Priority Areas for Ecosystem-based Adaptation to Climate Change in the Kruger to Canyons Biosphere

Bringing livelihoods, ecosystem services, climate change adaptation and biodiversity issues together to identify an integrated set of natural and semi-natural priority areas for supporting system resilience

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1. Introduction

The Kruger to Canyons Biosphere (K2C) project aims to develop an Ecosystem-based Adaptation view of the K2C. This requires that social, water, biodiversity and climate change issues are brought together in a coherent and integrated view of the area.

Various systematic prioritization processes have been undertaken for the area. Can these be brought together in a sensible way that aids understanding and prioritization of conservation activities focussed on climate change adaptation within the Kruger to Canyons Biosphere? A desktop Ecosystem-based Adaptation spatial prioritization for the Kruger to Canyons Biosphere was undertaken. This aims to bring livelihood, ecosystem services and ecological infrastructure, climate change adaptation and biodiversity issues together. The analysis aims to guide a range of K2C management actions, including the revision of the zoning for the biosphere.

The project then evaluated the results of the assessment to identify the highest overall priority areas of the K2C that are in communal rangelands and adjacent to protected areas. This aspect of the project was largely focussed on guiding Conservation South Africa's sustainable land management interventions aimed at supporting climate change adaptation.

Project context and objectives

The current overall project is funded by Conservation South Africa, and co-funded by the GEF5 PA Project which is being implemented through the Kruger 2 Canyons Biosphere. This report is focussed on the Conservation South Africa component.

The project will undertake a rapid assessment of the spatial priorities for Ecosystem-based Adaptation within the Kruger to Canyons Biosphere, and in doing so meet the following key objectives:

- To develop a rapid systemic spatial assessment for landscape interventions in the K2C, integrating climate change, social requirements, water resource requirements, ecosystem services, and biodiversity.
- Evaluate the results of the assessment to identify the highest overall priority areas of the K2C that are in communal rangelands and adjacent to protected areas.
- To develop a data archive to allow CSA to share the results via its online Resilience Atlas.

The key concepts underlying the assessment of spatial priorities

This assessment takes an Ecosystem-based Adaptation view of the environment. It covers both the range of biodiversity (terrestrial, river and wetland), implementation issues linked to biodiversity (such as protected area expansion), ecosystem service deliver (e.g. ecological infrastructure important for water linked services), and the human demand for ecosystem services (particularly where poor communities are directly reliant on the environment for services). It also explicitly includes climate change issues, as climate change will impact on biodiversity, and with this the ability of biodiversity and ecosystems to provide ecosystem services that support human society. This is particularly important in rural areas such as the Kruger to Canyons Biosphere, where the link between people and the environments that support them (and place them at risk in terms of floods, droughts and fires) is far more direct than in more urbanized environments. Natural landscapes play a critical role in delivering the key ecosystem services (such as sufficient quantity of clean drinking water) on which people depend. Further, these natural (and semi-natural) environments are critical to supporting climate change resilience and in directly contributing to human adaptation to the impacts of climate change.

The overall assessment is built on four underlying spatial assessments of the landscape:

1. **Areas supporting climate change resilience.** Some features in the landscape are more likely to be important for supporting the resilience of ecosystems (and hence the broader social ecological system dependent on functional ecosystems) to climate change impacts than others. Such features include: riparian corridors and buffers; areas with temperature, rainfall and altitudinal gradients; areas of high diversity; areas of high plant endemism; refuge sites including south-facing slopes and kloofs; and priority large unfragmented landscapes. Keeping these areas in a natural or near-natural state will help ecosystems and species to adapt naturally to climate change, thus supporting healthy landscapes and the ability of ecosystems to continue to provide ecosystem services to communities. The analysis process identified the key features which support overall climate change resilience for environmental systems in the catchment.

2. **Ecological infrastructure**. Most people are aware of concept of built infrastructure, which refers to the roads, rail, power lines, water pipes and sewerage plants which support human society. Related to this concept of built infrastructure is that of Ecological Infrastructure, which refers to the natural and semi-natural ecosystems that deliver valuable services to people e.g. fresh water, climate regulation, soil formation and disaster risk reduction. Ecological Infrastructure includes healthy mountain catchments, rivers, wetlands, nodes and corridors of natural habitat, which form a network of interconnected structural elements in the landscape. Importantly, Ecological Infrastructure is not designed to be a catch-all phrase which can be equated to “natural systems”, but rather talks to specifically identified places which are delivering particular ecosystem services which are of value to communities.

   The analysis and mapping process identified the key specific areas of natural and semi-natural habitat important for delivering ecosystem services to the people. The analysis focussed on water related ecosystem services linked to the quantity and quality of water supply, the control of soil erosion and reduction of sediment inputs into systems, and areas important for reducing flood risk.

3. **A systematically identified set of biodiversity priorities.** Independent of climate change, there are a range of key biodiversity assets and priority areas which underpin all ecosystems and the services these ecosystems deliver. An intact and functional landscape is critical to supporting society. Therefore, we have identified a set of overall spatial biodiversity priorities for the district. This component integrates existing provincial conservation plans for the two provinces (Limpopo and Mpumalanga), the river and wetland priorities identified in the national Freshwater Ecosystem Priority Areas assessment, Strategic Water Source Areas, levels of threat to ecosystems, protection levels of ecosystems, and priorities from Protected Area Expansion.

4. **Priorities for supporting livelihoods.** We have identified the social priority areas where people are most directly dependent on the environment for the delivery of ecosystem services. The assessment was a spatial analysis of poverty and local direct natural resource dependency, which was used to develop a social demand / livelihoods index for communities within the Kruger to Canyons Biosphere. The data-driven demand index, consists of two composite indices, namely a revised poverty index (incorporating sub-indices of people who are not employed, a dependency ratio, low income households, consumption and access to services), and a local direct natural resource use dependency

index (incorporating sub-indices of access to piped water, dependency on the environment for wood for cooking, dependency on the environment for wood for heating and dependency on the environment for building materials).

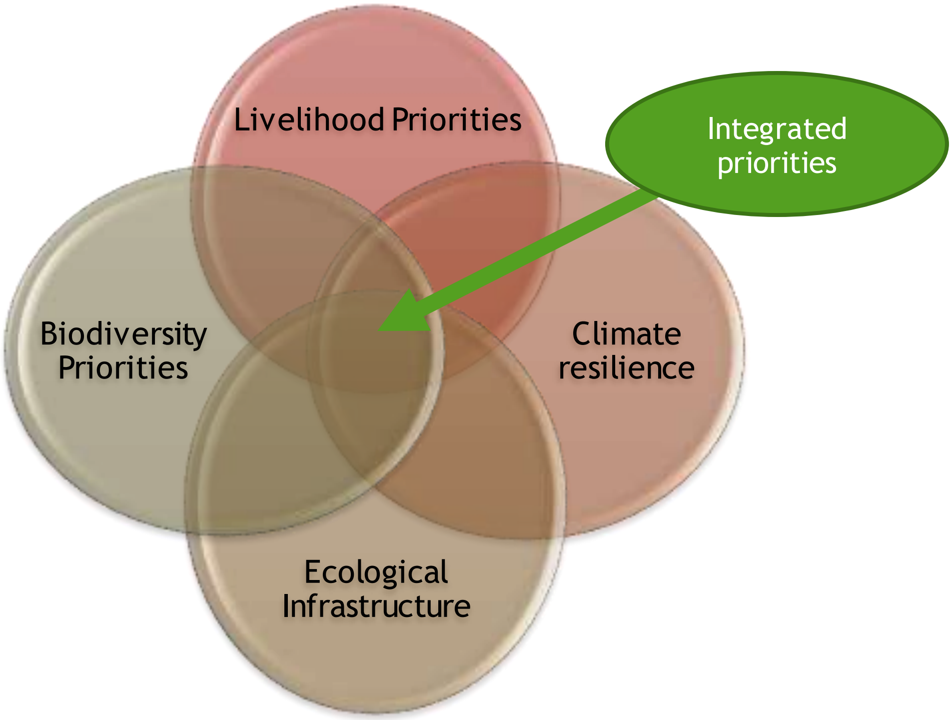

Figure 1: Summary of the spatial analysis used to define priorities for Ecosystem-based Adaptation.

Once these four building blocks are in place, we can identify priority areas where these individual components overlap. We have provisionally conceptualized these areas as being the spatial conservation priorities for the Kruger to Canyons Biosphere. These are strongly linked to the concept of Ecosystem-Based Adaptation:

5. **Ecosystem-based Adaptation**. In addition to supporting well-functioning landscapes in the long term, some of the areas important for climate change resilience may also provide more specific, immediate benefits that assist directly with human adaptation to the impacts of climate change, known as Ecosystem-based Adaptation[1]. For example, buffers of natural vegetation along riparian corridors and around wetlands mitigate floods, reduce erosion and improve water quality. Ecosystem-based Adaptation has the potential to be both more effective and less costly than engineered solutions, and can be more easily applied in rural landscapes, and implementation efforts can be easily aligned with job creation and other projects with significant social benefits. The analysis focussed on the key question: Where do these four layers (Areas supporting resilience to climate change impacts, ecological infrastructure, the systematically identified set of biodiversity priorities, and priorities for supporting livelihoods) overlap most strongly?

This assessment should not be seen as a definitive spatial picture for the biosphere. Rather, it is an exploratory desktop examination of the biosphere.

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[1] The Convention on Biological Diversity defines ecosystem-based adaptation as "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change", and the first major international report on ecosystem-based adaptation was published by the World Bank in 2009. South Africa's National Climate Change Response White Paper fully supports this approach

2. Ecological Infrastructure:

Ecological Infrastructure refers to the functioning ecosystems that deliver valuable services to people e.g. fresh water, climate regulation, soil formation and disaster risk reduction. Ecological infrastructure includes healthy mountain catchments, rivers, wetlands, coastal dunes, nodes and corridors of natural habitat, which form a network of interconnected structural elements in the landscape.

Conceptual basis and key data sources

The analysis was based on the emerging South African conceptual framework for Ecological Infrastructure (EI)[2]. The current study focussed on identifying functioning ecosystems that deliver valuable services to people. As other components are specifically dealt with elsewhere in the current analysis, we have focussed on the specific areas of water related EI in the Kruger to Canyons Biosphere:

- Water production and stream flow augmentation e.g. natural areas with high water yield and portions of the landscape required to support flow during the dry season. Protecting or improving these areas of EI would reduce requirements for additional water storage and would ensure water supply to people directly dependent on water from streams, springs and pools.
- Erosion control e.g. erosion prone areas which need to be kept intact or rehabilitated. Protecting or improving these areas of EI would reduce capacity reduction of storage schemes and reduce water treatment costs.
- Enhancement of water quality, including areas important for sediment trapping, and reducing levels of phosphates, nitrates and toxicants. Protecting or improving these areas of EI would reduce water treatment costs.
- Flood attenuation e.g. the particular types of wetland which are important for delaying flood peaks and reducing flood intensity. Protecting or improving these areas of EI would reduce risk to water supply infrastructure during extreme flood events.

The approach taken was to build a bottom-up set of EI, rather than assuming that all of intact nature was delivering valuable services to people. Therefore, we needed to make the case linking an area to a specific valuable service. There was no scope for new data collection, so we were largely applying a new concept and analysis to existing data. The most important specific sources were the CSIR/SANBI ProEcoServ project and the Kotze et al. wetland ecosystem services evaluation (Table 1)[3]. Additional data sources are detailed in Table 2.

[2] This EI concept is currently best articulated in:
The SANBI/SANBI Grasslands/CSIR/ProEcoserv summary of Ecological Infrastructure concepts (http://www.grasslands.org.za/ document-archive/ category/15-dialogue-on-ecological-infrastructure?download= 63%3Afactsheetonecologicalinfrastructure).
The proceedings of the November 2012 SANBI Grasslands Dialogue on Ecological Infrastructure (http://www.grasslands.org.za/ document-archive/category/15-dialogue-on-ecological-infrastructure?download=66%3Aproceedings-of-dialogue-on-ecological-infrastructure-2012s).

[3] The ProEcoServ project (implemented by CSIR and SANBI) in South Africa. Provided useful national analyses and concepts which the current project refined at a local scale. http://www.proecoserv.org/.
The wetland services evaluation (Wet-EcoServices, A technique for rapidly assessing ecosystem services supplied by wetlands, 2005 by Donovan Kotze, Gary Marneweck, Allan Batchelor, David Lindley and Nacelle Collins – later also published by the Water Research Commission in 2008 as WRC Report TT 339/08), is a technique for rapidly assessing ecosystem services supplied by South African wetlands. It forms the conceptual basis used in this project for identifying which services are provided by a specific wetland type.

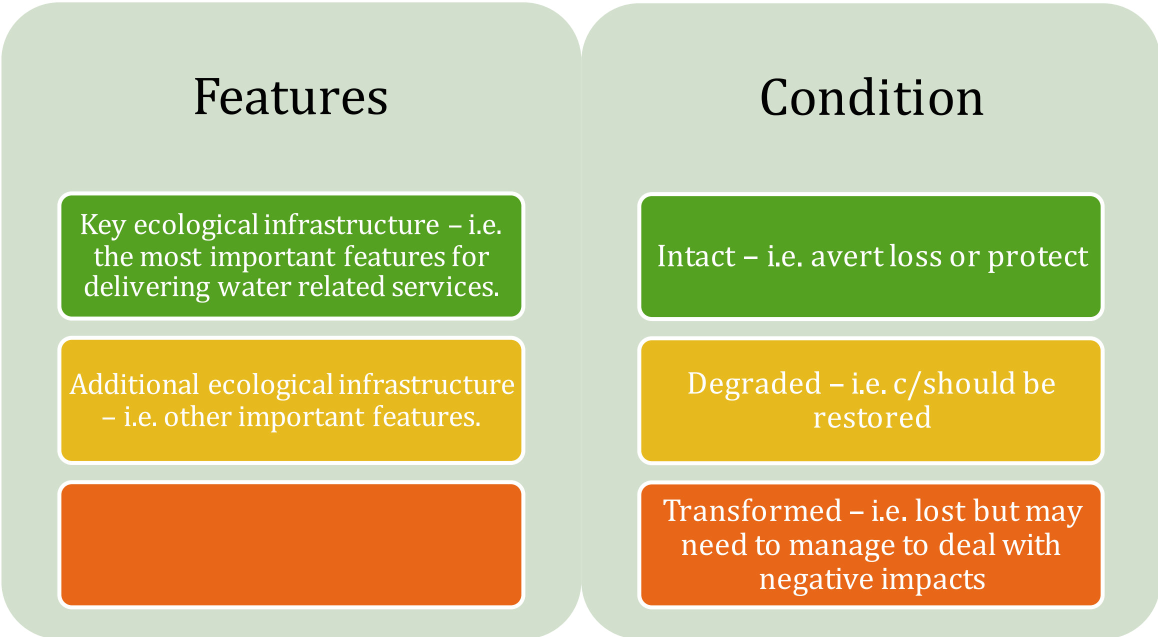

Figure 1: Two separate concepts were used to classify Ecological infrastructure. Theoretically six categories can result from the combination of these two concepts - however, we have kept all transformed EI as a single category.

Ecological Infrastructure was classified based on two key criteria (See Figure 2):

- The value of the feature in terms of delivering water related ecological services feature. This evaluation assumed that all features were in a natural state. We differentiated between:
  - Key ecological infrastructure – i.e. the most important features for delivering water related services. These are areas which are very likely to be critical to the delivery of services.
  - Additional ecological infrastructure – i.e. other important features for delivering water related services. These are areas which are likely to be delivering fewer services, or fulfil a supporting role in service delivery.
- The current condition of the feature providing the services. We used the most up to date integrated landcover[4] for the Kruger to Canyons Biosphere (Figure). Based on this landcover, we differentiated between three categories.
  - Ecological Infrastructure (Natural): Areas that are in a natural or semi-natural condition, and which should be protected to ensure long term ecological service delivery.
  - Ecological Infrastructure (Degraded): Areas that are currently in a poor or degraded condition, but which could be rehabilitated to improve ecological service delivery. Areas impacted by gullies and other erosion features were considered to be degraded.
  - Transformed Ecological Infrastructure: Areas where Ecological Infrastructure has been lost, but where there may be opportunities to mitigate/reduce negative impacts through improved management practices. Cultivated areas, plantations, dams, urban, industrial and mining areas were included in this category.

[4] GeoTerraImage. 2015. 2013-2014 South African National Land-Cover Dataset. Department of Environmental Affairs, Pretoria.

Theoretically six categories can result from the combination of these two concepts. However, only five are utilized as all types of transformed EI were kept in one category, as the original feature value is no longer relevant in a highly transformed landscape.

Table 1: Rating of the hydrological benefits likely to be provided by a wetland based on its particular hydro-geomorphic type (Kotze et al. 2005).

WETLAND HYDRO-GEOMORPHIC TYPE	HYDROLOGICAL FUNCTIONS POTENTIALLY PERFORMED BY THE WETLAND								
	Flood attenuation		Stream flow augmentation		Erosion control	Enhancement of water quality			
	Early wet season	Late wet season	Early wet season	Late wet season		Sediment trapping	Phos-phates	Nitrates	Toxicants[1]
1. Floodplain	++	+	0	0	++	++	++	+	+
2. Valley bottom – channelled	+	0	0	0	++	+	+	+	+
3. Valley bottom – unchanneled	+	+	+?	+?	++	++	+	+	++
4. Hillslope seepage feeding a stream channel	+	0	+	+	++	0	0	++	++
5. Hillslope seepage not feeding a stream	+	0	0	0	++	0	0	++	+
7. Pan/ Depression	+	+	0	0	0	0	0	+	+

Note: [1]Toxicants are taken to include heavy metals and biocides

Rating:
0 Function unlikely to be performed to any significant extent
\+ Function likely to be present at least to some degree
++ Function very likely to be present (and often performed to a high level)

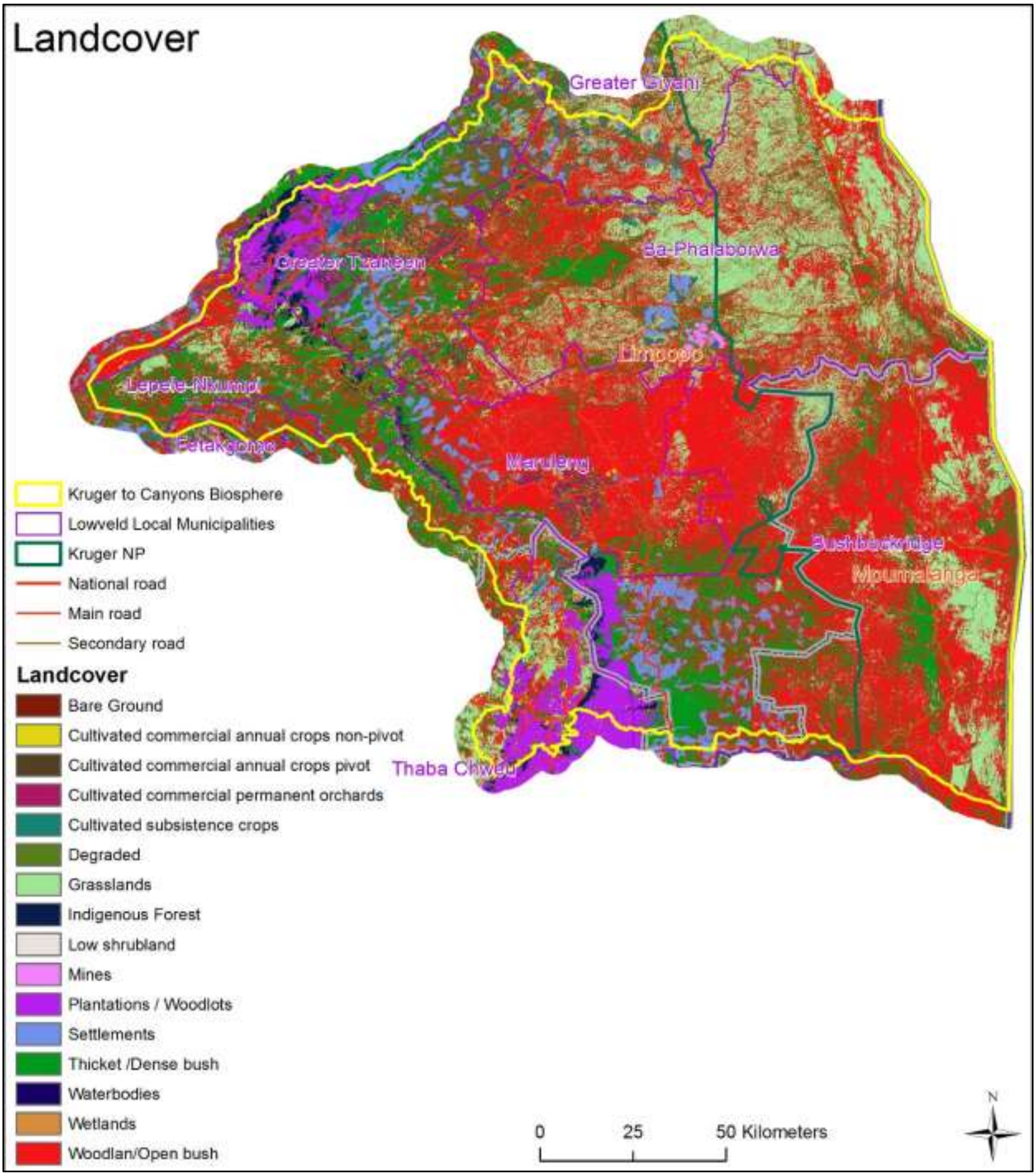

Figure 3: The latest available DEA landcover was used for the assessment. GeoTerraImage. 2015. 2013-2014 South African National Land-Cover Dataset. Department of Environmental Affairs, Pretoria.

Category	Original Source	Use
Wetland & river base data	Nel JL, Driver A, Strydom W, Maherry A, Petersen C, et al. (2011) Atlas of Freshwater Ecosystem Priority Areas in South Africa: Maps to support sustainable development of water resources. Atlas and accompanying data available from CSIR or WRC.	Each wetland and river type was buffered by specific distances - see methods table.
Addition minor rivers	Surveys and mapping 1:50 000 river data	The FEPA river dataset only includes major rivers and tributaries. This additional dataset was used to identify minor perennial and non-perennial streams.
Wetland ecosystem service delivery analysis	Kotze DC, Marneweck GC, Batchelor AL, Lindley DS, Collins NB (2005) Wet-EcoServices. A technique for rapidly assessing ecosystem services supplied by wetlands.	Evaluation of delivery of services by different wetland types used to help define wetland value.
Gullies	Mararakanye N, Le Roux JJ (2012) Gully location mapping at a national scale for South Africa. South African Geographical Journal 94: 208-218. doi:10.1080/03736245.2012.742786	Gully dataset was used directly.
Runoff & Strategic Water Source Areas	Proecoserv: Nel, J.L., O'Farrell, P., Le Maitre, D.C., Smith, J. and Reyers, B. 2013. Spatial mapping of ecosystem services. CSIR Report, 2013. Nel, J.L., Colvin, C., Le Maitre, D.C., Smith, J. and Haines, I. 2013. South Africa's Strategic Water Source Areas. CSIR report for WWF-South Africa. CSIR/NRE/ECOS/ER/2013/0031/A	The identified Strategic Water Source Areas were converted to a 30m raster grid.
Landcover	The latest available DEA landcover was used for the assessment. GeoTerraImage. 2015. 2013-2014 South African National Land-Cover Dataset. Department of Environmental Affairs, Pretoria.	The landcover types were categorized into Natural, Degraded and Transformed. They were a primary determinant in categorizing the condition of features.

Table 2: Additional data sources used in the mapping of Ecological Infrastructure.

Water production and stream flow augmentation

The project identified areas important for water production and stream flow regulation. The method (detailed in Table 3) is described below:

Strategic Water Source Areas from the CSIR[5] were considered to be the high water yield areas of the Kruger to Canyons Biosphere. The CSIR project used the Water Resources of South Africa data (WR2005) for Mean Annual Runoff at a quaternary catchment scale, which was then disaggregated to a 1 x 1 minute grid resolution using published rainfall-runoff relationships for South Africa. The final map of Strategic Water Source Areas was produced by grouping areas generating 50% of the mean annual runoff for the country. This cut-off equates to areas with runoff values of over 135mm/year. These areas were designated as high water yield. See Figure 2.

