I have ongoing postgraduate research projects in the area. One could also look at developing undergraduate courses that have a strong field/hands-on component to them.
- It would be an ideal space for students to undertake fieldwork as it is relatively close to universities based in Gauteng and KwaZulu-Natal. What makes it attractive is that there is still a lot we don't know about how the ecology functions in this World Heritage Site.
- This area is perfect for action research especially w.r.t. communities' use of and interaction with natural resources. Also, if we can somehow have a permanent team responsible for translation of all research taking place in the area, and also facilitating co-learning processes I think we will have a winning recipe ito research in the area. Like what we intended for the science centre with Sihle - a platform that continually engages communities on behalf of (and with) all researchers in the area, regardless of scientific fields. And which then also become the place for training, sourcing of field assistants, co-development of research etc etc. I don't think these types of things should be left to each individual research project/research group, because then it will rarely actually realize!
- Working with collaborators to develop local and personal ecological expertise.
- Save the aquifers - more data = better model
- Creating employment
- Our WRC proposal suggested the inclusion of two MSc students on the remote sensing of wetland vegetation.
- Statistical training could be provided using data collected in the area and developed to answer important research questions from the project.
- Develop expertise in groundwater modeling
- I plan to use this research area for my students to conduct their studies (Hons and MSc). One of the main reasons for students to join a research team is availability of student funding. In addition, using various communication platforms (webinars, adverts, monthly articles, social media, etc,) on a regular basis to highlight research progress would increase awareness and interest. Lastly, highlighting the scenic nature of the area and special biodiversity features regularly may spark interest.
- Potentially could run a workshop / module for Hons or taught MSc students
- The region has a long research history and published data that serves as an ideal coastal zone training area for geosciences.
- Student opportunities. Accommodation, small boats/vehicles, portable water quality instruments, sampling equipment.
- Water resource management especially with regard to aspects of wetlands/peatlands and lakes - spatial extent, water quality/quantity, citizen science initiatives - monitoring, biodiversity and ecological conditions in these water systems.
- Relatively pristine areas have provided strong enticements for, and involvements with training
- Will send you my answer

- Base station to from where to conduct field surveys and small laboratory preparation for sample analysis etc. Electricity (stable), running water, fridge/freezer facilities, benches for microscopy, equipment calibration, boating facilities or at least area for housing them, wifi
- Awareness creation of communities and tribal authorities re water use and impacts needed. We have asked Working for.... programmes to do Wetland Wise Use training but this never realized.
- Quality housing, basic amenities and schooling for developers and career driven individuals
-

Stakeholder and community engagement

Identification of key land owners and land custodians - include letters of support from relevant land owners, land custodians et cetera.

Key landowners and land custodians have been engaged and support this proposal and have contributed to its development.

Stakeholder engagement processes used

1. An open process soliciting inputs and invitations to invite others stakeholders to support the initial landscape nomination. Positive responses were received from a wide range of stakeholders supporting the nomination were received from Land custodians Tribal authorities; conservation agencies, academic institutions, relevant government departments, with many (57) supporting the initial nomination.

2. Discussions and inputs during EFTEON MCP cluster stakeholder engagement (16 July 2020): Participants (47 represented) discussed in more detail what the extent should be, which was often noted to be larger than the criteria stipulated by EFTEON.

3. Inputs were also solicited via a survey sent via email to academic and stakeholder institutions on the 9th August and a reminder with a date extension was sent on the 18th August. The Survey was passed on to additional stakeholders as new collaborators were suggested. A total of 28 respondents participated in the survey providing substantive input for the proposal. All agreed to join the proposal as collaborators. Responses received are incredibly rich. While we have endeavored to include the essence of all comments within the proposal, it is important for EFTEON to have a record of the details as much of this would help to guide the programs development if this landscape is successful. As such responses have been captured in appropriate places within the "Scoring criteria" addendum.

4. The final total number of people supporting this proposal is 88 demonstrating broad consultations and additions of interest of individuals made known during this process.

5. Note in particular survey responses to landscape extent and core site questions

    a. Discussions by the core writing team in relation to EFTEON specified criteria: It was agreed to limit "core sites" to areas which meet micromet assumptions and near-natural conditions, with secure tenure to avoid unexpected land use change within the site.

6. Email exchanges with stakeholders and collaborators

7. Meetings and engagement with local communities and land custodians specifically to assess long-term

accessibility were undertaken.

