NORTHERN DRAKENSBERG
EFTEON LANDSCAPE PROPOSAL

Submitted by

SAEON Grasslands-Forest-Wetlands Node and Ezemvelo KZN Wildlife

With input and support from collaborators (listed in Appendix A)

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1. OVERVIEW OF AND OPPORTUNITY PRESENTED BY THE NORTHERN DRAKENSBERG TO ACT AS AN EFTEON LANDSCAPE

The proposed landscape forms part of the Northern Drakensberg Strategic Water Source Area (SWSA) in the upper uThukela catchment (V11 and V13), stretching from Royal Natal to Giants Castle and across to include Spioenkop Nature Reserve, Bergville and Winterton, with a satellite site area of Zingela/Emaweni on the uThukela river between Colenso and Weenen (Figure 1 and Figure 2). The landscape includes a vast tract of the protected, near pristine UNESCO World Heritage Ukhahlamba Drakensberg Park which falls under the management of Ezemvelo KZN Wildlife (EKZNW), contrasted with the heavily engineered Thukela-Vaal Pump storage scheme. The Northern Drakensberg, which is part of a recognised biodiversity hotspot, falls primarily in the grassland biome with small, scattered patches of Afrotemperate forest. Whereas, the satellite site of Zingela/Emaweni falls within the savanna biome. The complex terrain and high levels of endemism make the landscape sensitive to global change. There is a heavy dependence on the ecosystem services this landscape provides at national, regional and local scales with the livelihoods of the local population closely linked to the natural resources and ecosystem integrity. High soil carbon stocks and the catchments' substantive contribution to the country's water resources, coupled with trends in land transformation impacting on these ecosystem functions provide a development context of national significance in which to understand global change impacts on ecosystem functioning along a river course from point and plot scale to cumulative downstream impacts. The altitudinal and land cover/land use gradients, are ideal for assessing change over time (or space-for-time approaches) in a linked terrestrial aquatic system. Long term observations in this location offer significant potential to advance the EFTEON global change science agenda while also providing evidence based information to inform the sustainable management of a national priority catchment with high biodiversity and carbon value. Rural landscapes, such as the Northern Drakensberg, provide much of the water, food and energy resources that the country requires. Yet, like in other rural landscapes, complex socio-ecological challenges are emerging with respect to land use practices, resilience and the role of the landscape in land use based climate change mitigation. Land use choices within the landscape will influence the net outcome of local resilience, influence downstream societies and ability of the landscape to contribute to the country's land use based mitigation targets. Protection and restoration to ensure optimum functioning of rural landscapes should underpin rural development and downstream urban expansion.

There is a long history of environmental research in the proposed landscape that has strongly influenced policy and management at a regional and national scale in addition to advancing understanding across a range of disciplines (Toucher *et al*., 2016). Vegetation structure, composition and diversity surveys have been established with some having been run for almost half a century, and have provided an invaluable contribution to the scientific rationale of veld management and burning policy of temperate grasslands in the country (Tainton, 1999). These surveys are positioned to assess the influence of land tenures, fire and grazing (de Villiers and O'Connor, 2012; Granger, 1984; Gordijn *et al*., 2018; Morris *et al*., 2020), plus the relationship of diversity with ecosystem processes. The Cathedral Peak research catchments that were established in 1945 fall within the landscape (Figure 2). These catchments have been instrumental in developing South African hydrological research and have provided much of the evidence base for the country's water and forestry policy.

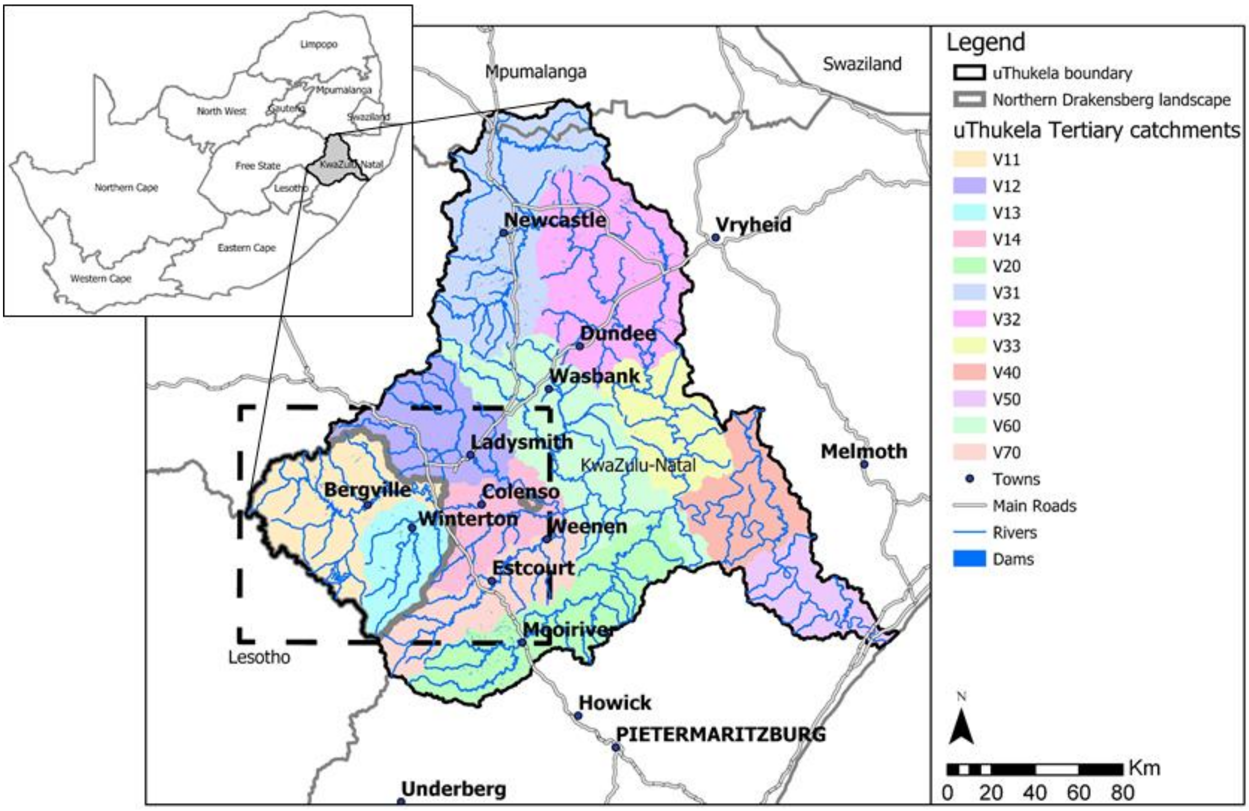

Figure 1: Location of the Northern Drakensberg proposed EFTEON landscape within the uThukela primary catchment.

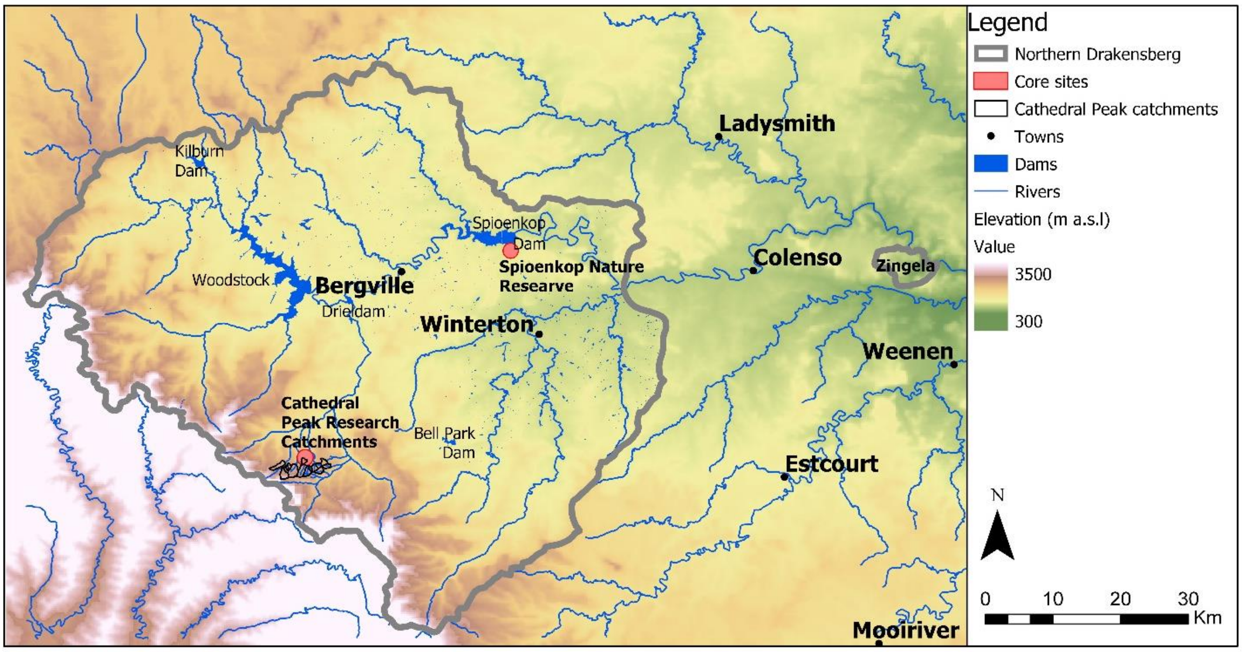

Figure 2: Northern Drakensberg EFTEON landscape showing elevation across the landscape, proposed joint core site and key reservoirs

Beyond this several notable socio-ecological studies have been undertaken in the landscape. The proposed core site/s fall within the protected areas managed by EKZNW. The joint development of this proposal, and more importantly, the long history EKZNW has of supporting and facilitating research activities in the protected areas, ***demonstrates the long term security of access*** to the sites by researchers. For example, the support of the current research activities in the Cathedral Peak research catchments and Brotherton burning trials by EKZNW. This is teamed with the long term community support of research activities in the landscape, for example, support and interest shown by both commercial and small holder farmers in no-till research activities. Research activities within the protected area need to go through an already well established EKZNW approval process. Furthermore, the Cathedral Peak research catchments are designated as a research area within the World Heritage site; further demonstrating the support of research activities by EKZNW.

The extent of the collaborator list, including academics, land custodians, NGO's and governmental authorities, from diverse disciplines and institutions (APPENDIX A) demonstrates the broad interest in the landscape. The current collaboration by scientists and stakeholders in the landscape, (i) from numerous national and international institutions, (ii) some who have had a long history of involvement in the area and others who are working in the area for the first time, ***demonstrates the accessibility of the landscape to researchers***. Further to this, although the core research infrastructure in the Cathedral Peak research catchments belongs to SAEON, additional equipment has been deployed by colleagues from other institutions, for example from Université de Bourgogne, for their specific needs, providing proof of concept for the feasibility of this landscape to facilitate high level science and evidence of the ***accessibility for the deployment of additional long and short term research infrastructure.*** The heavily instrumented Cathedral Peak research catchments have been established as a Long Term Ecological Research (LTER) site with the data accessible and available to national and international academics and researchers. A ***wealth of historical and contemporary datasets are available*** for the landscape, and these to a large extent, have been catalogued.

By building on the synergies between the EFTEON conceptual design and the current SAEON Cathedral Peak LTER site, a research infrastructure platform that ***spans an extensive altitude and vegetation gradient in a strategic water source area with nested scales and catchments***, encompassing a major altitudinal limited biome boundary between the savanna and grassland systems within the country becomes feasible and cost effective. It is proposed that the core EFTEON site be located at a lower altitude, such as at Spioenkop Nature Reserve (managed by EKZNW), in an area of transition between the grassland and savanna biomes where options for several sites in near-natural vegetation are suitable for the deploy of micrometeorological equipment. Satellite sites in neighboring smallholder and commercial agricultural areas, as well as in the more arid, savanna area of Zingela/Emaweni to expand the transect are suggested. This area encapsulates the linked altitudinal and climatic controls on these ecosystems. Further to this, the ongoing long term comparative ecohydrological and flux measurements in the low lying Maputaland Coastal Plain by the SAEON Grasslands node allows for comparison and pairing of a high altitude temperate site with a tropical and subtropical coastal system. At several sites within the landscape the ***opportunities exist and a proof of concept for the use of experiments and manipulations to observe environmental processes***. For example, the fire exclusion catchment of the Cathedral Peak research catchments, the Brotherton burning trials, the Nutnet experiment, and the previous studies related to no-till farming practices in both the smallholder and commercial agricultural areas. At the satellite site of Zingela manipulations or experiments could include, for example, various restoration activities, or managing livestock grazing with ecotourism.

The long term historical data available in the landscape allows for nationally relevant questions around the impacts of environmental change on biodiversity, water resources and other ecosystem services to be addressed. With part of the landscape falling into a World Heritage site, through co-generation approaches, the potential to address questions related to the conflict between protected areas and neighbouring communities, the economic benefits of the protected areas and the sustainable use of these landscapes exists. The landscape provides the opportunity to address questions related to ecosystem structure, function and processes as well as land-atmosphere interactions and processes; anthropogenic impacts on those ecosystems and the dynamics between and within the socio-ecological systems. Given that the Maloti-Drakensberg is a centre of floristic diversity and endemism, it provides the opportunity to address unique biodiversity related questions. The nested scales within the landscape, from vegetation plots, small headwater catchments to larger tertiary catchments allow for scaling questions to be addressed, and integration of impacts through the catchment. A more detailed set of suggested potential questions is provided in APPENDIX B: Potential research questions the landscape is suited to addressing.

Understanding the patterns of land use and the drivers of change in rural landscapes across South Africa are important in the development context, and a holistic understanding of how these patterns and drivers vary within and between different landscapes is needed. The social ecological component aspects undertaken in the Northern Drakensberg would be intentionally designed to understand changes in different social ecological systems across different climatic and ecological zones within the landscape and to be comparable to other EFTEON sites.

In the sections which follow the suitability of the Northern Drakensberg as an EFTEON landscape will be further detailed. Chapter 2 characterises the landscape, whereas Chapter 3 unpacks the changes that have occurred in the landscape, and those projected to occur. The logistical and operational suitability is described in Chapter 4 and a stakeholder analysis presented in Chapter 5. The Appendices contain supporting information.

2. CHARACTERISTICS OF THE NORTHERN DRAKENSBERG LANDSCAPE

The proposed landscape ranges in altitude from over 3 000 m in the protected areas of the uKhahlamba Drakensberg park to approximately 700 m in the lower lying areas of Zingela in the uThukela valley. This altitudinal gradient is strongly associated with the climatic variability, with the Mean Annual Precipitation (MAP) of the landscape ranging from approximately 1 600 mm in the high altitude areas to 650 mm at the satellite site of Zingela. Correspondingly the vegetation is diverse.

2.1 Significance of the Landscape

Montane regions are renowned natural resource centres, host phenomenal biological diversity, and characterised by areas in which climatic conditions change rapidly over short distances along altitude gradients; making these invaluable natural laboratories. The synergistic influence of land use changes, propensity to biological invasions and sensitivity of high altitude areas to warming make mountain ecosystems some of the most vulnerable under global change.

The Northern Drakensberg is part of a recognised biodiversity hotspot, holding a large number of endemic and threatened animal and plant species, as well as the uKhahlamba Drakensberg National Park being a designated Ramsar wetland. Mountain biodiversity is considered some of the most vulnerable under global change. The temperate grasslands of the study area, globally represent some of the most transformed biomes (Hoekstra *et al*., 2005), and in South Africa only 2% of these grasslands are protected while 65% were considered in various stages of degradation (Carbutt and Martindale, 2014). The proposed landscape forms part of the Drakensberg Mountain Centre of plant diversity (1300 to 3500 m a.s.l) that has a total of ±2 500 species with a high endemism level of 9% (Carbutt, 2019). Additional centres of plant endemism, falling within the landscape at lower altitudes, are being described (Mucina *et al*., 2006; Carbutt, 2019). The native faunal diversity is largely restricted to conservation areas which contains critical habitat and breeding sites for many vulnerable to critically endangered mammal and bird species (Mkize *et al*., 2012), and is known as an important part of the centre of herpetofaunal diversity in southern Africa (Branch *et al*., 2014).

The proposed landscape is a large part of the Northern Drakensberg SWSA (Le Maitre *et al*., 2018). The Northern Drakensberg SWSA generates 4.94% of South Africa's mean annual runoff (MAR), meeting 18.9% of the Vaal systems water needs through the Thukela-Vaal transfer scheme, as well as the water demands of the towns located in the uThukela catchment including Richards Bay. The Thukela-Vaal transfer scheme, or alternatively known as the Drakensberg Pumped Storage scheme, is an example of where power and water need to work together. The pump storage scheme can generate electricity for up to 10 hours, contributing 1000 MW to the national electricity grid during peak periods. Beyond the regional and national reliance on the water, many communities are directly dependent on the rivers flowing from the Northern Drakensberg area. Understanding of the socio ecological system and climate impacts on the ability of the area to supply water resources is of paramount importance at a national, regional and local scale to the well-being of society and economic sustainability both in the short and long term.

Notably, approximately 60% of the national carbon stock is found in grasslands, with 89% of the Carbon (C) stock in the soil (White *et al*., 2000; Eze *et al*., 2018), primarily in the form of soil organic C. The grassy layer of the Northern Drakensberg landscape is maintained by both fire and climatic factors, for example, the influence of the distribution of precipitation and temperature on plant growth, carbon cycling, leaching and soil erosion (Albaladejo *et al*., 2013; Eze *et al*., 2018). The same factors that maintain the grassy layer could be enhancing the C sequestration potential of these grasslands. For example, cold temperatures delay organic matter decomposition and reduce microbial activity which ultimately reduces the amount of CO_2 released to the atmosphere (soil respiration), having a consequential increase on the amount of stored C in the soil (Anderson, 1991; Hawkes *et al*., 2017). Furthermore, high rainfall and fire boost the recovery of grasses, their productivity, and their ability to absorb CO_2 from the atmosphere. Unlike trees, two-third of grassland productivity is underground, with an extensive amount of C stored underground as opposed to aboveground. Preliminary findings are showing unprecedented high soil C pools in these Northern Drakensberg grasslands. Fire adds an important dynamic into the C sequestration potential of these grasslands because fire is arguably responsible for adding CO_2 into the atmosphere. However, less acknowledged is the contribution of fire to C storage through fire-driven C (e.g. charcoal or ash) termed pyrogenic organic C which is considered the most stable form of C. A large portion of this C is transported by streams as particulate and dissolved organic C (i.e. Dissolved pyrogenic C), and understanding the movement of soil C into water resources is gaining interest. The Northern Drakensberg landscape offers the opportunity to explore these carbon-water interactions, hydropedology and soil C dynamics across an altitudinal gradient, under varied land cover/land use and management thereof including degraded areas, and a changing climate. The carbon stocks and carbon sequestration potential of these grasslands make them of regional and international importance.