Various features important for delivering ecosystem services were then identified using the Wet-EcoServices categorization of wetlands and the services provided (Table 1), the National Wetland Inventory, the river data in the FEPA project and rivers in the 1:50 000 topocadastral data. Where possible buffer widths were linked to literature or legislation, but elsewhere these widths were determined using an iterative expert approach. The features, their classification and their treatment are detailed in Table 3:

- In high water yield areas, all areas were considered important to some degree, however all natural wetlands and riparian buffers (which were wider around large rivers and narrow around smaller rivers) were most strongly highlighted. The remaining terrestrial high water yield areas were categorized per their current condition.
- In lower water yield areas, only wetlands and areas within more limited riparian buffers were included (again with narrower buffers for smaller systems and wider buffers for large systems).
- In all areas wetlands and buffers were include for the specific wetland types which are specifically important for water production and stream flow augmentation.

Scores and categories were determined by overlaying the features and the transformation data. The value at a point was determined by the highest value at that point. This map is shown in Figure 3.

Erosion control

The study identified areas important for erosion control. These are erosion prone areas which need to be kept intact or rehabilitated. Protecting or improving these areas of EI would reduce capacity reduction of storage schemes and reduce water treatment costs. The method (detailed in Table 4) is described below:

- Erosion prone areas were prioritized. Areas with gully erosion were used from the national gully erosion mapping study by DAFF[6]. All gullied areas were included. Areas identified were cross checked against satellite imagery, which confirmed that the identified areas were both sufficiently accurate and comprehensive. This data was supplemented by all erosion gullies and other eroded areas identified in the various landcover layers. Areas with existing erosion were buffered by 1000m to identify erosion prone areas.

[5] Nel, J.L., Colvin, C., Le Maitre, D.C., Smith, J. and Haines, I. 2013. South Africa's Strategic Water Source Areas. CSIR report for WWF-South Africa. CSIR/NRE/ECOS/ER/2013/0031/A

[6] Mararakanye N, Le Roux JJ (2012) Gully location mapping at a national scale for South Africa. South African Geographical Journal 94: 208-218.

- Wetland types specifically important for erosion control were prioritized. These include channelled valley-bottom wetlands, floodplain wetlands, seeps, unchannelled valley-bottom wetlands and valleyhead seeps, all with a 100m buffer.
- Riparian buffers were also included, with wider buffers around large rivers and narrow buffers on smaller rivers.
- Scores and categories were determined by overlaying the features and the transformation data. The value at a point was determined by the highest value at that point.

A composite map was developed, which is shown in Figure 4.

Water Quality

The project identified areas important for enhancement or maintenance of water quality, including areas important for sediment trapping, and reducing levels of phosphates, nitrates and toxicants. Protecting or improving these areas of EI would reduce water treatment costs. The method (detailed in Table 5) is described below:

- Wetlands specifically important for water quality enhancement were prioritized. The wetland plus a wide (100m) buffer were used for the wetland types which are most important from a water quality perspective (floodplain wetland, seep, unchannelled valley-bottom wetland, valleyhead seep).
- The wetland plus a narrower 50m buffer being included as additional ecological infrastructure for types which play a role in water quality but are not as critical (channelled valley-bottom wetlands and depression and flat pans).
- A two-stage buffering of rivers was undertaken. Riparian buffer areas immediately adjacent to key rivers were scored highest (100m on larger rivers). A broader but lower value buffer was then added. A buffer of 250m was used on larger rivers and 32m on all other rivers.
- Scores and categories were determined by overlaying the features and the transformation data. The value at a point was determined by the highest value at that point.

A composite map was developed, which is shown in Figure 5.

Flood attenuation

The project identified areas important for flood attenuation e.g. the types of wetland which are important for delaying flood peaks and reducing flood intensity. Protecting or improving these areas of EI would reduce risk to water supply infrastructure during extreme flood events. The method (detailed in Table 6) is described below:

- Wetlands specifically important for flood attenuation were prioritized. The wetland plus a wide (100m) buffer were used for the wetland types which are most important from a flood attenuation perspective (floodplain wetland). The wetland plus a narrower 50m buffer were included as additional ecological infrastructure for types which play a secondary role in flood attenuation but are not as critical (channelled valley-bottom wetlands, depression and flat pans, seeps, unchannelled valley-bottom wetlands and valleyhead seeps).
- A single stage buffering of rivers was undertaken and these areas were also included as additional ecological infrastructure. A buffer of 250m was used on larger rivers and 100m on smaller perennial rivers.

- Scores and categories were determined by overlaying the features and the transformation data. The value at a point was determined by the highest value at that point.

A composite map was developed, which is shown in Figure 6.

Overall Integration of Ecological Infrastructure Map

The previous sections described how four summary layers of areas of important Ecological Infrastructure were developed. These layers described areas of Ecological infrastructure important for:

- Water production and stream flow augmentation e.g. natural areas with high water yield and portions of the landscape required to support flow during the dry season.
- Erosion control i.e. erosion prone areas which need to be kept intact or rehabilitated. Protecting or improving these areas of EI would reduce capacity reduction of storage schemes and reduce water treatment costs.
- Enhancement of water quality, including areas important for sediment trapping, and reducing levels of phosphates, nitrates and toxicants.
- Flood attenuation e.g. the types of wetland which are important for delaying flood peaks and reducing flood intensity.

The project utilized a simple but robust approach to integrating the four individual layers of areas of important Ecological Infrastructure:

- The individual summary layers were overlaid.
- Scores and categories were determined by overlaying the features and the transformation data.
- The highest score from any individual layer was identified and this score was used as the value for that point.

A composite map was developed which is shown in Figure 7.

The combination of the feature summary layers with the transformation data resulted in five categories:

- Key Ecological Infrastructure (Natural) – i.e. the most important features for delivering water related services and which are still in a natural or semi-natural condition. These are areas which are very likely to be critical to the delivery of services, and priority should be given to maintaining these areas in a natural state. These areas should be the focus for proactive conservation efforts such a stewardship, appropriate land management should be incentivised, and emerging threats such as alien vegetation should be carefully managed.
- Additional Ecological Infrastructure (Natural) – i.e. other important features for delivering water related services and which are still in a natural or semi-natural condition. These are areas which are likely to be delivering fewer services, or only fulfil a supporting role in service delivery. Nevertheless, in the context of a water stressed catchment, these areas should also be maintained in a natural state, and should be appropriately managed.
- Key Ecological Infrastructure (Degraded)– i.e. the types of features which are most important features for delivering water related services, but which have been degraded through inappropriate land management practices. These areas are currently in a poor or degraded condition, but could be rehabilitated to improve ecological service delivery. These areas are a logical focus area for projects aimed at rehabilitation, and could result in significant improvements in water delivery from more resilient system of Ecological

Infrastructure. Investment in these areas, or appropriate incentives to improve land management practices, should be investigated.

- Additional Ecological Infrastructure (Degraded)– i.e. the types of features which play an important secondary role in delivering water related services, but which have been degraded through inappropriate land management practices. As with the previous category, these areas should also be considered for rehabilitation projects and improved management. However, they are likely to be of lower value than the previous categories.
- Transformed Ecological Infrastructure: These are areas where Ecological Infrastructure has been lost, but where there may be opportunities to mitigate/reduce negative impacts through improved management practices and interventions with the production sectors (e.g. arable agriculture) active in these areas. At a finer scale, it may be possible to identify areas important for delivering ecosystem services (e.g. wetland buffers in wattle plantation areas), and through sector based interventions secure appropriate management of these areas. In the long term, it may be worthwhile to consider the full cost-benefit of activities and sectors which heavily impact of ecosystem service delivery, and make appropriate decisions on the continuation or withdrawal of activities from key areas where restoration could improve ecosystem service delivery.

Cumulative Ecological Infrastructure Value

In addition to producing the individual and combined Ecological Infrastructure maps, we wanted to identify the specific areas that were of greatest importance to allow these areas to be included in the overall prioritization. A scoring approach was used where for each individual Ecological Infrastructure layer (as well as for the integrated layer). The following scores were applied:

- Key Ecological Infrastructure (Natural) – a score of 10.
- Additional Ecological Infrastructure (Natural) a score of 8.
- Key Ecological Infrastructure (Degraded)– a score of 6.
- Additional Ecological Infrastructure (Degraded)– a score of 3.
- Transformed Ecological Infrastructure – a score of 1.

A cumulative Ecological Infrastructure value was developed by adding the above scores for each layer, as well as the scores for the integrated layer), and then converting this to a 0-100 range. This layer is shown in Figure 8.

			Ecological Infrastructure: Intact areas for protection (i.e. Areas that are in good condition)	Potential Ecological Infrastructure: Areas for rehabilitation (i.e. Areas that are in poor condition)	Transformed Ecological Infrastructure (i.e. Areas where value has been lost, but there may be opportunities to reduce negative impacts)
Water production & stream flow augmentation					
In high yield/strategic water source areas (over 135mm runoff)	Rivers	Riparian buffers (100m minimum; 500m larger rivers)	2	2	1
	Terrestrial areas	All natural habitat types (as per landcover)	1		
		Degraded areas (as per landcover)		1	
		Transformed areas (as per landcover)			1
	Wetlands	All natural wetlands	2	2	1
In lower yield areas (under 135mm runoff)	Rivers	Riparian buffers (32m minimum; 100m larger rivers)	2	2	1
	Wetlands	All natural wetlands	1	1	1
All areas	Wetlands specifically important for water production & stream flow augmentation	Unchannelled valley-bottom wetland with 50m buffer	1	1	1
		Valleyhead seep with 50m buffer	1	1	1

Values: 2 = Key ecological infrastructure; 1 = Other Ecological Infrastructure

Table 3: Methods used to identify key areas of Ecological Infrastructure important for water production and stream flow augmentation.

			Ecological Infrastructure: Intact areas for protection (i.e. Areas that are in good condition)	Potential Ecological Infrastructure: Areas for rehabilitation (i.e. Areas that are in poor condition)	Transformed Ecological Infrastructure (i.e. Areas where value has been lost, but there may be opportunities to reduce negative impacts)
Erosion control					
Wetlands	Wetlands specifically important for erosion control	Channelled valley-bottom wetland with 100m buffer	2	2	1
		Floodplain wetland with 100m buffer	2	2	1
		Seep with 100m buffer	2	2	1
		Unchannelled valley-bottom wetland with 100m buffer	2	2	1
		Valleyhead seep with 100m buffer	2	2	1
Erosion prone areas which need to be kept intact or rehabilitated	Terrestrial areas	Areas with gully or other erosion buffered by 1000m	2	2	1
Rivers	Rivers	Riparian buffers (32m minimum; 100m larger rivers)	2	2	1

Values: 2 = Key ecological infrastructure; 1 = Other Ecological Infrastructure

Table 4: Methods used to identify key areas of Ecological Infrastructure important for erosion control.

			Ecological Infrastructure: Intact areas for protection (i.e. Areas that are in good condition)	Potential Ecological Infrastructure: Areas for rehabilitation (i.e. Areas that are in poor condition)	Transformed Ecological Infrastructure (i.e. Areas where value has been lost, but there may be opportunities to reduce negative impacts)
Enhancement of water quality (including sediment trapping, phosphates, nitrates and toxicants)					
Wetlands	Wetlands specifically important for water quality enhancement	Channelled valley-bottom wetland with 50m buffer	1	1	1
		Floodplain wetland with 100m buffer	2	2	1
		Pans (Depression & flat) with 50m buffer	1	1	1
		Seep with 100m buffer	2	2	1
		Unchannelled valley-bottom wetland with 100m buffer	2	2	1
		Valleyhead seep with 100m buffer	2	2	1
Rivers	Rivers	Riparian buffers (32m minimum; 100m larger rivers)	2	2	1
		Riparian buffers (250m on larger rivers, 100m on smaller but perennial rivers)	1	1	1

Values: 2 = Key ecological infrastructure; 1 = Other Ecological Infrastructure

Table 5: Methods used to identify key areas of Ecological Infrastructure important for water quality.

			Ecological Infrastructure: Intact areas for protection (i.e. Areas that are in good condition)	Potential Ecological Infrastructure: Areas for rehabilitation (i.e. Areas that are in poor condition)	Transformed Ecological Infrastructure (i.e. Areas where value has been lost, but there may be opportunities to reduce negative impacts)
Flood attenuation					
Rivers	Rivers	Riparian buffers (250m on larger rivers, 100m on smaller but perennial rivers)	1	1	1
Wetlands	Wetlands specifically important for flood attenuation	Channelled valley-bottom wetland with 50m buffer	1	1	1
		Floodplain wetland with 100m buffer	2	2	1
		Pans (Depression & flat) with 50m buffer	1	1	1
		Seep with 50m buffer	1	1	1
		Unchannelled valley-bottom wetland with 50m buffer	1	1	1
		Valleyhead seep with 50m buffer	1	1	1

Values:
2 = Key ecological infrastructure; 1 = Other Ecological Infrastructure

Table 6: Methods used to identify key areas of Ecological Infrastructure important for flood attenuation.

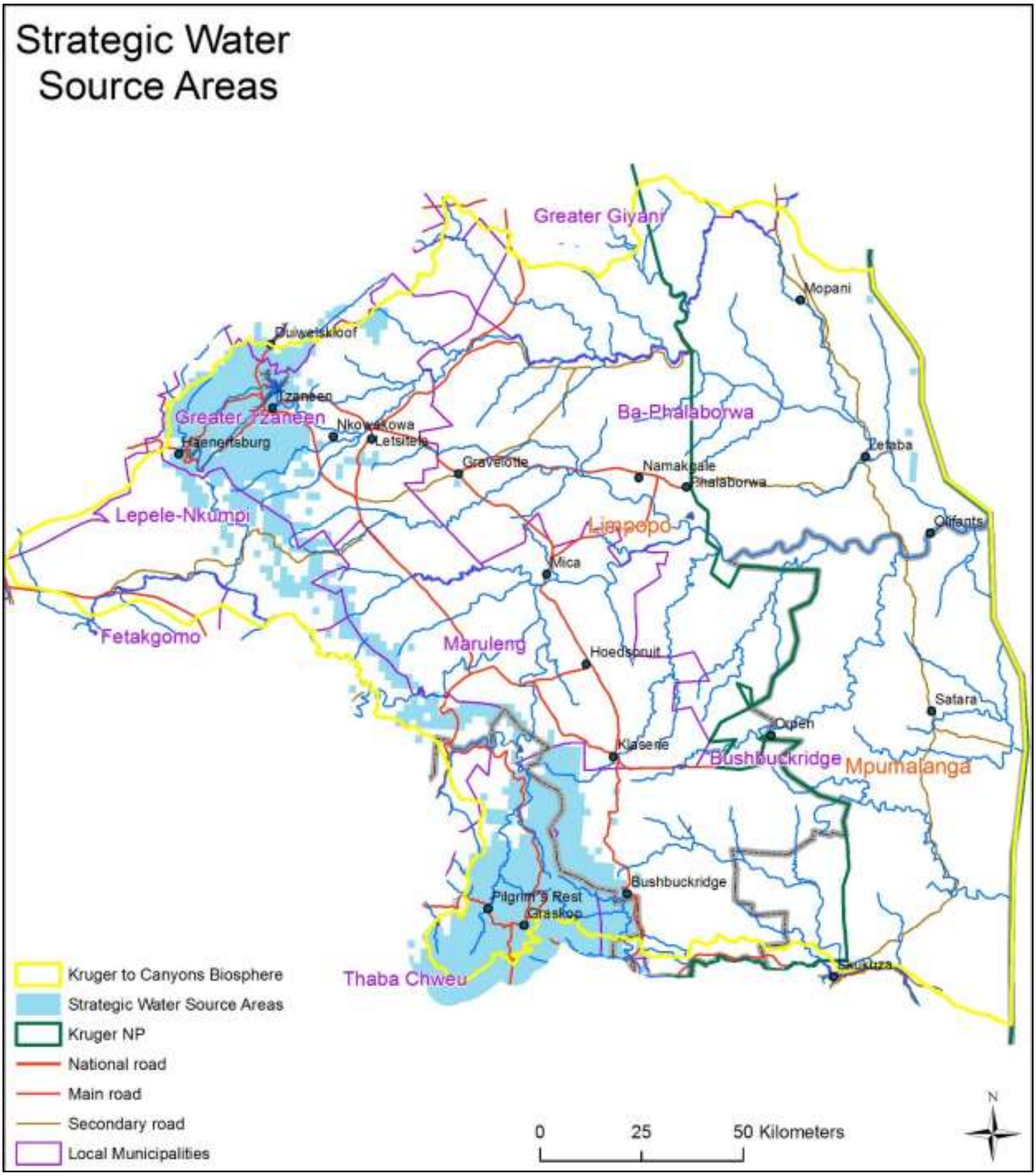

Figure 2: Strategic Water Source Areas in the Kruger to Canyons Biosphere.

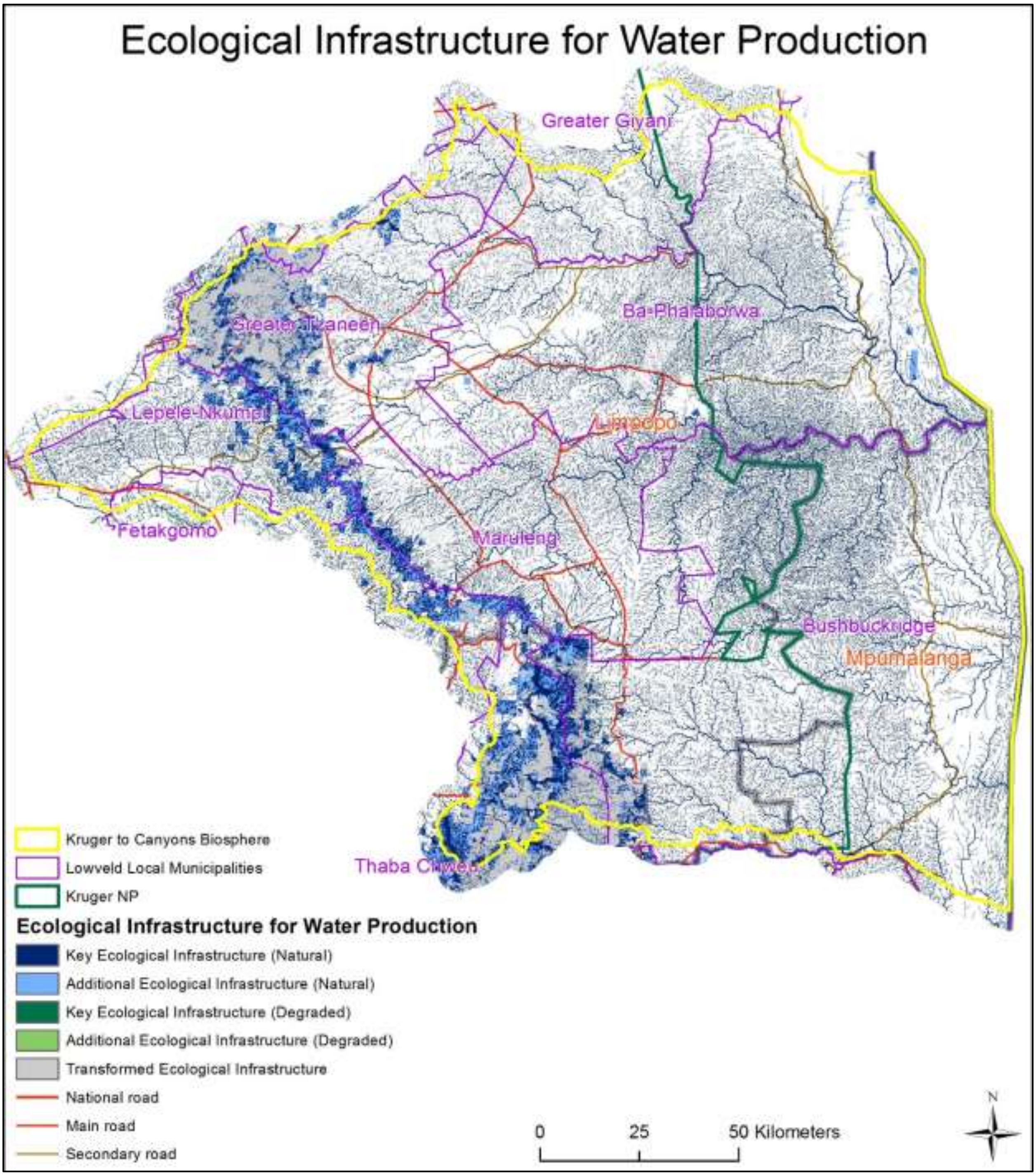

Figure 3: Areas of Ecological Infrastructure important for important for water production and stream flow augmentation.

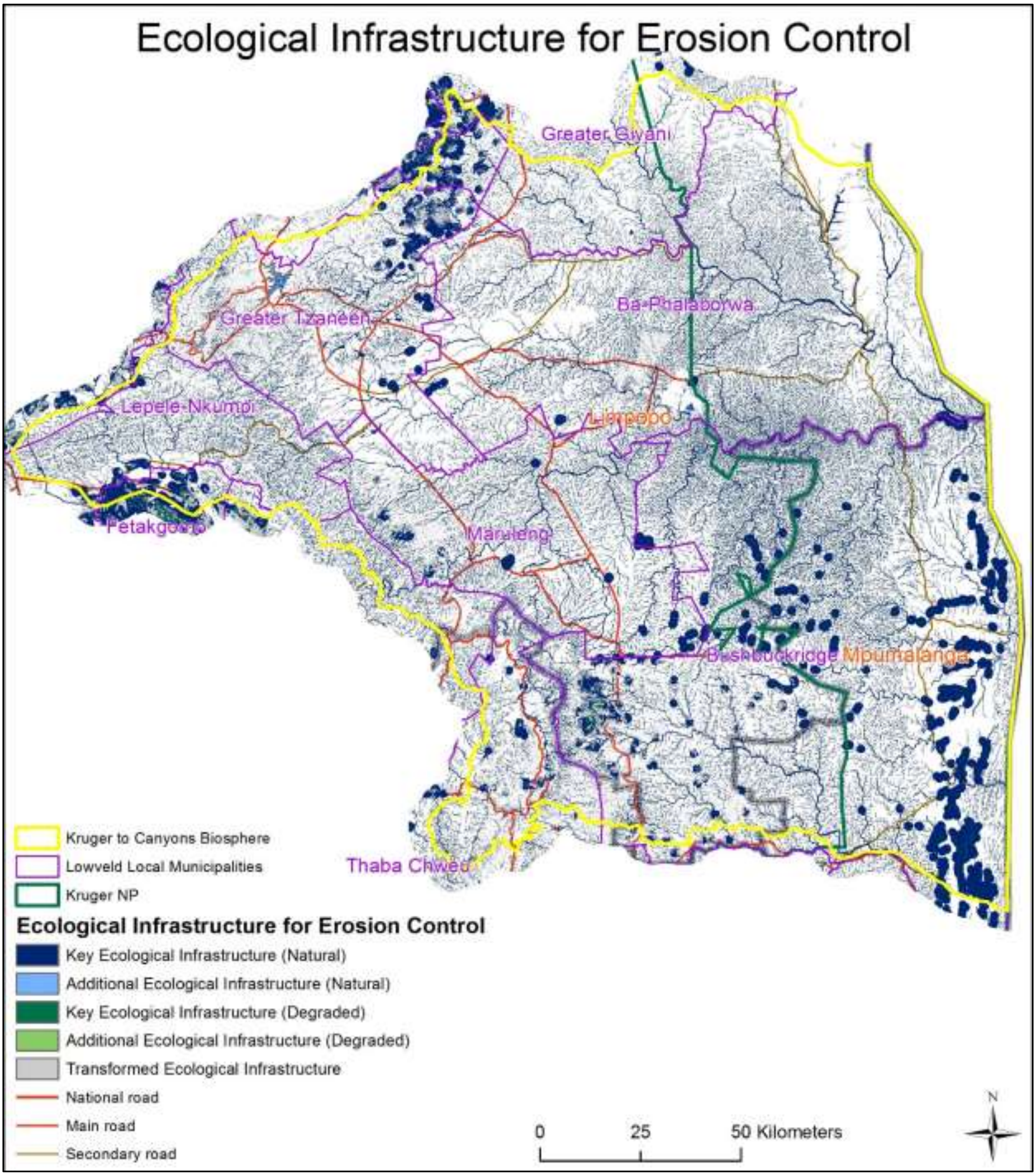

Figure 4: Areas of Ecological Infrastructure important for erosion control and sediment retention.