8. While the survey was used to demonstrate support for the landscape (28 repondants), a number of additional letters of support were received from SMCRI, SANBI, PID, KZN Museum, UNIZULU, UJ, UKZN-CWRR, CEH, ASSET, TMM, iSimangaliso, EKZNW, Coastal Cashews, Chris Meyer Science Centre, LSCDT, UKDM, DEFF, OTS, DWS, Prof Rob Hart (UKZN) and Inkosi Nxumalo, of the Mabasa TA.

   (Back) (Back to stakeholder analysis)

Demonstrate broad support from the wider scientific community.

There is significant support from a broad representation of the scientific community

The Co-authorship of the proposal represents a diversity of institutions including land custodians, academics, government departments and stakeholders.

Organisations represented

** Letter of support received; ** Co-author on proposal; *** Substantial input; # support proposal as listed collaborator*

Key landowners and land custodians

- Mabasa Traditional Authority * (offer to host core site)
- iSimangaliso Wetland Park*
- Ezemvelo KZN Wildlife*
- Coastal Cashews #

Government departments

- Umkhanyakude District Municipality *
- South African National Biodiversity Institute *
- Department of Environmental Affairs *
- Department of Health KZN (Mseleni Hospital) #
- Department of Health KZN, Manguzi Hospital #
- Department of Water Affairs **

Academic institutions

- ASSET *
- Agricultural Research Council ***
- Center for Ecology and Hydrology-UK *
- Council for Geosciences ***
- Council for Scientific and Industrial Research **
- Human Science Research Council #
- KZN Museum *
- Nelson Mandela Metropolitan University #
- Oceanographic Research Institute **
- Organization for Tropical Studies *
- Nsasani Trust *
- Rhodes University ***
- SAEON **
- SMCRI *

- University of Cape Town **
- University of Johannesburg *
- University of KwaZulu-Natal *
- University of Pretoria ***
- University of Witwatersrand **
- University of Zululand **

Institutions and NGO's working on Capacity development

- Lake Sibaya Conservation and Development Trust *
- Christoph Meyer Maths and Science Centre *
- Organization for Tropical Studies * and Nsasani Trust *
- Endangered Wildlife Trust #
- Groundtruth **

Sector and industry partners and private

- TMM Forestry *
- Partners in Development *
- JG Afrika ***
- MER ***
- Private ***
- Tembe Lodge #
- Terratest ***
- VLG Statistical Services ***

NGO's

- Wildlands Trust #
- Wildlandscapes # (Back)

Contributors

Table 5: Contributors to the proposal who provided input either through the survey, though email, community/stakeholder engagement meetings and through commenting on the document.

Althea Grundling	Agricultural Research Council
James Blignaut	ASSET
Greg Botha	Council for Geosciences
Dr Lungile Leslie Hobe	DEPARTMENT OF HEALTH KZN (Mseleni Hospital)
Maluleke Michael Department of Water Affairs	Department of Water Affairs
Fourie Naomi	Department of Water Affairs
Catharine Hanekom	Ezemvelo KZN Wildlife
Brigitte Church	Ezemvelo KZN Wildlife
Mark Graham	GroundTruth
Caiphus Khumalo	iSimangaliso Wetland Park
Sifiso Vumasa	iSimangaliso Wetland Park
Jabulani Ngubane	iSimangaliso Wetland Park
Phumlani Lugagu	iSimangaliso Wetland Park
Sibusiso Bukhosini (CEO)	Isimangaliso Wetland Park
Mark Schapers	JG Afrika
Gavin Whitelaw	KZN Museum
Jabulani Mkhabela	Lake Sibaya Conservation and Development Trust
Lungisani Nxumalo	Lake Sibaya Conservation and Development Trust
Ticky forbs	MER
Victor Fredlund	Christoph Meyer Maths and Science Centre
Kathleen Smart	Rhodes University
Charlie Shackleton	Rhodes University

Juliet Hermes	SAEON_Egagasini
Tommy Bornman	SAEON_Elwandle/SMCRI
Paul Gordijn	SAEON_Grasslands
Michele Toucher	SAEON_Grasslands
Sachin Dorasamy	SAEON_Grasslands
Siphiwe Mfeka	SAEON_Grasslands
Nancy Job	South African National Biodiversity institute
Simon Johnson	Terratest
Kimm Wier	TMM Forestry
Erwin Sieben	University of KwaZulu-Natal
Rob Hart	University of KwaZulu-Natal
Jeffrey Smithers	University of KwaZulu-Natal:CWRR
Mlungisi M. Shabalala	University of KwaZulu-Natal:CWRR
Seifu Kebede Gurmessa	University of KwaZulu-Natal:CWRR
Christopher Curtis	University of Johannesburg
Allister stark	University of Pretoria
Bruce Kelbe	University of Zululand
Ricky Taylor	University of Zululand
Victoria Goodall	VLG Statistical Services
Dave Still	Partners in Development
Craig Malqueeny	Ezemvelo KZN Wildlife
Christopher Evans	Center for Ecology and Hydrology-UK