As characterised by the UNESCO World Heritage status, the Drakensberg area has a rich social history and the greatest wealth of rock art paintings south of the Sahara (Ndlovu, 2016). There are approximately 690 rock art sites, with over 35 000 individual images (UNESCO 2019), with many of these falling within the proposed landscape. The rock art in the area has been extensively researched, with findings indicating that the San were the authors of most paintings in the Drakensberg area with the earliest painting being dated to approximately 3 000 BP and continuing until the 20th century. It is believed that from around the 13th century, Iron Age agriculturalists came to live side by side with the San in the area (Ndlovu, 2016). The San attached spiritual significance to the rock art, as do their descendants who have been absorbed into communities in the area (Ndlovu, 2016). Whereas for other communities in the area, the significance of the mountain ranges is through non-spiritual attributes. At the satellite site of Zingela tools dating to 200 000 years BP and rock art sites have been found along the cliffs although thorough surveys are still to be carried out. Iron smelting sites have also been noted. The region is steeped in the history of the Zulu Empire and the interactions between it and the British Empire, demonstrating the rich cultural heritage of the proposed landscape area.

The rich cultural and social history, the high levels of biodiversity, the carbon stocks and carbon sequestration potential, the national and local dependence on water supplies from the landscape makes the landscape of international, national and local significance. Although research has been extensive in the area, there are still vast gaps in knowledge and understanding, with numerous growing challenges and pressures on society and the landscape under global change.

2.2 Significant Land Cover types within the Landscape

The two main biomes covered by the proposed landscape include savanna and grassland; the south western portion of the area borders on C_3 alpine grasslands from which there is a significant transition zone or ecotone to lower altitude C_4 grasslands to the east (Figure 3). The savanna biome is concentrated below 1 000 m a.s.l. at the satellite site, Zingela (Table 1). Within the grasslands there are scattered patches of evergreen Afrotemperate forest and gallery forest or macrophyllous thicket at lower elevations on cooler, moist and/or fire protected areas (Mucina and Rutherford, 2006).

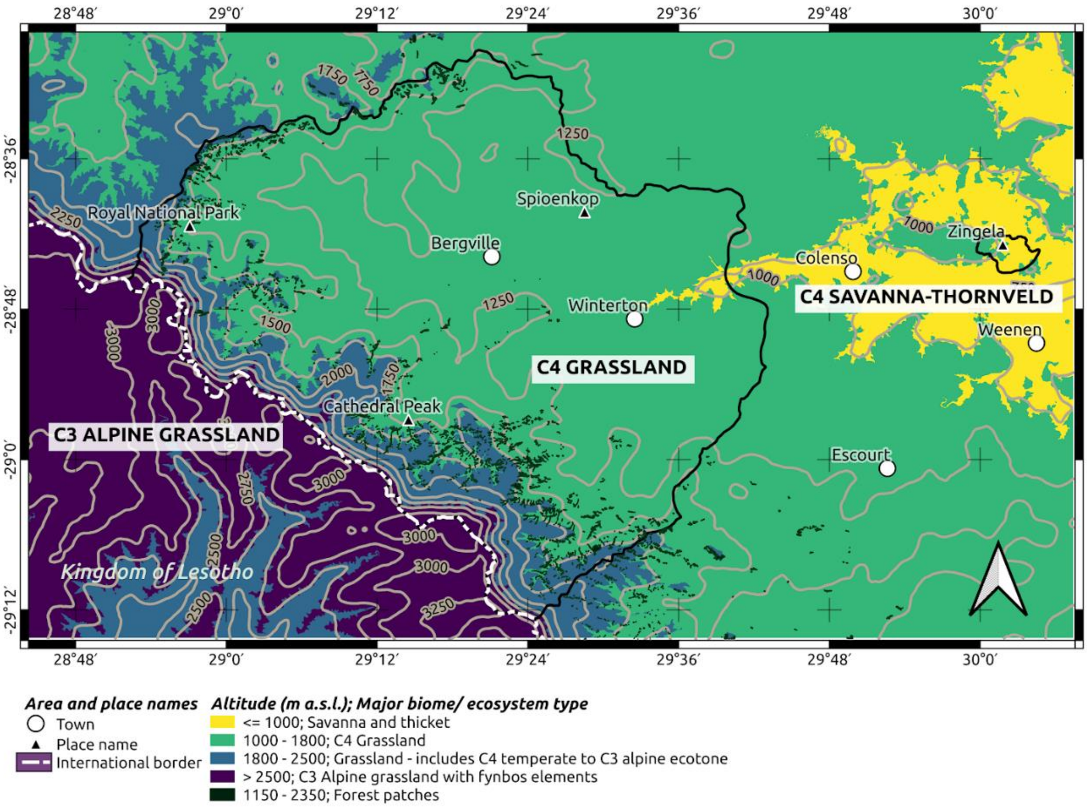

Figure 3: The major biomes (grassland and savanna) and vegetation types summarized by associated altitude (Table 1). Scattered patches of evergreen forest are concentrated between 1150 and 2350 m a.s.l. (SANBI, 2018).

2.3 Socio-Ecological context of the Landscape

The social history of the landscape is rich, dating back to the pulsed San habitation of the area from 25,000 BP (Mazel, 1989; Ndlovu, 2016). There has, and continues to be, a heavy dependence on the natural resource base by those living in the landscape. From meeting basic survival needs and spiritual needs, to the economic activities in the area.

Table 1: Biomes and vegetation types described by their associated median and altitude range (SANBI, 2018)

Biome	Vegetation type	Altitude (m a.s.l.) range		
		Median	Min.	Max.
Grassland	Mooi River Highland Grassland	1503	1288	1791
Savanna	Thukela Valley Bushveld	902	657	1479
Grassland	Basotho Montane Shrubland	1765	1452	2166
Grassland	Drakensberg-Amathole Afromontane Fynbos	1874	1464	2490
Grassland	Eastern Free State Sandy Grassland	1718	1620	2223
Grassland	Income Sandy Grassland	908	825	1098
Grassland	KwaZulu-Natal Highland Thornveld	1124	940	1567
Grassland	Lesotho Highland Basalt Grassland	2605	1808	3083
Grassland	Drakensberg Afroalpine Heathland	3057	2709	3461
Grassland	Drakensberg Foothill Moist Grassland	1485	1182	2013
Grassland	Eastern Free State Sandy Grassland	1796	1651	2122
Grassland	Low Escarpment Moist Grassland	1606	1156	2040
Forests	Northern Afrotemperate Forest	1653	1138	2349
Grassland	Northern Drakensberg Highland Grassland	1809	1347	2356
Grassland	Northern KwaZulu-Natal Moist Grassland	1206	966	1658
Forests	Southern Mistbelt Forest	1743	1179	1845
Savanna	Thukela Thornveld	1038	790	1583
Grassland	uKhahlamba Basalt Grassland	2130	1584	3349

The proposed landscape roughly aligns to the Okhahlamba Local Municipality area which is sparsely populated and predominantly managed through Traditional Authorities with a population of 135 132 (StatsSA Community survey, 2016). The area is characterised by high levels of unemployment (~43 % in 2011 census), poverty (StatsSA Community survey, 2016) and significant service delivery backlogs, with ~55% of households' dependent on agriculture. The economic activities of the region are heavily reliant on the natural resource base, from ecotourism to large scale commercial dryland and irrigated cropping, livestock and dairy agriculture (Figure 4). Also reliant on this same resource for livelihoods are smallholder farmers for their maize and livestock-based farming systems (Figure 4). The urban areas in the landscape are the towns of Bergville and Winterton, with rural intensification occurring adjacent to these towns (Figure 4). This landscape is under increasing threat from mining, fracking and intensive investment initiatives.

Years of overgrazing and inappropriate land management practices have heavily degraded parts of the landscape, manifested as reduced ground cover and high carbon rich soil loss (Asmal, 1995; Bangamwabo, 2009; Grellier *et al*., 2013). The strongly interlinked social and ecological systems, together with changes in climate, makes the need for sustainable and equitable management of land, water and soil crucial. However, the dependence on the natural resource base at multiple levels and scales, the varying levels of vulnerability and resilience, together with high levels of degradation makes sustainable management challenging and often leads to conflicts between the different groups in the landscape that are characteristic of many areas in South Africa, as well as conflicts over local and national interests. There are significant opportunities for research into the dynamic interrelationships between and within the water-ecosystem-society domains in this landscape and across scales, and the knowledge gained will aid in addressing these challenges.

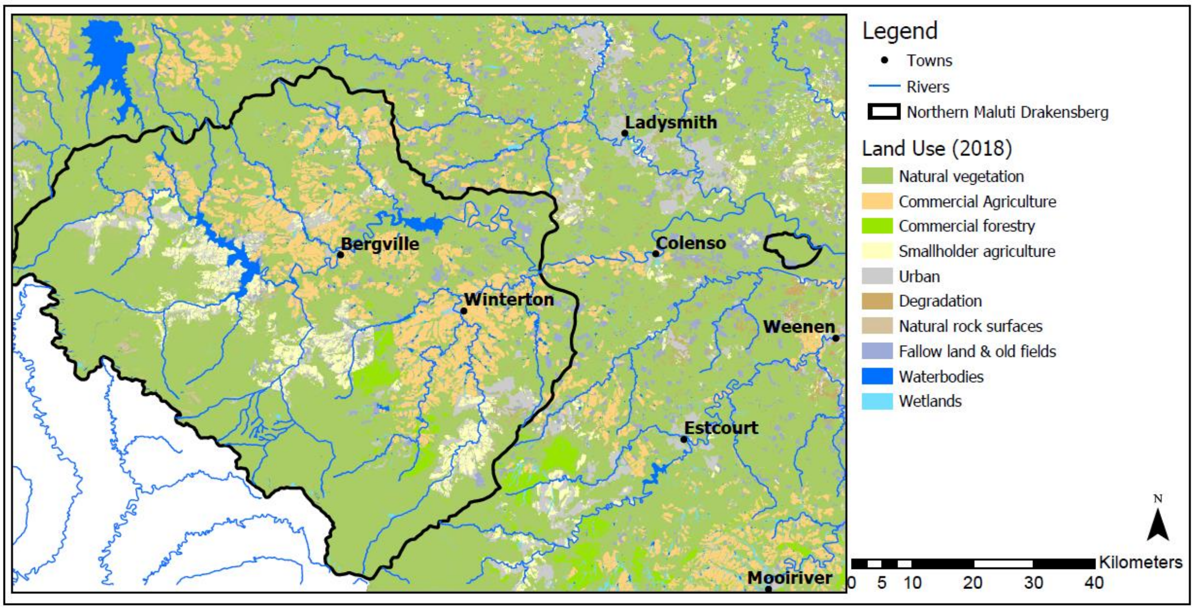

Figure 4: Broad grouping of land cover types in the Northern Drakensberg landscape (adapted from SANLC, 2018)

Due to lack of resources and other factors, the communities in this area have received little to no support related to water and sanitation services in their villages (significant service delivery delays), relying instead on very old infrastructure (pre 1994) and undeveloped water sources (springs and small streams) for their household water needs. There is little focus on agricultural and landscape-based water resource management. Climate change mitigation and adaptation processes have been limited to training and awareness within municipal structures, to enable development of environmental management plans. Smallholder farmers in these communities rely heavily on their natural resource base to support their non-commercial to semi-commercial maize and livestock-based farming systems. Irrigation infrastructure is virtually non-existent although some individuals use local sources for vegetable production at household level. Grazing management systems are managed by the Traditional Authorities and for the most part are limited to setting annual dates for the cycles of livestock being moved into the mountain grazing areas (summer) and being allowed back into the village confines (winter). To ensure their livelihoods, these communities have to start grappling with the natural resources management issues.

In the protected areas, trans frontier crime including cattle theft, firearms and illicit drug trafficking through the Parks, arson fires, poaching and illegal hunting, alien vegetation and increased soil erosion due to the creation of additional trails for illicit activities or poorly maintained trails are some of the challenges being faced by the those responsible for the management of these areas coupled with decreasing budgets and a changing climatic conditions (Kruger, 2007). During times of climate extremes, such as the 2015/2016 drought, there is increased pressure on the protected areas by the adjacent communities, leading to increased conflict between conservation mandate and community needs.

The socio-ecological interactions in the landscape are not unique to this area, for in many areas in South Africa there is a strong dependence on a degrading and constrained natural resource base for livelihoods and economic development by different communities at multiple scales. Establishing the Northern Drakensberg as an EFTEON landscape will facilitate the research into the dynamic interrelationships within and between the social and ecological systems, with the knowledge gained giving insights for areas with similar challenges.

2.4 Coupling of the Terrestrial and Aquatic systems in the Landscape

Aquatic ecosystems are strongly influenced by the terrestrial environment. The Northern Drakensberg aquatic ecosystem consists of an interconnected system of wetlands, including mountain tarns, peatlands and marshes, and a network of streams and river courses with associated riparian areas. The river systems in the mountainous, protected areas of this landscape are oligotrophic and characterised by steep gradients. Isotopic studies on food webs in the Drakensberg have shown clear cross-ecosystem links between aquatic and riparian habitats. Moreover, the riparian habitats are important areas for bi-phasic life history keystone species in the aquatic ecosystems (for example, amphibians and odonates). The aquatic biota are adapted to fast-flowing, highly oxygenated water with excellent water quality. This means that the aquatic systems are highly sensitive to increases in sediment loads and nutrients, and increases in water temperatures. Not only are the riparian zones critical for maintaining good aquatic ecosystem health, but also the terrestrial habits within the broader catchment context are intimately linked to healthy aquatic ecosystems. The latter relates specifically to stormflow and baseflow regulation for the rivers in this area, and sediment fluxes. High stream power in these rivers makes them particularly sensitive to erosion; the oligotrophic nature of these rivers makes them highly sensitive to small changes in sediment loads and nutrients. Moving out of the protected areas, the natural gradients in the river's energy and species turnover are disrupted. Thus, the aquatic ecosystem reflects the climate, and changes thereof, of the terrestrial environment as well as the land cover/land use and management.

The uKhahlamba Drakensberg National Park is designated as a Ramsar site (Natal Drakensberg Park) with a large number of wetlands occurring in these high altitude areas. Outside of the protected areas, the landscape is also rich in wetlands, however many of these have been disturbed by anthropogenic activities. With the area being a SWSA, these wetland systems are of enormous importance, as wetland systems are fundamental units of the hydrologic landscape and the main filter for water and solute transport from the atmosphere to the stream (Graham *et al*., 2015). Wetland systems of the area deliver a wide array of ecosystem benefits and have high levels of endemism. Many of these wetland ecosystems are threatened by and vulnerable to global change, with unanswered questions on how global change will impact on the desiccation regimes and seasonality of these systems.

As water and material are constantly moving downslope, water inputs are primarily via subsurface flows from an up-slope direction. Water movement through wetland systems is mainly in the form of interflow (Kotze *et al*., 2012). And thus, the attenuation of water within the landscape is higher within wetland systems. This attenuation of water allows for the settling out, or filtration of sediment, soil organic carbon (SOC) as well as other minerals. It is estimated that 20–30% of the Earth's soil pool of carbon (Lal, 2008) is stored in wetlands (Roulet, 2000; Bridgham *et al*., 2006), although wetlands comprise only about 5–8% of the terrestrial land surface (Mitsch and Gosselink, 2007). Soil carbon results from samples analysed from the wetland systems in Cathedral Peak indicate average values of 10% C in top soils and 7% C in the subsoil samples (Harrison, 2020). This is corroborated in a study by Chatanga and Sieben (2019) in which wetland systems in the Northern Drakensberg were identified to have high carbon sequestration and storage capacity**.**

Mompati *et al*. (in press) show that the Northern Drakensberg appears to experience some of the highest wet deposition loads of sulphur and nitrogen in the country. What the impacts of this atmospheric deposition on the terrestrial and aquatic ecosystems will be is largely unknown; however, the levels exceed those known to have caused change in some northern hemisphere systems.

Not only are the high altitude wetlands threatened by global change, they also offer the opportunity through palaeoenvironmental studies to reconstruct vegetation, climate and pollution histories in the region and determine trajectories of environmental change.

3. THE NORTHERN DRAKENSBERG LANDSCAPE IN THE FACE OF GLOBAL CHANGE

The Northern Drakensberg has only relatively recently been subjected to extensive anthropogenic occupation and transformation. Occupation of the Northern Drakensberg by San people groups from 25 000 BP was typically pulsed and at low densities (Mazel, 1989). From 600 BP, San settlement intensified and notably, with the arrival of bantu agropastoralists from the lower Tugela basin (near Zingela where occupation is known from CE 550) fire usage and use of the landscape intensified towards the 20th Century (Wright and Mazel, 2007). Over the last 150 years commercial agriculture has vastly transformed arable grassland (Figure 5). The landscape presents an opportunity to compare near-natural protected areas, transition areas, highly degraded areas, smallholder farmer areas and more intensive commercial agricultural areas. The synergistic influence of land use changes and transformation plus the sensitivity of mountain ecosystems to climate change make mountain ecosystems particularly vulnerable to global climate change.