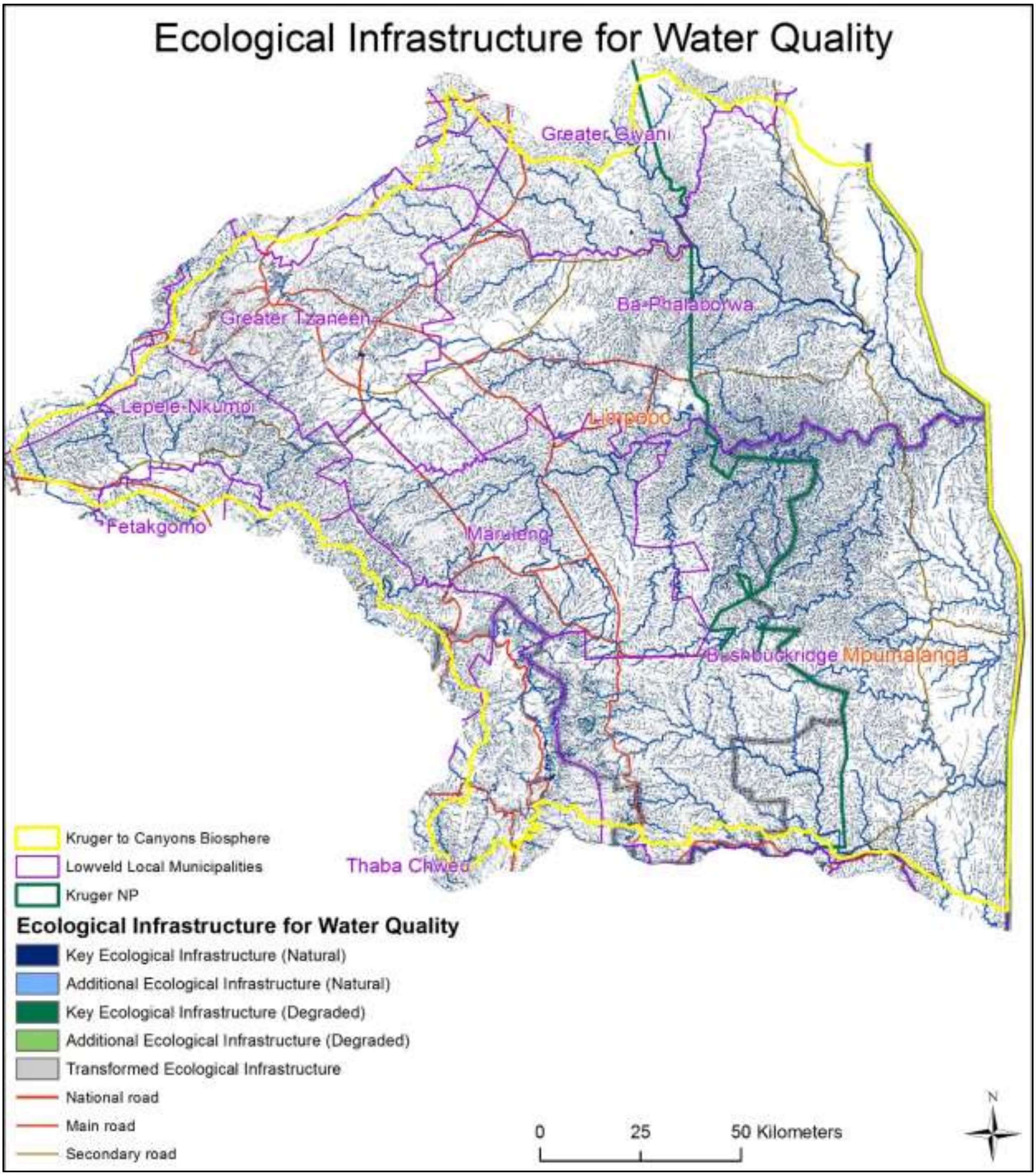

Figure 5: Areas of Ecological Infrastructure important for important for maintaining or enhancing water quality.

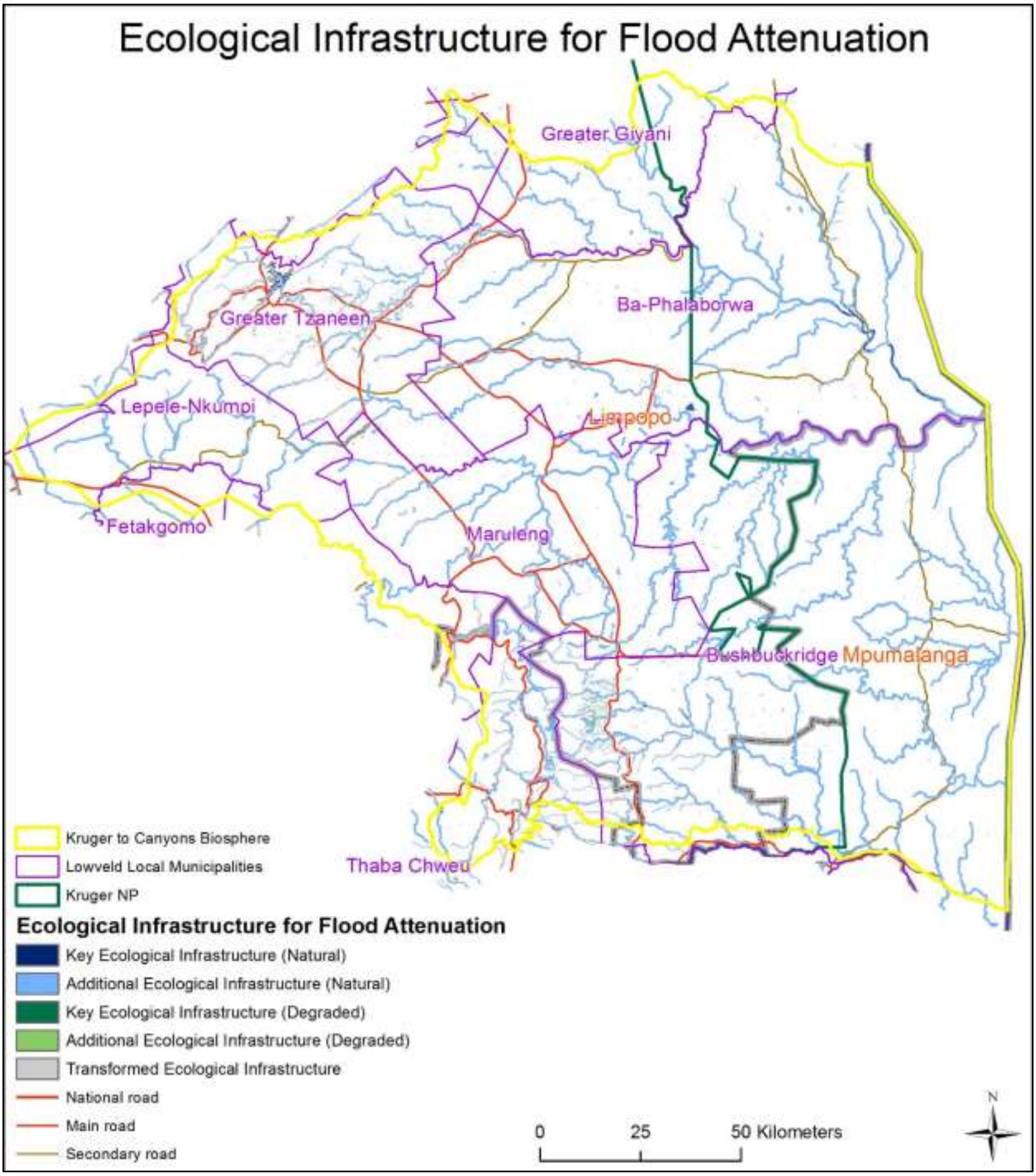

Figure 6: Areas of Ecological Infrastructure important for important for flood attenuation.

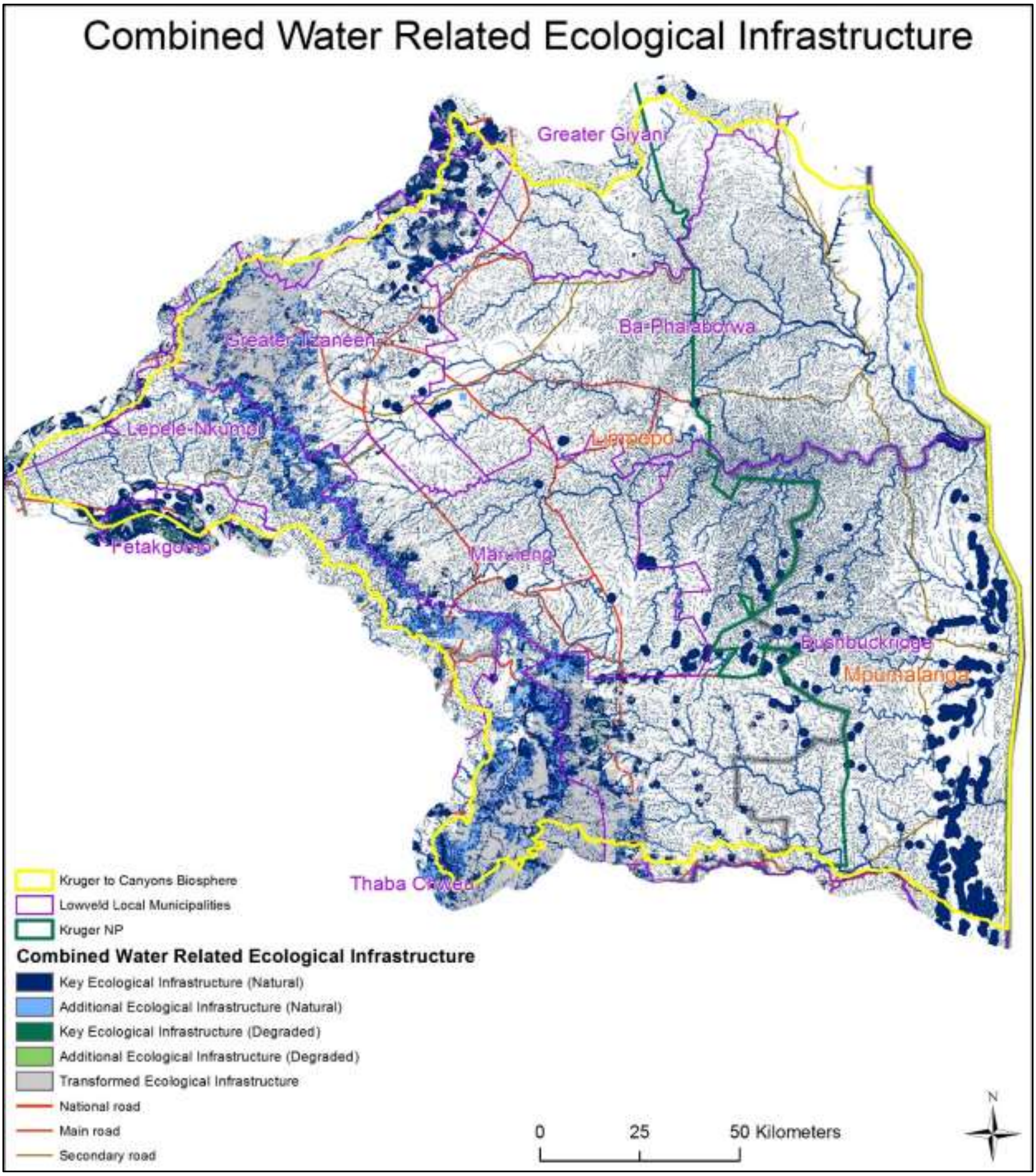

Figure 7: Integrated map of Water Related Ecological Infrastructure important for the Kruger to Canyons Biosphere.

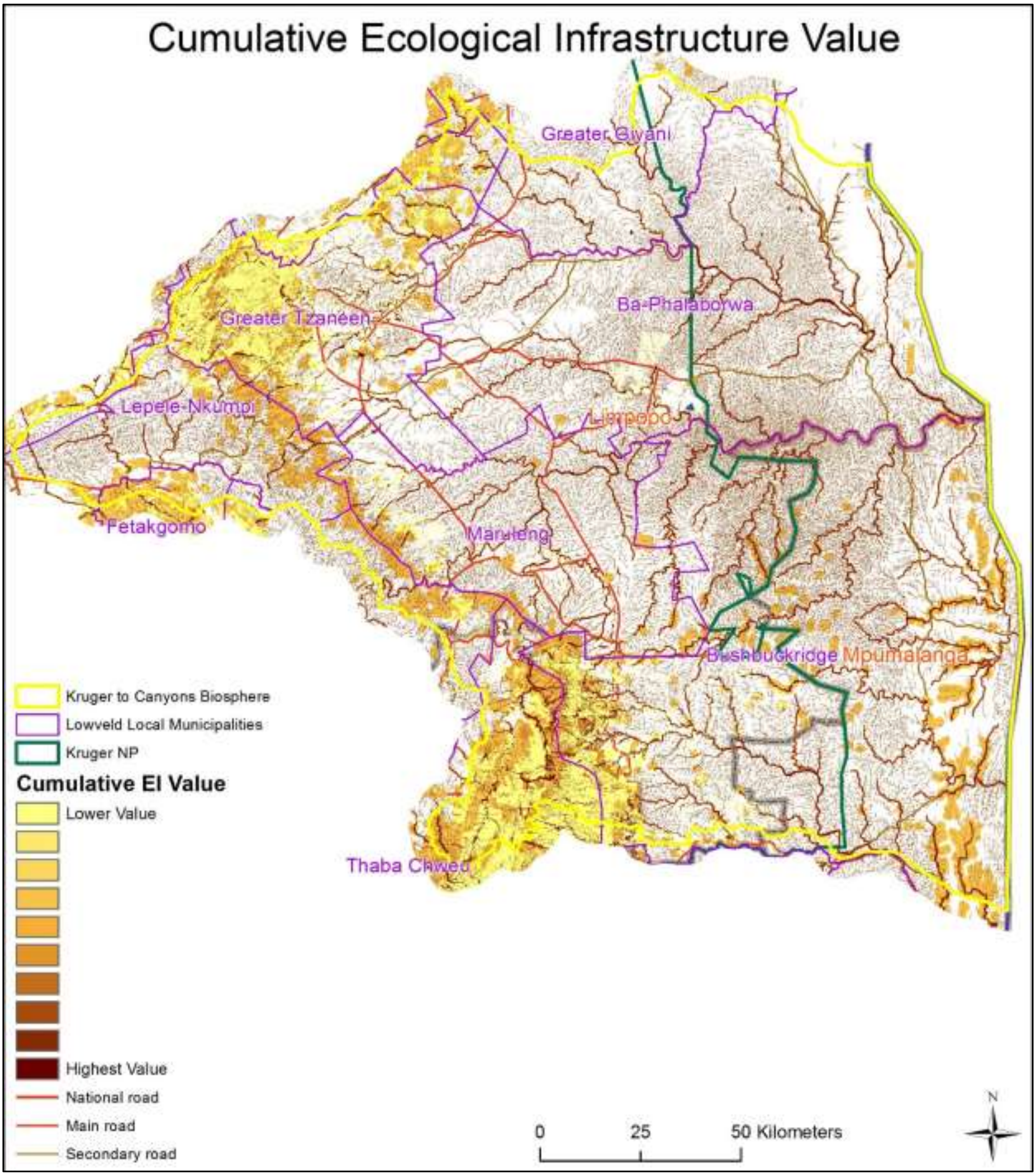

Figure 8: Cumulative value for Water Related Ecological Infrastructure in the Kruger to Canyons Biosphere.

3. Areas important for supporting climate change resilience:

Some features in the landscape are more likely to be more important for supporting resilience of landscapes to climate change than others. Such features include: riparian corridors and buffers; areas with temperature, rainfall and altitudinal gradients; areas of high diversity; areas of high plant endemism; refuge sites including south-facing slopes and kloofs; and priority large unfragmented landscapes. These features were mapped, and then combined to provide a single map of areas important for resilience of biodiversity to climate change at the landscape scale. Keeping these areas in a natural or near-natural state will allow ecosystems and species to adapt naturally to climate change, thus supporting healthy landscapes and the ability of ecosystems to continue to provide ecosystem services.

Identifying areas important for supporting climate change resilience:

The logic for, and derivation of, the input layers required for identifying is summarised in the following paragraphs.

Riparian corridors and buffers: Corridors provide critical ecological linkages between large core patches of intact habitat through hostile matrix areas of heavily modified habitat. Corridors are seen to be critical for the movement of a variety of animal species in the short term (pollinators, predators) from source to sink areas, to provide for genetic interchange between spatially separate populations of animals in the medium term, and in the long term are hoped to be important for the migration of plant and other species under conditions of global climate change. One of the most clearly defined corridors, especially in heavily modified arable agriculture landscapes, are those associated with rivers. Importantly, the river associated movement corridors also provide upland-lowland linkages on the landscape scale. A corridor layer was created based on the 2nd order and larger rivers[7] and a cost surface[8] derived from a transformation and fragmentation layer[9]. A total corridor width of approximately 1km was aimed for in completely transformed landscapes, and 10km in completely natural areas, with the corridors varying in width in response to the level and pattern of transformation.

Areas with important temperature, rainfall and altitudinal gradients: Maintaining these areas is important in order to allow species and ecosystems to rapidly adapt to changing climate, as they represent the shortest routes for the species which make up ecosystems to move along upland-lowland and climatic gradients in order to remain within acceptable climate envelopes. These areas are particularly important for species which are not able to move rapidly in response to climate change. These areas also have high levels of climate and landscape heterogeneity, and hence are likely to contain a range of important micro-climates which may act as local refugia for those species that otherwise may not be

[7] Department of Water Affairs 1 in 500 000 river layer developed by Resource Quality Services.

[8] This is a GIS layer used in the subsequent analysis which in this case describes how difficult it is for biodiversity elements to cross that area, e.g. it is far easier for a species to migrate through an intact natural area compared to area of arable agriculture (e.g. a mosaic of ploughed fields, roads and fences), and both would be far easier than through a built-up urban area.

[9] Transformation and fragmentation layer developed by Stephen Holness for the National Protected Areas Expansion Strategy Conservation Assessment 2008. The layer was used in a cost surface based analysis which calculated the total cost of moving away from the river centre line. Transformed areas had a cost friction of 10x that of natural habitat, while degraded and fragmented areas had a cost 2x that of natural areas. The result of this process is a variable width corridor which takes into account the pattern of land transformation, e.g. one could have a 5km wide buffer on one side of a river in natural habitat, with a 500m buffer in agricultural fields on the other side of the river.

able to adapt to rapid environmental change. A series of topographic and climatic indices were combined in the preparation of this layer:

- *Altitudinal heterogeneity:* A 90m resolution digital elevation model was examined at a 0.01 degree or just over 1 km squared resolution. Altitudinal differences were calculated based on the maximum and minimum altitudes found within a roving 7x7 grid (i.e. approximately 49km^2 area). The output was divided into 8 quantiles with the top category considered to be the areas best representing high altitude gradient areas. This quantile corresponded to areas with greater than 340m of altitude variation within the 49km^2 area.
- *Precipitation gradients:* Precipitation data from the Agricultural Research Council was examined at a 0.01 degree or just over 1 km squared resolution. Precipitation gradients were calculated based on the maximum and minimum values found within a roving 7x7 grid (i.e. approximately 49km^2 area). The output was divided into 8 quantiles with the top category considered to be the areas best representing high precipitation gradient areas. This quantile corresponded to areas with greater than 235mm of precipitation variation within the 49km^2 area.
- *Temperature gradients:* Temperature data from Agricultural Research Council was examined at a 0.01 degree or just over 1 km squared resolution. Temperature gradients were calculated based on the maximum and minimum values found within a roving 7x7 grid (i.e. approximately 49km^2 area). Areas with over 4°C difference in average temperature within a 49km^2 area, were classified as areas with high temperature gradients.

These three layers were combined to provide a summary layer of all areas with high climate and landscape heterogeneity and gradients.

Areas with high biotic diversity: These are areas where relatively high numbers of biomes, vegetation groups or vegetation types occur in close proximity[10]. They contain an extremely diverse set of habitats, landscapes and microclimates, and represent areas that are likely to be very important for supporting biodiversity adaptation capacity. These areas have high levels of floristic diversity and are likely to represent areas of high levels of speciation. Areas with high levels of biodiversity heterogeneity were identified using the South African Vegetation Map[11] at three scales: biome, vegetation group and vegetation type. The number of biomes, groups or types was calculated for each 49km^2 area. Areas were considered to have high habitat heterogeneity if they contained three or more biomes, three or more vegetation groups, or four or more vegetation types.

- *Biome heterogeneity:* The South African Vegetation Map was converted to a 0.01 degree or just over 1 km^2 resolution raster layer in Idrisi. The number of biomes found within a roving 7x7 grid (i.e. approximately 49km^2 area) was calculated. Various other methods (such as other relative richness indices, and varying in pixel size and search radius) were also explored, but this simple method gave a robust clearly understandable answer. Areas were considered to have high diversity at the biome level if 3 or more biomes were found within the 49km^2 area.
- *Vegetation group heterogeneity:* Similar to the biome heterogeneity calculation, the vegetation map was converted to a 0.01-degree raster layer, and the number of vegetation groups found within a roving 7x7 grid (i.e. approximately 49km^2 area) was calculated. Areas were considered to have high diversity at the bioregion level if 3 or more bioregions were found within the 49km^2 area. Note that this will inevitably include the areas identified in the biome heterogeneity assessment, in addition to extra areas.

[10] Importantly, these represent areas of high biotic diversity under current conditions. Although there is no guarantee that these patterns will persist in their current form under future climate change, we believe these areas are likely to be of higher importance than other areas, as they represent a large portion of current biodiversity, contain diverse conditions (e.g. soil and micro-climate) which are likely to continue to support a range of communities, and contain important ecotones which are associated with numerous ecological processes.
[11] Mucina, L. & Rutherford, M.C., 2006: The vegetation of South Africa, Lesotho and Swaziland.

- *Vegetation type heterogeneity:* As for the above calculations, the vegetation map was converted to a raster, and the number of vegetation types found within a roving 7x7 grid (i.e. approximately 49km^2 area) was calculated. Areas were considered to have high diversity at the bioregion level if 4 or more vegetation types were found within the 49km^2 area.

These three layers were combined to provide a summary layer of all areas with high habitat heterogeneity.

Centres of floral endemism: Southern Africa has extremely high levels of floristic diversity and endemism, with more than 10% of vascular plant species (over 30 000 species) found in 2.5% of the world's surface area. 60% of these species are endemic to the region[12]. Most of these endemic species are concentrated in a few relatively small and clearly defined centres of endemism. At a national scale these centres represent i.) an area of concentrated unique biodiversity pattern (i.e. there are concentrations of endemic plant species here which are not found elsewhere), ii.) areas with a particular combination of ecological processes that have resulted in high levels of biodiversity and endemism developing, and iii.) the characteristics which allow these high levels of diversity to persist, as these are areas where species have survived previous eras of climate change, and hence are likely to be very important for supporting biodiversity adaptation capacity. The floristic centres of endemism summarised in Regions of Floristic Endemism in Southern Africa were clipped to remaining extent of natural habitat (transformed, degraded and fragmented areas were excluded from the dataset[13]).

Local refugia- south-facing slopes and kloofs: Refuge sites include south-facing slopes and kloofs. These sites tend to be wetter and cooler that the surrounding landscape, and represent key shorter term refugia which allow species to persist in landscapes.

- *South facing slopes:* A 90m digital elevation model was used as the basis for identifying south facing slopes. Standard Idrisi modules were used to identify all areas with a southerly aspect, which was defined as having an aspect of between 135° and 235°. Slope angles were then calculated to identify all steeper slopes (i.e. those areas where aspect is likely to play an important role in solar inputs), which were defined as all slopes steeper than 10°. These layers were combined to get a subset of steep south facing slopes; this layer was converted to a vector layer and all areas under 25ha were removed; and the layer was reconverted to a raster layer.
- *Kloofs:* The identification of kloofs/gorges at a landscape scale requires some assumptions to be made about what a kloof is. For the purposes of this analysis, kloofs are areas with steep slopes near rivers. The 90m digital elevation model used in previous analyses was again used as the basis for identifying steep slopes, which for this analysis were defined as being steeper than 15° (this value is deliberately higher than that used for the south facing slope calculation), using standard modules of Idrisi. River lines[14] were converted to a raster layer with the same resolution as the 90m DEM, on the basis that any pixel that overlapped with a river line was classified as river and given a numerical value. A maximum filter was then run in Idrisi using a 7x7 roving window to identify all pixels which were within a maximum of 7 pixels (x or y distance) away from a river pixel. These areas were defined as being river proximity pixels, and were intersected with the steep slopes raster layer to give the subset of areas with steep

[12] Van Wyk, A. & Smith, G., 2001: *Regions of floristic endemism in Southern Africa*, Umdaus Press, Hatfield, 199pp.