(Back)

Diverse disciplines represented: Survey participants were asked the following: “Please indicate your areas of specialization/discipline and your primary interest in this area (e.g. policy implementation, research areas focus, land management etc.)”

- Hydrologist; interest is in land-water interactions under a changing climate
- Research facilitation
- Hydroecology, wetlands, wetland plants, mangroves, swamp forest
- Geohydrology/hydrogeology, interested in Socio-Economic and Ecosystem Dependency (Balance water supply-environmental needs)
- Hydrology (Isotope/tracer hydrology)
- Geochemistry, pollutants, climate change
- Marine ecology - research area focus on coral reef monitoring and land-sea interactions
- Aquatic ecology in the northern KZN area including St Lucia, Sibaya and the Kosi system. Have published on all these systems with experience going back 50 years.
- Everything?:) Mostly wetlands & water, but also action research around communities and the relationship with their environment, landscape/land use change, wise use of resources, governance, climate change, water & land management
- Ecology; plant ecology
- groundwater
- Land management
- Research, remote sensing of wetlands and wetland vegetation
- Statistical ecology and data management. Interest in the area: research focus and data management.
- Surface-Groundwater modeling
- Hydrological modelling, crop water use, land use change
- Research in climate science, meteorology, coastal oceanography, coral reefs
- Cenozoic geology, palaeo-environmental change, geochronology
- Aquatic research and monitoring (estuarine, coastal freshwaters) with a focus on fish assemblages
- Water Resource Scientist
- Limnological-ecological research
- Research focus as well as data infrastructure (e.g. weather stations, moisture and temperature probes, water level monitoring).

- Research/monitoring of coastal lakes, estuaries and marine benthic ecosystems. A focus on biodiversity of coastal and marine invertebrates and connectivity of processes and species across realms
- Implementation of afforestation water use legislation - National Water Act, 1998
- Research, land-atmosphere feedbacks.
- Human health
- Resource economics

(Back)

Survey responses to the following question: Your research objectives - Natural landscape opportunities: What features of the area would make this a good place to pursue your research interests?

- Multiple land cover types and land uses to observe vegetation water use and feedbacks the the hydrological system: Net environmental and economic costs of alternative land use choices under different future climate scenarios
- The Maputaland area requires a holistic approach to catchment management. It represents a critical biosphere and hydrosphere coupled with the socio-economic linkage. With decline of the Lake Sibaya lake levels, we are faced with a critical time whereby decisions taken now can still at least slow down the decline.
- 1. The connectivity between terrestrial, freshwater and marine ecosystems. 2. A region that is likely to be highly sensitive to future environmental change (e.g. ENSO)
- The tight connection between the wetland-terrestrial-marine environments. This largely due to the geology and hydrological dynamics of the region. In addition, this area is both a terrestrial and marine biodiversity hotspot.
- Peatlands, wetlands, lakes, areas with food gardens, areas where community is committed to action research processes
- There is a range of natural (and rangeland systems) with different suites of herbivores that provide a unique opportunity for comparison.
- The diversity and variety of wetland types in the landscape makes it a unique area to develop a remote sensing tool for wetland monitoring.
- It supports strong groundwater- surface water interaction
- Lake Sibaya, Wetlands, Groundwater
- The entire domain and adjoining coastal ocean
- Wetland deposits including peat and diatomite in drainage systems linked to the coastal lakes can provide high resolution evidence of palaeo-environmental change during the past ~8,000 years.
- The mosaic of surface waters, small streams, rivers, pans, swamps, lakes and estuaries which are groundwater dependent, and connected on different temporal scales (geological, dry/wet cycles, seasonal, tidal) and spatial scales.
- Spatial layers for water related ecosystems including artificial water bodies i.e. dams etc.
- All aquatic systems with particular focus on coastal lakes, rivers, estuaries and the nearshore marine environment. The area provides enormous opportunity for biodiversity monitoring transects across ecosystem types and across three aquatic realms, freshwater, estuarine, marine.
- I am not sure if this proposal will result in available funding. Considering the financial situation of the government, funding for projects from the Departmental side is very limited. The unique water resources - wetlands, peatlands, lakes, estuaries are the features of the area that we are specifically interested in.
- The shrinking of Lake Sibaya, exposing the soil, and the soil drying out.
- Availability of wetlands and following up on families that survive mainly on this form of sustenance
- Availability of clean water