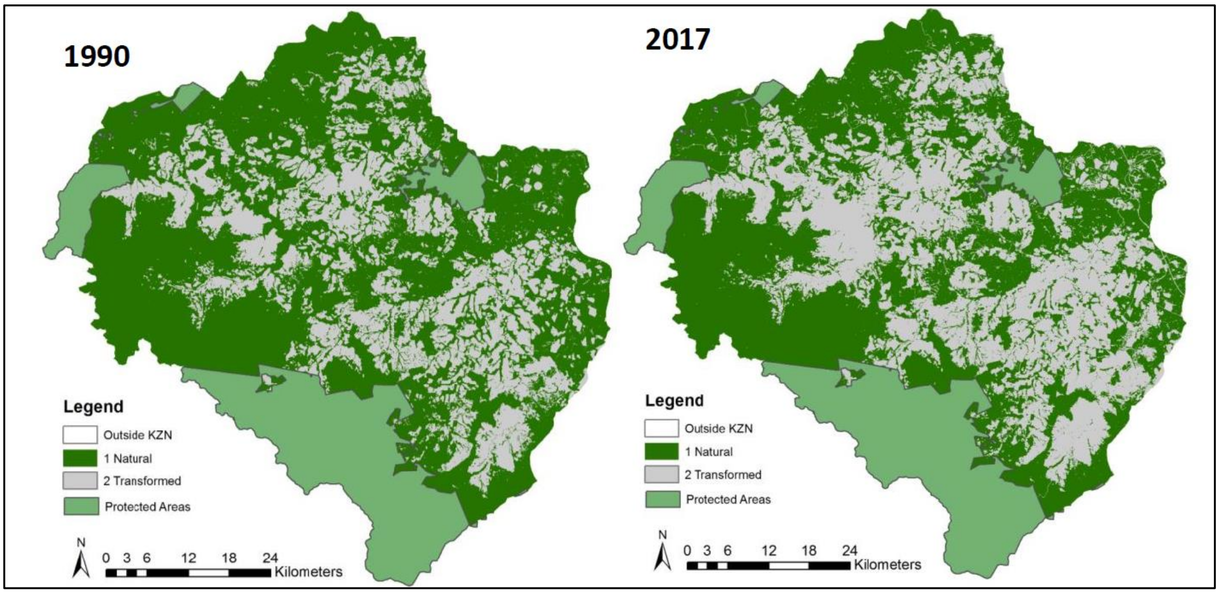

Figure 5: Change in transformed and natural land cover inside and outside of protected areas from 1990 to 2017 using comparable classification (Jewitt *et al*., 2015; Jewitt, 2020).

3.1 Biome and ecosystem shifts in the face of global change

A significant portion (66 761 ha or 20%) of the proposed landscape is protected area and considered near-natural or 'pristine' (Jewitt *et al*., 2015; Jewitt, 2020). Recurrent fire and winter frosts are critical for maintaining these mesic grassland and savanna areas in an open state. Before the intensification of human settlement in the area, seasonal fires were driven by lightning ignition (Mucina and Rutherford, 2006). Outside of protected areas, intensifying grazing regimes threaten the biodiversity of these grasslands, and increases their vulnerability to woody shrub and tree ingression. However, even within protected areas, CO_2 fertilisation of C_3 woody species, particularly over the last century, has made these areas vulnerable to woody ingression (Grellier *et al*., 2012). The ingression of woody species from lower to higher altitudes in the proposed study area represents an important ecotone or transition zone which provides an indication of warming temperatures, moisture regimes and increased atmospheric [CO_2] (Figure 6).

Shifts in biological communities have cascading consequences for ecosystem functioning and their associated services. Under the predicted warmer conditions, species from lower altitudes are predicted to move to higher elevations. Montane biodiversity is particularly vulnerable with the encroachment of woody savanna species and expansion of thicket into grasslands (Bentley *et al*., 2019; Silveira *et al*., 2019). High altitude communities are bounded by the maximum elevation of the Drakensberg and are considered particularly vulnerable to the effects of warming. It is known that with the expansion of woody species or less flammable C_3 grasses into C_4 grasslands that fire can be suppressed; consequently, the rate of woody and C_3 grass ingression into grassland may increase (e.g. McGranagan *et al*., 2013). These shifts in biomes/ecosystems pose threats to endemic grassland diversity.

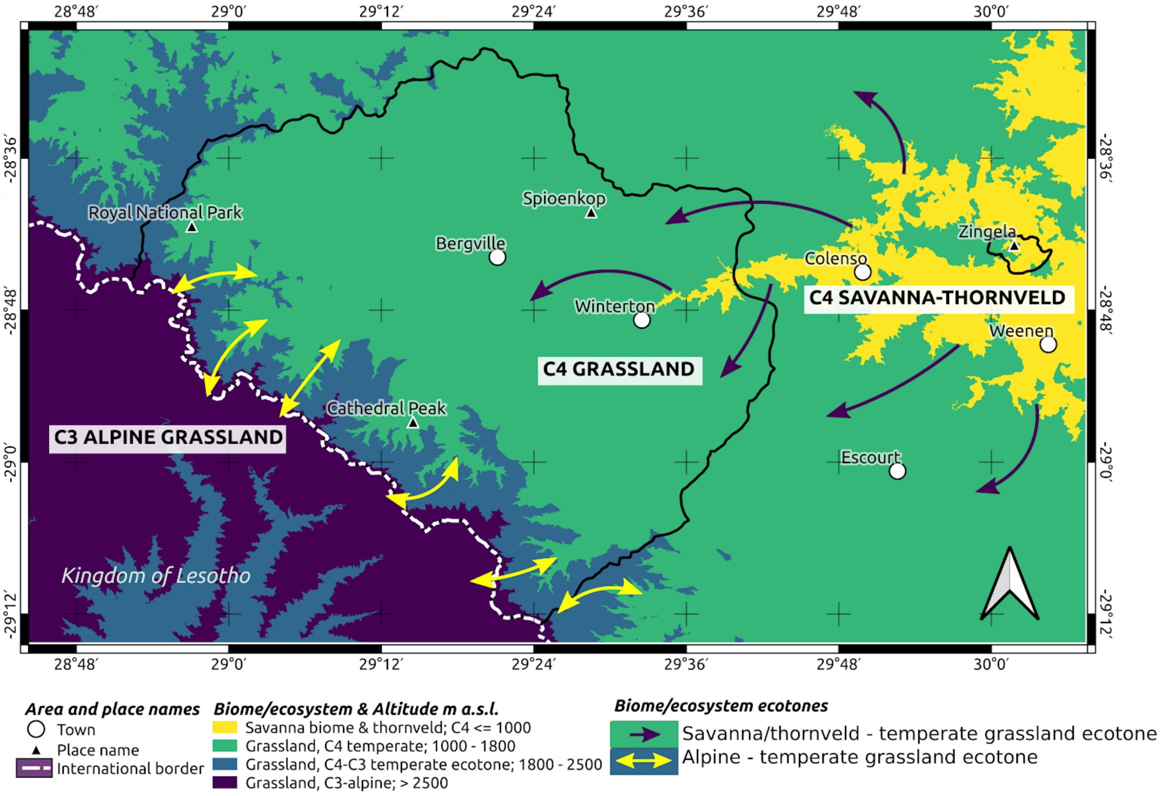

Figure 6: Schematic of selected altitude associated ecosystem transition zones within the study area. With increasing temperature and atmospheric CO_2 fertilization high altitude C_3 grass communities may either retreat to higher altitudes where possible, or with increasing [CO_2] expand to lower altitudes. Over the last century woody elements have ingressed from low to high altitude grassland (Gordijn, unpublished data, 2020; Grellier *et al*., 2012).

3.2 Land use change in the landscape

In 1990, 32 % of the landscape outside of the protected areas had been transformed and by 2017, this had increased to 42 % (Jewitt *et al*., 2015; Jewitt, 2020; Figure 5). Additionally, much of the remaining near-natural land cover may be being used for commercial and communal rangelands, with varying intensities. Shifts in biome/ecosystem boundaries, as described above, are problematic for the many commercial and communal rangelands. The ingression of woody species into grasslands and heavy grazing in the landscape has been associated with soil degradation, gully formation and hydrological functioning plus rangeland productivity (Grellier *et al*., 2013).

The dominant land uses in the landscape are commercial and smallholder agriculture, rural and urban settlements (Figure 7 and Figure 8). These land uses have remained the dominant between 1990 and 2017, increasing in extent. The land cover classifications differ between 1990 and 2017, and the resolution of the mapping improved. Thus, a direct comparison could not be made but a few aspects can be highlighted. Commercial agriculture in the landscape includes dryland and irrigated cropping and orchards, dairy and livestock. Commercial agricultural fields and orchards, both irrigated and dryland, occupied approximately 12% of the landscape in 1990 and this increased by 1% by 2017. However, the portion that is irrigated was far greater in 2017, ~ 5% in 2017 whereas in 1990 it was ~1.5%. Subsistence or smallholder farming covers approximately 5% of the landscape area as defined in the 2017 coverage. Many of these areas were classified as urban villages in the 1990 coverage. The area of erosion in the landscape remained constant between 1990 and 2017 at ~0.6% of the landscape, with ~1.4% of the landscape being classified as degraded in 2017. This shows the extent of erosion and degradation in the landscape.

Associated with the Thukela-Vaal Transfer Scheme substantial surface water infrastructure has been constructed in the upper uThukela which has significantly altered downstream flows. The Scheme transfers 377 million m^3/annum (UW, 2019) from this area of the uThukela Catchment to the Vaal System; as well as facilitating the generation of electricity. In addition to this are extractions for irrigation and water treatment plants (WTP). The scheme consists of:

- Woodstock dam on the upper reaches of the uThukela River, which is the main source of water for the scheme, with a storage capacity of 373 million m^3;
- Driel Barrage is a reservoir downstream of Woodstock Dam with a storage capacity of 8.7 million m^3. Water is released from Woodstock Dam to Driel Barrage, from where it is pumped to a transfer canal (max. capacity of 20 $m^3.s^{-1}$) that feeds the Jagersrust Balancing Dam.
- Diversion weirs in the Upper Thukela River which divert run-of-river flows upstream of Woodstock Dam into the transfer canal, which flows in Jagersrust Balancing Dam.
- The relatively small Jagersrust Balancing Dam (capacity 0.476 million m^3), provides balancing storage at the end of the transfer canal from where water is pumped to Kilburn Dam;
- Kilburn Dam (capacity 27 million m^3), the lower reservoir in the Eskom pump storage scheme, provides both the storage for the transferred water and is a sump for the water discharged after electricity generation. From here, water is pumped up to Driekloof dam for use in electricity generation or, when Driekloof is spilling it transfers into Sterkfontein dam for releases to the Vaal catchment.

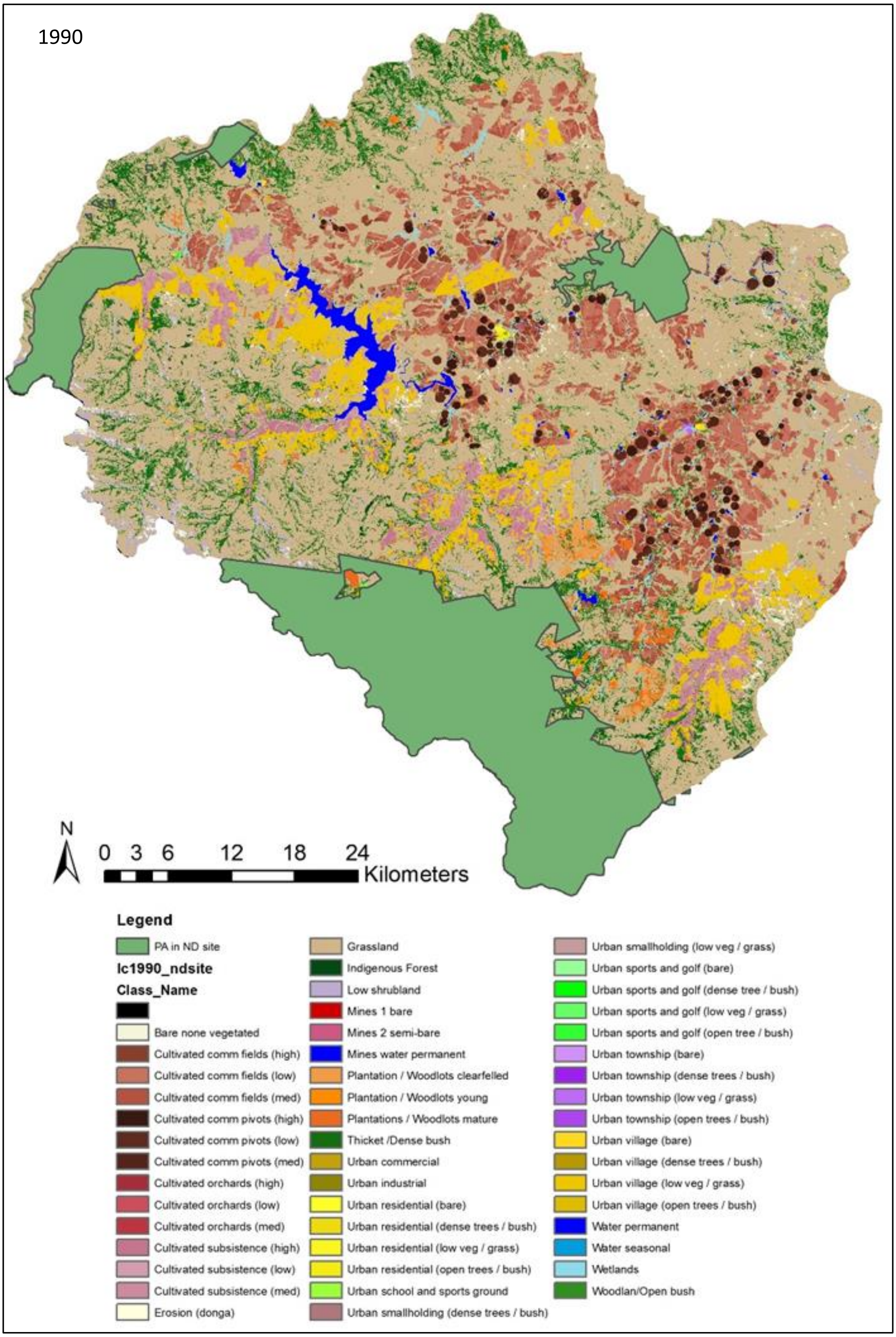

Figure 7: Land cover of the Northern Drakensberg landscape in 1990 (GeoTerraImage, 2016).

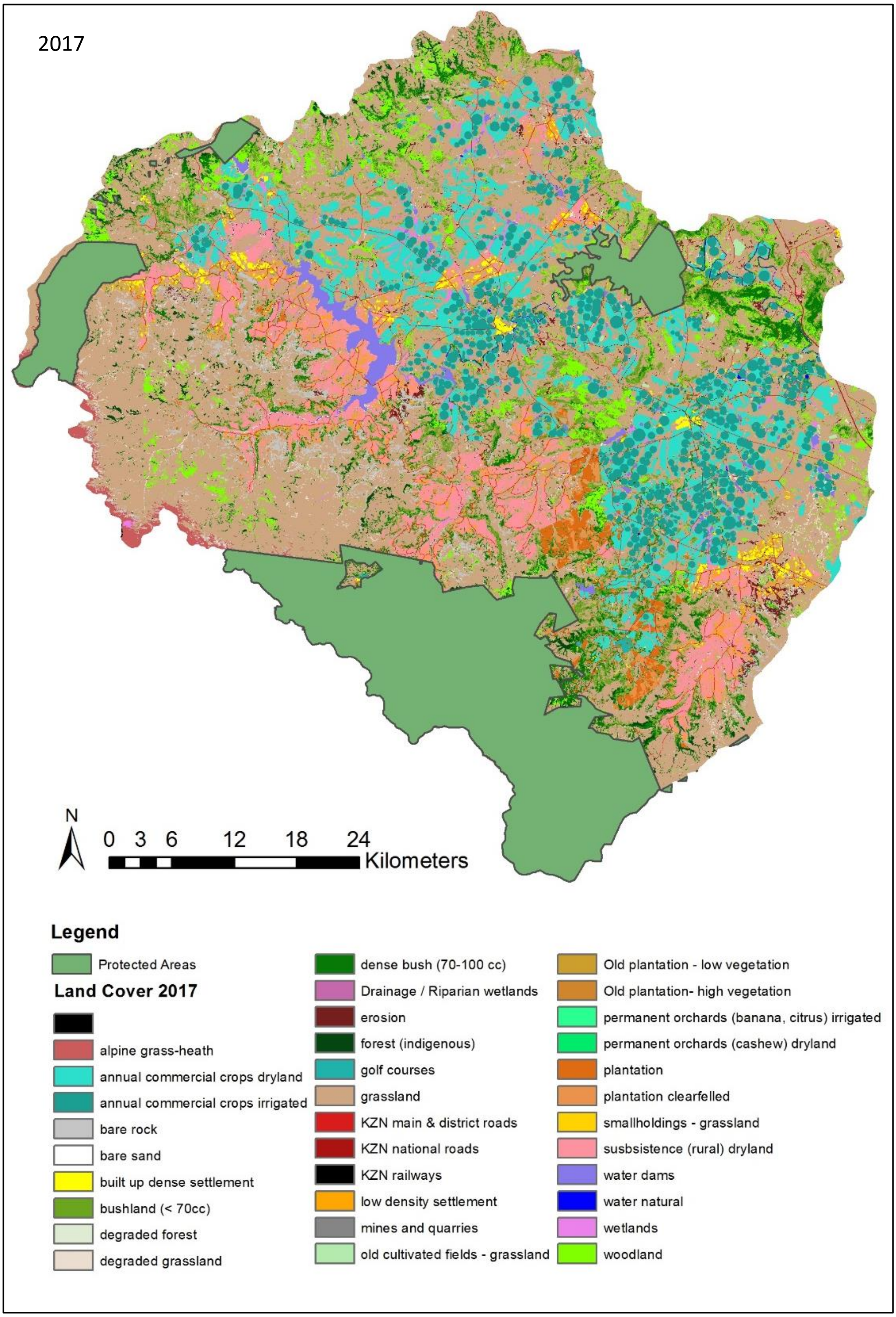

Figure 8: Land cover of the Northern Drakensberg landscape in 2017 (Ezemvelo KZN Wildlife, GeoTerraImage, 2018)

- Spioenkop Dam (capacity of 280 million m^3), downstream of Driel Barrage, was constructed to aid in mitigating the effect of the transfer scheme. The dam, operated by DWS has several functions, it supplies water to Ladysmith, meets irrigation water requirements between the dam and the confluence of the Little uThukela River, releases of water (when required) to dilute the effluent discharged by SAPPI into the Lower uThukela River near the river mouth and can support the Tugela-Mhlathuze Water Transfer Scheme at Middeldrift if necessary.