[13] Transformation and fragmentation layer developed by Stephen Holness for the National Protected Areas Expansion Strategy Conservation Assessment 2008.

[14] Department of Water Affairs 1 in 500 000 river layer developed by the Resource Quality Services. This layer is of the larger rivers which one would expect on a 1 in 500 000 map, but with the actual river alignments being as accurate as those found on 1:50 000 maps. For this analysis rivers of all orders were used.

slopes near rivers. This was converted to a vector layer and all areas under 25ha were removed; and the layer was reconverted to a raster layer.

The local refugia layer was derived by spatially combining the south-facing slopes and kloofs layers.

Priority large unfragmented landscapes: These include existing protected areas as well as large areas identified in the National Protected Area Expansion Strategy as priorities for protected area expansion to meet biodiversity targets for terrestrial and freshwater ecosystems. The ecological processes which support climate change adaptation are more likely to remain functional in unfragmented landscapes than in fragmented ones.

- *Protected areas:* Formal protected areas which include National Parks, provincial Nature Reserves, proclaimed Mountain Catchment Areas and local authority Nature Reserves were included. Representation of species, ecosystems and ecological processes in an ecologically robust protected area network is widely recognized as one of the most effective adaptation strategies for responding to climate change. Intact natural habitats found in protected areas are likely to play an important role in supporting landscape scale resilience to climate change through acting as refuge areas for ecosystems and species which are likely to be under more pressure in production landscapes, in supporting the ecological processes required for long term adaptation to climate change, and in the provision of key ecosystem services. Although not all protected areas will have the same importance, even small reserves will be important for supporting local scale adaptation. In addition, the layer of priority large unfragmented landscapes (see below) is incomplete if considered without the existing protected areas.
- *Priority large unfragmented landscapes:* The spatial assessment of the National Protected Area Expansion Strategy used a systematic consevation planning process to identify focus areas for land-based protected area expansion which are large, intact and unfragmented areas of high importance for biodiversity representation and ecological persistence, suitable for the creation or expansion of large protected areas. They present the best opportunities for meeting the ecosystem-specific protected area targets set in the NPAES, and were designed with strong emphasis on climate change resilience, supporting ecological processes and the requirements for freshwater ecosystems. Although these areas were identified from a large formal protected areas expansion perspective, and therefore do not sufficiently address all conservation priorities (e.g. threatened species and habitats in highly fragmented landscapes such as the Chrissiesmeer area are poorly incorporated), they nevertheless represent the best exampes of intact landscapes with functioning ecological processes which are likely to play a significant role in long term climate change adaptation.

The priority unfragmented areas layer was derived by spatially combining the existing protected areas with the priority large unfragmented landscapes layer.

Combination and refinement process:

Figure 15 summarizes the combination and refinement process for the climate change resilience layer.

A base raster file was constructed with a resolution of 0.00083333333DD (i.e 3 arc seconds or 90m). Where neccessary (and this was avoided for many layers by utilizing an indentical base raster layer in the underlying analyses) input layers were reclassified and resampled to the extent of the base layer, so that the extent and resolution of all input layers were identical. A cumulative total area approach was used to summarize each resilience theme (e.g. areas with important temperature, rainfall and altitudinal gradients were summarized by combining all the areas identified as important in the underlying analyses, and all areas identified would have the same value whether they include only a steep temperture gradient or whether they had steep gradients for more than one variable). Areas important for each resilience theme were then given an equal numerical value. An unmodified value representing the value of a particular area for supporting climate change resilience was then calculated by adding the individual resilience theme scores. Crucially, these areas can support resilience to climate change only if they remain in a natural or near-natural state. For this reason areas where natural habitat has already been irreversibly lost were removed from the analysis, and degraded and fragmented areas were reduced in value by half[15]. The result was the final "Areas important for supporting climate change resilience layer". It is shown in Figure 16.

Areas important for climate change resilience need to be managed and conserved through a range of mechanisms including land-use planning, environmental impact assessments, protected area expansion, and working with industry sectors to minimise their spatial footprint and other impacts.

[15] Transformation and fragmentation layer developed by Stephen Holness for the National Protected Areas Expansion Strategy.

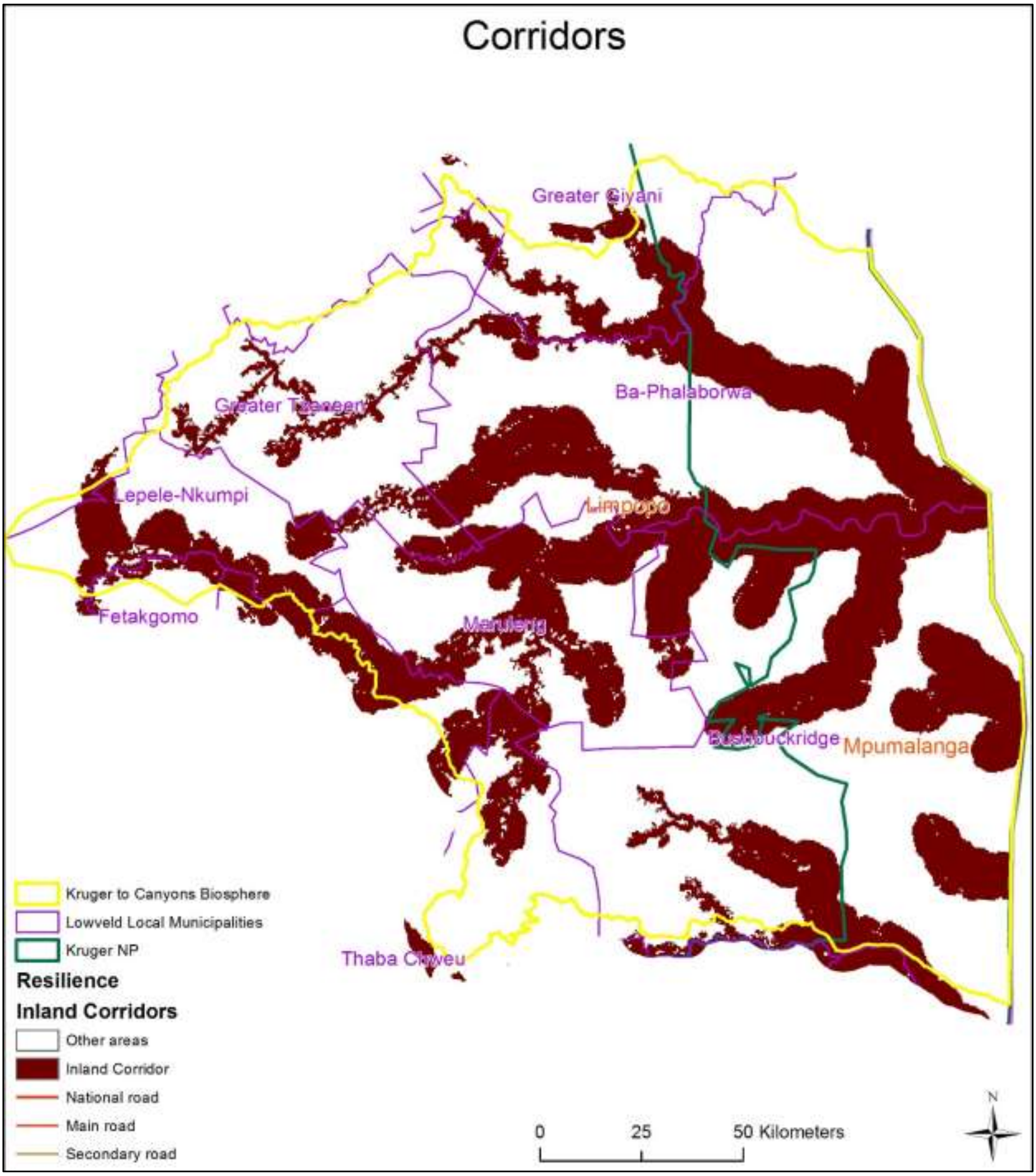

Figure 9: Inland corridors layer in the Kruger to Canyons Biosphere.

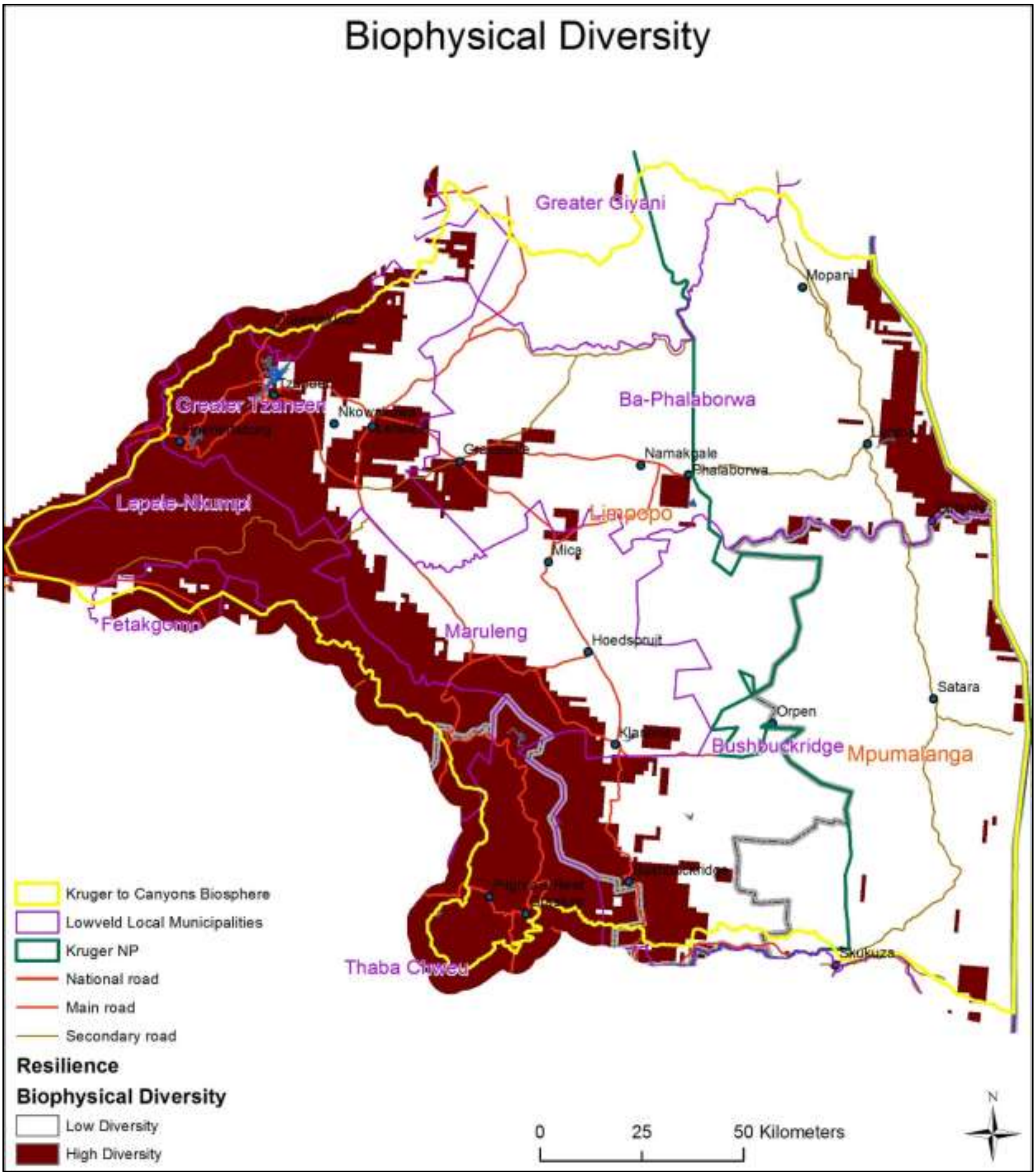

Figure 10: Combined areas of steep altitude, temperature and precipitation gradients in the Kruger to Canyons Biosphere.

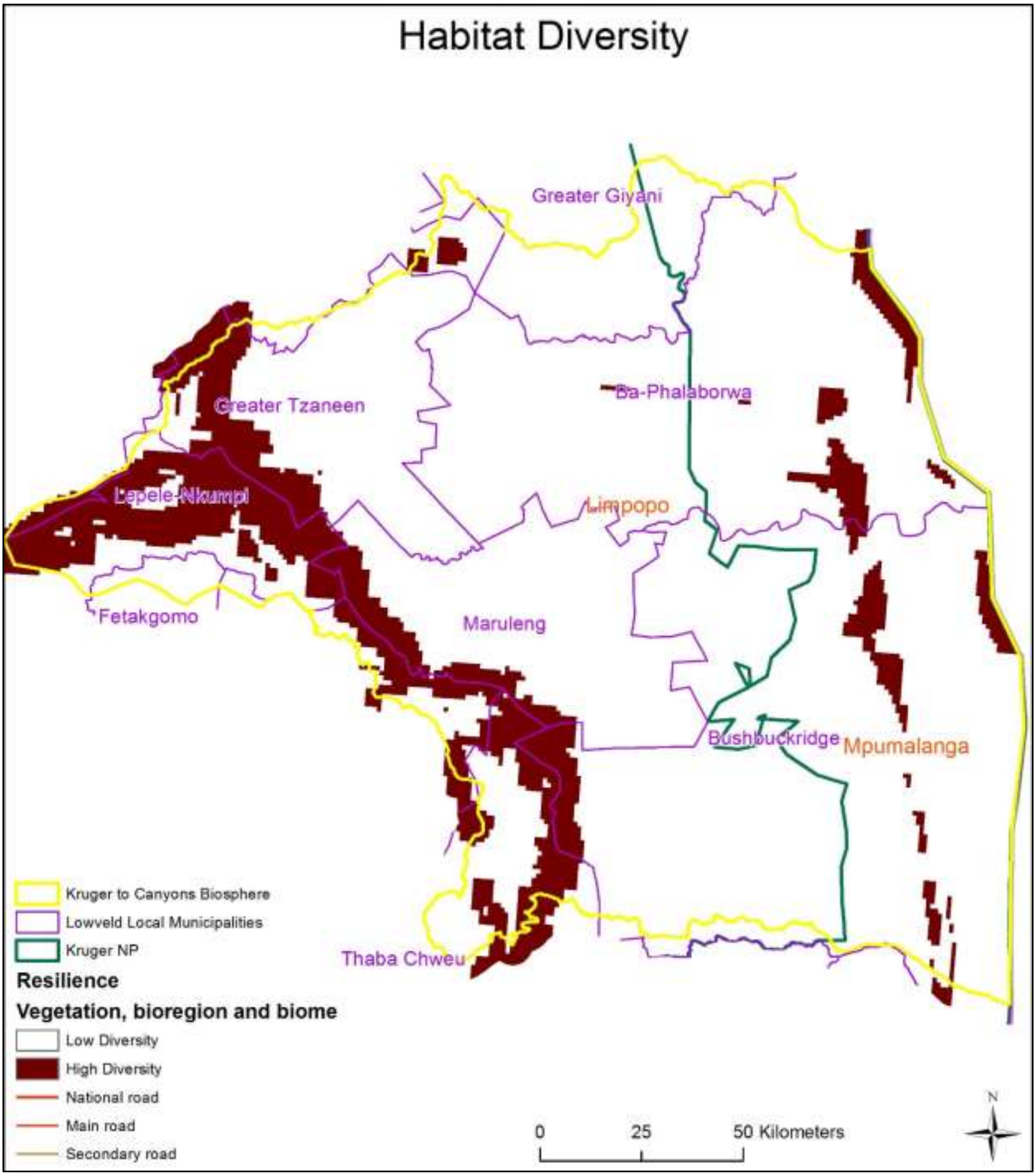

Figure 11: Combined areas of high habitat diversity in the Kruger to Canyons Biosphere. This map is compiled from three underlying maps of high diversity at the vegetation type, vegetation group and biome levels.

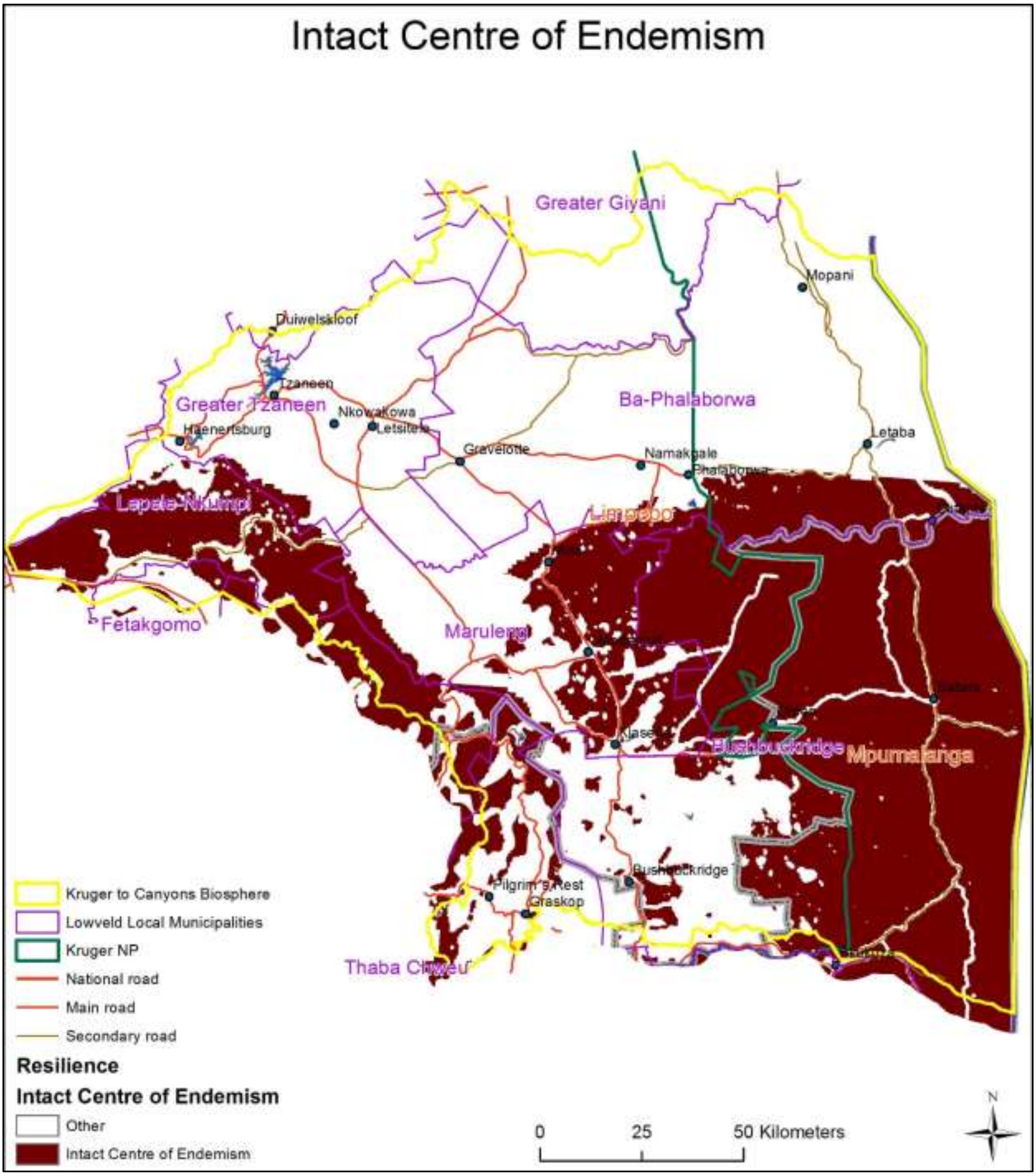

Figure 12: Remaining intact areas of Centres of Endemism in the Kruger to Canyons Biosphere.

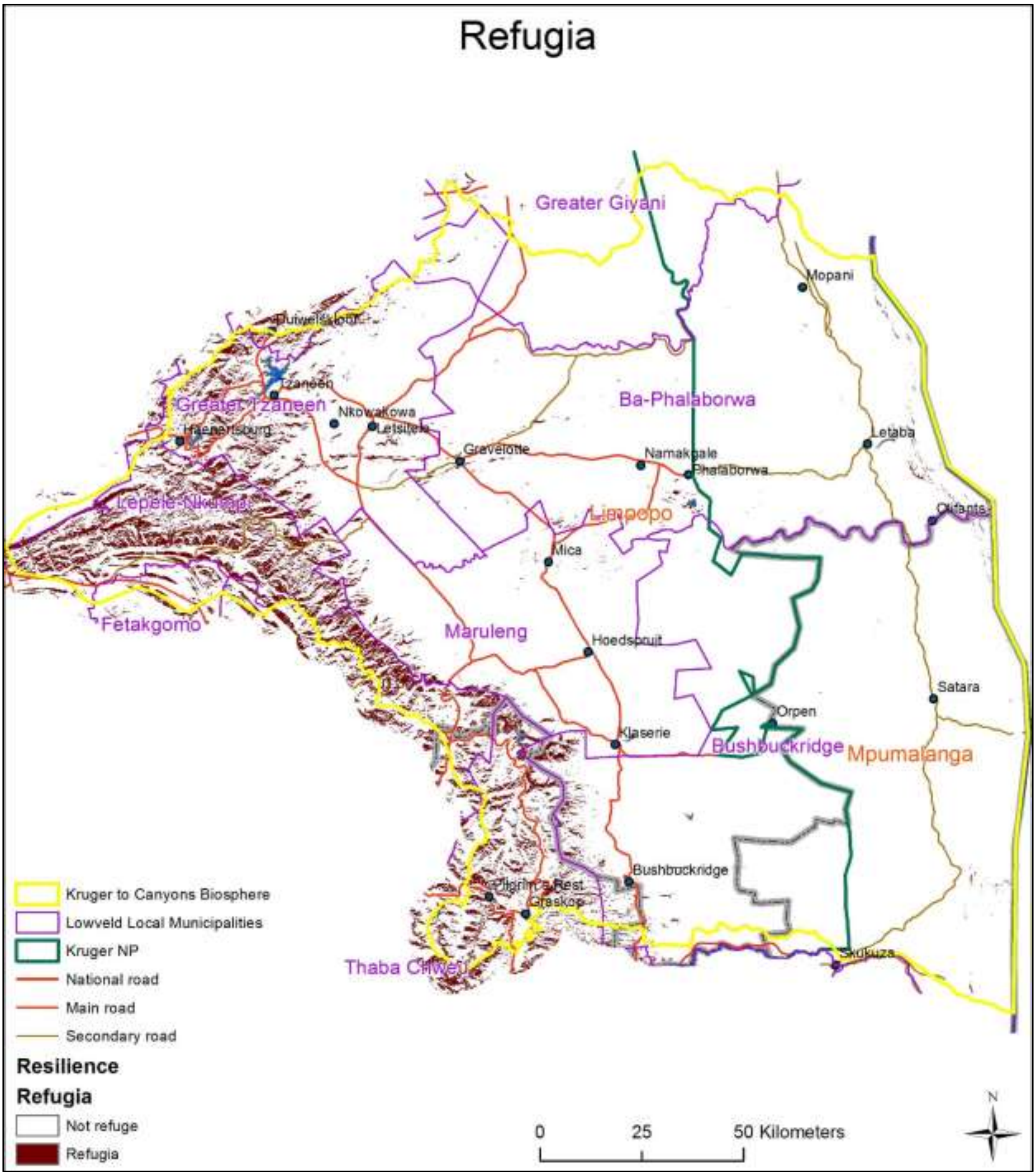

Figure 13: Local refugia consisting of a combination of south facing slopes and gorges in the Kruger to Canyons Biosphere.