Spatial extent

Responses in relation to this context and question: “For a proposal to be successful, it needs to demonstrate that the proposed spatial extent is a coherent, connected “landscape”, in which processes can be observed (preferably not exceeding 50 km2). It must be suited to addressing the objectives of the EFTEON program, and we will also need to demonstrate how the investment will enable stakeholder research efforts and interests within the specific region.

The broad area of interest is the Northern Maputaland Coastal Plain. Given that stakeholder and research interests span a larger area than that envisaged by EFTEON, it is vital to identify the most appropriate spatial extent to put forward as an EFTEON landscape that

will also provide optimized benefit to research efforts within the broader area of interest. It should be an area of 1) particular significance (e.g. biodiversity hotspot, strategic water source area, new developments etc.) with 2) a mosaic of land uses (pristine, transformed and lived-in landscapes), which 3) preferably represents transition zones (e.g. between biomes, altitude or climate gradient, land and sea), and 4) has elements that are positioned in the face of change (e.g. land use, socio-economic).

Using a connected hydrological unit as the principle for a "coherent unit", the proposed landscape is catchment W70A, indicated by the red boundary on the attached image below. The entire catchment is a uniquely rain fed groundwater driven system that also encapsulates the coastal lake systems, enabling contrasts between the Kosi (open estuary), Lake Sibaya (fresh water) and the uMgobezeleni (open/closed) systems.

Q: Are you in agreement with the spatial extent of the landscape? Y, N Other. If your answer to the question above was "No", please indicate the spatial extent of the landscape that you propose.

- **Three** “no” responses were received advocating for a larger area with following reasons provided:
    - Add a 5 to 10 km buffer to the W70A catchment to include more of the Lebombo and shifting groundwater boundaries
    - Using the international boundary as a delimiter of the spatial extent is presumably an unavoidable constraint = unfortunately, physically and process wise to make no sense.
    - To fulfill the definition of 'landscape above' - the project will need to include the full extent of the coastal plain (i.e. both the savanna biome and the IOCBB components). That is - the coast to the Lebombo Mts..
- **One** “Yes/” answer both selected
    - For remote sensing, we can monitor at the wider Maputaland Coastal Plain, however, for the equipment, I am happy for others to select a smaller extent. Therefore my answers are yes and no:)

- **22 “**Yes” responses from the survey
    - My answer is "yes" for now. However, if there is scope for opportunities in the future to expand further south to include the Mkuze swamps that would be of interest from a marine/reef ecology point of view so that the entire extent of land adjacent to all three reef complexes is considered. The current proposed spatial landscape extent lies adjacent to the Northern and Central Reef Complexes and therefore does not align with the Southern Reef Complex in one of the marine sanctuary zone.
    - With the caveat that ecological baselines and understanding will likely be informed by work in nearby neighbouring aquatic systems outside of the outlined area.
    - Agreement with the above is based purely on logistical grounds. Scientifically, there are good reasons to expand its spatial footprint to include the Kosi system in the N, and the Phongola floodplain below Jozini Dam in the N-W.

(Back)

How researchers would use the EFTEON program

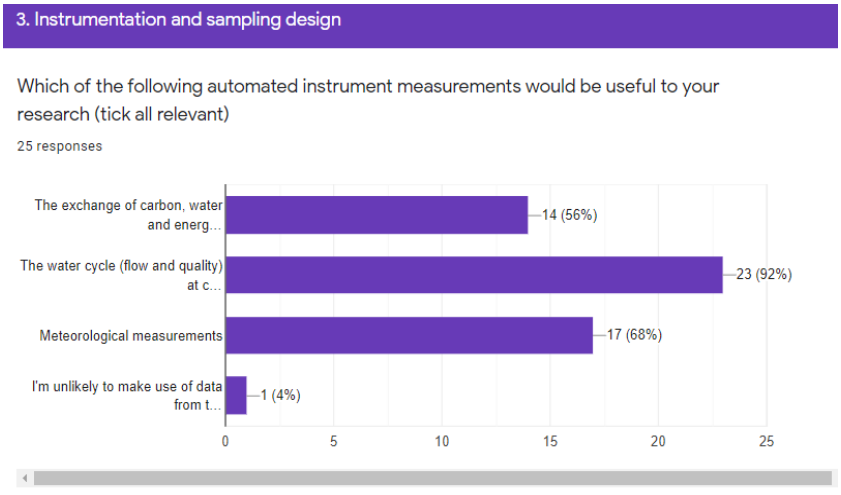


Figure 33: Responses to which automated measurements would be useful to their research