There are five WTP in the greater Okhahlamba Local Municipality area, namely Moyeni WTP, Langkloof WTP, Bergville WTP, Winterton WTP and Loskop WTP. The Moyeni, Langkloof and Bergville WTP's are upstream of Spioenkop dam. A preliminary assessment of the water availability in the uThukela catchment by DWS in 2018 concluded that "all available water (including Spioenkop Dam) has been allocated and it is evident that alternative options need to be considered to make more water available for the competing water users in the uThukela River System" (DWS 2018: 5 – 6). It was recommended that an updated hydrology and yield analysis of the uThukela catchment should be done and potential augmentation measures should be considered, one of which includes the raising of Spioenkop dam wall (UW, 2019).

The Zingela satellite site comprises two spatially contiguous, privately owned farms managed as conservation areas on the banks of the uThukela River roughly 200 km upstream from the river mouth, namely Emaweni (2500 ha) and Zingela (1200 ha). Zingela has not always been managed as a conservation area. Prior to 1983 it was a commercial farm, with areas under potatoes and drawing irrigation water from the uThukela river. Large mammals were reintroduced in the 80's and 90's and a low impact, ecotourism business was built around the natural assets of the area. Beyond the large mammals that were reintroduced, species such as aardvark, clawless otters, porcupine, leopard and spotted hyenas have recently been seen and appear to be making good recoveries. Several snake species are often seen, but notable is that Pythons are common particularly large female specimens at a time when in many areas such animals are disappearing suggesting suitable circumstances exist for the longevity of this species. Crocodiles were probably historically extirpated but, from unknown sources, they have now returned and move freely up and down the river. Overgrazing took place historically, leading to reduced carrying capacity and erosion, with gullies having formed over time. Invasive alien species, such as *Opuntia spp* (Prickly pear), are widespread. Questions remain over the extent of the impacts of overgrazing and extent of the invasive alien species, as well as the optimum management practices to address these issues. Allowing for the opportunity of experimental trials of various land management practices to be undertaken with the results and outcomes having a direct application.

3.3 Projected Climatic Impacts on the Landscape

Important areas for observing changes are those that are considered most vulnerable to change. An area considered to be one of the most vulnerable is mountainous regions (Beniston, 2003; Huber, 2005; Beniston and Stoffel, 2014; Moran-Tejeda *et al*., 2014) due to the communities in mountainous areas often being constrained by the natural resource base and the sensitivity of the physical environment (Beniston and Stoffel, 2014). Mountainous regions are considered as sentinels for environmental change; due to the large range of both physical and biological systems distinguishable in these regions, changes should be identifiable much earlier than in low land regions (Beniston and

Stoffel, 2014). However, mountains are not well instrumented regions (Kelleher *et al*., 2015; Di Matteo *et al*., 2017) hampering detection studies. This is coupled with most of the CMIP5 GCM models showing less skill in precipitation simulation over regions with complex topography.

Majozi (2017), for the Cathedral Peak catchments, found an increase in temperature and decrease in rainfall. However, the gap in data between the historical and contemporary monitoring periods, and the short contemporary period created uncertainty in the results. Nel and Sunmer (2006) and Nel (2009) considered the seasonal and inter-annual variability of rainfall finding no evidence of rainfall trends. However, no studies have comprehensively assessed long-term trends in the landscape.

The regional climate projections for the area produced by the CSIR CCAM model using six different CMIP5 GCM projections (8.5 RCP) agree on an increase in average temperature of between 3 - 4°C and a decrease in annual precipitation for the time period 2080 - 2100 relative to 1971 - 2000 (Archer *et al*., 2018). An increased fire risk for the region is also indicated. Dosio *et al*. (2019) who also indicated a drier future for the region found that uncertainty existed over the proposed landscape region in the projected change of many of the rainfall indices considered. The Drakensberg plays an important role in the local weather systems, with Koseki *et al.* (2018) providing evidence of the influence of the Drakensberg on synoptic-scale atmospheric circulation over the south Indian Ocean. Furthermore, Koseki and Demissie (2018), using regional climate modelling, showed the influence of the Drakensberg on the regional climate of southwestern Africa. Demonstrating the need for increased monitoring and climatic data in the landscape region to support detection of changes in climate and improvement in regional downscaling of the complex microclimates in the landscape.

3.4 Carbon Flows in the Face of Global Change

Climate variability influences the carbon cycle of terrestrial ecosystems. Temperature and humidity determine primary plant production and the carbon emissions (for e.g. CO_2, CH_4) resulting from the degradation of organic matter in the soil. Since (i) these linkages can act as an important feedback mechanism on atmospheric greenhouse gases, and (ii) they are the largest fluxes into and out of the atmosphere, understanding the links between climate dynamics and the carbon cycle in ecosystems is a major concern (Jenkinson *et al*., 1991; Davidson and Janssens, 2006; Bahn *et al*., 2010; Lu *et al*., 2013; Bradford *et al*., 2016; Hawkes *et al*., 2017). However, despite an impressive amount of scientific work over the past 20-30 years, there is still disagreement about how climate change is affecting global soil carbon stocks (Davidson and Janssens, 2006; Crowther *et al*., 2015; 2016; Bradford *et al*., 2016). The impacts of climate on soil carbon stocks are complex, non-linear and highly time-dependent. Carbon fluxes are controlled not only by average temperature and humidity, but also by their intra-seasonal spatial and temporal variability (Vargas *et al*., 2012; Räsänen *et al*., 2017). More than soil moisture, it is the frequency of rainfall events that accounts for variations in soil respiration (Degens and Sparling, 1995). In addition to climatic effects, land use and land cover appear to be the main factors controlling soil carbon dynamics (Raich and Schlesinger 1992; Raich *et al*. 2002). However, the cumulative effects of these two factors are not yet fully understood, even though they seem essential for planning effective adaptation and mitigation strategies in future scenarios of global climate and land use change (Lozano-García *et al*. 2017).

Much of South Africa's grasslands are considered degraded, leading to an overall decrease in the soil organic carbon stock, with an impact on ecosystems and the resources produced (Dlamini *et al*., 2014; Minasny *et al*., 2017). Current land management practices that alter the distribution of plant species, consequently alter the distribution of soil organic carbon (SOC) stocks and their quality (Bond-Lamberty *et al*., 2004). Soil organic matter (SOC) management should therefore become a major concern for the South African government, as current estimates show a decrease in C sequestration in grasslands (Dintwe *et al*., 2015). The study of pristine, transitional areas (C4, C3) is fundamental for estimating soil organic carbon supply and storage: production, composition and quality, stability and degradability.

Dissolved organic carbon is a key factor of the quality of freshwater ecosystems, especially in upland montane streams, because i) it is the primary source of food and energy in these kind of ecosystems (Brett *et al*., 2017; Maurice *et al*., 2002), ii) it filters solar UV radiations (Zuo and Jones, 1997) and iii) it supports the mobility of pollutants such as trace metals (Broadley *et al*., 2019) and hydrophobic organic compounds (Piccolo, 1994). Several studies have shown that, in similar climatic, morphological and geological conditions, soil and stream DOC concentrations directly depends on the vegetation cover (Amiotte-suchet *et al*., 2007; Sanderman *et al*., 2008; Gauthier *et al*., 2010; Guigue *et al*., 2015). Any change in land cover should affect DOC concentrations in surface water, however, there are very few studies on the control factors of the DOC flux in streams draining grassland ecosystems (Don and Schulze, 2008; Fu *et al*., 2019). A key question remains unresolved: what is the fate of soil organic matter and how does it control the DOC outputs in grassland soils of montane regions which are being deeply affected by climate change and land use change.

Building on the Cathedral Peak LTER, and expanding it to the Northern Drakensberg landscape as an EFTEON site will provide a unique opportunity to allow for the improvement in the understanding of the carbon fluxes at the soil-atmosphere interface under near natural grassland, woody ingression transition zone and varying fire management, and carbon fluxes at the catchment outlets (dissolved and particulate organic carbon) at nested scales.

3.5 Development Pathways for the Landscape

The KZN Provincial Growth and Development Plan 2019 through to the Okhahlamba Local Municipality in their Integrated Development Plan (2020-2021) has recognised the implications of the uKhahlamba Drakensberg Park World Heritage Site and the World Heritage Convention Act (No. 49 of 1999). Through the Spatial Development Framework “no go” areas have been zoned which includes the uKhahlamba Drakensberg Park World Heritage Site and an expansion of the protected area in the municipality, with a demarcated buffer zone for the World Heritage site. Linked to this, ecotourism is identified as a major economic activity for the area with the potential for further development of this being highlighted. In this regard, both the KZN Tourism Masterplan and uThukela Tourism Strategy have identified the potential to develop a cable car in the Drakensberg.

The spatial development framework (SDF) for the area sees Bergville as the primary development node and Winterton as the secondary development node, with a tourism development corridor from Winterton to the Cathkin Park and scenic route along the protected area north. The municipality, in alignment with the National Development Plan and KZN Provincial Growth and Development Plan

2019, has recognised the need to protect the agricultural resource as well as the development and promote the agricultural potential of the area. Linked to this an Agri-Hub (or Agri-Park) is to be located in Bergville, servicing the district. The Department of Rural Development and Land Reform (DRDLR) are working to establish 44 of these Agri-Parks across the country. “An Agri-park is a networked innovation system of agro-production, processing, logistics, marketing, training and extension services, located in a District Municipality (uThukela IDP, 2020).” Given the intention of establishing this Agri-Park in Bergville, research in the landscape that will facilitate better land management decisions and sustainable use of natural resources will be of broad benefit.

An ongoing threat to the area is fracking. Rhino Oil and Gas Exploration South Africa (Pty) Ltd has lodged an application for an Exploration Right (ER) with the Petroleum Agency South Africa (PASA), 12/3/346 ER. The application which is being contested includes portions of land in the proposed landscape (Figure 9). As mentioned above, there is no additional water capacity in the uThukela catchment and augmentation measures need to be considered which may have developmental implications for the landscape.

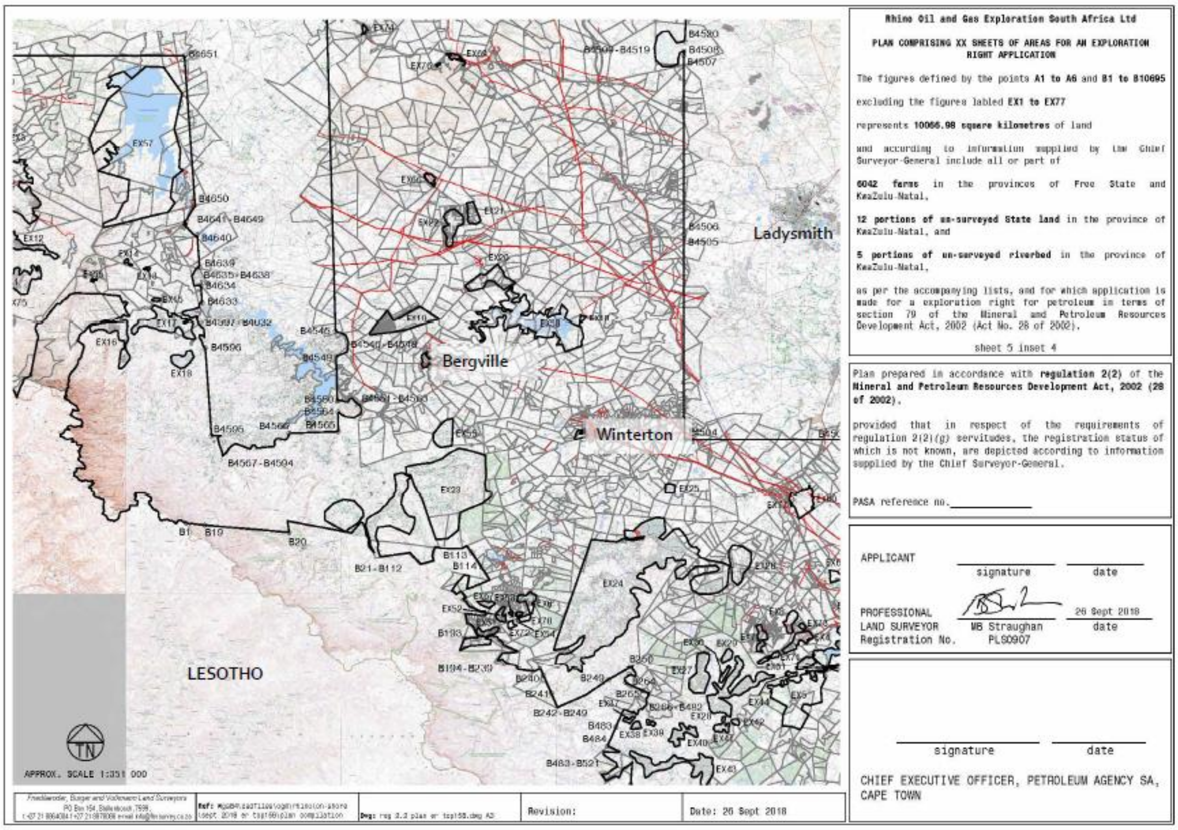

Figure 9: Portions of land in identified for natural gas exploration in the Northern Drakensberg by Rhino Oil and Gas (12/3/346 ER application scoping report)

4. LOGISTICAL AND OPERATIONAL SUITABILITY OF THE NORTHERN DRAKENSBERG LANDSCAPE

The earliest rainfall records for the Northern Drakensberg date to 1923 (Bonheim, 0299797 W) and the earliest streamflow records to Nov 1924 (V1H001). Following from this, the Cathedral Peak Research catchments were established in 1945 and the initiation of the use of the Northern Drakensberg landscape for the installation of research equipment. Since that time, various long term programmes with varying levels of observation and monitoring equipment have been undertaken in the landscape, for example, the Smallholder System Innovations (SSI) programme undertaken in the Potshini village had relatively intensive monitoring (Kongo *et al*., 2010) including a Large Aperture Scintillometer, runoff plots and soil water sensors (Figure 10). Providing evidence of the suitability of the landscape for research infrastructure.

Figure 10: Large Aperture Scintillometer (left, Kongo *et al*., 2010) and 10 m runoff plots with tipping bucket gauges (right) in the Potshini village

The past has shown us that research sites in isolated locations can produce outstanding science and often become innovation hubs. Although there may be logistical challenges, the benefits to science and innovation mostly outweigh these. A gathering of scientists from different disciplines in an area where there are limited distractions creates the opportunity for engagement within and across the disciplines stimulating creativity and building collaborations. Take for example the Cathedral Peak historical research site, the Rhodes Fresh Water Unit Research station, the Hluhluwe-iMfolozi Research centre and Marion Island research base, of varying remoteness and logistical challenges but all of whom have produced leading science and scientists.

4.1 Security of Tenure for Operations at suggested Core Sites

The suggested core sites as well as some of the satellite sites fall within areas managed by EKZNW, namely the uKhahlamba Drakensberg Park and the Spioenkop Nature Reserve. EKZNW are in support of the proposal as demonstrated by the attached letter (APPENDIX C), and are willing to entertain a Memorandum of Agreement to host EFTEON. Currently there is a Memorandum of Agreement in place between EKZNW and SAEON for the hosting of the SAEON Grasslands-Forests-Wetlands node which includes, for example, access to certain research sites, databases, infrastructure and services, in accordance with certain conditions.

EKZNW has a long history of undertaking and supporting research activities in the area under their management. Research activities within the protected area need to go through an approval process. EKZNW has a process for application and approval of research activities in the protected areas in place to which EFTEON could aligns its processes. Furthermore, the Cathedral Peak research catchments are designated as a research area within the World Heritage site; and the advantages and value of this are significant.

4.2 Existing Research Infrastructure and Current Research Activities in the Northern Drakensberg Landscape

A number of institutions currently have ongoing monitoring in the Northern Drakensberg landscape, including EKZNW, Mahlathini Development Foundation, DWS and SAWS. However, the most intensive monitoring is being undertaken by the SAEON Grasslands-Wetlands-Forests node together with collaborators.

4.2.1 Existing Research infrastructure

As in many areas of South Africa, the climatic and hydrological monitoring stations have decreased over time. However, with the diversity of institutions involved the monitoring in the landscape in terms of meteorological variables (Figure 11). Across the landscape there are currently,

- two SAWS automatic weather stations that are active,
- two DWS rain gauges, one being located at Spioenkop Dam and site also monitors evaporation,
- EKZNW monitors rainfall manually Monk’s Cowl,
- Mahlathini Development Foundation supports meteorological stations in six villages,
- It is known that two of the commercial farmers in the landscape have long rainfall records, and there are ARC rain gauges that may still be active, and
- The SAEON Grasslands node maintains six automatic weather stations within the landscape, from the high altitude Vulture’s retreat station at 3010 m a.s.l to the Bambanani station at 1222 m a.s.l. In addition, there are numerous rain gauges distributed through the Cathedral Peak catchments.

DWS currently maintains streamflow monitoring at four weirs in the catchment (Figure 11), as well as the overflow spills at Woodstock, Spioenkop and Driel barrage. The canals related to the Thukela-Vaal transfer scheme are monitored by DWS as are the offtakes for the water treatment plants. Water quality is monitored at eight points in the landscape, as well as below the waste water treatment plants. SAEON Grasslands node monitors streamflow and water quality at six weirs in the Cathedral Peak catchments. It should be noted that there are several DWS weir structures in the landscape that are currently inactive that could be reinstated.