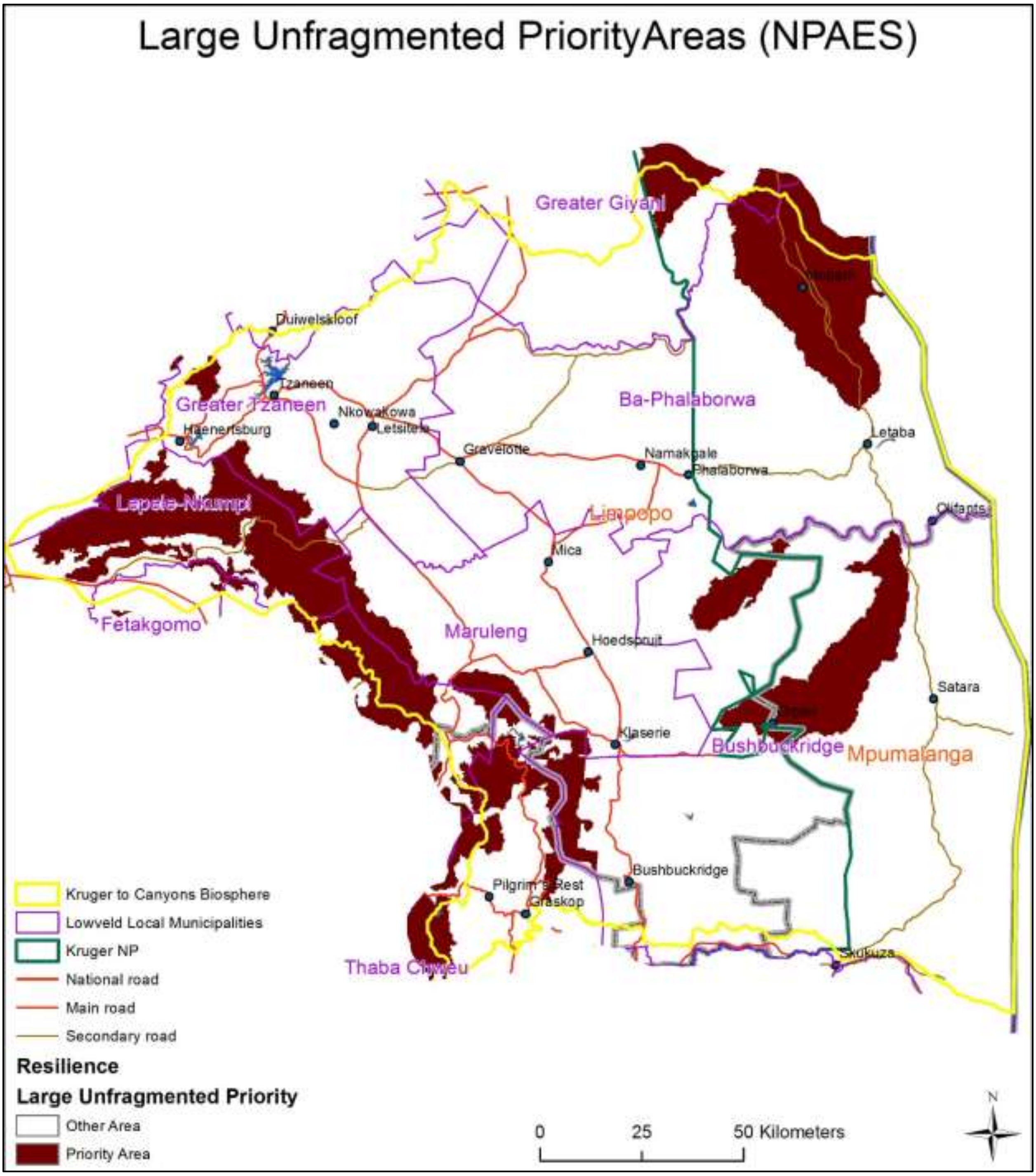

Figure 14: Large unfragmented priority areas in the Kruger to Canyons Biosphere.

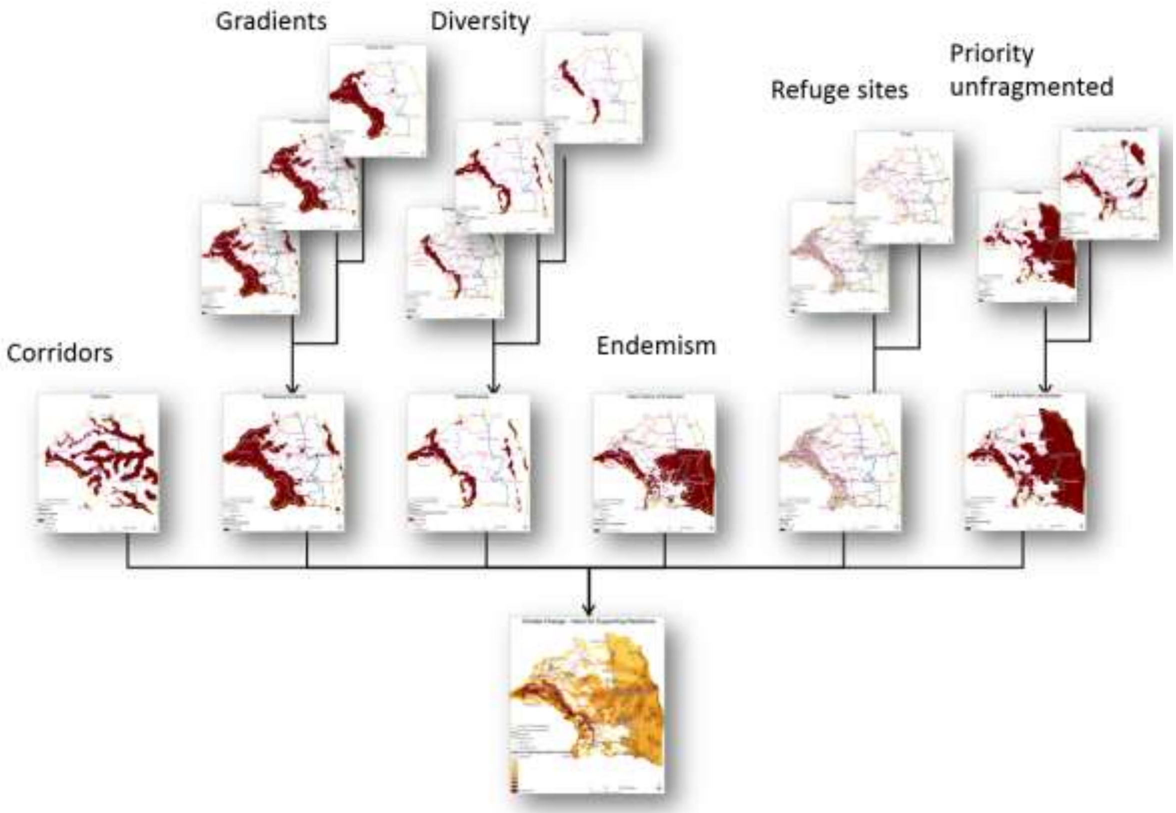

Figure 15: Diagram illustrating the integration method used to identify areas most important for supporting resilience to climate change impacts at a landscape scale.

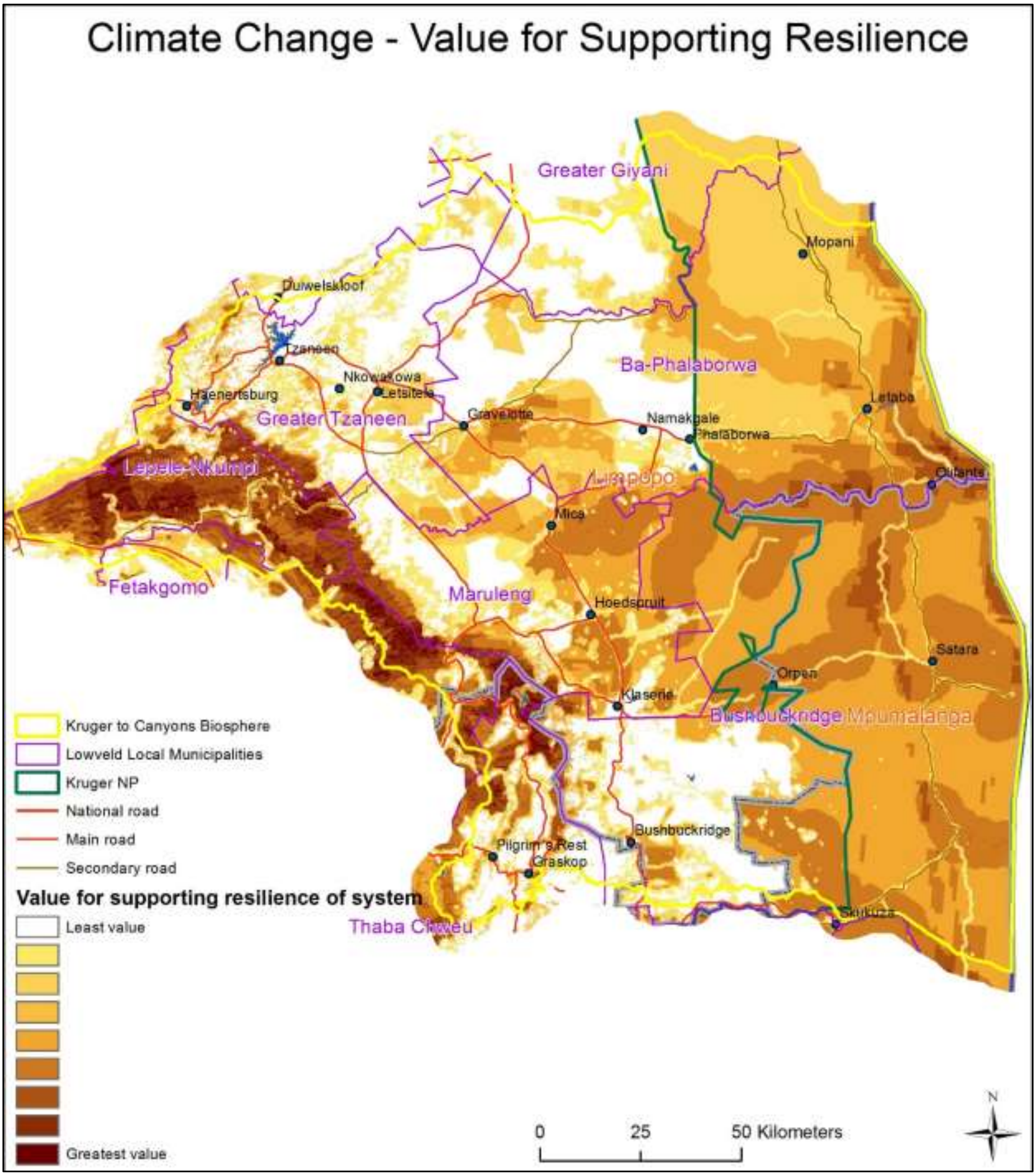

Figure 16: Value of areas for supporting resilience to climate change impacts in the Kruger to Canyons Biosphere.

4. Other biodiversity priorities

There are a range of key biodiversity assets and priority areas which underpin all ecosystem services across the district. As an intact and functional landscape is critical to supporting society we have identified a set of overall spatial biodiversity priorities for inclusion into the integrated analysis.

Critical Biodiversity Areas from the provincial conservation plans

There are two relevant provincial conservation plans[16].

- Mpumalanga Biodiversity Sector Plan (2014)
- Limpopo Conservation Plan v2 (2013)

These plans both identify Critical Biodiversity Areas and Ecological Support Areas. Although the exact categories, and levels of priority, differ by province, we have integrated them into a single coherent summary. These outputs are a key input into spatial prioritization in the catchment:

- **Protected Areas:** An updated Protected Area layer was used. All areas were given a score of 10.
- **Critical Biodiversity Area One:** This category was used to identify the highest value areas selected in each of the provincial plans. The identified areas represent the sites where little or no choice exists in terms of meeting targets, and they often contain highly threatened, rare or localized habitats or features. Importantly, although these areas are called Critical Biodiversity Areas, they are not solely identified based on "pure" biodiversity criteria, and in almost all instances take climate change, ecosystem services and ecological processes into account. The prioritization would also tend to have avoided areas with high levels of conflict with other land uses (Although, in CBA1 areas there would often have been little or no choice of sites). All these areas received score of 10.
- **Critical Biodiversity Areas Two:** This category was used to identify the group of second highest value areas selected in each of the provincial plans. The identified areas represent the sites where some choice exists in terms of meeting targets. Although they are also Critical Biodiversity Areas (and have a similar desired state, land use controls, and objectives), these areas contain features which could be conserved at other locations, and are generally less threatened, more common or less localized habitats or features. Again, although these areas are called Critical Biodiversity Areas, they are not solely identified based on "pure" biodiversity criteria, and in almost all instances take climate change, ecosystem services and ecological processes into account. Further, as choice exists in terms of their identification, their selection would have avoided areas with high levels of conflict with other land uses. All these areas received score of 5.
- **Ecological Support Areas:** The provincial plans identified various categories of Ecological Support Area which are areas that need to be kept in a functional state to support existing Protected Areas and Critical Biodiversity Areas. These include important catchments and riparian areas that were not identified at a higher level of priority. Again, as some Ecological Support Area categories (especially ESA2 in Limpopo) include transformed landscapes, we excluded these areas using the landcover. Remaining intact ESA areas were given a score of 2.

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[16] Desmet, P. G., Holness, S., Skowno, A. & Egan, V.T. (2013) Limpopo Conservation Plan v.2: Technical Report. Contract Number EDET/2216/2012. Report for Limpopo Department of Economic Development, Environment & Tourism (LEDET) by ECOSOL GIS.

Lötter, M. C., R. Lechmere-Oertel, and M. Cadman. (2014) Mpumalanga Biodiversity Sector Plan Handbook. Mpumalanga Tourism and Parks Agency, Mbombela (Nelspruit).

A composite layer was developed from the two provincial plans, and transformed and degraded areas were removed to show the value of remaining intact Critical Biodiversity Areas and Ecological Support Areas (Figure 17).

Protected Area Expansion Priorities

Protected Area Expansion Strategy Priority Areas are areas which have been identified as priorities in provincial and national Protected Area Expansion Strategies[17]. For the Kruger to Canyons Biosphere the following strategies and data sources are relevant:

- National Protected Area Expansion Strategy (2016).
- Mpumalanga Protected Area Expansion Strategy (2015).
- Limpopo Protected Area Expansion Strategy (2014).

Note that the National Protected Area Expansion Strategy (2016) is fully aligned with the two provincial Protected Area expansion strategies, and therefore was not separately included. Areas identified at a fine scale in the provincial plans were collated into a single GIS layer, and all priorities were allocated a value of 10 (Figure 18).

Aquatic prioritization

Data produced by the National Biodiversity Assessment and the National Freshwater Ecosystem Priority Areas project (NFEPA) exist on aquatic priority areas in South Africa[18]. In addition, the wetland data for Mpumalanga was updated with the new 2014 wetland data for Mpumalanga[19]. The current assessment brings these analyses together into a single integrated layer of aquatic priorities.

Conceptually we have divided the aquatic features into four groups:

- *The aquatic feature (actual river or wetland).* The individual features from the underlying analyses were scored per their priority level. Prioritized rivers had a range of scores per their category (FEPA rivers = 10, Phase2FEPA=4, Fish Support Area and FishCorrid=3 and Upstream Management Areas=2); Other rivers were given a score of 1; Wetland (priority FEPA wetlands = 10, Other wetlands =1.
- *The immediate buffer (river buffer or wetland buffer).* Priority rivers and wetlands were all buffered by 1km, with the buffer allocated a value of 5.

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[17] Department of Environmental Affairs (2016) National Protected Areas Expansion Strategy for South Africa 2016. Department of Environmental Affairs, Pretoria, South Africa.
Desmet, P. G., Holness, S., Skowno, A. & Mphaphuli, D. (2014) Limpopo Protected Area Expansion Strategy Technical Report. Contract Number (EDET/QUT/2371/13). Report for Limpopo Department of Economic Development, Environment & Tourism (LEDET) by ECOSOL GIS.
Lötter, M. (2015) Spatial Assessment informing the Mpumalanga Protected Area Expansion Strategy - 20 and 5 year spatial priorities. Mpumalanga Tourism & Parks Agency, Mbombela (Nelspruit).

[18] Nel, J.L., Driver, A. & Swartz, E.R. 2012. National Biodiversity Assessment 2011: Technical Report. Volume 2: Freshwater Component. CSIR Report Number CSIR/NRE/ECO/IR/2012/0022/A. Council for Scientific and Industrial Research, Stellenbosch.
Nel, J.L., Driver, A., Strydom, W.F., Maherry, A., Petersen, C., Hill, L., Roux, D.J., Nienaber, S., Van Deventer, H., Swartz, S. & Smith-Adao, L.B. 2011. Atlas of Freshwater Ecosystem Priority Areas in South Africa. WRC Report No. TT 500/11. Water Research Commission, Pretoria."
[19] WRC project with the provisional title "Supporting better decision-making around coal mining in the Mpumalanga Highveld through the development of mapping tools and refinement of spatial data on wetlands" WRC Report No K5/2281.

- *The catchment (FEPA river catchment or wetland cluster).* Priority catchments identified in the NFEPA project were scored using the values described in the aquatic feature section. Priority wetland clusters from NFEPA were given a score of 10.
- *Strategic Water Source Areas:* Strategic Water Source Areas from the CSIR[20] were considered to be the high water yield areas of the Kruger to Canyons Biosphere and were given a score of 10.

Firstly, a composite layer of all aquatic features was developed by identifying the maximum value from the four individual summary input layers. This layer included areas that were transformed. Secondly, an additional summed layer examined the aggregated score across the four input layers. This layer had transformed sites excluded. Finally, these two layers were added together to give a final set of aquatic biodiversity priorities, that are largely focussed on intact high value sites, but where some impacted sites are included if they are within an overall high priority landscape. The combined aquatic features value layer is shown in Figure 19.

Threatened Habitats

Ecosystem Threat Status is perhaps the single most important description of the level of priority of an ecosystem. It describes how much of an ecosystem remains in an intact state compared to national biodiversity targets[21]. It is the equivalent of a Red List category for a plant or animal. We have used the ecosystem threat status values for terrestrial habitat types[22], as it was beyond the scope of this project to develop a new integrated layer for each ecosystem type. The base data for this layer are shown in Figure 20.

Each feature type was scored with highest values being given to the most threatened habitat types:
- Least Threatened = 0
- Vulnerable = 4
- Endangered =8
- Critically Endangered =10

Transformed and degraded areas were removed to ensure that only the ecosystem threat status of remaining intact areas was considered.

Ecosystem Protection Levels

The second major national indicator of habitat priority is the Ecosystem Protection Level, which describes how much of each habitat is protected in existing formal Protected Areas (e.g. Nature Reserves)[23]. We developed an integrated layer of protection level for terrestrial

[20] Nel, J.L., Colvin, C., Le Maitre, D.C., Smith, J. and Haines, I. 2013. South Africa's Strategic Water Source Areas. CSIR report for WWF-South Africa. CSIR/NRE/ECOS/ER/2013/0031/A
[21] Driver, A., Sink, K.J., Nel, J.L., Holness, S., Van Niekerk, L., Daniels, F., Majiedt, P.A., Jonas, Z. & Maze, K. 2012. National Biodiversity Assessment 2011: An assessment of South Africa's biodiversity and ecosystems. Synthesis Report. South African National Biodiversity Institute and Department of Environmental Affairs, Pretoria.
[22] Jonas, Z., Daniels, F., Driver, A., Malatji, K.N., Dlamini, M., Malebu, T., April, V. & Holness, S. 2012. National Biodiversity Assessment 2011: Technical Report. Volume 1: Terrestrial Component. South African National Biodiversity Institute, Pretoria.
[23] Driver, A., Sink, K.J., Nel, J.L., Holness, S., Van Niekerk, L., Daniels, F., Majiedt, P.A., Jonas, Z. & Maze, K. 2012. National Biodiversity Assessment 2011: An assessment of South Africa's biodiversity and ecosystems. Synthesis Report. South African National Biodiversity Institute and Department of Environmental Affairs, Pretoria.

ecosystems, rivers and wetlands based on work done for the NPAES (2016)[24]. The following scoring was used:

- Well protected = 0;
- Moderately protected = 3;
- Poorly protected = 6;
- Not protected = 10

Again, for the integration, we excluded transformed areas to provide a map of priority remaining under-protected ecosystems (Figure 21).

Overall integration

A combined biodiversity prioritization was produced using the following method. The individual layers (Critical Biodiversity Areas, Protected Area expansion priorities, aquatic priorities, under protected habitats and threatened habitats) were summed using an equal weighting. The values were then doubled to produce a layer from 0-100 to aid integration with the other layers. Finally, all transformed areas were removed to leave high value natural areas only. The results of the current interim analysis are shown in Figure 22.

[24] Department of Environmental Affairs (2016) National Protected Areas Expansion Strategy for South Africa 2016. Department of Environmental Affairs, Pretoria, South Africa.

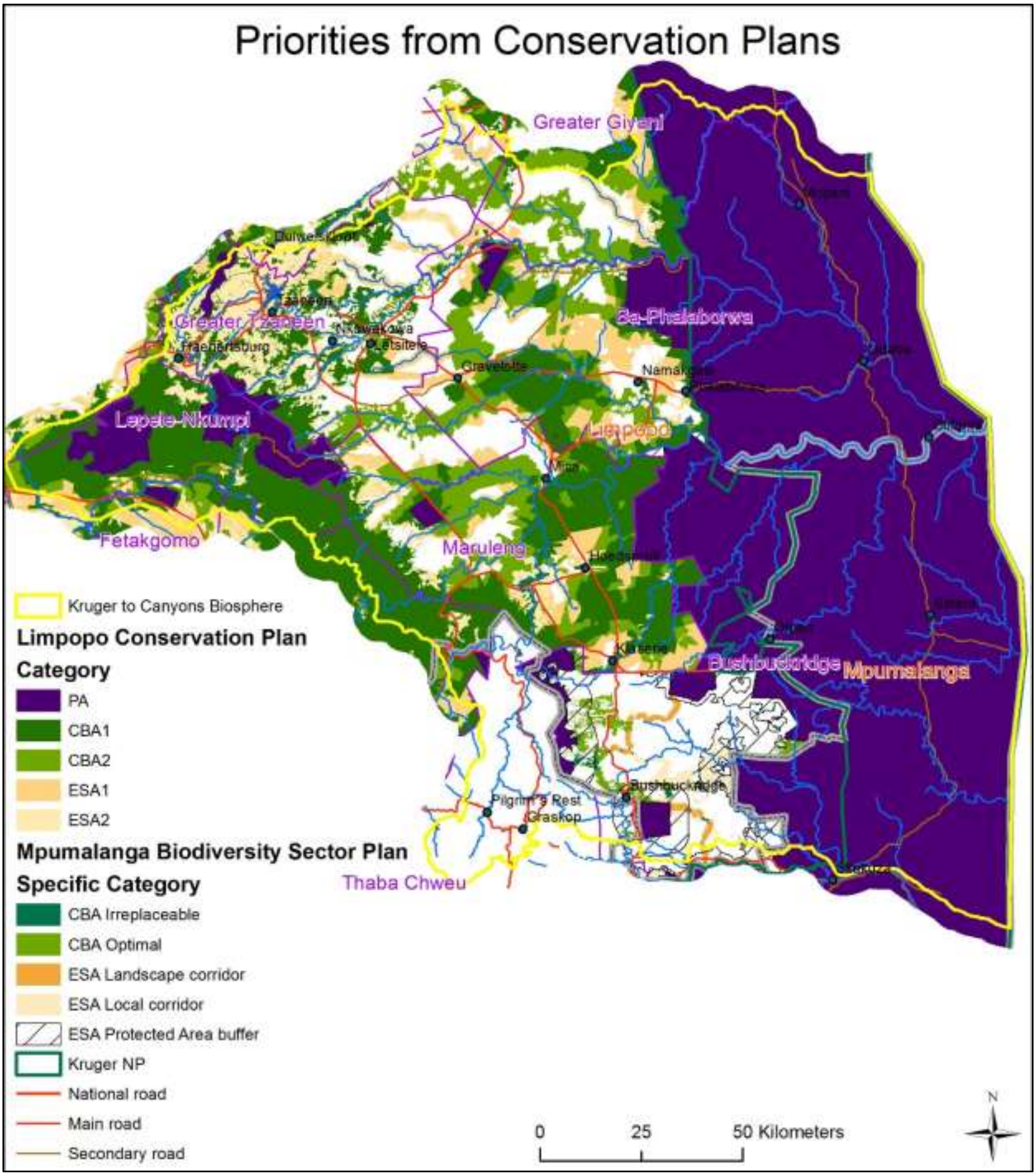

Figure 17: Integrated layer of Critical Biodiversity Areas and Ecological Support areas from the provincial conservation plans.