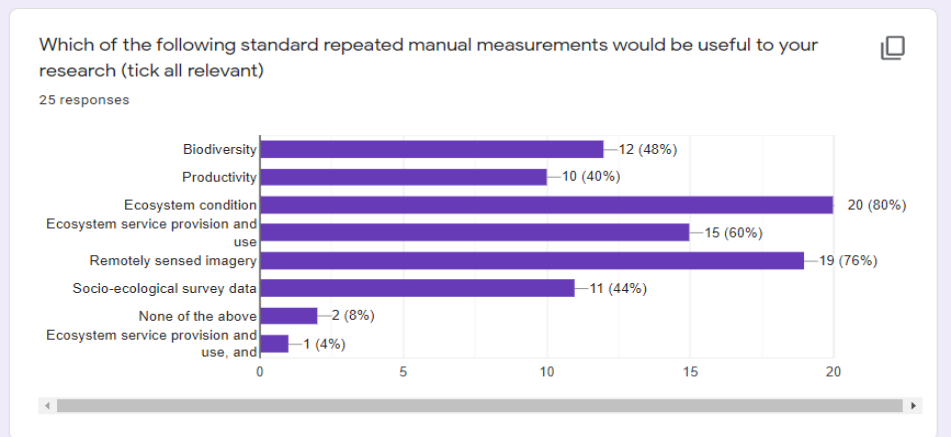


Figure 34: Responses to what repeated manual measurements would be useful

(Back)

Funding leverage

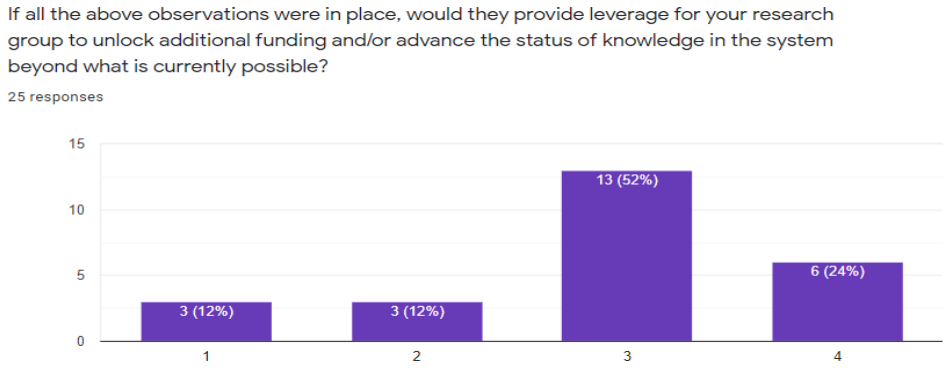


Figure 35: responses to survey questions to determine likelihood of EFTEON program leveraging additional funding if this landscape was successful (1 unlikely- 4 Highly likely)

Recommendations for EFTEON variables (demonstration of interest and support)

Participants were asked “Are there any specific recommendations for this landscape for variables the EFTEON program should include in their program that would be beneficial to your research and/or in general?” responses have been logically grouped below. Wording has not been changed

- Solar radiation, cloud cover.
- Groundwater chemistry and use of a network of monitoring boreholes to track season and longer cyclical variations.
- Groundwater, stream meteorological measurements
- Higher resolution rainfall gauges and more weather stations
- Surface water spatio-temporal availability.
- Water quality and environmental contamination
- In situ monitoring of the freshwater aquatic landscape - Lake Sibaya, Kosi Lakes?
- Groundwater table depth throughout catchment and tendencies.
- Quantify development, human densities, and changes in technology used locally