Figure 11: Existing meteorological and hydrological monitoring stations in Northern Drakensberg landscape

The primary concentration of existing research infrastructure is at the Cathedral Peak LTER site. The SAEON Grasslands-Wetlands-Forests node has been actively involved in the landscape since 2011, with long term research observations having intensified over time (Figure 12), and the Cathedral Peak research catchments being formally registered as an LTER site. During this time the relationships with EKZNW have been established, as well as with other stakeholders such as Berg Flying to support servicing the high altitude (3010 m a.s.l) automatic weather station. A wealth of knowledge around the site (from security aspects, fire management and logistics to technical and scientific expertise) has been built up by the scientists and technicians working there. These existing relationships and knowledge would be invaluable should the landscape become an EFTEON platform; and would enhance the investments made into the area.

Focused attention has been paid to the near-natural, Catchment VI which was the primary control catchment under the historical period; degraded Catchment III which was previously afforested to Pine from 1956 to 1983 when it burnt out; and fire-exclusion Catchment IX which has become woody. The research infrastructure array (Figure 12) has been structured to allow for an understanding of the interactions and feedbacks between water-carbon-energy-biodiversity in an integrated manner, as well as allowing for comparisons with historical data. The monitoring array at the Cathedral Peak LTER site includes,

- Climate variables are monitored at two points in catchments (Mike's Pass and Catchment IX), additionally rainfall is monitored at a further 30 sites where historical records are available. A further high altitude site, Vulture's Retreat, at 3010 m a.s.l has been installed. The Mike's Pass and Vulture's Retreat Automatic Weather Station are live and can be accessed from http://gfw.dirisa.org/weather. Micro meteorological stations are also installed in Catchments III, VI and IX. The contemporary rainfall dataset for the 30 rain gauges (https://doi.org/10.15493/SAEON.GFW.10000002) and fog dataset for the Mike's Pass AWS (https://doi.org/10.15493/SAEON.GFW.10000009) have been published.
- Streamflow is monitored at the outlets of catchments III, IV, V, VI, VII and IX. The contemporary streamflow dataset (https://doi.org/10.15493/SAEON.GFW.10000007) has been published.
- Fluxes and the energy balance are monitored in the near pristine Catchment VI with an Eddy Covariance system, and alongside this soil respiration is monitored with a Li-Cor8100 (this is the only one of its kind running continuously in a natural system in SA, with over two years of data). Complimented by monthly soil respiration measurements across different land management treatments using cost effective techniques. A Large Aperture Scintillometer was installed for a short period in Catchment VI as well.
- The energy balance components are monitored in Catchments III and IX as well for use in the Surface Renewal method to solve for total evaporation.

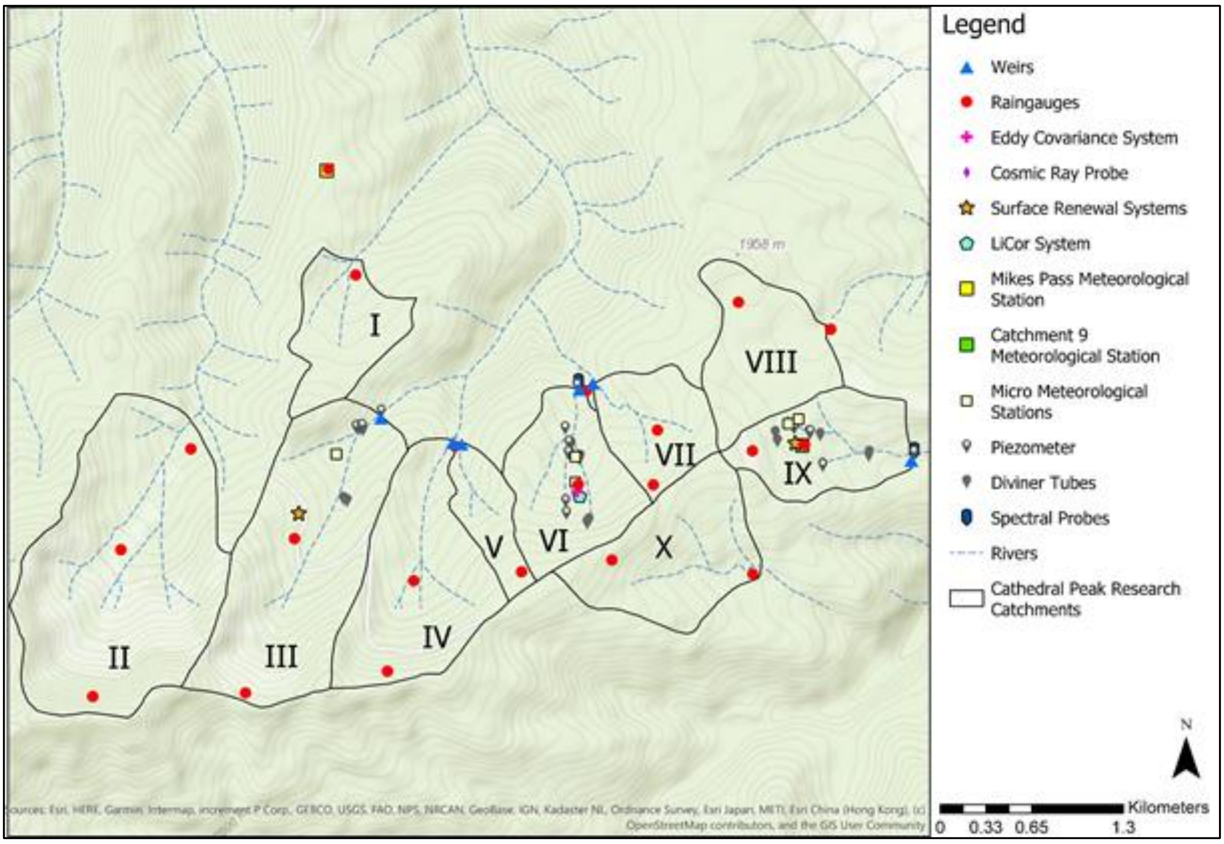

Figure 12: Research infrastructure array at the Cathedral Peak LTER site

- Soil water is monitored in Catchment VI using a Cosmic Ray Probe for spatial soil water, TDR soil water probes installed to a depth of 1.4 m at the Eddy Covariance tower and distributed soil water Diviner tubes and piezometers. In Catchments III and IX soil water is monitored using TDR probes at the site of the energy balance measurements and spatially with diviner tubes and piezometers.
- Water quality measurements of EC, TDS, PH and temperature are taken on a monthly basis at each of the monitored weirs. Additionally, water quality variables are monitored continuously at Catchments VI and IX using Spectral probes.

The coordinates of the current, active research infrastructure and associated datasets are provided in APPENDIX D. Beyond the research infrastructure installed, vegetation structure, composition and diversity surveys, soil surveys and sampling have been undertaken and the Brotherton Burning trials remain ongoing. A NUTNET experiment has recently been implemented near the Brotherton burning trials. EKZNW undertakes annual game counts, as do Zingela/Emaweni. As these are not continuous measurements they are described under the Historical datasets section which follows.

The location of DWS weirs, SAWS and SAEON AWS stations, EKZNW raingauges and the Cathedral Peak LTER site, will facilitate research activities at nested scales within the landscape, scaling to the downstream, integrating satellite site of Zingela on the uThukela river.

4.2.2 Current Research Activities

South African National Biodiversity Institute (SANBI) is leading the implementation of the Living Catchments project in partnership with the Water Research Commission (WRC) through funding from the Department of Science and Innovation. The project is focussing on establishing a community of practice in the upper Thukela that will address challenges and opportunities at the nexus of built and ecological infrastructure for water security in an integrated way. This focus is rooted in a recognition that there is a well-established community in this region that has expertise relating to ecosystems, biodiversity and water and that the expertise is distributed between the research community, policy makers, implementers and other local stakeholders/communities. The project will benefit the EFTEON initiative because it aims to create spaces for co-learning, co-creation of solutions and enabling collaboration to address developmental and societal challenges at the nexus of water and ecological infrastructure. These spaces will connect the EFTEON researchers with policy practitioners, communities, project implementers such that the outputs of research and associated change processes have a more transformative impact in the upper Thukela. Social learning tools will be applied to capture the learning across disparate fields, knowledge systems and for strengthening the implementation, research and policy feedback loop.

The Afromontane Research Unit (ARU) is actively undertaking research on the Mont-aux-Sources/Royal Natal National Park alpine components of the proposed EFTEON landscape, with the intention of creating a transboundary Long-term Social-Ecological Research site focused on Mont-aux-Sources. The landscape becoming an EFTEON site would complement these activities of the ARU and simultaneously benefit from them.

A WRC funded project titled "Towards sustainable and equitable management of water resources: Understanding the interlinkages between water, ecosystems and society through spatial mapping of ecosystem services and livelihood benefits" led by the Centre for Water Resources Research, UKZN with Mahlathini Development Foundation and SAEON as collaborators started in April this year (2020) in the villages adjacent to Cathedral Peak area. Additionally, Mahlathini Development Foundation are involved in participatory innovation development and research in the landscape under the Maize Trust's Smallholder Farmer innovation programme in CA, the WRC's smallholder climate change adaptation decision support system for smallholder farmers and the Nedbank Green Trust's local food systems project. Participatory innovation development relies on the exploration of scientific data alongside the visual and qualitative indicators used with farmers. Specifically, the changes in rainfall patterns are related to yields, growth and soil health options, runoff and water proactivity of different cropping options. The landscape becoming an EFTEON site will further enable the activities of Mahlathini Development Foundation in the area. There is also ongoing research funded by the WRC on developing water accounts for the uThukela catchment. The Water Resource Classes and associated Resource Quality Objectives are being determined for the uThukela catchment by the Department of Water and Sanitation with the outcomes due in 2022.

A case study site for a multi-institutional project (SAEON, Rhodes, UKZN, UFS ARU, UWC) funded by the NRF on improving the understanding of how global change drivers (climate, land use change and atmospheric CO_2) impact the ability of ecosystems to supply freshwater and sustain biodiversity is located in the landscape, with one of the core outcomes to understand the impacts of woody encroachment on water resources. Study sites are distributed in the Eastern Cape, Western Cape, Phalaborwa and Cathedral Peak Catchment IX. If this landscape were to become an EFTEON site there would be the opportunity to include a lower altitude study site in the transition area between grassland and savanna biome to further the understanding of woody encroachment impacts.

At the Zingela site there are ongoing research activities related to the giraffe population in the area as well as a focus on the freshwater eel movement and distribution in the Thukela river. Research is also underway on the spread of alien invasive species within Zingela.

4.3 Historical Datasets and Research Activities in the Northern Drakensberg Landscape

As evidence of the historical research activities in the landscape, 187 peer-reviewed journal publications have been produced that have a focus on the landscape, with these publications increasing over time (Figure 13a). A range of broad themes have been addressed in the landscape (Figure 13b), with ecology and within fire ecology being the most predominant followed by hydrology. In addition, there are 68 theses and many grey literature reports that have been produced with a focus on the landscape.

Since 2011, considerable effort has been placed on collating the historical datasets from the Cathedral Peak research catchments and the vegetation plots across the landscape (Granger, 1984; Gordijn *et al*. 2018) as well as capturing the tacit knowledge that exists. The Council for Scientific and Industrial Research (CSIR) was the custodian of the hydrological and climatological datasets for the Cathedral Peak research catchments until SAEON's involvement. An electronic version of the historic data was obtained from the CSIR (with the assistance of Eric Prinsloo), by SAEON. This data set is referred to as "Hydrodat". It includes streamflow, weather station, rainfall and water chemistry data in raw and processed forms for the various research catchments across the country. It also contains the ACSYS program which was used to process data. The data sets are a combination of historically manually recorded data, and data recorded using Casella type gauges as well as later instrumented logger data. These datasets have been captured in the SAEON Observations Database or are waiting to be uploaded. Beyond this, there are many datasets for the landscape or sites within the landscape that are held by various scientists, institutions or described in publications and reports.

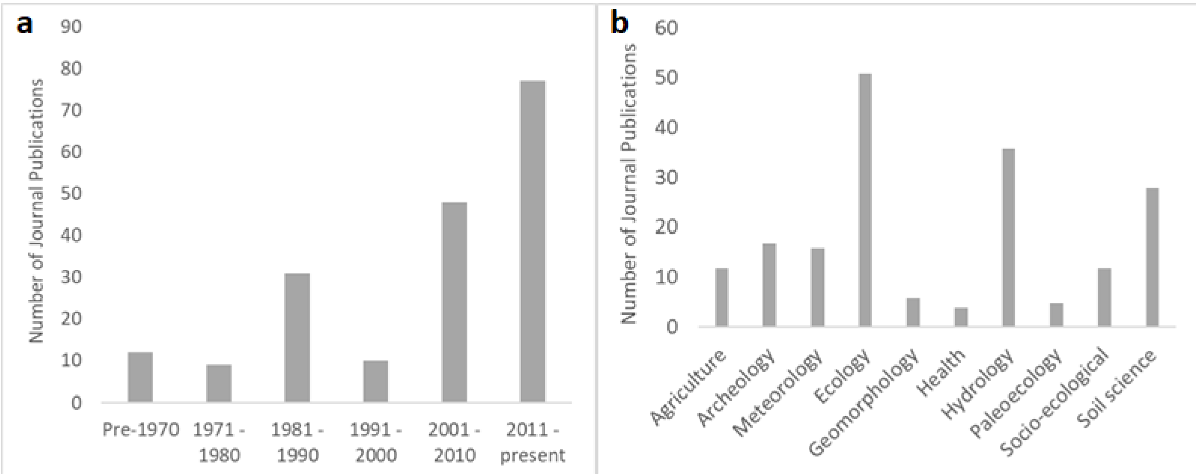

Figure 13: Distribution of peer-reviewed journal publications (a) over time and (b) broad theme

The primary, available historical or periodic datasets for the landscape are:

- Historical datasets for the Cathedral Peak research catchments (contemporary datasets detailed in Section 4.2.1), include
    - climatology records exist from 1948 to 1996 (varying number of stations and variables);
    - streamflow and water quality records from 1948 to 1996 (varying number of weirs and variables);
    - vegetation structure, composition and diversity surveys for vegetation plots in the catchments and surrounds;
    - fire records, both management and wildfires; and
    - soil surveys have been undertaken for Catchments III, IV and IX.
- The Brotherton burning trials are an example of a long term experiment undertaken and sustained on the platform, where since the 1980's specific burning treatments have been applied to a set grassland plots in a randomised design. Since 2017 a passive warming treatment using open-top chambers has been added to part of the experiment.
- EKZNW datasets for the protected areas, include
    - biodiversity and animal surveys; and
    - fire management records and wildfires.

- The vegetation dataset for the larger landscape, including Cathedral Peak, comprises approximately 150 vegetation plots, known as the Cathkin Key area vegetation surveys.
- Mahlathini development foundation have been collecting social and economic indicator data (e.g. input savings costs, months of food provisioning) for subsistence farmers in parts of the landscape since 2013, as well as agronomic and soils data for these same farmers.
- An invertebrate survey was undertaken for the area in 2005 - 2007. The forest areas at Royal Natal, Cathedral Peak, Monks Cowl and Highmoor were surveyed as well as seven grassland sites at Cathedral Peak. The sampling done was standardised and quantified, with the identifications done by experts. This dataset, consisting of about 4500 records, is available.
- A notable portion of the research undertaken in the landscape has been conducted in the Potshini Village (Soil science papers in Figure 13b and few of hydrology papers), including
    - process based studies looking at the soil carbon dynamics and degradation; and
    - different cropping methods to improve the crop yields such as in-situ rainwater harvesting through the Smallholder Systems Innovations (SSI) research programme funded by International Water Management Institute.
    - These datasets are housed in the CWRR, UKZN and with KwaZulu-Natal Department of Agriculture and Rural Development.
- Okhombe village has been another site where a notable number of studies have been conducted. These include community-led land rehabilitation through the implementation of several erosion control methods alongside research on the drivers of erosion and a focus on the geomorphology of the valley. An automatic weather station at a school near this site has been maintained by SAEON.
- Agricultural related datasets, include
    - Soil fertility experiments at Bergville, Geluksberg and Winterton by M. Farina and colleagues between 1973 and 1998 which contributed to improving the profitability of crop production in rain-fed crop production in South Africa by promoting cost-effective use of fertilizer and amelioration of soil acidity. This data resides with KwaZulu-Natal Department of Agriculture and Rural Development.
    - No-till (NT) and conservation agriculture (CA) experiments at Winterton on both commercial and smallholder farms. This data resides with KwaZulu-Natal Department of Agriculture and Rural Development.

The SAWS and DWS stations where monitoring was undertaken historically have been captured in APPENDIX E. Where more details are available for the datasets above, these have also been captured in APPENDIX E. It should be noted that any ongoing, continuous monitoring has been recorded under existing infrastructure (with details of the datasets in APPENDIX D).

4.4 Suitability of the suggested Core sites for Research Infrastructure

As the Cathedral Peak research catchments are heavily instrumented, the proposal is that the EFTEON core site be located at a lower altitude within the landscape. A suggested location for the core site is the Spioenkop Nature reserve. Within the Spioenkop Nature Reserve there are several potential sites that meet the requirements for micrometeorological measurements of stable atmospheric conditions, flat or gently sloping terrain with homogenous vegetation for a distance around the site equivalent to the expected footprint. The vegetation of the Spioenkop Nature Reserve is Highland Thornveld, some areas are more grassy while others are woodier, characteristic of the area being an area of transition. Possible sites that are more grassy and more encroached have been identified that meet the requirements (for example, Figure 14). However, other options exist. It was assumed that the height of the equipment would be 6 m, given the average height of the vegetation at 2 m. Thus using the commonly accepted 1:100 rule of thumb, a rough fetch area of 600 m was used. The greatest difference in elevation across the 1.2 km diameter of the buffers was 70 m (a slope of ~6%). The Spioenkop Nature reserve is 12 km outside the town of Winterton, accessed via the tarred R600. There is a gravel road network within the reserve that could be used to access the possible sites.