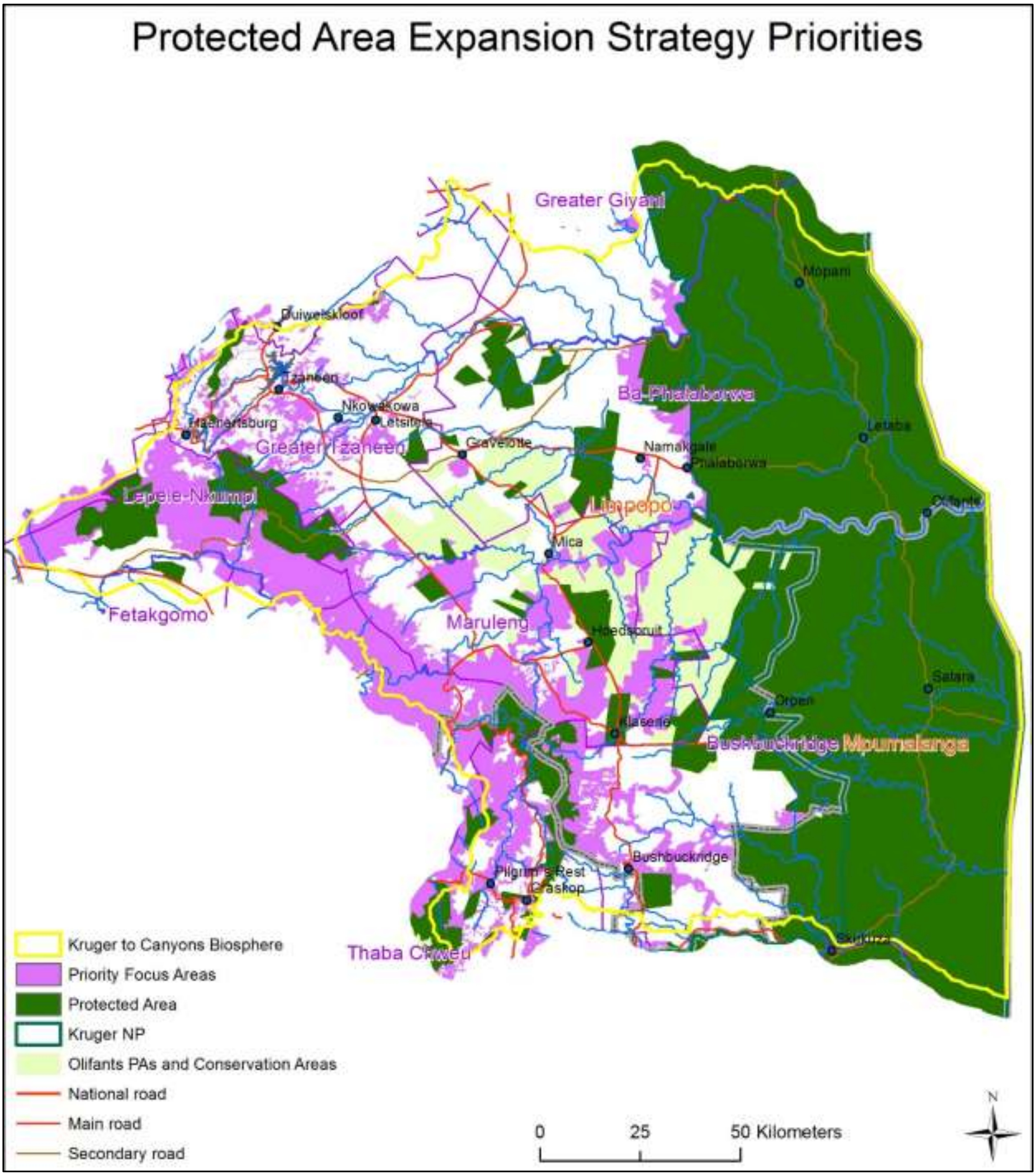

Figure 18: PAES priorities identified in provincial and national planning processes.

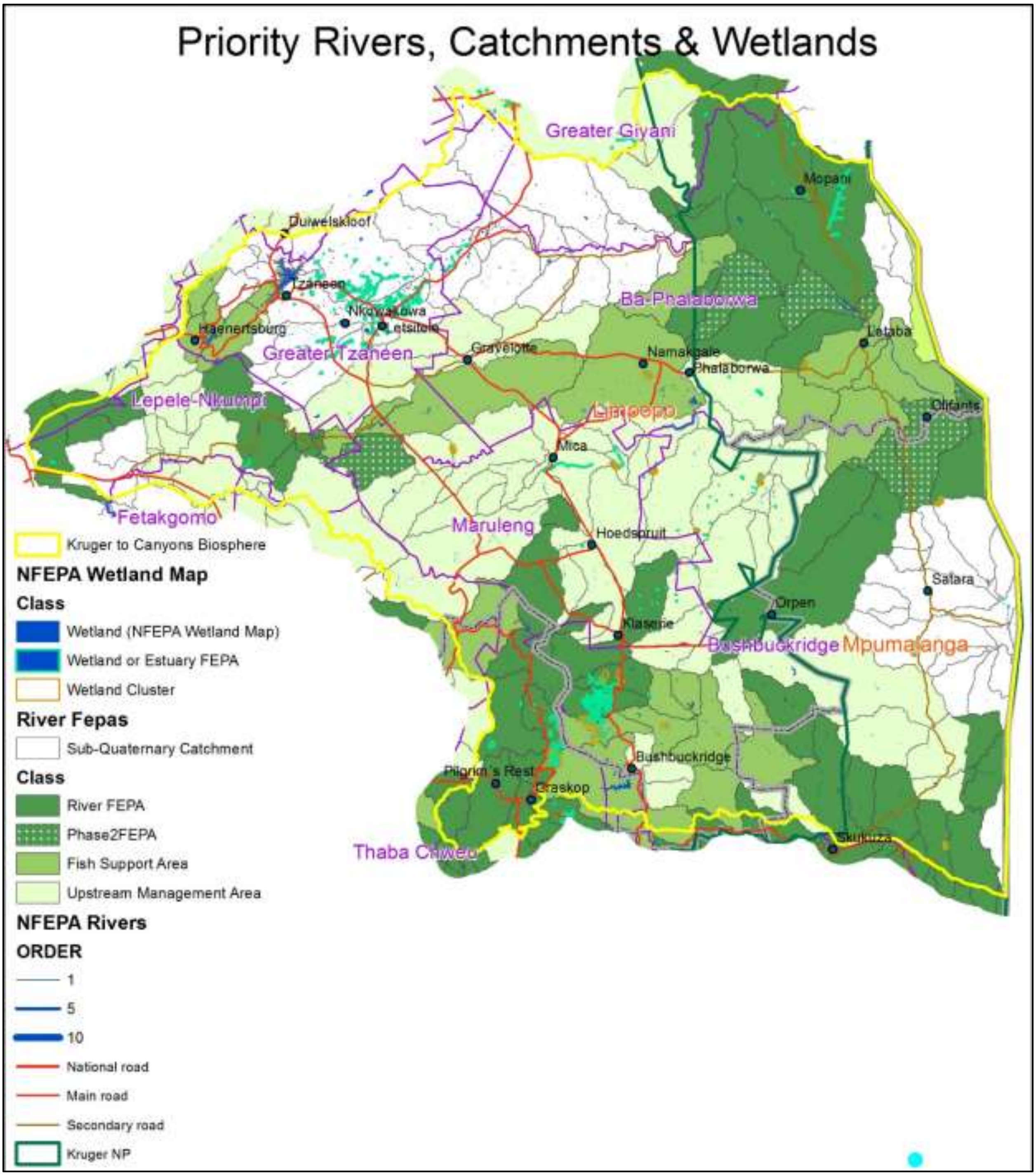

Figure 19: Aquatic Biodiversity Priorities in the Kruger to Canyons Biosphere.

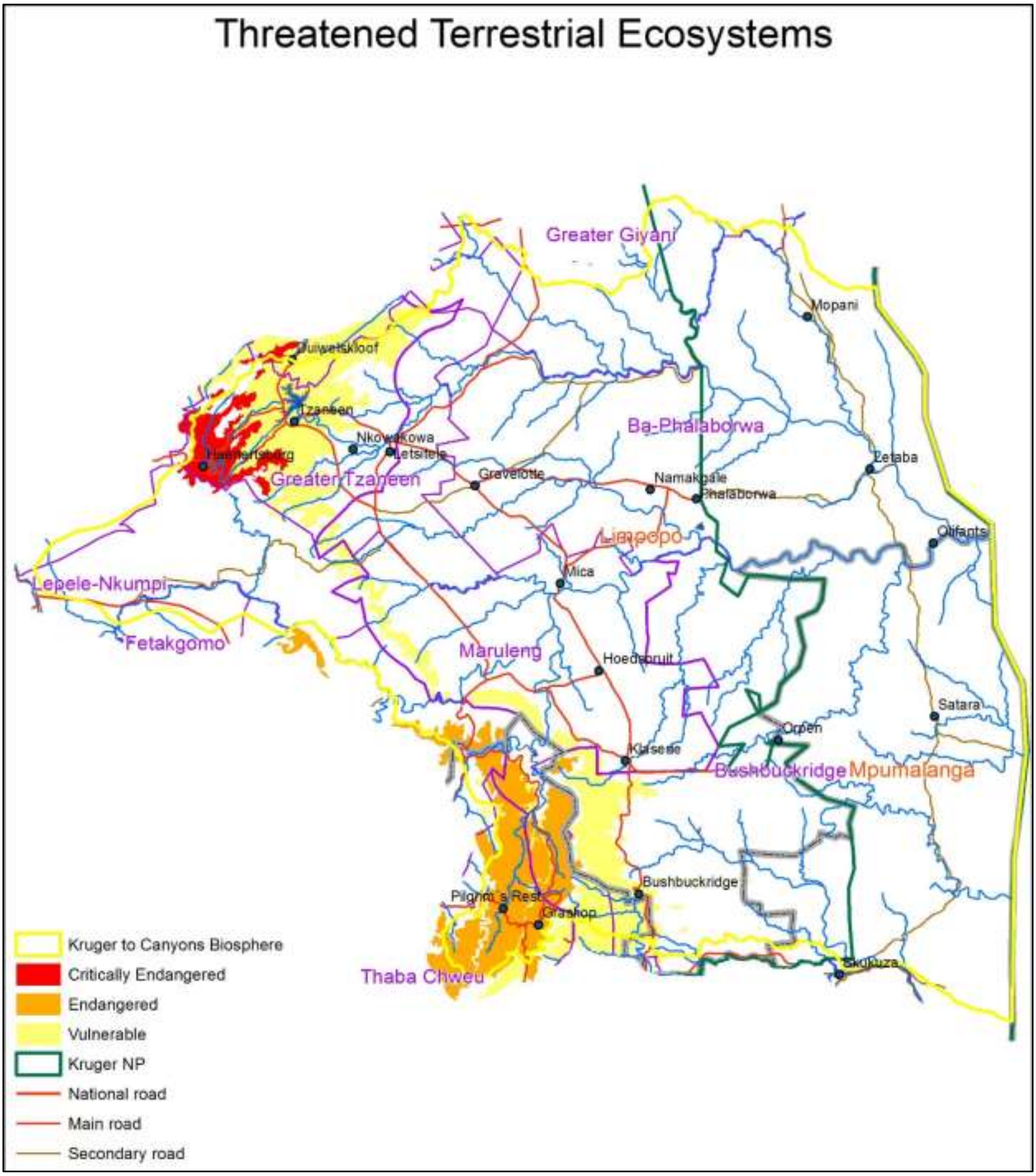

Figure 20: Threatened terrestrial ecosystems in the Kruger to Canyons Biosphere.

Figure 21: Integrated map of protection levels of ecosystems (terrestrial, wetland and river) for the study area.

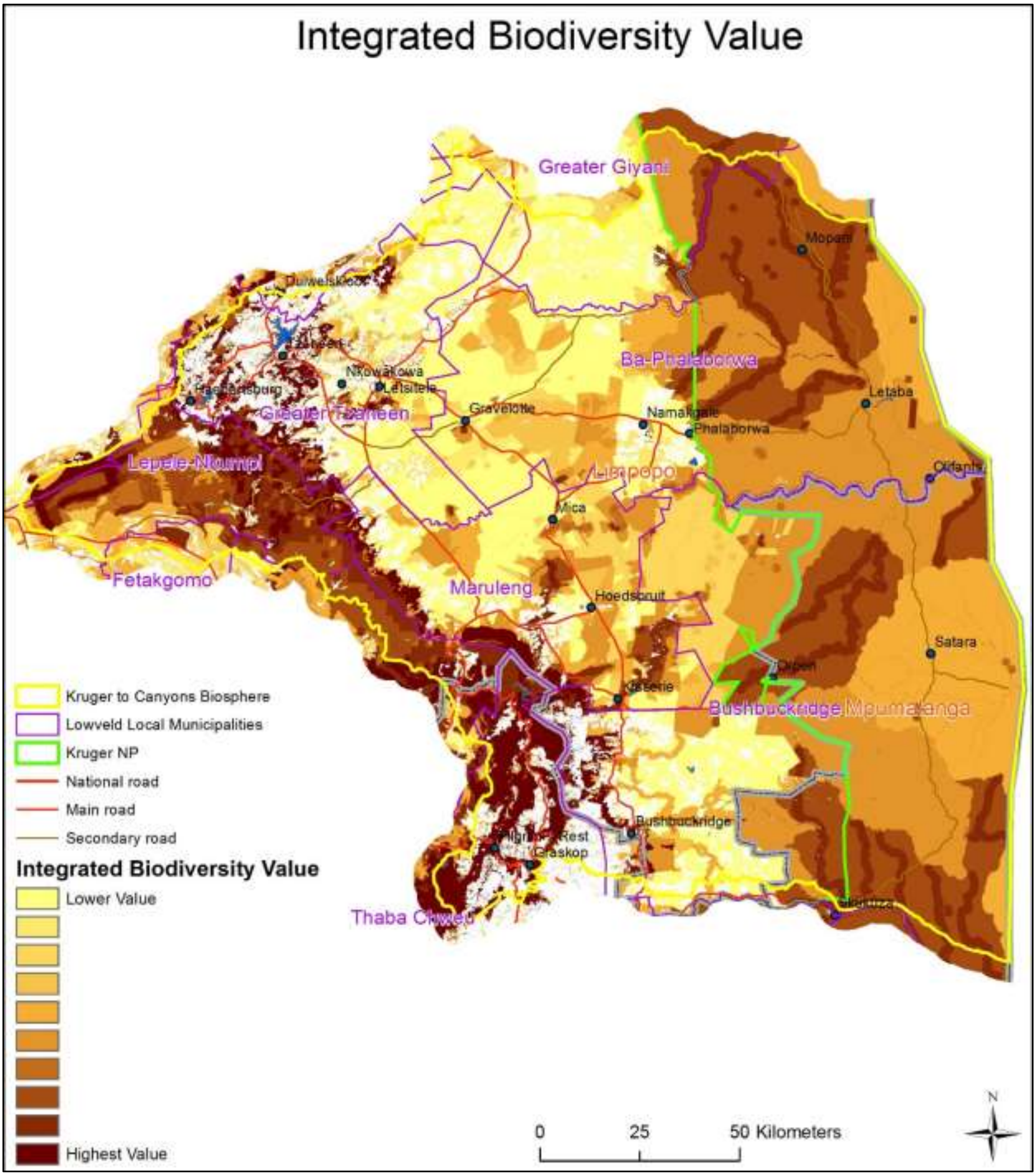

Figure 22: Combined biodiversity prioritization for the Kruger to Canyons Biosphere.

5. Social demand priorities

As buffer areas protected areas and protected area expansion are heavily dependent on the link between human/social needs and the environment, we have identified the social priority areas where people are most directly dependent on the environment for the delivery of ecosystem services.

Overall prioritization method

The study extends the spatial analysis undertaken for CSA in the Alfred Nzo District in the Eastern Cape [25]. The analysis focusses on the question: Where are the poorest people who are most dependent on the direct use of local natural resources in the Kruger to Canyons Biosphere? This study primarily draws on analysis of Census 2011[26] data to devise a social demand index that for communities within the Kruger to Canyons Biosphere. The data-driven social demand index, consists of two composite indices namely:

- A poverty index, incorporating sub-indices of:
  - The proportion of low income households.
  - A dependency ratio which examined the ratio of people who are employed to those who are not.
  - Access to services (Specifically looking at proportions of households with access to electricity, decent sanitation, water supplies and refuse collection).
  - Consumption (Examining levels of ownership of various goods as a proxy for poverty).
- Local direct natural resource use dependency index, incorporating sub-indices of:
  - Access to piped water.
  - Dependency on the environment for wood for cooking.
  - Dependency on the environment for wood for heating.
  - Dependency on the environment for building materials.

The analysis is undertaken at a community level, which is the smallest discreet geographic unit recognized in the South African 2011 census. The indices are relative and compare national baseline. The objective is to identify an efficient set of indicators of poverty and natural resource dependency, with indicators identified and thresholds set at levels to meaningfully differentiate the most vulnerable focal rural communities.

The study identified where the poorest people who are most dependent on the direct use of local natural resources live, and then we extended this further to identify the broader areas supplying these natural resources (as in general households would be dependent on the areas surrounding the homestead rather than just the homestead footprint itself). Finally, the areas of high demand were combined with the landcover maps to identify the natural and semi-natural areas in these high demand areas.

[25] The methodology was adapted from that developed by the author for Holness SD, Frazee S & Lupindo Y, 2014: Adapting to climate change in the Alfred Nzo District: Protecting Ecological Infrastructure to support Ecosystem-based Adaptation to climate change, Conservation South Africa.

[26] Specific sources:
Statistics South Africa, 2011: Census 2011 Release v1.1, Statistics South Africa, Pretoria. Sourced via AfriGIS.
Statistics South Africa, 2013: Census 2011 spatial metadata report. No other details provided.
Statistics South Africa, 2014: The South African MPI -Creating a multidimensional poverty index using census data, Statistics South Africa, Pretoria.

Poverty index

Components of the Poverty Index:

The Poverty Index is based on proportions of households which meet specfic poverty criteria. The Poverty Index is made up of four components:

The proportion of low income households. Household income was derived from the Census 2011 data. We attempted use the Census data to identify households which were living on the equivalent of one government grant or less per year. Unfortunately, as the Census divides incomes into specific categories which do not coincide with values such as a nationally defined poverty line or a government grant, we had to use the nearest category division to identify the lowest income households. Households were low income if they had a combined income of under R9600/year or had with no income at all. The data were further processed using the following approach:

- The base value was then converted to an index to provide identify areas of relative high and low proportions of low income households. A n/n_{90} method[27] was used to calculate values[28].
- This approach gives an index from 0 (lowest proportion of low income households) to 10 (highest proportion of low income households).

A dependency ratio which examined the ratio of people who are employed to those who are not. For each sub-place, the total shows the ratio of people who are employed to people who are unemployed, discouraged work-seekers, not economically active or under 15. It attempts to identify areas where there are very high dependency levels. This data was further processed using the following approach:

- (100 – (Ratio employed/100))/10. The formula gives a value between 0 (areas with lowest dependency levels) and 10 (areas with highest dependency levels).
- The standard formula and method described for population density was used to calculate values[29].

This approach gives an index from 0 (lowest dependency ratio) to 10 (highest dependency ratio).

Access to services (Specifically looking at proportions of households with access to electricity, decent sanitation, water supplies and refuse collection). Level of access to services provides an additional measure of poverty. We defined reasonable access to services as the following:

- For access to electricity, we examined whether households were using electricity for lighting. In many cases, even though electricity is theoretically available for cooking and heating it may be too expensive to be used on these energy intensive tasks. However, use of electricity for lighting is far more widespread and provides a good indication of whether electricity access is available.

[27] The base values are converted to an index in order to identify areas of relative high and low values, allow the different measures to be combined, and to deal with some statistical issues such as the skewed sample data (i.e. where there are a few very high values in the dataset). We used the following formula to calculate values: 10*(n/n90), where n is the individual value for a unit, and n90 is the value for the 90th percentile of that value for communities in South Africa. Any resultant values over 10 were reclassified as 10.
This approach gives an index from 0 (lowest values) to 10 (highest values).
[28] For the "low income households index" the n_{90} value was 0.464183.
[29] For the dependency ratio the n_{90} value was 9.7723.

- We defined decent access to sanitation as having a flushing toilet (either linked to a sewage system or a septic tank), a chemical toilet or a ventilated pit toilet. Insufficient access was defined as a standard pit toilet (i.e. not ventilated), a bucket system or no toilet at all.
- We defined decent access to water as having access to piped water either in one's house, in the yard or within 200m. Anything further than that, or where there is no access to piped water, was defined at insufficient access to water.
- We defined reasonable access to refuse collection as having refuse removed by a local authority or private company (at any frequency). Any other arrangement was being insufficient.

A ratio of sufficient access to each individual service was calculated (ranging from 1 = full access to 0 = no access). Poverty of access to a specific service was then calculated by subtracting the value from 1. Finally, poverty of access to the four components were summarised adding the individual scores. This gave a score between 0 and 4, with the highest scores being in areas with no access to services. This value was then processed as follows:

- The standard formula and method described for population density was used to calculate values[30] to benchmark the levels of access to services (measured as a proportion with decent access) by a community against the levels found across South Africa.
- This approach gives an index from 0 (highest levels of access to services) to 10 (lowest levels of access to services).

Consumption (Examining levels of ownership of various goods as a proxy for poverty). As reported household income often gives a poor reflection of actual household income, we developed an additional indicator of poverty based on the ownership of goods as reflected in the Census 2011 data. The index of poverty as measured by the lack of ownership of all goods (i.e. car, cell phone, computer, DVD player, refrigerator, radio, satellite television, electric/gas stove, television, vacuum cleaner and washing machine) was derived as follows:

- The ownership of all types of goods recorded in the census was summarized for our planning units.
- We then added up everything owned by a household and divided this by the maximum possible levels of goods ownership (i.e. the sum of items owned and items not owned). This gave an ownership ratio, which we then subtracted from 1 to give a lack of ownership ratio.
- The standard formula and method described for population density was used to calculate values[31] to benchmark the levels of ownership of goods by a community against the levels found in the whole catchment.
- This approach gives an index from 0 (highest levels of consumption) to 10 (lowest levels of consumption). Note that as level of consumption is being used as a proxy for poverty, the highest value of the index identifies communities with the least goods.

Poverty Index. Finally, a Poverty Index was calculated using an equal weighted average of the four indices discussed above. This gives an overall picture of which areas have the highest dependency ratio which examined the ratio of people who are employed to those

[30] For the "lack of services" the benchmark n_{90} value was 3.32836.
[31] For the "consumption index" the n_{90} value was 0.8531478.

who are not, the highest proportion of low income households, the highest levels of the consumption based measure of poverty (examining levels of ownership of various goods as a proxy for poverty), and the highest level of poverty of access to services (specifically looking at access to electricity, decent sanitation, water supplies and refuse collection). The Poverty Index is summarized in Figure 27.