- In general: long-term monitoring of certain selected socio-economic indicators [e.g household water use, temporal patterns in water borne/related diseases]
- Natural resource use (e.g. hardwoods, fire wood, food, medicinal).
- Can we add camera traps on the towers to monitor landscape activities (e.g. cutting of swamp forests)? We will also benefit from targeted drone images and relevé information being shared.
- Invasive plant distribution and dispersal mechanisms.
- Fire spread, seasonality and behavior.
- Herbivore densities and spatio-temporal movement patterns.
- Atmospheric deposition

(Back)

In addition to this written submissions from CSIR included equipment that EFTEON should consider, or that collaborators could contribute to expanding the array:

- Laboratories including wet lab facilities for sorting of specimens and dissecting of animals.
- Drying ovens
- Water quality and SMC metres
- Peat auger
- Camera traps
- Height poles
- Measuring tape
- Drone for shared use (e.g. for monitoring of fish traps extent and harvesting of mangroves)
- Underwater SBRUV cameras for monitoring of fish in estuaries and freshwater lakes
- Internet connection
- Spot lights for night work
- Dissecting sets
- Fish acoustic tags for telemetry
- GPS handheld
- Dumpy level
- 4.8 m aluminium estuarine boat for wetland work (max 6 people) (will be provided by SMCRI for the region)
- In situ temperature and salinity recorders (x7) in the estuaries (SAEON already has 2 in Sibaya) (some will be provided by SMCRI for the estuaries)
- Water Quality multiprobe with handheld display and 50 m cable (depth, salinity, temperature, oxygen, turbidity, ph, chlorophyll) & calibration fluids (SAEON is getting one for site)

Survey responses to the following question: Your research objectives - Questions and ideas: Please provide a short description of the topics and/or questions that you think would be interesting to address in the Maputaland Coastal Plain?

- Can cogenerative approaches and community engagement lead to better research and traction of research results on land action outcomes?
- Describe the main geomorphological processes active in this landscape (e.g: wind-blown sand, rise and fall of groundwater, groundwater flows into wetlands/coastal lakes/estuaries/sea. Accumulation of peat. Role of peat as an aquatard. Impacts of cyclones, sand supply balance in the nearshore environment. Fire and woody plants, importance of grazing to create grazing lawns in the hygrophilous grasslands - and impacts of overgrazing)
- Climate change: Linkage of tropical cyclones to groundwater recharge. Exploration of water sensitive/ water saving alternatives to community economic activities. Strengthen larger stakeholder and community businesses to become actively involved in water saving.
- a) What is the relative importance of cyclones vs other type of rains recharging groundwaters, b) What is the source of water to different type of trees and how this in turn is affected by change in climate;
- How the wetland-terrestrial environment may influence the adjacent coral reefs. This in terms of pollutants, nutrients and groundwater/salinity influences. Also having solar radiation, cloud cover, atmospheric temperature and CO_2 data would be useful to couple with data emanating from the long-term Nine-mile Reef coral monitoring station and for ad hoc coral bleaching assessments.