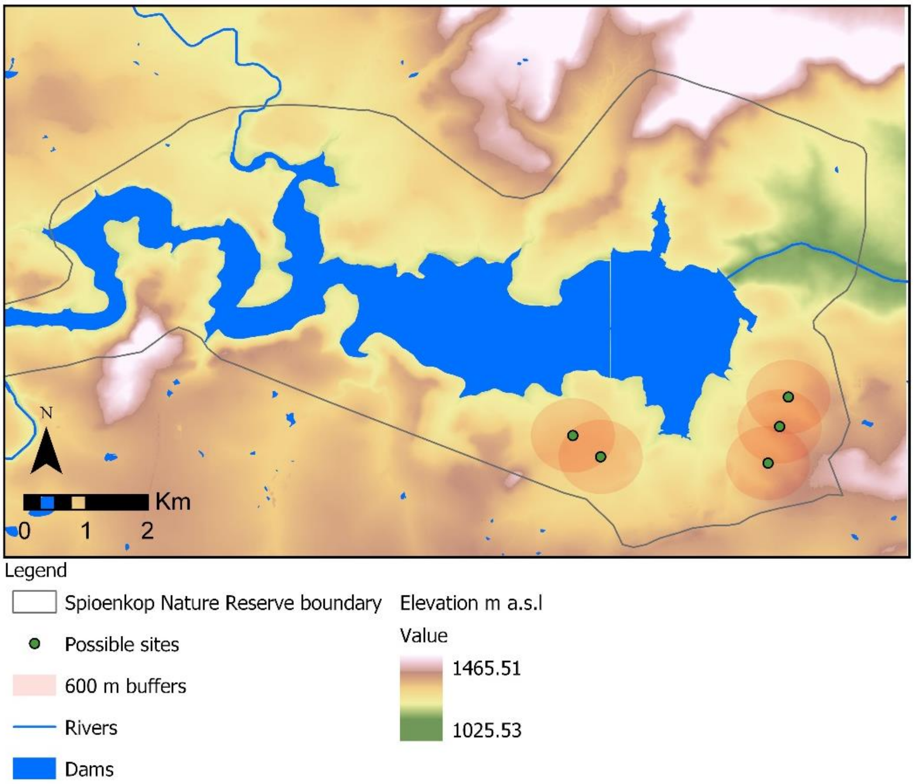

Figure 14: Possible micrometeorology site locations at Spioenkop Nature Reserve

It is recognised that the Cathedral Peak LTER site where micrometeorological measurements are taken is not ideal, and that this necessitates corrections to the data. However, the benefits of the site being within the heavily instrumented pristine, high altitude, headwater catchment are significant. The site is accessed via the tarred R394 to the Cathedral Peak/Didima gate. The 4 x 4 Mike's Pass road is then used to gain access to the catchments, with fairly good road access to the bottom, middle and top of most catchments. These roads at the Cathedral Peak site enabling access to remote sites are notable as road access is often absent in other areas, however, it must be noted that maintenance of these roads will need to be factored in. Through the EKZNW patrols there is a security presence in the protected areas.

There are several other potential core sites in community rangeland areas in the landscape that would meet the requirements for accurate micrometeorological measurements should the landscape committee deem the Spioenkop Nature reserve not suitable. However, engagement with the communities through the EKZNW community liaison officer or Mahlathini development foundation will need to be undertaken.

With regards to security at the Spioenkop Nature reserve site, being within a protected area that is actively patrolled due to the presence of rhino, a level of security will be ensured. The SAEON Grasslands node has experience with proven security solutions with appropriate structures and locking mechanisms that have been installed at the Cathedral Peak LTER site (Figure 15). No theft or vandalism of equipment (by humans) has occurred since these security solutions were installed. This experience and information related to the security solutions will be willingly shared and advice, where needed, provided. An additional concern in a grassland or savanna area is the risk of fire. The experience gained in protecting the equipment installed in the Cathedral Peak LTER site from fire will be willingly shared and advice provided where needed.

Figure 15: An example of the security solution for a solar panel at a weir, Cathedral Peak LTER

4.5 Availability of Support Facilities at the suggested Core Sites and across the Landscape

The two main towns in the landscape are Bergville and Winterton. These are growing towns which are located close to each other (22 km apart) serve the surrounding agricultural communities and provide a hub for ecotourism activities. The towns have medical facilities, grocery shops as well as several hardware and agricultural supply shops. Winterton has a well-respected primary and pre-primary school. Accommodation is available for rent in both towns, and employment opportunities related to tourism and support of the agricultural sector exist. As well as the option to rent office facilities.

At the Spioenkop Nature reserve site (which is only 12 km from Winterton) there is,

- A prefab house with five rooms that could possibly be used as a temporary office space. However, the building is in need of repair and investment to make it a long term solution.
- A potential option at this site is the use of park homes or fitted container office and laboratory solutions. There are several concrete slabs that had prefab houses/offices that could be used.

There are existing water and electricity services to these sites. These fitted containers could also be explored to provide short-term accommodation for visiting researchers at the site.

- The potential to have an internet connection.
- At the Spioenkop Nature Reserve site there is currently a large hall which has been condemned; however, the potential exists to create an educational facility at this site.
- Within the EKZNW Nature reserve there are camping facilities, both alongside the dam and Iphika Hunting Camp which is a tented safari camp with solar power, two accommodation units, and is available at discounted rate when available.
- In terms of short-term accommodation for visiting scientists/researchers, adjacent to the reserve is Spioenkop Lodge which can accommodate 15 people in full board or self-catering options. Several other accommodation options (self-catering or B&B) are available within a 10 km radius of the reserve.

At the Cathedral Peak research site (which is approximately 40 km from Winterton) there is,

- A research house with basic accommodation for 12 people, electricity, cell phone reception, kitchen and secure lock up facilities.
- A designated office space which could accommodate four people, and a storeroom area. Through further engagement with EKZNW it is possible that more space could be made available.
- The potential to have an internet connection.
- Didma EKZNW resort cottages available at public rates less 30%. Conference facilities are available at Didma EKZNW resort.
- Accommodation and conference facilities are also available at Cathedral Peak hotel.
- A Department of Arts and Culture education center, which is currently in need of repair, could accommodate 40 people with kitchen facilities, meeting venue/lecture space if invested in.
- The closest hospital is Emmaus which is 25 km away.

The main Zingela administration complex is approximately 26km from Weenen and 35km from Colenso on gravel roads. At the satellite site of Zingela/Emaweni there are,

- Currently 5 lodges, 1 permanent tented camp and numerous campsites available for researchers to use on a self-catered or fully catered basis, at a negotiated reduced rate.
- Electricity is supplied by ESKOM and there is an internet connection.
- High clearance vehicles would be required to fully access the Zingela areas while the Emaweni core area will be accessible by 2-wheel drive vehicles.

Beyond the sites listed above, research accommodation is available at

- Royal Natal
  The Royal Roost: Two bedrooms each with two beds, small lounge area with kitchenette which is available at staff cost-recovery rates (~R100 pppn).
  Mahai and Rugged Glenn Campsites
  Thendele Resort cottages available at public rates less 30%.
  Potentially Busingatha which is community accommodation near the entrance of Royal Natal.
- Monks Cowl
  One bedroom staff accommodation (2 beds) available at staff cost-recovery rates (~R150 pppn)

Monks Cowl Campsite
- Mnweni Tourism centre, in the Mnweni area between Cathedral Peak and Royal Natal, offers accommodation.

At Royal Natal there is also an education centre available, and through engagement with EKZNW the potential for further facilities at this site. There are numerous Drakensberg resorts in the landscape and several Bed and Breakfasts in and near the towns of Bergville and Winterton.

Pietermaritzburg is less than a 2-hour drive from the landscape. Any services which are not available in the smaller towns of Winterton and Bergville will be available in the city of Pietermaritzburg. For example, an airport with connecting flights to Johannesburg, extensive medical facilities, several High Schools with boarding options. The SAEON Grasslands node, located in Pietermaritzburg, could offer assistance and support for the site.

4.6 Suitability of the Landscape for Human Capacity Development

Human capacity development including undergraduate, postgraduate and technical training as well as community engagement and outreach activities have taken place in the landscape historically and remain ongoing. To date 68 postgraduate students have undertaken studies related directly to the landscape area, increasing in number more recently (Figure 16a). The majority of postgraduate students have graduated through the University of KwaZulu-Natal and the former University of Natal (Figure 16b), a number of other universities are represented including three international universities. The current postgraduate studies in the landscape,

- supported by SAEON, 1 PostDoc candidate, 7 PhD candidates and 3 Master's students. These students are affiliated to UFS Soil Science, UFS ARU, WITS and UKZN.
- two ARU post-docs lined up for work on the Amphitheatre summit post-COVID; ARU is currently working with MDTP on mitigating degradation issues on the Amphitheatre summit. One ARU post-doc worked on SAEON carbon flux data in 2019.
- at Zingel satellite site, 3 Master's students, 1 PhD and 1 PostDoc registered through UKZN.

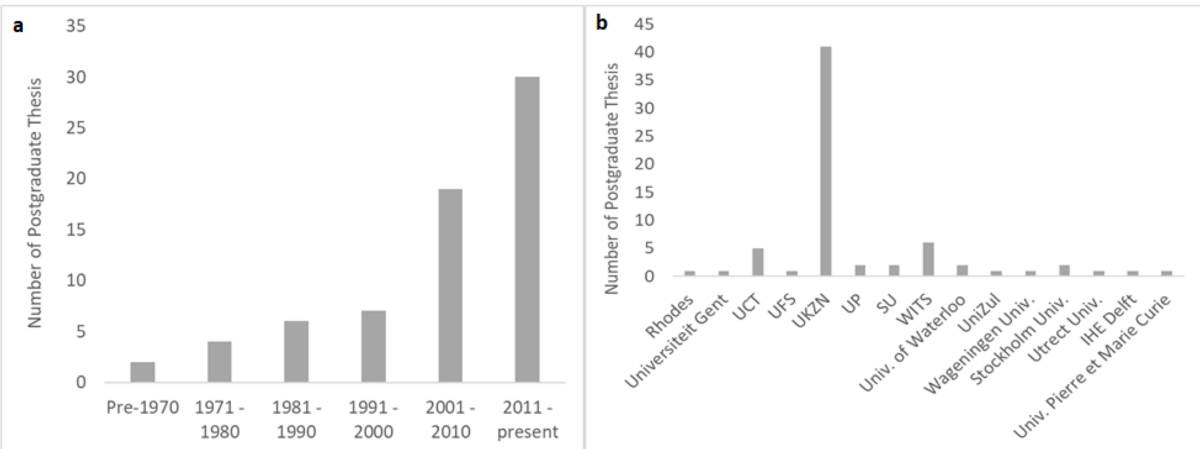

Figure 16: Distribution of Postgraduate studies (a) over time and (b) across Universities

The factors contributing to the suitability of the landscape for human capacity development include,

- The vast volume of historical research in the landscape which has resulted in a depth of knowledge being generated which is of benefit for undergraduate and postgraduate training. Many of the collaborators listed on this proposal have a vast amount of experience and tacit knowledge about the landscape.
- The extensive historical and contemporary dataset that are available for the landscape are highly valuable for postgraduate studies.
- Despite the historical research activities in the area, the research opportunities remain extensive with many of the key socio-ecological challenges facing South Africa being prevalent in the landscape. Investigating them in this landscape comes with the advantage of the historical base of knowledge and the existing datasets.
- Several groups, in particular EKZNW and the Mahlathini development foundation, have developed strong relationships with the stakeholder groups in the landscape and are actively engaged in science outreach activities.
- Reasonably priced researcher accommodation is available through EKZNW as detailed in Section 4.5.
- The Department of Arts and Culture has an educational centre at Cathedral Peak which can accommodate 40 people with kitchen facilities, meeting venue/lecture space has been used by several groups. Repairs are needed to the facility, but if invested in this could become a valuable training facility. There is also a Rock Art centre at the Didima camp for educational tours.
- At the Zingela satellite site there are lodges and camping options for large groups.
- There is also an educational centre at Royal Natal.
- Accommodation at a reasonable cost for large groups (hostel type accommodation with lecture/meeting venues) is also available at the ATKV Drakensville Environmental centre (https://drakensville.co.za/media/1222/environmental-centre.pdf); Dragon Peaks Mountain resort and Amphitheatre Backpackers.
- The landscape is easily accessible using National roads, approximately a 3-hour drive from Durban as well as Johannesburg.

Evidence of the suitability of the landscape to human capacity development includes,

- The University of KwaZulu-Natal Hydrology Honours class undertakes site visits to the Cathedral Peak LTER site and surrounding areas annually.
- WITS University 3rd year Geography class undertakes site visits to the Cathedral Peak LTER site and surrounding areas annually.
- A postgraduate winter field school was successfully hosted in at the Cathedral Peak LTER site.
- A technicians training course was successfully hosted in at the Cathedral Peak LTER site.
- The ARU, in partnership with Wageningen University, had planned a cross-disciplinary Land Dynamics Workshop for the Upper Tugela region (wholly in this proposed Landscape) for October 2020, but has been moved to 2021 due to COVID-19.
- School and University groups (both national and international) are regularly hosted at Zingela. These include the Virginia Commonwealth University – 16 credit Tugela Source to Sea module (a course which demonstrates the type of interdisciplinary capacity building possible should the landscape become an EFTEON landscape -

https://www.youtube.com/watch?v=8iPXpO24Oyk), Exeter University Giraffe Research Project and Nile Crocodile Research Project.

- Mahlathini development foundation Conservation Agriculture Farmer Innovation Programme.
- EKZNW community liaison committees and school interactions.
- ACCESS Habitable planet workshop co-hosted on site (UKZN & SAEON) 2017

5. STAKEHOLDER ANALYSIS

Across the proposed landscape there is a considerable history of research with scientists and researchers from several Universities (national and international), research institutions, NGO's and governmental departments being involved. Land owners, land custodians and villages in the landscape have been involved in and supportive of these research activities. Evidence of this has been provided in Section 4.3 where the historical research activities are documented and in the various letters accompanying this proposal (APPENDIX F: Letters of Support). In developing this proposal, a broad engagement of the science community and the representatives of the various stakeholder groups in the landscape was undertaken, with input on the proposal sought to ensure that it reflects the research interests and needs of the broad community. The letters are listed in APPENDIX F: Letters of Support and each letter is hyperlinked to the Google Drive folder where they are stored is, and the letters are provided as an attached pdf (Northern Drakensberg Letters of support).

5.1 Land Owners, Land Custodians and Structures in place for Community Engagement

As detailed in Section 4.1, much of the proposed landscape area falls under the custodianship of EKZNW who have agreed, in principle, to enter into a Memorandum of Agreement to host the EFTEON node in this landscape. EKZNW are fully supportive of this proposal and are co-proposers of the Northern Drakensberg as an EFTEON landscape. The formal support of the proposal by EKZNW is indicated in a letter attached to this proposal. EKZNW prioritises developing strong relationships and connections with the villages adjacent to the protected areas that they manage. Through the EKZNW community liaison officer relationships with the villages adjacent to the Ukhahlamba Drakensberg Park and Spioenkop Nature Reserve have been established and for each of the resorts community liaison committees formed with representatives of the respective villages involved.

For the satellite site of Zingela, the owners of Zingela and Emaweni have expressed their full support of the proposal which is best encapsulated in this quote from them "In many ways we see EFTEON as a natural progression along our research pathway. A necessary backdrop to all the research projects and academic field trips mentioned above is ongoing and accurate long term collection of environmental data within and surrounding the study site. It is believed that, with the proposed installation of long term environmental and ecological monitoring infrastructure, the already impressive research resume in the area could be further enhanced. Any equipment installed would be of great value and we would undertake to look after it as we fully understand and support how essential it is both for ourselves and the broader scientific community." Both Emaweni and Zingela have good relationships with their respective communities and work together with them on conservation management projects. Working through Zingela owners, the communities could be engaged.

The No-Till club who have several members in the landscape have expressed their interest and support of the proposal with the agreement to facilitate engagements between EFTEON scientists and the agricultural land owners in the landscape. The farmers in this region have been at the forefront of conservation agriculture as well as other sustainable land management practices such as regenerative agriculture. The No Till club believes that the data and research that would accompany the landscape becoming an EFTEON site will allow landowners to further capitalize on the benefits of these sustainable land management practices, as well as this gained knowledge being transferable to other members of the No-Till club.

The Mahlathini Development Foundation have facilitated several collaborative, farmer centred projects with villages in the Northern Drakensberg landscape since 2006. They have built up relationships in the landscape with 18 villages. Through the “Farmer Centred Innovation in Conservation Agriculture” they are implementing in the Bergville area, there are 18 village learning groups involved, and 348 smaller holder farmers. Should the proposal be successful, working through Mahlathini Development Foundation, engagements with villages in the landscape could be facilitated. Mr NT Madondo, who is a resident of the area, and has acted as a facilitator for Mahlathini Development Foundation and UKZN between smaller holder farmers and researchers since 2006 has indicated support of the proposal. ASSET have also offered their support through their work with local smallholders for the last two decades, and through a long standing relationship with Conservation Agriculture farmers in the area involved with the KwaZulu-Natal No-till Club.

5.2 Scientific Community

A survey was sent out to the 63 collaborators (APPENDIX A) in early August 2020 to solicit their inputs on the proposal and to understand how the landscape becoming an EFTEON site would be of value to them. The inputs received were incorporated into the proposal. Several collaborators contributed to the writing of the proposal, and comments were provided by numerous other.

The collaborator group is a multidisciplinary group from a range of institutions and organisations. Support for the proposal was indicated by academics from the University of Johannesburg, WITS, University of KwaZulu-Natal (Grassland science, Geography and Centre for Water Resources Research) and University of Free State (Afromontane Research Unit and Department of Soil, Crop and Climate Sciences). The capacity building potential in the landscape has been highlighted in the letters of support received from these academic institutions.