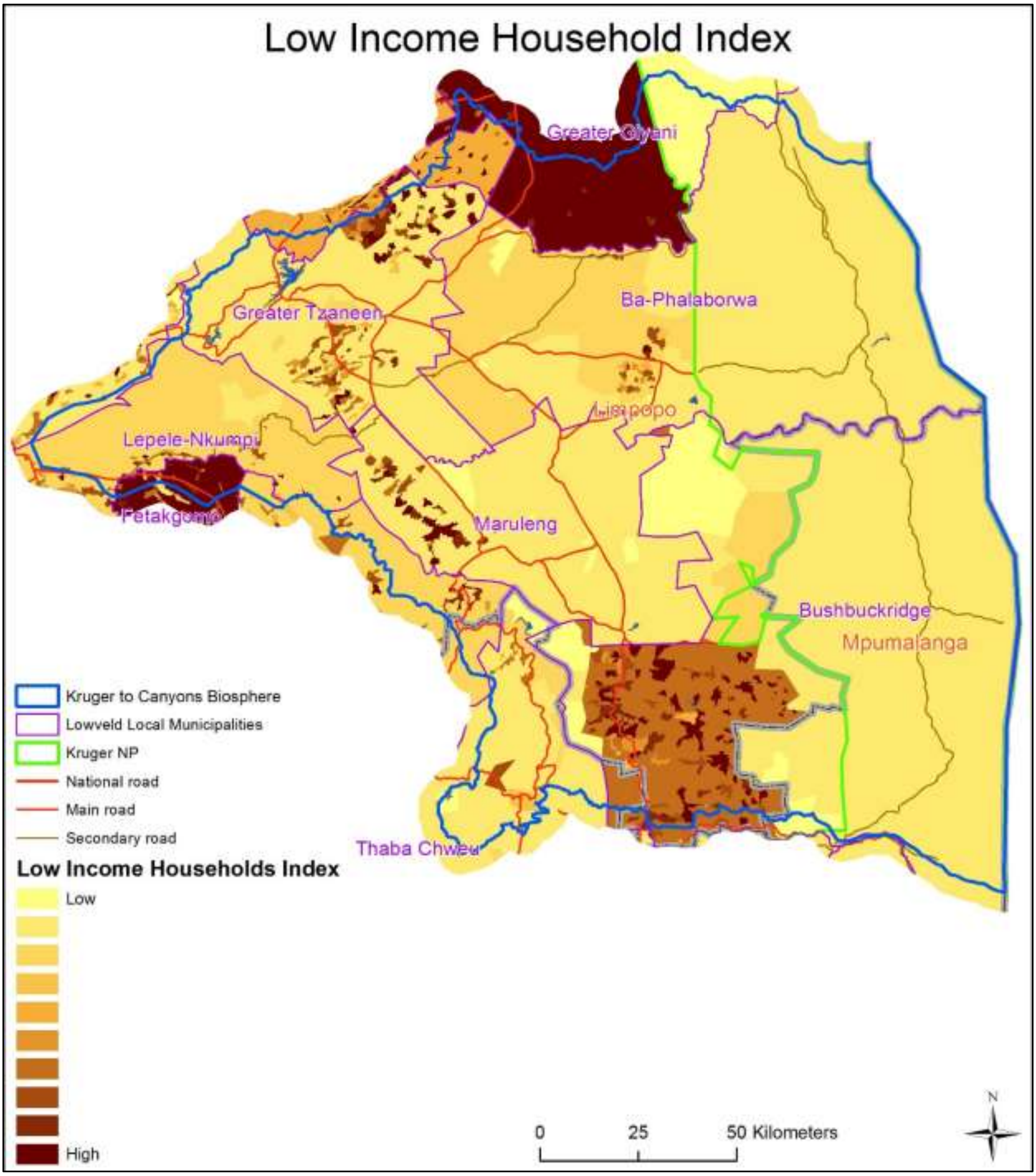

Figure 23: The index of low income households. Household income was derived from the Census 2011 data.

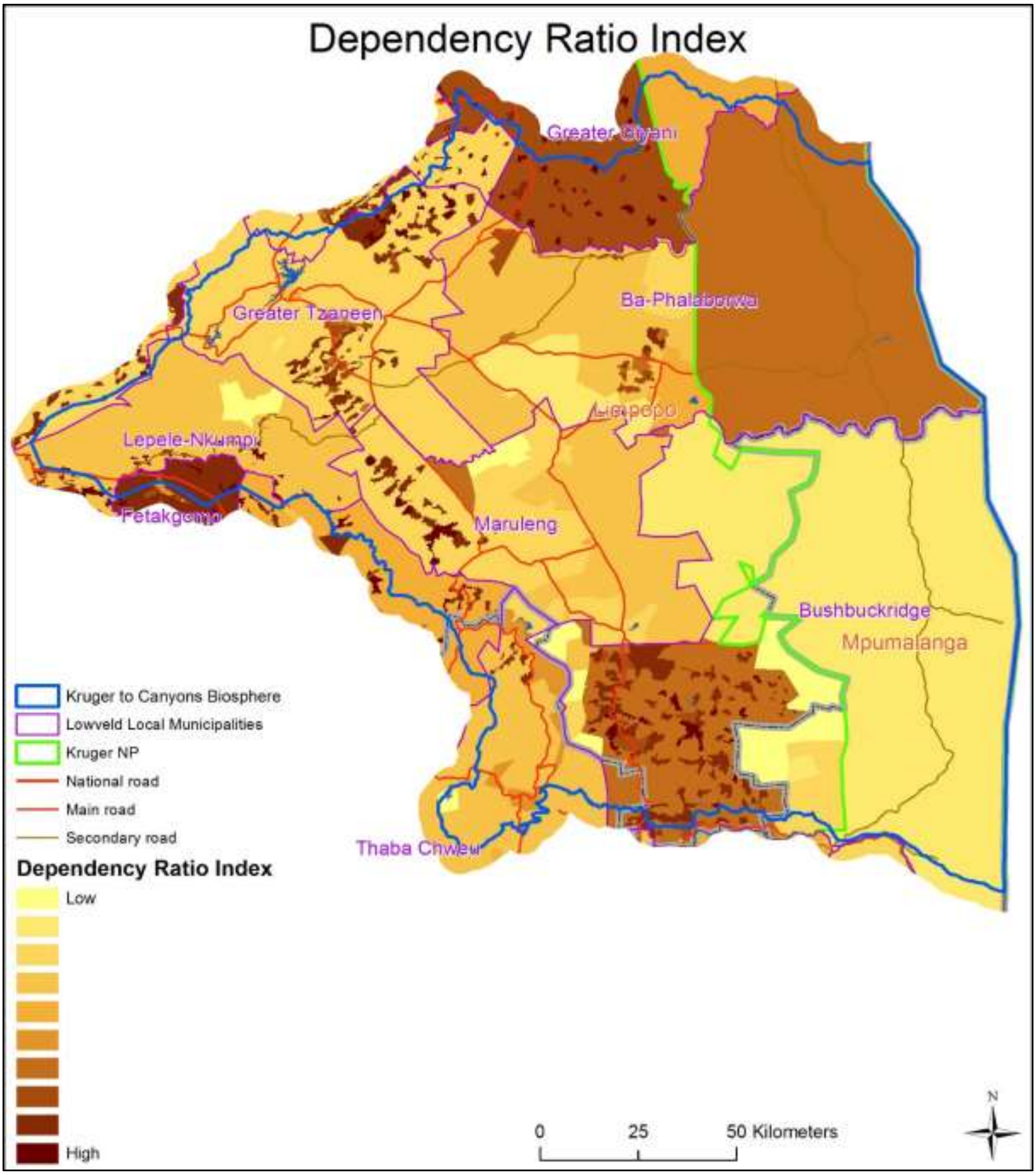

Figure 24: Map shows an index of the ratio of people who are employed to people who are unemployed, discouraged work-seekers, not economically active or under 15. It attempts to identify areas where there are very high dependency levels. The index ranges from 0 to 10 and is benchmarked against the 90th percentile of values for sub-places in the Kruger to Canyons Biosphere. Derived from Census 2011 data.

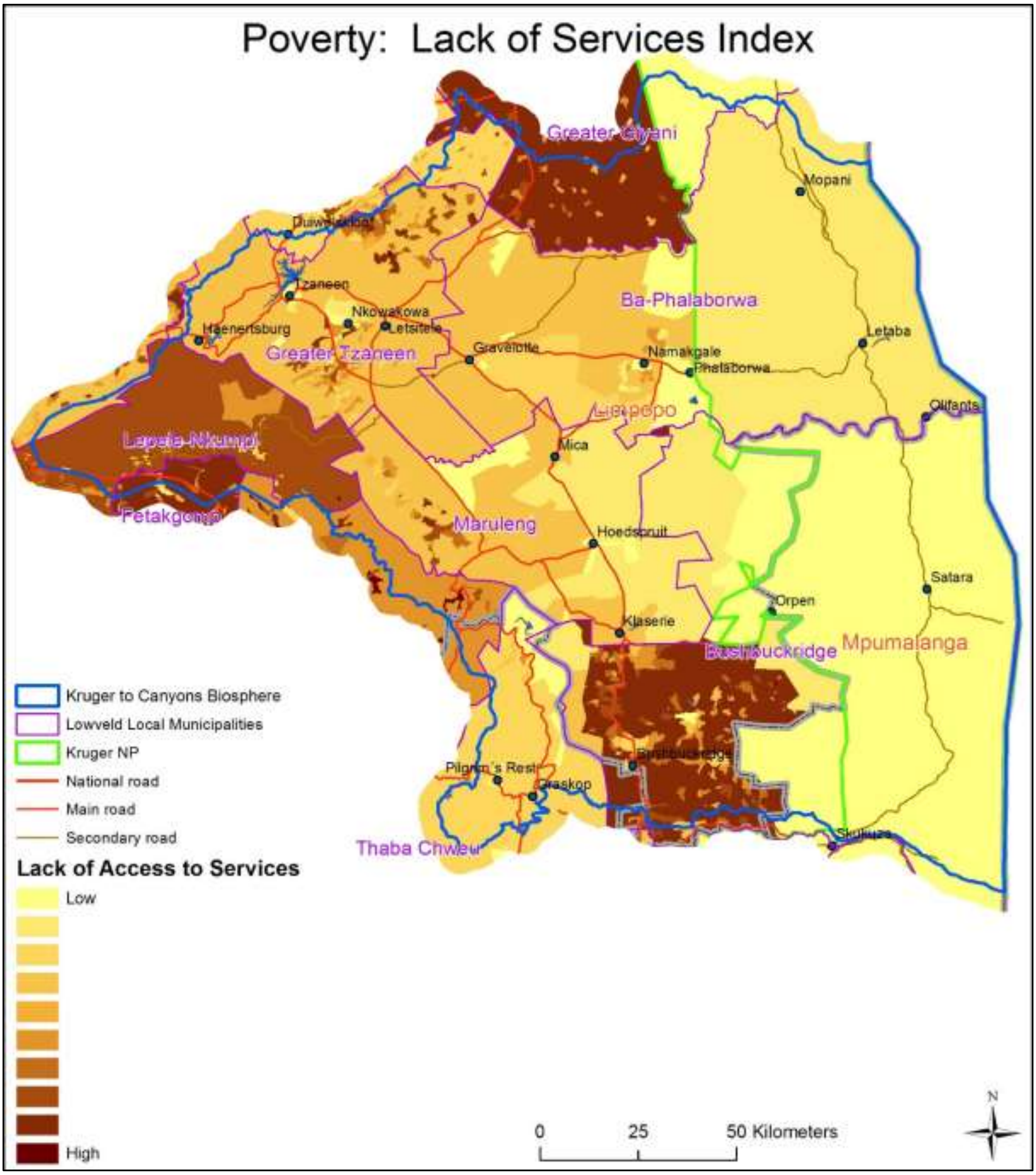

Figure 25: Map shows an index of the poverty measured by a lack of access to services (no decent access to sanitation, no piped water within 200m, no collection of refuse, no access to electricity for lighting). Derived from Census 2011 data. Note that the darkest colours indicate areas where people have the least access to services.

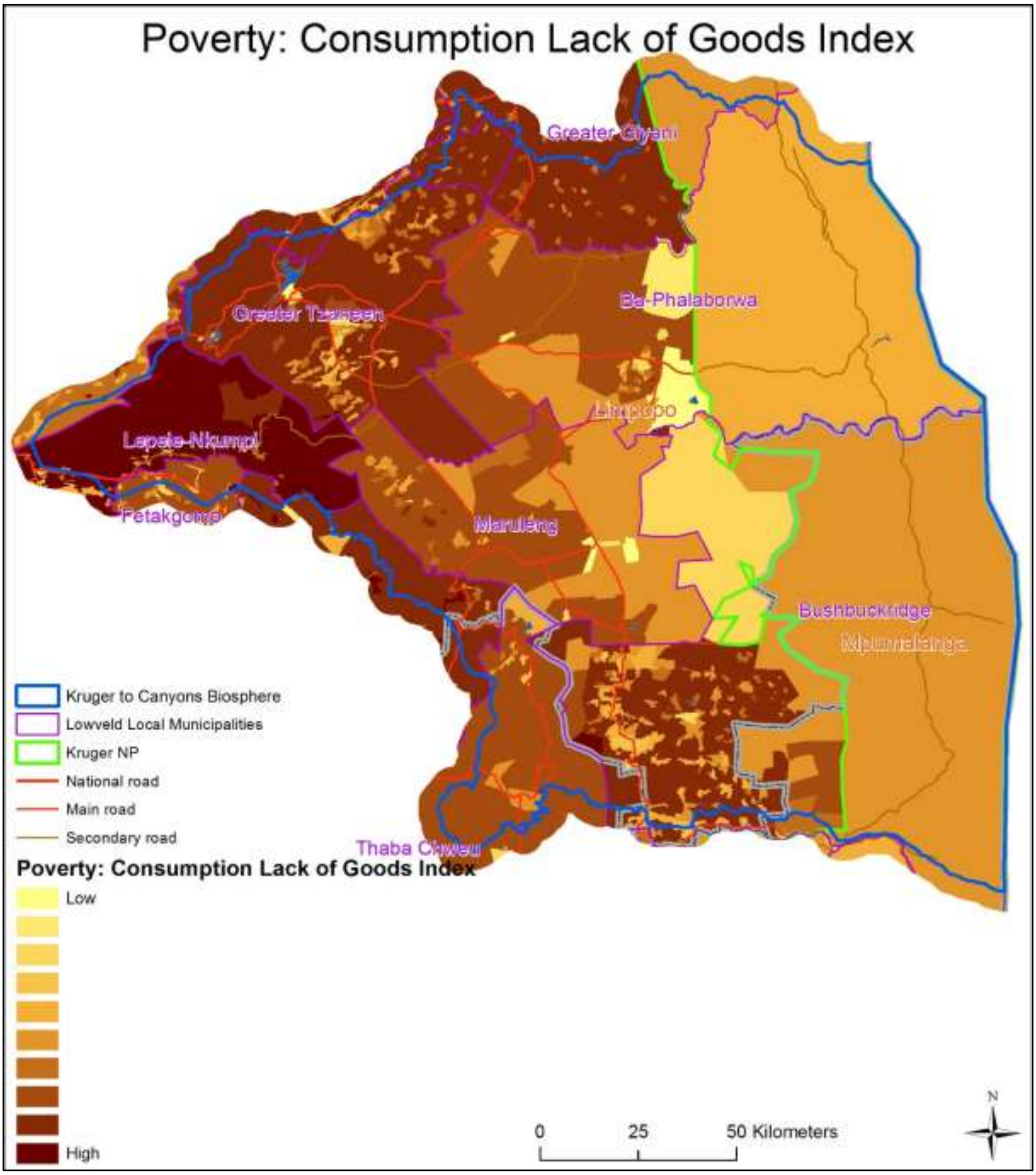

Figure 26: Map shows an index of poverty as measured by the lack of ownership of all goods. The index ranges from 0 to 10 and is benchmarked against the levels of poverty of consumption of the 90th percentile of values for sub-places in the Kruger to Canyons Biosphere. Derived from Census 2011 data. Note that the darkest colours indicate areas where people have the least possessions.

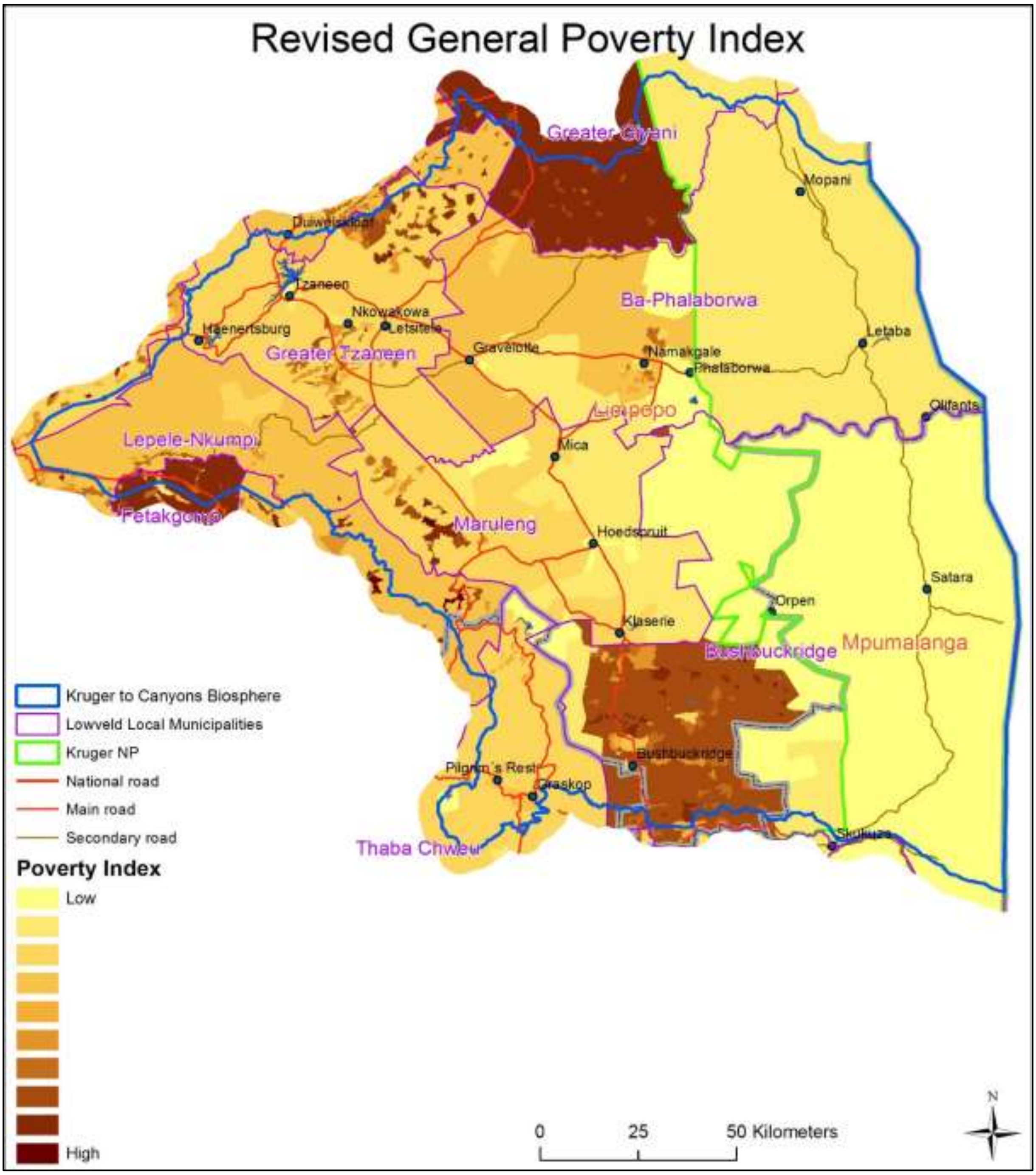

Figure 27: Map summarizing the "general poverty index" for the Kruger to Canyons Biosphere. This consists of an equal weighted summary of values derived from the general indicators of population density, density of people who are not employed, the unemployed to employed ratio, the density of low income households, the poverty of access to all goods, and the poverty of access to services.

Local direct natural resource dependence

In addition to the general poverty index, we developed a local direct natural resource dependence index which examined where households are directly dependent on the environment for traditional building materials, for wood for cooking, for wood for heating, and for the direct supply of water (i.e. where people do not have easy access to piped water). As before, we made use of collected in Census 2011 data collated by StatsSA at a sub-place level. The data will help us to identify as precisely as possible where people are directly dependent on natural and semi-natural environments for the supply of environmental goods and services.

The local direct natural resource dependence index comprised the following input layers:

Supply of building materials. A map was developed showing the density of traditional dwellings (number of traditional houses per km^2) based on the Census 2011 data for the Kruger to Canyons Biosphere. These households are likely to be dependent on the environment for building materials such as poles, thatch etc. The data were further processed using the following approach:

- The base value was then converted to an index to provide identify areas of relative high and low density of traditional dwellings, allow the different measures to be combined, and to deal with some statistical issues such as the skewed sample data (i.e. where there are a few very high values in the dataset).
- We used the following formula to calculate values: $10*(n/n_{90})$, where n is the individual value for a unit, and n_{90} is the value for the 90th percentile of that value in the Kruger to Canyons Biosphere[32]. Any resultant values over 10 were reclassified as 10.
- This approach gives an index from 0 (lowest density) to 10 (highest density).
- The results are shown in Figure 28.

Use of wood for cooking. A map was developed of the density of households dependent on wood for cooking (households/km^2), based on the Census 2011 data for the Kruger to Canyons Biosphere. These households are likely to be getting wood from the surrounding environment. The data were further processed using the following approach:

- The base value was then converted to an index to provide identify areas of relative high and low density of households who are dependent on wood for cooking. The reasons for doing this were explained in the building materials section.
- The standard formula and method described for building materials was used to calculate values[33].
- This approach gives an index from 0 (lowest density of households dependent on wood for cooking) to 10 (highest density of households dependent on wood for cooking).
- The results are shown in Figure 29.

Use of wood for heating. A map was developed of the density of households dependent on wood for heating (households/km^2), based on the Census 2011 data for the Kruger to Canyons Biosphere. These households are likely to be getting wood from the surrounding environment. The data were further processed using the following approach:

- The base value was then converted to an index to provide identify areas of relative high and low density of households who are dependent on wood for heating. The reasons for doing this were explained in the building materials section.

[32] For the “traditional dwellings” calculations n_{90} was 11.7147 households/ km^2 for the Kruger Buffer.
[33] For the “wood for cooking density” the n_{90} value was 121.882004.

- The standard formula and method described for building materials was used to calculate values[34].
- This approach gives an index from 0 (lowest density of households dependent on wood for heating) to 10 (highest density of households dependent on wood for heating).
- The results are shown in Figure 30.

Direct supply of water from the environment. A map was developed to show the density of households who either have no piped water or must travel more than 200m to access piped water (households/km^2). These households are likely to be directly dependent on water sources from their immediate environment (rivers, springs etc.) or may be at risk in times of climate stress (e.g. they are dependent on rain water tanks which may dry up). The data were further processed using the following approach:

- The base value was converted to an index to provide identify areas of relative high and low density of households who are directly dependent on the environment for their water supply.
- The standard formula and method described for building materials was used to calculate values[35].
- This approach gives an index from 0 (lowest density of households directly dependent on the environment for their water) to 10 (highest density of households directly dependent on the environment for their water).
- The results are shown in Figure 31.

Local Direct Natural Resource Dependence Index. Finally, a local direct natural resource dependence index was calculated using an equal weighted average of the values derived from the indicators of areas where households are directly dependent on the environment for traditional building materials, for wood for cooking, for wood for heating, and for the direct supply of water. See Figure 32 for the results of this analysis.

Overall social demand index

As explained in the previous sections, the analysis developed two key initial summary indices:

- Poverty index - this gives an overall picture of which areas have the highest dependency ratio which examined the ratio of people who are employed to those who are not, the highest proportion of low income households, the highest levels of the consumption based measure of poverty (examining levels of ownership of various goods as a proxy for poverty), and the highest level of poverty of access to services (specifically looking at access to electricity, decent sanitation, water supplies and refuse collection).
- Local direct natural resource dependence index – this examined where households are directly dependent on the environment for traditional building materials, for wood for cooking, for wood for heating, and for the direct supply of water.

These two initial summary indices were combined (by means of an equal weighted average) to produce a single social demand index[36]. The results are shown in Figure 33. This map

[34] For the "wood for heating density" the n_{90} value was 119.452003.
[35] For "direct water supply dependency" the n_{90} value was 109.132004.
[36] Note that the analysis is set up to provide an integrated vulnerability index. However, discussions within the RESILIM team indicated that there were mixed opinions on whether it was useful to combine the general poverty index and the local direct natural resource use dependency index. Further, it was debated whether this combined measure should be called a "Vulnerability index". This discussion was not resolved, therefore we have retained the terminology and the combined index.

gives a good indication of where people lived who were likely to be strongly dependent on their direct environment for the supply of goods and services.

The values for the single vulnerability index were then summarized (using zonal statistics on a raster version of the data) for each quinary catchment. Note that this is a geographically weighted summary and hence evaluates that vulnerability index values across all sites in a catchment. A mean value for each quinary catchment was then derived. We then utilized a normalization method to benchmark the values against 90th percentile of values for the catchment. This used the formula $100*n/n^{90}$, with values over 100 being reclassified as 100. This approach gives a layer with values between 0 and 100 which can be combined with the other assessments. Finally, we used a layer of natural and degraded areas to extract the areas of natural and semi-natural landscapes in areas of highest social demand. The results of this analysis are shown in Figure 34.