- Drivers of hydrodynamic changes and the effects thereof. This is not "interesting"; it is not blue sky research; it is a critical component of the sustainability of human usage of the southern Mozambique coastal plain.
- I'll send a list separately...
- "Determine the environmental (and herbivore driven) limits of grassland and forest biodiversity in the study area.
- Assess the contribution of local and other drivers on woody plant encroachment.
- Determine what drives the spread of alien functional plant groups and assess/predict their group impact on indigenous plant diversity.
- Assess ecological cascade effects of removing or adding herbivores on vegetation structure, composition and diversity.
- Compare spatio-temporal patterns of movement and land use of similar indigenous and domestic herbivores in the study area.
- It would be good to include collaborations which aim to understand nutrient cycling and the influence of the above processes on this.
- My colleagues and I from the CSIR have submitted a WRC proposal to fund the remote sensing of wetland types and changes on the Maputaland Coastal Plain. We would require funding to undertake this endeavor.
- I think the site provides a valuable opportunity for data collection and collating historic data. There will definitely be opportunities for interdisciplinary work and meta-analysis using long-term data from the area.
- What is the groundwater catchment and recharge?
- How deep is the groundwater mined by the vegetation, particularly the commercial plantations?
- What is the sustainable yield of the aquifer?"
- What is the (individual) water footprint of the various land uses in the area?
- What is the (individual) physical water use efficiency of the various land uses?
- What is the (individual) economic water use efficiency of the various land uses?
- Are current land uses sustainable from a water resources perspective? Do they possess long-term socio-economic benefits?
- What are the perceptions of water resources by the various stakeholders within the area?
- What are the perceptions of climate change by the various stakeholders within the area?
- Can a water-scarcity index be developed for households within the area?"
- Local land surface atmosphere interactions, local land-sea interactions
- The Sibaya/Mkhuze drainage interfluve preserves evidence of large 'perched' wetlands that survived the major sea-level recession and groundwater drawdown associated with the stepped cooling and environmental desiccation leading up to the 'Last Glacial Maximum' at ~20ka.
- The buried 'Kosi Bay Formation' coastal wetland and dune landscape is preserved beneath the coastal wetlands. Palaeo-channels incised into the old dune strata will have a major impact on deep groundwater flow across the study area.
- The influence of connectivities (groundwater, surface water, freshwater, estuarine, marine) various spatial and temporal scales on fish assemblages, including unique and little known species. Distribution and potential impacts of aquatic alien invasive species.
- Mapping of water related ecosystems; Water security aspects within the catchment; Protection/Conservation areas/designated sites of international importance; Land-based activities in and surrounding water related ecosystems
- 1. The connectivity of the Maputaland aquatic ecosystems including freshwater lakes, estuaries and the nearshore marine environment by focusing on species that have reproductive phases that require obligatory movements into and out of these freshwater systems (e.g. catadromous species, eels, crustaceans)
- 2. The genetic relatedness of invertebrate species that co-occur in aquatic ecosystems (estuaries) outside of Maputaland. Preliminary studies suggest a high degree of crypto biodiversity and endemicity in this area.
- 3. Documenting alien and invasive estuarine species
- 4. Species inventories from coastal lakes and estuaries, noting ingression of tropical species over time (particularly focusing dispersing vs non-dispersing species) to improve red listing, threat status and protection level of these ecosystems
- What is the available water for use in the system considering the long-term reduction in rainfall? What low water use socio-economic activities will do well in the area for people to depend on? What is the potential for sea water ingress as a result of the reduction in water table? What is the extent of the reduction in water table - in depth but also in area extent in the catchment? How likely is the occurrence of large storm events for the area? Government funding for projects are very limited and specific projects are not currently on the table.
- I think the albedo forcing related to Lake Sibaya shrinking is a hugely interesting one, particularly within the broader climatic modelling skill set of the group. Hillebrand et al., 2020 state there is no empirical evidence for threshold changes, and I think this would be an interesting system to test this in. Is the lake an example of positively reinforced change?

- The relationship between environmental changes and incidence of malignancy in this population.
- benefits of wetland farming in the economical development of this area
- Too many in this context unfortunately, but they usually involve thinking out ways that ecosystems (or their components) can pay for themselves.

Demonstrate contact with communities and residential areas, engagement with relevant authorities or resident groups.

Representatives from the community and local farmers as well as relevant authorities have participated in the development of this proposal and a portfolio of evidence is provided for the broader stakeholder engagement process to ensure engagement with relevant authorities and resident groups as is evidenced by the offer to Co-host the core site within the Mabasa Traditional Council. Confirmed support from local NGOs relating capacity development opportunities.

Stage 3

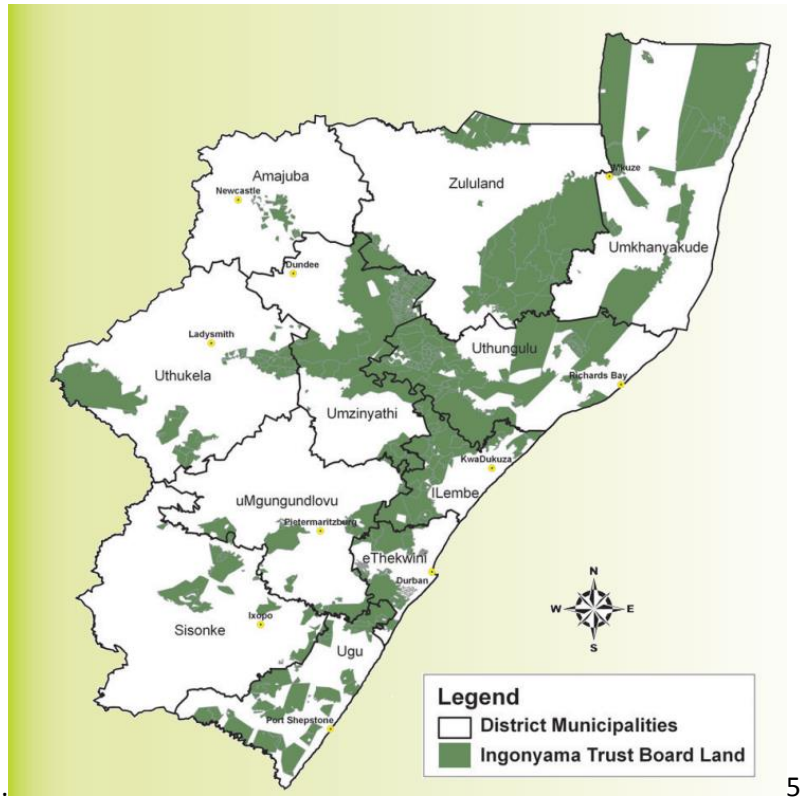
Sufficient geographical and spatial coverage between the landscapes