SANBI, through the Living Catchments project, are leading the work on improving the science-policy-practice interface in the Northern Drakensberg landscape. In the letter of support received from SANBI they indicate the importance of the Northern Drakensberg platform in facilitating co-learning, co-creation of solutions and collaboration for the community of practice to address developmental and societal challenges at the nexus of water and ecological infrastructure. The INR and the Southern African Program on Ecosystem Change and Society (SAPECS) letters of support similarly indicated the value of the landscape for social-ecological research.

The Agricultural Crop Research Services, KwaZulu-Natal Department of Agriculture and Rural Development who have been actively involved in agricultural related research, for example, soil fertility and no-till methods, in the landscape have expressed their support indicating that the Northern Drakensberg becoming an EFTEON landscape would make field research projects in the area more cost effective and promote human capacity development through contact between researchers of different generations, different disciplines, and between researchers and farmers. Dr James from the Albany Museum also highlighted how the logistical and operational benefits to research in the landscape if it were to become an EFTEON site.

International support for the platform has been received from Prof M te Beest who is currently working in the landscape and has a long history of doing so; from the Biogeosciences laboratory at the Université de Bourgogne, France who have been actively working in the Cathedral Peak research catchments since 2016; from Prof J Vonesh at Center for Environmental Studies, Virginia Commonwealth University, United States of America who uses the uThukela catchment for undergraduate field schools; and from the Department of Water Resources and Ecosystems, IHE Delft Institute for Water Education. The letters of support from each of these international collaborators highlight the potential of the landscape for capacity building and strengthening international ties.

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APPENDIX A: List of Collaborators

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APPENDIX B: Potential research questions the landscape is suited to addressing

Beyond the overarching questions provided above, specific questions relating to ecosystem structure, function and processes as well as land-atmosphere interactions and processes include, for example:

- How does the grassland species diversity and composition affect ecosystem functioning, particularly water provisioning services and carbon-nutrient cycling?
- How is grassland community structure related to landscape level processes?
- How can degraded grassland and soil areas be rehabilitated?
- How much carbon is stored in our grasslands and by what processes?
- Understanding hillslope processes and flow paths across a gradient. What are the residence times of water in the catchments and how are these affected by catchment landscape features and topography?
- Baseline dynamics between fire, vegetation, water and carbon-nutrients in the mesic fire climax grasslands.
- Better understanding of the relationship between precipitation and topography in mountainous, normally inaccessible, scarcely monitored areas.

Potential questions related to the anthropogenic impacts on the ecosystem are, for example:

- What changes in the climate are evident over time, including extreme events?
- Is grassland species diversity and composition changing over time, and what are the drivers of this change? For example, changes in C_3/C_4 communities?
- What are the long term impacts of different fire treatment and alternative land management regimes on grassland species diversity, composition and ultimately the ecosystem services provided by that grassland?
- How will the carbon cycle be affected by climate change and what will the consequences be of a change in the carbon cycle?
- How will nutrient cycles change in the long term?
- How will the water balance from this strategic water source area change in the long term and is the hydrological cycle being amplified?
- Is the quality of the water from the strategic water source area changing over time, how and what are the drivers of this?
- What are the dynamics between land cover/land use change and hydrological response (including woody encroachment, degradation, alien invasive species, subsistence and commercial agriculture)?
- What are the consequences of landscape fragmentation on ecosystem processes and services?
- Through substitution of space for time studies across an altitudinal gradient and varying microhabitats understand the dynamics between climate, land, water and carbon.

Suggested potential questions relating to the dynamics between and within socio ecological systems:

- How can we best incorporate indigenous knowledge to improve the management, protection and restoration of ecosystem services in the grassland biome?
- What are the relationships between ecosystem services and agriculture to ensure a sustainable food production (food security) that also meets increasing demands (under a changing climate)?
- How can agricultural practices (particularly grazing in this area) be improved to ensure environmental sustainability?

- How can fire be better managed in this landscape, where arson fires are common as well as management burns?
- Protection of areas and restoration – where are the gains and losses in terms of ecosystem service provision and economically?
- Trade offs between protected areas and adjacent community needs. Related to this are the impacts of tourism on the area from an ecological and social view. Economies, social ecologies and future-casting of the "ruralopoli" that form a wedge between the Park and the commercial farmlands.
- What are the influences of land tenure on environmental resilience?
- The social and economic related impacts of informal movement through the mountain passes, including the illicit activities (e.g. marijuana, cattle rustle, possibly firearms, human trafficking).
- What role the towns of Bergville and Winterton play in this landscape, what are their impacts on the environment, what are the consequences of poor governance of these towns on the larger landscape economically, socially and environmentally.
- Improve the science-policy-practice interface: identify silos, entry points to enable collaboration, opportunities and co-learning for the uptake of research outputs into policy and practice.

Given the floristic diversity and endemism, specific biodiversity related questions could include, for example:

- Biodiversity knowledge gaps in the proposed site area exist (e.g. there will be large data gaps for the out-of-the-way areas like Mweni, and even deeper into RNNP, at the base of the Amphitheatre). Thus, the need for baseline surveys on what is present (to allow for a better spatial inventory that can be used as a baseline for future comparisons).
- Ecology and management of mega-fauna like Eland (especially relating to increasing woodiness potentially), plus aspects of reintroducing mega-fauna back to the system (for example, would elephants not be a way of controlling *Leucosidea*).
- Alien invasive species and non-native naturalized species (non-invasive) - what is there, where is it, is it spreading, what will happen in future (climate change, land-use change, human pressure/mobility, e.g. the cableway proposed for Mweni and international visitors using the Chain Ladder route to the summit)?
- Medicinal plant trade from high peripheral rural populations and impacts on the Park and surrounds in general.

Additional potential questions could include:

- How do we detect critical thresholds/tipping points in the ecosystem?
- How do we improve monitoring to allow for integration of processes at different scales or the extrapolation of point based measurements to landscape scale?
- How can remotely sensed data be best used to supplement and enhance in-situ measurements (climate, hydrological and ecological measurements)?
- The climate and process observations from these mountainous areas could be highly valuable in improving climate modelling and downscaling.
- How can citizen science data be used to supplement and enhance scientific observations and monitoring?
- What are the value of long term experiments, and how can the results from them be most beneficial to society?

APPENDIX C: Letter of Support from EKZNW

An image of the letter is captured below. The letter is also included in the attached PDF document or can be viewed using this hyperlink which takes you to the Google Drive folder where it is stored.

EZEMVELO KZN WILDLIFE

Conservation, Partnerships & Ecotourism

OFFICE OF THE CHIEF EXECUTIVE OFFICER

To whom it may concern,

SUPPORT FOR NORTHERN DRAKENSBERG EFTEON LANDSCAPE PROPOSAL

Ezemvelo KwaZulu-Natal Wildlife (Ezemvelo) is the biodiversity authority for the KwaZulu-Natal province in terms of the KwaZulu-Natal Nature Conservation Management Act 9 of 1997.

Ezemvelo has been part of the development of and fully supports the Northern Drakensberg EFTEON Landscape proposal. The landscape will assist in advancing global change science for society in this area of high biodiversity value that faces many socio-economic, water resource and land management challenges. The meteorological, hydrological, socio-economic, health and biodiversity data collected at the network of sites in the landscape will be used to complement research, monitoring and biodiversity conservation planning activities that are undertaken and coordinated by Ezemvelo.

Ezemvelo manages the uKhahlamba Drakensberg Park (part of the Maloti-Drakensberg Park World Heritage Site) and Spioenkop Nature Reserve protected areas that fall within the project area. Within these areas we currently support research activities in the Cathedral Peak research catchments which have been designated as a research area within the World Heritage site. We commit to assessing the suitability of these protected areas for instrumentation, as well as making any biodiversity and climate data sets collected by Ezemvelo available, subject to due process being followed.

Should this landscape be selected, Ezemvelo, in principle, agrees to discuss with EFTEON management the possibility of a Memorandum of Agreement for hosting the EFTEON Northern Drakensberg node. This hosting agreement could potentially include, for example, access to research sites, databases, temporary access to office space and overnight research accommodation for researchers at the Didima (Cathedral Peak), Royal Natal and Monk's Cowl resorts in the uKhahlamba Drakensberg Park and at Spioenkop Nature Reserve.

We will commit to a timely and fair review of any biological permit and research project applications for research activities within the protected areas linked to this initiative.

Kind Regards,

MR NTSIKELELO DLULANE
ACTING CHIEF EXECUTIVE OFFICER

Date: 01/10/2020

P O Box 13053, Cascades, 3202 • 1 Peter Brown Drive, Montrose, 3202 • Tel : +27 33 845 1999 Fax : +27 33 845 1699
www.kznwildlife.com

APPENDIX D: Current Research Infrastructure and associated data

Current Meteorological, Micrometeorological & Flux Stations						
Custodian	***Gauge***	***Variable/s***	***Equipment***	***Record period***	***Location***	
					Latitude	***Longitude***
SAEON	Mike's Pass	Wind sp/dr, Air temp., HR, radiation, ground temp., rainfall, Fog, baro.	CS Automatic Weather Station	Aug 2012 - present	-28.975	29.235
SAEON	Mike's Pass 2	Rainfall	Tipping bucket rain gauge	Nov 2016 – present	-28.975	29.235
SAEON	Mike's Pass 3	Rainfall	Tipping bucket rain gauge	Nov 2016 - present	-28.975	29.235
SAEON	Davis Mike's Pass	Rainfall	Davis Tipping bucket raingauge	Nov 2016 - present	-28.975	29.235
SAEON	Ground level Mike's Pass	Rainfall	WMO specification built ground level, tipping bucket raingauge	Jan 2015 - present	-28.975	29.235
SAEON	Nipher Mike's Pass	Rainfall	Tipping bucket raingauge in Nipher shield	Jan 2015 - present	-28.975	29.235
SAEON	Fog gauge Mike's Pass	Fog	Juvick type fog gauge	Apr 2014 - present	-28.975	29.235
SAEON	Research Office station	Wind sp/dr, Air temp., HR, radiation, ground temp., rainfall, baro.	CS Automatic Weather Station	Feb 2013 - present	-28.940	29.235
SAEON	Vulture's Retreat	Wind sp/dr, Air temp., HR, radiation, ground temp., rainfall, snowfall, soil moisture, baro.	CS Automatic Weather Station	Aug 2015 - present	-28.975	29.235
SAEON	EC CP VI	CO_2 & H_2O exchange; energy balance components, RH, air temperature, wind sp/dir.	Extended open path eddy covariance	2014 - present	-28.993	29.251
SAEON	SR III	Energy balance components	4-Component Net Radiometer, soil heat flux plates, soil thermocouples, fine wires, 2-D sonic anemometer, soil water (CS616)	Nov 2018 - present	-28.994	29.233
SAEON	SR IX	Energy balance components	4-Component Net Radiometer, soil heat flux plates, soil thermocouples, fine wires, 2-D sonic anemometer, soil water (CS616)	Nov 2018 - present	-28.990	29.265
SAEON	Licor CP VI	Soil respiration (CO2 + H2O flux, soil moisture, air and soil temperature, solar radiation, Baro)	Soil respiration chambers: Licor 8100 8 chamber	Sept 2017 - present	-28.993	29.251
SAEON	IC	Rainfall	Tipping bucket rain gauge	Nov 2013 - present	-28.981	29.237
SAEON	IIA	Rainfall	Tipping bucket rain gauge	Nov 2013 - present	-29.005	29.222

SAEON	IIC	Rainfall	Tipping bucket rain gauge	Nov 2013 - present	-28.996	29.235
SAEON	IIB	Rainfall	Tipping bucket rain gauge	Jan 2014 - present	-28.996	29.223
SAEON	IIIA	Rainfall	Tipping bucket rain gauge	Nov 2013 – present	-29.005	29.232
SAEON	IIIB	Rainfall	Tipping bucket rain gauge	Nov 2013 – present	-28.996	29.234
SAEON	IIIC	Rainfall	Tipping bucket rain gauge	Jan 2018 - present	-28.989	29.239
SAEON	IVB	Rainfall	Tipping bucket rain gauge	Oct 2013 – present	-28.999	29.241
SAEON	IVC	Rainfall	Tipping bucket rain gauge	Oct 2013 – present	-28.991	29.244
SAEON	IVA	Rainfall	Tipping bucket rain gauge	Oct 2013 – present	-29.003	29.238
SAEON	VA	Rainfall	Tipping bucket rain gauge	Oct 2013 – present	-28.998	29.248
SAEON	VIBR	Rainfall	Tipping bucket rain gauge	Oct 2013 – present	-28.993	29.252
SAEON	VIIA	Rainfall	Tipping bucket rain gauge	Oct 2013 – present	-28.993	29.256
SAEON	VIIC	Rainfall	Tipping bucket rain gauge	Oct 2013 – present	-28.988	29.253
SAEON	VIIB	Rainfall	Tipping bucket rain gauge	Nov 2013 - present	-28.99	29.257
SAEON	VIIIA	Rainfall	Tipping bucket rain gauge	Nov 2013 - present	-28.982	29.264
SAEON	VIIIC	Rainfall	Tipping bucket rain gauge	Nov 2013 - present	-28.983	29.269
SAEON	IXA	Rainfall	Tipping bucket rain gauge	Nov 2013 - present	-28.992	29.263
SAEON	IXB	Rainfall	Tipping bucket rain gauge	Nov 2013 - present	-28.991	29.266
SAEON	IXC	Rainfall	Tipping bucket rain gauge	Nov 2013 - present	-28.992	29.274
SAEON	XA	Rainfall	Tipping bucket rain gauge	Nov 2013 - present	-28.997	29.254
SAEON	XC	Rainfall	Tipping bucket rain gauge	Dec 2013 - present	-28.998	29.262
SAEON	CAT9 AWS	Wind sp/dr, Air temp., HR, radiation, rainfall	CS Automatic Weather Station	Nov 2018 - present	-28.990	29.266
SAEON	Bambanani	Wind sp/dr, Air temp., HR, rainfall, baro.	CS Automatic Weather Station	May 2016 - present	-28.688	29.132
SAEON	Okhombe	Wind sp/dr, Air temp., HR, rainfall, baro.	CS Automatic Weather Station	June 2016 - present	-28.708	29.092
DWS	Rhenosterfontein @ Spioenkop Dam (V1E010, previously V1E006)	Rainfall, evaporation	Tipping bucket rain gauge	Mar 1992 - present	-28.679	29.516
SAWS	Giant's Castle 0268016 W (previously 0267887 W)	Air temp., rainfall	Automatic weather station	Mar 1947 - present	-29.16	29.31

SAWS	Royal Natal 0298791 W	Air temp., rainfall	Automatic weather station	Jan 1948 - present	-28.7	28.95
SAWS/EKZNW	Monk's Cowl 0267693 W	Rainfall	Rain gauge	Jun 1962 – present	-29.05	29.4
SAWS	Cathedral Peak Hotel 0299357 W	Rainfall	Rain gauge	Oct 1936 - present	-28.57	29.12
SAWS	Bergville 0299614 W	Rainfall	Rain gauge	Oct 1930 – unknown (present)	-28.44	29.21
ARC	Acton Valley 0299700 A	Rainfall	Rain gauge	Jan 1948 – unknown (present)	-28.40	29.24
ARC	Venterslaager 0299788 A	Rainfall	Rain gauge	Jan 1935 – unknown (present)	-28.38	29.27
ARC	Hathaway 0299896 A	Rainfall	Rain gauge	Jul 1956 – unknown (present)	-28.56	29.30
SAWS	Heartsease 0299900 W	Rainfall	Rain gauge	Dec 1927 – unknown (present)	-29.01	29.29
ARC	Glenisla 0300022 A	Rainfall	Rain gauge	Oct 1973 – unknown (present)	-28.52	29.31
Mahlathini Development Foundation	Emabunzini – V. Khumalo	Rainfall	Rain gauge	Feb 2020 - present	-28.869	29.290
Mahlathini Development Foundation	Eqeleni – N. Zikode	Rainfall	Rain gauge	Feb 2020 - present	-29.290	29.365
Mahlathini Development Foundation	Vimbukhalo – S. Mpulo	Rainfall	Rain gauge	Mar 2020 - present	-29.365	29.365
Mahlathini Development Foundation	Ndunwane – B. Hlatshwayo	Rainfall	Rain gauge	Mar 2020 - present	-29.365	29.365
Mahlathini Development Foundation	Ezibomvini – P. Hlongwane	Rainfall	Rain gauge	Mar 2020 - present	-28.864	29.395

Mahlathini Development Foundation	Stulwane – N. Msele	Rainfall	Rain gauge	Mar 2020 - present	-28.911	29.375

Current Hydrological Stations						
Quantity						
Custodian	***Gauge***	***Variable/s***	***Equipment***	***Record period***	***Location***	
					Latitude	***Longitude***
SAEON	V1H007 (CP III)	Stage height, water temperature	CS451 Pressure Transducer	Jul 2016 - present	-28.989	29.239
SAEON	V1H005 (CP IV)	Stage height, water temperature	OTT logger	Feb 2016 - present	-28.990	29.243
SAEON	V1H008 (CP V)	Stage height, water temperature	CS451 Pressure Transducer	Feb 2016 - present	-28.990	29.244
SAEON	V1H022 (CP VI)	Stage height, water temperature	CS451 Pressure Transducer; OTT logger	Feb 2016 - present	-28.987	29.251
SAEON	V1H021 (CP VII)	Stage height, water temperature	OTT logger	Feb 2016 - present	-28.987	29.252
SAEON	V1H023 (CP IX)	Stage height, water temperature	CS451 Pressure Transducer	Oct 2016 - present	-28.991	29.273
DWS	V1H001 (Tugela drift)	Stage height	OTT logger	Nov 1924 - present	-28.735	29.821
DWS	V1H010 (Winterton)	Stage height	OTT logger	Nov 1964 - present	-28.818	29.545
DWS	V1H026 (Tugela River - Kleine Waterval)	Stage height	OTT logger	Jul 1967 - present	-28.721	29.375
DWS	V1H041 (Mlambonja river)	Stage height	OTT logger	Dec 1976 - present	-28.812	29.310
DWS	V1R001 (Spioenkop dam)	Spill, withdrawals		May 1971 - present	-28.681	29.517
DWS	V1R002 (Driel barrage)	Spill, withdrawals		Feb 1976 - present	-28.763	29.291
DWS	V1R003 (Woodstock)	Spill, withdrawals		Oct 1983 - present	-28.758	29.246
Quality/Chemistry						
SAEON	CP III - YSI	Monthly Temperature, salinity, conductivity, DO, TDS, pH, ORP	YSI	May 2014 - present	-28.989	29.239
SAEON	CP IV - YSI	Monthly Temperature, salinity, conductivity, DO, TDS, pH, ORP	YSI	May 2014 - present	-28.990	29.243
SAEON	CP V - YSI	Monthly Temperature, salinity, conductivity, DO, TDS, pH, ORP	YSI	May 2014 - present	-28.990	29.244