- See Sections 3.3; 3.4; 3.5; 3.6; 3.7; 3.8
- The area falls within an Aquifer of international significance, and observations have relevance for the entire MCP, extending into Mozambique coast plain

The relevant social-ecological systems are represented

The extent of Ingonyama Trust land in Kwazulu Natal is substantial, making up 29.67 % of the land area (see Figure 36). Given the historically rural nature of Ingonyama Trust land, the development trajectory of Trust land is a ***significant development context*** for South Africa, with high potential for rapid change from near-natural baselines within the landscape proposed. It also supports some of the more vulnerable socio-economic communities within the country that have a relatively high reliance on natural resources for livelihoods. Combined vulnerability and reliance on natural systems makes these areas particularly sensitive to Global Change and an important social ecological context to understand, even more so that the proposed landscape is in a low lying vulnerable coastal area and a border region with Mozambique.

The proposed landscape is undergoing rapid change from a near-natural baseline with major implications for the strongly coupled social ecological system. Due to these close linkages there is a prime opportunity to observe the feedbacks between these, where they break down and shift the coupling of the system (e.g. if water came in from elsewhere (piped) what would happen versus a continued reliance on the local resources) or where they reinforce to a complete state collapse. Will the coupling increase over time with feedback to moderate or will it result in a breakdown?



[5]

Figure 36: Taken from The Ingonyama Trust Board Strategic Plan 2015-2020 the map above demonstrates the extent of Ingonyama Trust land within KZN. (Back)

Top ranked landscapes meet the research needs of all the thematic areas

A unique attribute of this landscape is the fact that the groundwater aquifer is the only available water resource for human and ecological needs. It is dependent on rainfall for recharge with no contributing perennial rivers. The impact of LULCC in the terrestrial environment on the water resource is tightly associated. These two points, along with the functional coherence of the landscape make it the ideal model of understanding global change impacts while also being of critical importance due to the regions high vulnerability and risk of global change because of these characteristics. The linked terrestrial and aquatic systems, with influences on and by the marine environment, make and ideal model for observing ecological biogeochemical processes and collaborator interests spans the physical, biophysical, biogeochemical and ecological across the terrestrial and aquatic systems as well as the marine. Carbon rich wetland peatland systems in various stages of intactness are ideal for measuring the implications of global change processes on the carbon (and water) dynamics in a system undergoing change and has implications for focusing attention on restoration initiatives (reactive) relative reevaluating landuse and water user/ licensing compliance (mitigating). The strong dependency of natural resources with limited alternatives for economic livelihoods, coupled with the stems dependency on localised rainfall (thus vulnerable to climate change impacts), make this region ideal for early detection of anthropogenic impacts on social ecological systems where causal effects and impacts can be feasibly measured using systems approaches. The region is an ideal case study for socio-economically vulnerable populations elsewhere in Africa, particularly in coastal areas.

APPENDIX C: DWS PORTFOLIO

The following assessments and background information are available via the on line “Evidence file” to supplement this proposal submission

- Aquifer of international significance
- Relevant policy and legislation framework
- DWS implementation strategy report 2017
- DWS RQO and inventory
- Lake Sibaya Intermediate EWR – Volume 1 - Ecoclassification Report.
- Lake Sibaya – Volume 2 - Intermediate EWR Assessment Report.
- Lake Sibaya EWR – Volume 3 - Specialist Reports.
- Lake Sibaya – Volume 4 - EcoSpecs and monitoring programme.
- Kosi Estuary Rapid Environmental Water Requirements Determination, Volume 1 - EWR Report.
- Kosi Estuary Rapid Environmental Water Requirements Determination, Volume 2 – Specialist Reports.