SAEON	CP VI - YSI	Monthly Temperature, salinity, conductivity, DO, TDS, pH, ORP	YSI	May 2014 - present	-28.987	29.251
SAEON	CP VII - YSI	Monthly Temperature, salinity, conductivity, DO, TDS, pH, ORP	YSI	May 2014 - present	-28.987	29.252
SAEON	CP IX - YSI	Monthly Temperature, salinity, conductivity, DO, TDS, pH, ORP	YSI	July 2014 - present	-28.991	29.273
SAEON	CP III - YSI	Samples are lab analysed for range of variables	ISCO Sampler	Campaigns	-28.989	29.239
SAEON	CP VI - YSI	Samples are lab analysed for range of variables	ISCO Sampler	Campaigns	-28.987	29.251
SAEON	CP IX - YSI	Samples are lab analysed for range of variables	ISCO Sampler	Campaigns	-28.991	29.273
Université de Bourgogne	CP VI - spectral	DOC, TOC	Spectral probe	June 2019 - present	-28.987	29.251
Université de Bourgogne	CP IX - spectral	DOC, TOC	Spectral probe	June 2019 - present	-28.991	29.273
DWS	V1H001Q01	EC, pH, TDS, NA, MG, CA, F, Cl, NO_3, NO_2, SO_4, PO_4, TAL, SI, K, NH_4, TDS		Monthly/periodic	-28.735	29.821
DWS	V1H010Q1	EC, pH, TDS, NA, MG, CA, F, Cl, NO_3, NO_2, SO_4, PO_4, TAL, SI, K, NH_4, TDS		Monthly/periodic	-28.818	29.545
DWS	V1H026Q1	EC, pH, TDS, NA, MG, CA, F, Cl, NO_3, NO_2, SO_4, PO_4, TAL, SI, K, NH_4, TDS		Monthly/periodic	-28.721	29.375
DWS	V1H031Q1	EC, pH, TDS, NA, MG, CA, F, Cl, NO_3, NO_2, SO_4, PO_4, TAL, SI, K, NH_4, TDS		Monthly/periodic	-28.722	29.351
DWS	V1H038Q1	EC, pH, TDS, NA, MG, CA, F, Cl, NO_3, NO_2, SO_4, PO_4, TAL, SI, K, NH_4, TDS		Monthly/periodic	-28.561	29.752
DWS	V1H041Q1	EC, pH, TDS, NA, MG, CA, F, Cl, NO_3, NO_2, SO_4, PO_4, TAL, SI, K, NH_4, TDS		Monthly/periodic	-28.812	29.310
DWS	V1H057Q1	EC, pH, TDS, NA, MG, CA, F, Cl, NO_3, NO_2, SO_4, PO_4, TAL, SI, K, NH_4, TDS		Monthly/periodic	-28.681	29.516
DWS	V1H058Q1	EC, pH, TDS, NA, MG, CA, F, Cl, NO_3, NO_2, SO_4, PO_4, TAL, SI, K, NH_4, TDS		Monthly/periodic	-28.762	29.292
Soil Water						
SAEON	CP III Soil pit	Volumetric soil water content in a profile	CS616 Water Content Reflectometer	Nov 2019 - present	-28.994	29.233
SAEON	CP VI Soil pit	Volumetric soil water content in a profile	CS616 Water Content Reflectometer	May 2019 - present	-28.993	29.251

SAEON	CP IX Soil pit	Volumetric soil water content in a profile	CS616 Water Content Reflectometer	Oct 2019 - present	-28.990	29.265
SAEON	CP VI CRP	Spatial, continuous soil water content	Cosmic Ray probe		-28.993	29.251
SAEON	CP III Diviner tubes	Monthly soil water content (every 10cm to a depth of 110cm); 6 tubes distributed through catchment	Soil Diviner tube	Mar 2019 - present	-28.9983 -28.9984 -28.9942 -28.9944 -28.9903 -28.9904	29.2341 29.2342 29.2368 29.2370 29.2379 29.2380
SAEON	CP VI Diviner tubes	Monthly soil water content (every 10cm to a depth of 110cm); 6 tubes distributed through catchment	Soil Diviner tube	Mar 2019 - present	-28.9954 -28.9956 -28.9933 -28.9933 -28.9894 -28.9895	29.2524 29.2523 29.2523 29.2522 29.2518 29.2519
SAEON	CP IX Diviner tubes	Monthly soil water content (every 10cm to a depth of 110cm); 6 tubes distributed through catchment	Soil Diviner tube	Mar 2019 - present	-28.9906 -28.9910 -28.9906 -28.9907 -28.9917 -28.9918	29.2643 29.2644 29.2672 29.2671 29.2703 29.2702

APPENDIX E: Historical Datasets

Vegetation related Datasets				
Custodian/ Author	**Dataset**	**Variable**	**Length/ Time period**	**URL (if available)**
Gordijn, P.	Cathedral Peak research catchment vegetation composition, diversity and soils data	Descending point surveys; higher plant presence/absence data; soil text texture and fertility analyses	1984 - 2015	https://doi.org/10.1016/j.ppees.2018.07.005
Gordijn, P.	Cathkin Key vegetation composition, diversity and soils data	Descending point surveys; higher plant presence/absence data & cover abundance; soil text texture and fertility analyses	1984 - 2018	
Gordijn, P.	Brotherton vegetation composition	Descending point surveys	1980 - 2019	
Gordijn, P.	Brotherton vegetation diversity	Vegetation cover abundance	2018	
Bentley, L.	C3 C4 grass distribution	C3 C4 grass species distribution data for the uKhahlamba Drakensberg	2018	
Manson, A.	Soils data	Brotherton soil fertility and texture data	2007	http://resolver.co.za/get.aspx?guid=dfef6339-7452-4d0c-b1f0-9dec0880cc24>
Gordijn, P.	Herbaceous biomass and basal cover	Brotherton herbaceous biomass and basal cover	2018	https://doi.org/10.15493/SAEON.GFW.10000001
Shezi, T. A.	Soils data	P, K, Ca, N, Mg, Zn, Mn, Cu, exchangeable acidity, acidity saturation, total cations, pH (KCl), organic carbon and percent clay of each plot.	2016 - 2017	http://www.sasdi.net/metaview.aspx?uuid=8cffc158ad63f4b7b5835920c069c475
Shezi, T. A.	Species data	Species and composition	2016 - 2017	http://www.sasdi.net/metaview.aspx?uuid=32d1012855a4e63c097703d94d2f8302
Shezi, T. A.	Environmental data	Location, altitude, aspect, slope, geology, soil type, land type, distance to settlement, distance to the closest kraal, and distance to the nearest perennial water of each plot.	2016 - 2017	http://www.sasdi.net/metaview.aspx?uuid=a96fb4ba1551166d8de0ad849e25f14d

Historical Meteorological Data

Note: Stations that have been reinstated are shaded in Gray; only stations with a record length of greater than 10 years are listed.

Custodian	***Gauge***	***Variable/s***	***Location***		***Record period***
			Latitude	***Longitude***	
SAEON	Mike's Pass	Rainfall, temp., RH, average solar radiation, average wind dir./sp.; Apan evaporation	-28.975	29.235	1948 - 1995

SAEON	Research Office station	Rainfall, temperature, RH, average solar radiation, average wind dir./sp.	-28.940	29.235	1952 - 1993
SAEON	IA	Rainfall	-28.988	29.234	1950 - 1985
SAEON	IC	Rainfall	-28.981	29.237	1950 - 1985
SAEON	IB	Rainfall			1973 - 1985
SAEON	IIA	Rainfall	-29.005	29.222	1948 - 1993
SAEON	IIC	Rainfall	-28.996	29.235	1948 - 1993
SAEON	IIB	Rainfall	-28.996	29.223	1948 - 1993
SAEON	IIIA	Rainfall	-29.005	29.232	1950 - 1985
SAEON	IIIB	Rainfall	-28.996	29.234	1950 - 1993
SAEON	IVB	Rainfall	-28.999	29.241	1949 - 1993
SAEON	IVC	Rainfall	-28.991	29.244	1949 - 1993
SAEON	IVA	Rainfall	-29.003	29.238	1949 - 1993
SAEON	VA	Rainfall	-28.998	29.248	1950 - 1993
SAEON	VIBR	Rainfall	-28.993	29.252	1953 - 1993
SAEON	VIIA	Rainfall	-28.993	29.256	1950 - 1993
SAEON	VIIC	Rainfall	-28.988	29.253	1953 - 1993
SAEON	VIIB	Rainfall	-28.99	29.257	1953 - 1985
SAEON	VIIIA	Rainfall	-28.982	29.264	1965 - 1993
SAEON	VIIIB	Rainfall	-28.985	29.269	1965 - 1985
SAEON	VIIIC	Rainfall	-28.983	29.269	1963 - 1985
SAEON	IXA	Rainfall	-28.992	29.263	1953 - 1993
SAEON	IXB	Rainfall	-28.991	29.266	1954 - 1985
SAEON	IXC	Rainfall	-28.992	29.274	1954 - 1993
SAEON	XA	Rainfall	-28.997	29.254	1955 - 1993
SAEON	XC	Rainfall			1955 - 1985
SAEON	XB	Rainfall	-28.998	29.263	1973 - 1985
SAEON	XIC	Rainfall			1973 - 1993
SAEON	XIB	Rainfall			1973 - 1985
SAEON	XIIA	Rainfall			1973 - 1985
SAEON	XIIB	Rainfall			1973 - 1985
SAEON	XIIIA	Rainfall			1973 - 1985
SAEON	XIIIB	Rainfall			1973 - 1985
SAEON	XIIIC	Rainfall			1973 - 1985
SAEON	XIV G	Rainfall			1972 - 1985
SAEON	XIV C	Rainfall			1973 - 1985
SAEON	XIV E	Rainfall			1973 - 1985
SAEON	XIVF	Rainfall			1973 - 1985
SAEON	XIVGR	Rainfall			1975 - 1993
SAEON	XVE	Rainfall			1972 - 1985
SAEON	XVB	Rainfall			1975 - 1985
SAEON	XVC	Rainfall			1975 - 1985
SAEON	XVD	Rainfall			1975 - 1985
SAEON	XVF	Rainfall			1975 - 1985
SAEON	XVG	Rainfall			1975 - 1985
SAEON	XVER	Rainfall			1976 - 1985
SAWS	Upper Little Tugela 0267788W	Rainfall	-29.133	29.45	1962 - 1968
SAWS	Clifford Chambers 0299008W	Rainfall	-28.40	29.02	1940 - 1987

SAWS	Olivia 0299223W	Rainfall	-28.43	29.08	1948 - 1986
ARC	Killarney 0299402A	Rainfall	-28.42	29.14	1970 - 1989
ARC	Cathedral Peak Forest. 0299417A	Rainfall	-28.57	29.14	1973 - 1989
SAWS	Hoffenthal 0299437W	Rainfall	-28.47	29.15	1931 - 1956
ARC	Eastlynn 0299493 A	Rainfall	-28.43	29.17	1970 - 1989
ARC	Avondale 0299555A	Rainfall	-28.45	29.19	1973 - 1989
ARC	Fairfax 0299588 A	Rainfall	-28.48	29.20	1972 - 1989
SAWS	Geluksberg 0299601 W	Rainfall	-28.31	29.21	1933 - 1953
ARC	Hunters Rest 0299611 A	Rainfall	-28.41	29.21	1959 - 1989
ARC	Hazelhurst 0299646 A	Rainfall	-28.46	29.22	1964 - 1988
ARC	Beaulieu 0299678 A	Rainfall	-28.48	29.23	1968 - 1989
SAWS	Bonheim 0299797 W	Rainfall	-28.47	29.28	1923 - 1953
ARC	Brandkraal 0299804 A	Rainfall	-28.54	29.27	1973 - 1989
SAWS	Bryn Eva 0299833 W	Rainfall	-28.53	29.28	1928 - 1957
ARC	Arthurs Seat 0299835 A	Rainfall	-28.55	29.28	1965 - 1985
ARC	Vectis 0300051 A	Rainfall	-28.51	29.32	1932 - 1989
ARC	Uitzicht 0300141 A	Rainfall	-28.51	29.35	1937 - 1988
SAWS	Loskop (Pol) 0300206 W	Rainfall	-28.56	29.37	1968 - 1993
ARC	Driemeyer 0300322 A	Rainfall	-28.52	29.41	1956 - 1987
DWS	Colenso V1E001	Rainfall, evaporation	-28.733	29.833	1935 - 1990
DWS	Kromdeel @ De Hoek Forest Res V1E003	Rainfall, evaporation	-29.008	29.624	1967 -1970
DWS	Van Reenen V1E005	Rainfall, evaporation	-28.366	29.378	1968 - 2018
DWS	Jagersrust @ Pump Station V1E007	Rainfall, evaporation	-28.600	29.116	1976 - 1997
DWS	Eendracht @ Driel Barrage V1E008	Rainfall, evaporation	-28.767	29.287	1980 - 2019

Historical Hydrological Data

Note: Stations that have been reinstated are shaded in Gray.

Custodian	*Gauge*	*Variable/s*	*Catchment*	*Record period*
SAEON	V1M06 (New no.: V1H006)	Streamflow, annual sediment est.	I	1951 – 1985
SAEON	V1M03 (New no.: V1H003)	Streamflow, annual sediment est.	II	1948 – 1993
SAEON	V1M07 (New no.: V1H007)	Streamflow, annual sediment est.	III	1952 – 1991
SAEON	V1M05 (New no.: V1H005)	Streamflow, annual sediment est.	IV	1949 – 1993
SAEON	V1M08 (New no.: V1H008)	Streamflow, annual sediment est.	V	1952 – 1997
SAEON	V1M22 (New no.: V1H022)	Streamflow, annual sediment est.	VI	1954 – 1997
SAEON	V1M21 (New no.: V1H021)	Streamflow, annual sediment est.	VII	1957 – 1993
SAEON	V1M25 (New no.: V1H025)	Streamflow, annual sediment est.	IIX	1963 – 1993
SAEON	V1M23 (New no.: V1H023)	Streamflow, annual sediment est.	IX	1954 – 1993
SAEON	V1M24 (New no.: V1H024)	Streamflow, annual sediment est.	X	1965 – 1985
SAEON	V1M42 (New no.: V1H042)	Streamflow	XI	1975 – 1985
SAEON	V1M43 (New no.: V1H043)	Streamflow	XII	1975 – 1985
SAEON	V1M44 (New no.: V1H044)	Streamflow	XIII	1976 – 1993
SAEON	V1M45 (New no.: V1H045)	Streamflow	XIV	1975 – 1993
SAEON	V1M46 (New no.: V1H046)	Streamflow	XV	1975 – 1992
Everson, C.E.	D-01 borehole	Groundwater level	VI	1994 - 1995
Everson, C.E.	D-02 borehole	Groundwater level	Vi	1994 - 1995
DWS	V1H002 (Bergville)	Streamflow	Bergville	1931 – 1970
DWS	V1H004 (The Delta)	Streamflow	The Delta	1962 – 1975
DWS	V1H029 (Geluksburg Spruit)	Streamflow	Geluksburg Spruit	1968 – 1993
DWS	V1H030 (Njongola river)	Streamflow	Njongola river	1968 – 1993
DWS	V1H031 (Sand spruit)	Streamflow	Sand spruit	1970 – 2005
DWS	V1H032 (Putterill spruit)	Streamflow	Putterill spruit	1974 – 1993
DWS	V1H033 (Tugela River)	Streamflow	Tugela River	1974 – 1983
DWS	V1H034 (Khombe river)	Streamflow	Khombe river	1974 – 1993
DWS	V1H039 (Little Tugela)	Streamflow	Little Tugela	1972 – 1996
DWS	V1H047 (Mdwaleni river)	Streamflow	Mdwaleni river	1985 – 1994
DWS	V1H051 (Klip river)	Streamflow	Klip river	1987 – 1993

APPENDIX F: Letters of Support

Letters of support for the Northern Drakensberg landscape proposal have been received from (the letters are included as an attached PDF document or can be viewed using the hyperlink for each letter which takes you to the Google Drive folder where they are stored):

1. Agricultural Crop Research Services, KZN Department of Agriculture & Rural Development
2. Afromontane Research Unit, University of Free State
3. ASSET Research
4. Biogeosciences Laboratory, University of Burgundy
5. Dr CJ Curtis, Dept of Geography, Environmental Management and Energy Studies, University of Johannesburg
6. Centre for Water Resources Research, University of KwaZulu-Natal
7. Dr H James, Albany Museum
8. Department of Water Resources and Ecosystems, IHE Delft Institute for Water Education
9. Institute of Natural Resources
10. Prof K P Kirkman, School of Life Sciences, UKZN.
11. Prof. M. te Beest, Utrecht University, The Netherlands, Nelson Mandela University & SAEON Grasslands-Forests-Wetlands Node
12. Mahlathini Development Foundation
13. No-Till Club KZN
14. Mr NT Madondo (community facilitator)
15. Owners of Emaweni and Zingela farms
16. Prof S Grab, University of the Witwatersrand
17. Dr M Tau, SANBI
18. Southern African Program on Ecosystem Change and Society (SAPECS)
19. Prof TR Hill, Discipline of Geography, UKZN.
20. Department of Soil, Crop and Climate Sciences, University of the Free State
21. Prof J Vonesh, Center for Environmental Studies, Virginia Commonwealth University, United States of America.