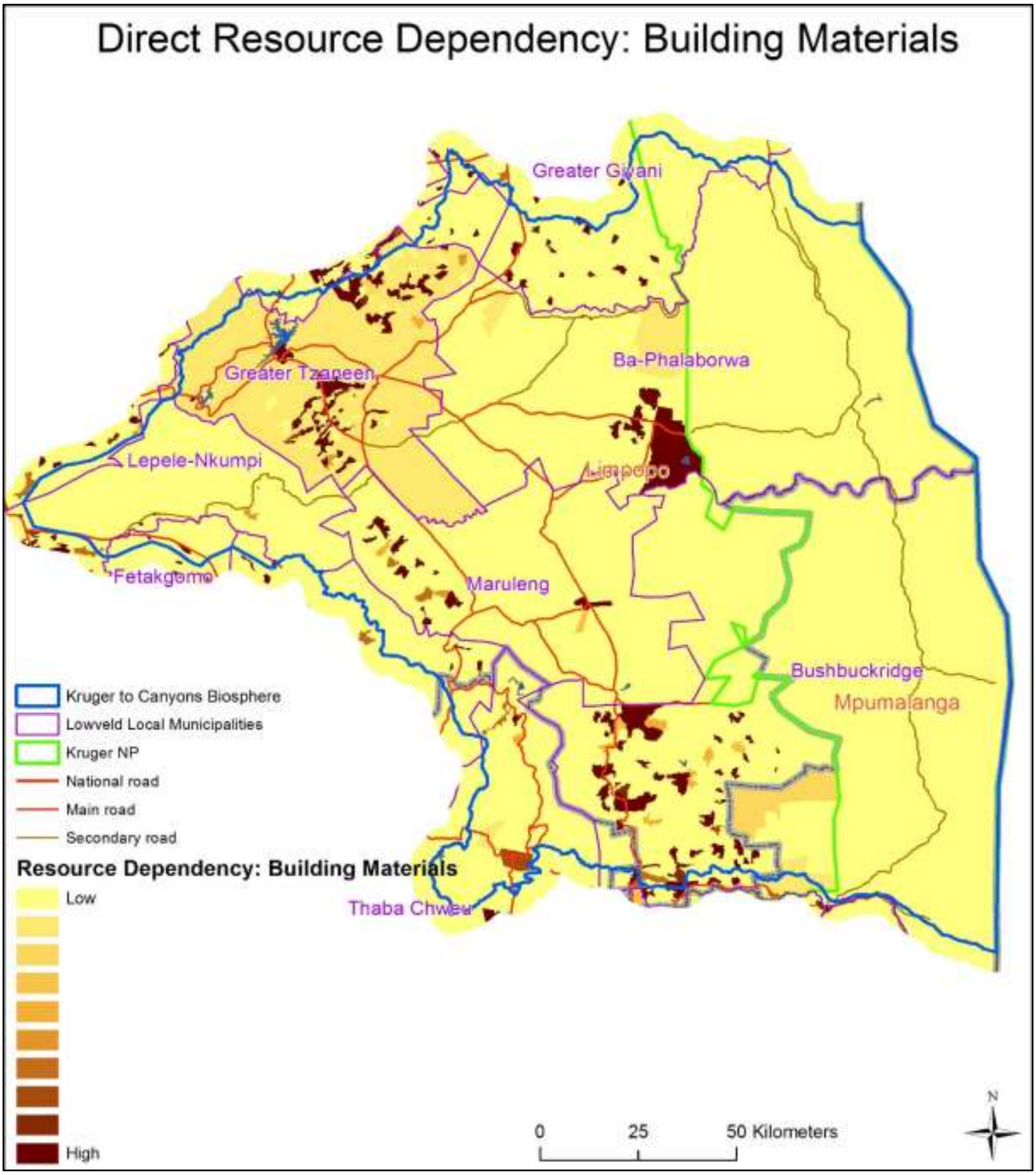

Figure 28: Map showing the index of density of traditional dwellings. These households are likely to be dependent on the environment for building materials such as poles, thatch etc. The index ranges from 0 to 10 and is benchmarked against the density of traditional dwellings that represents the 90th percentile of values for sub-places in the Kruger to Canyons Biosphere. Derived from Census 2011 data.

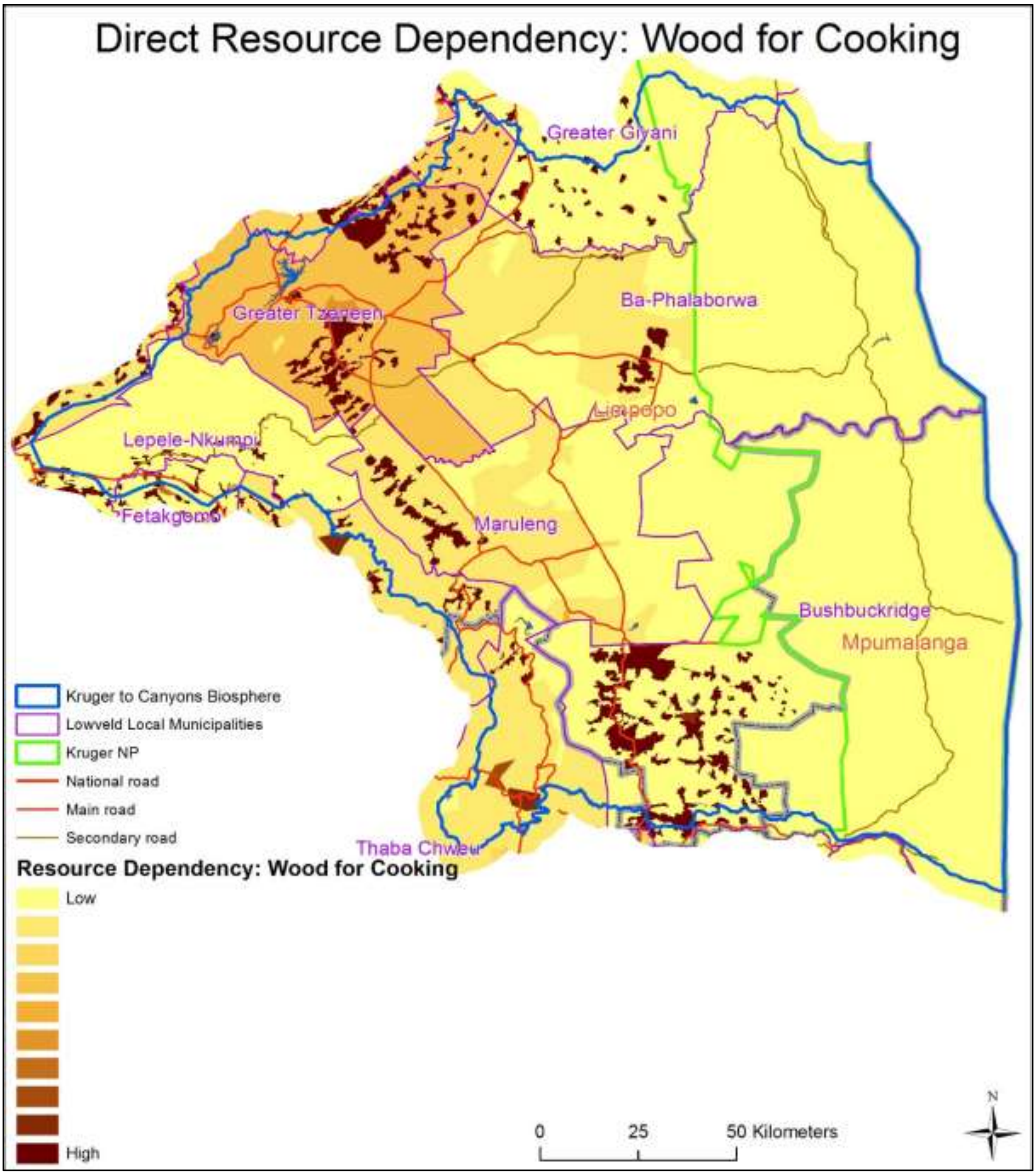

Figure 29: Map showing the index of density of households dependent on wood for cooking. The index ranges from 0 to 10 and is benchmarked against the density of density of households dependent on wood for cooking that represents the 90th percentile of values for sub-places in the Kruger to Canyons Biosphere. Derived from Census 2011 data.

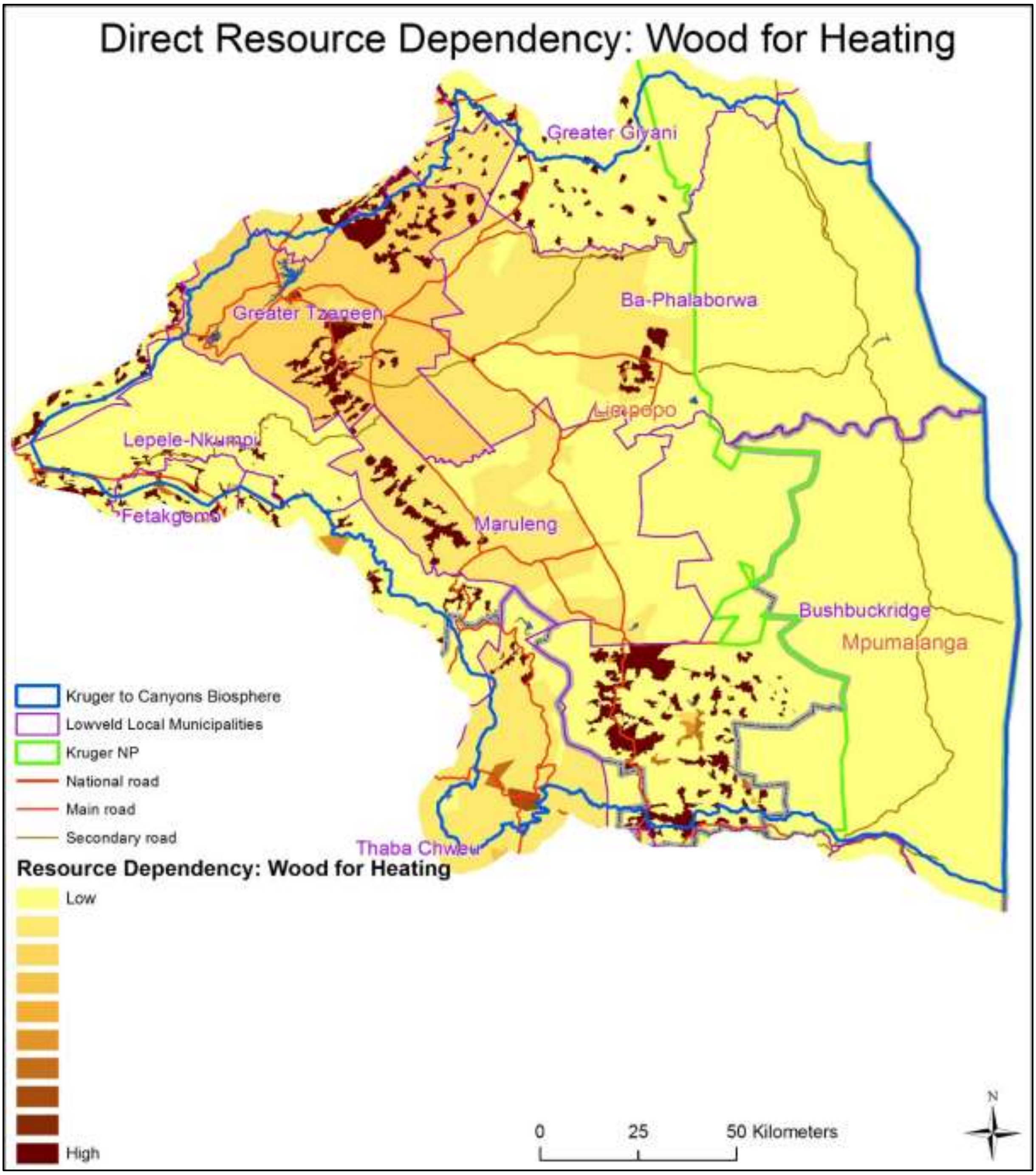

Figure 30: Map showing the index of density of households dependent on wood for heating. The index ranges from 0 to 10 and is benchmarked against the density of density of households dependent on wood for heating that represents the 90th percentile of values for sub-places in the Kruger to Canyons Biosphere. Derived from Census 2011 data.

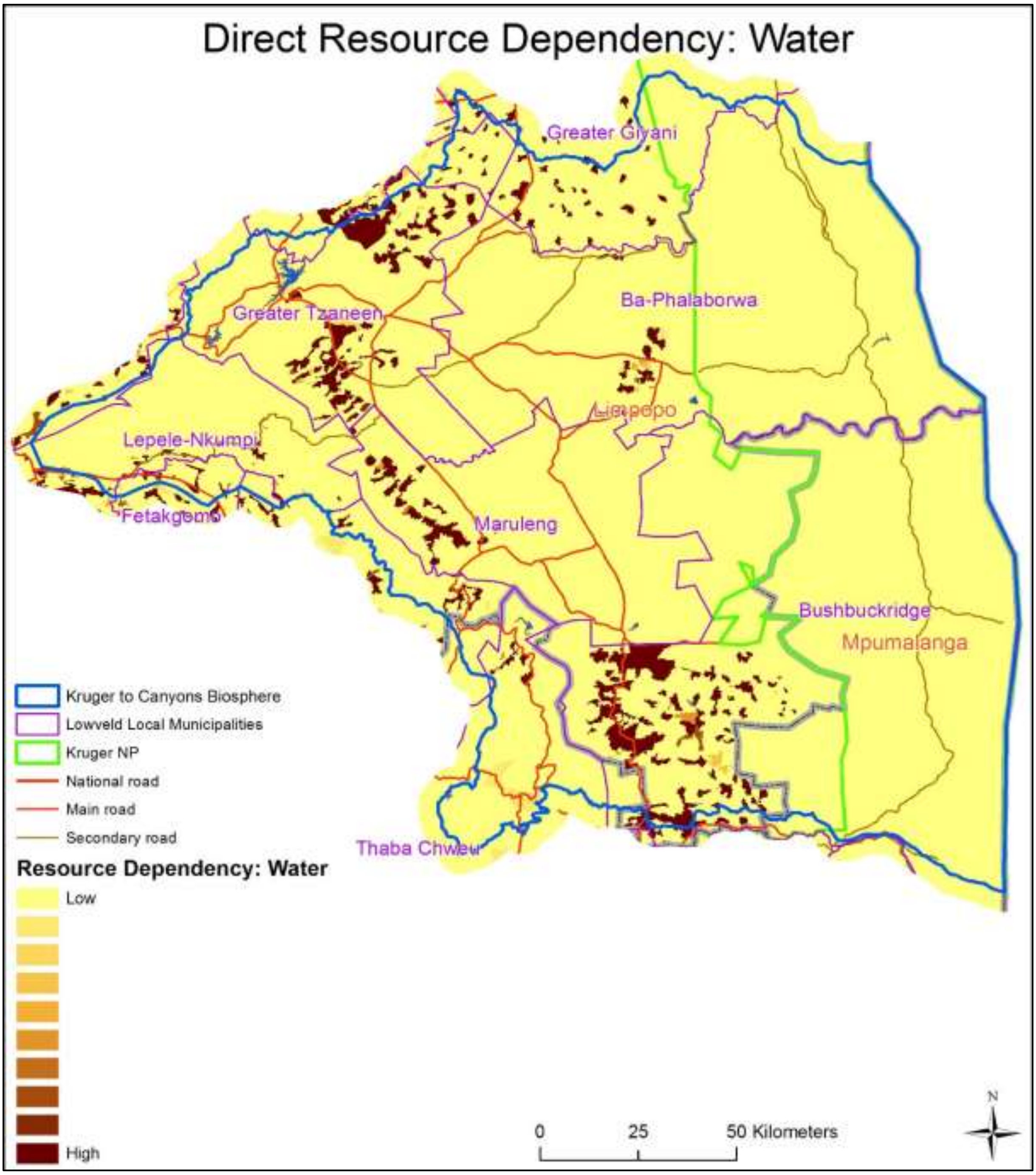

Figure 31: Map showing the index of density of households who either have no piped water or have to travel more than 200m to access piped water per km^2. The index ranges from 0 to 10 and is benchmarked against the density of households without piped water that represents the 90th percentile of values for sub-places in the Kruger to Canyons Biosphere. Derived from Census 2011 data.

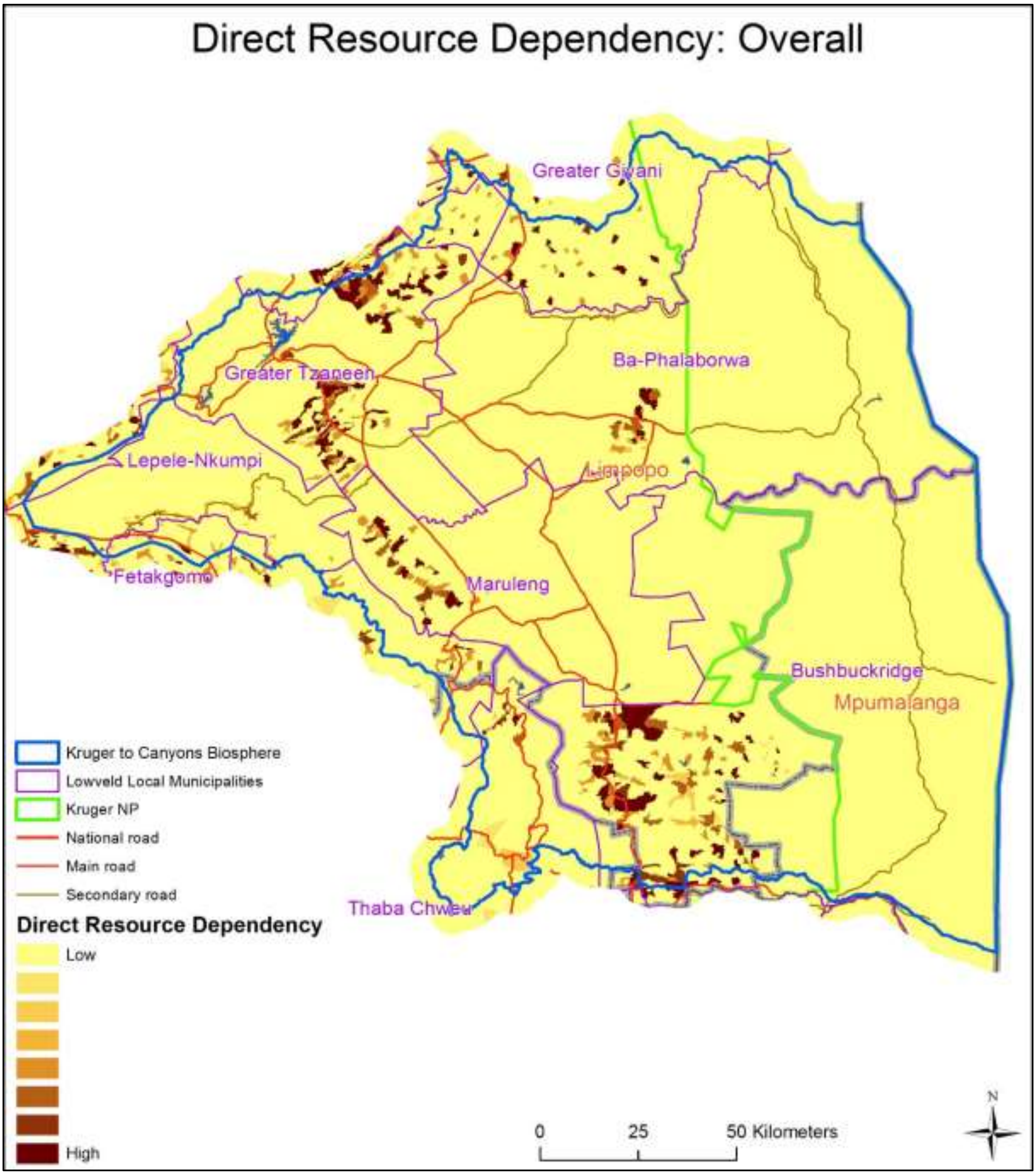

Figure 32: Map summarizing the Resource Dependency for the Kruger to Canyons Biosphere. This consists of an equal weighted summary of values derived from the general indicators of areas where households are directly dependent on the environment for traditional building materials, for wood for cooking, for wood for heating, and for the direct supply of water (i.e. where people do not have easy access to piped water).

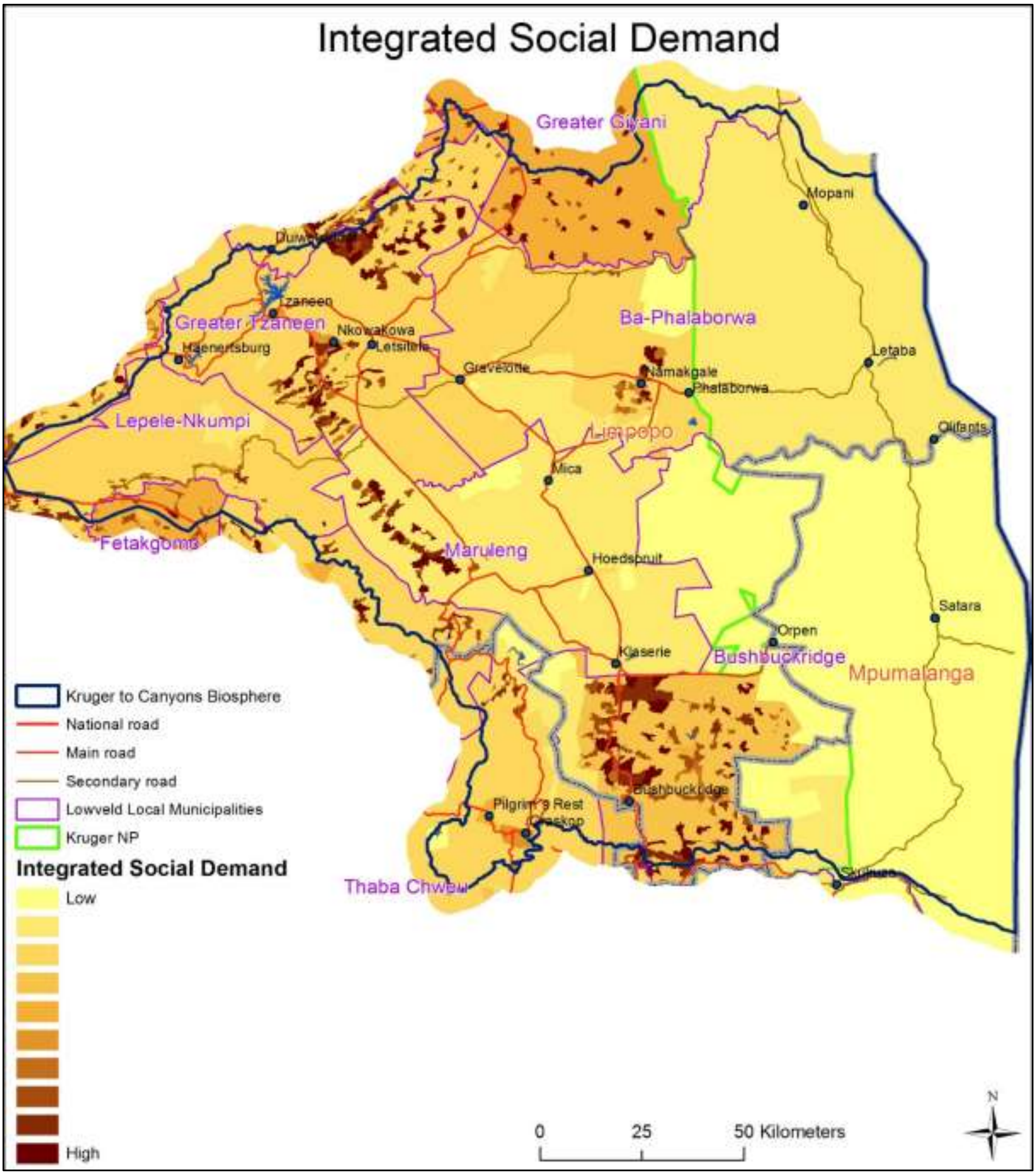

Figure 33: Map of the combined vulnerability index indicating areas of greatest poverty and high natural resource dependence for the Kruger to Canyons Biosphere.

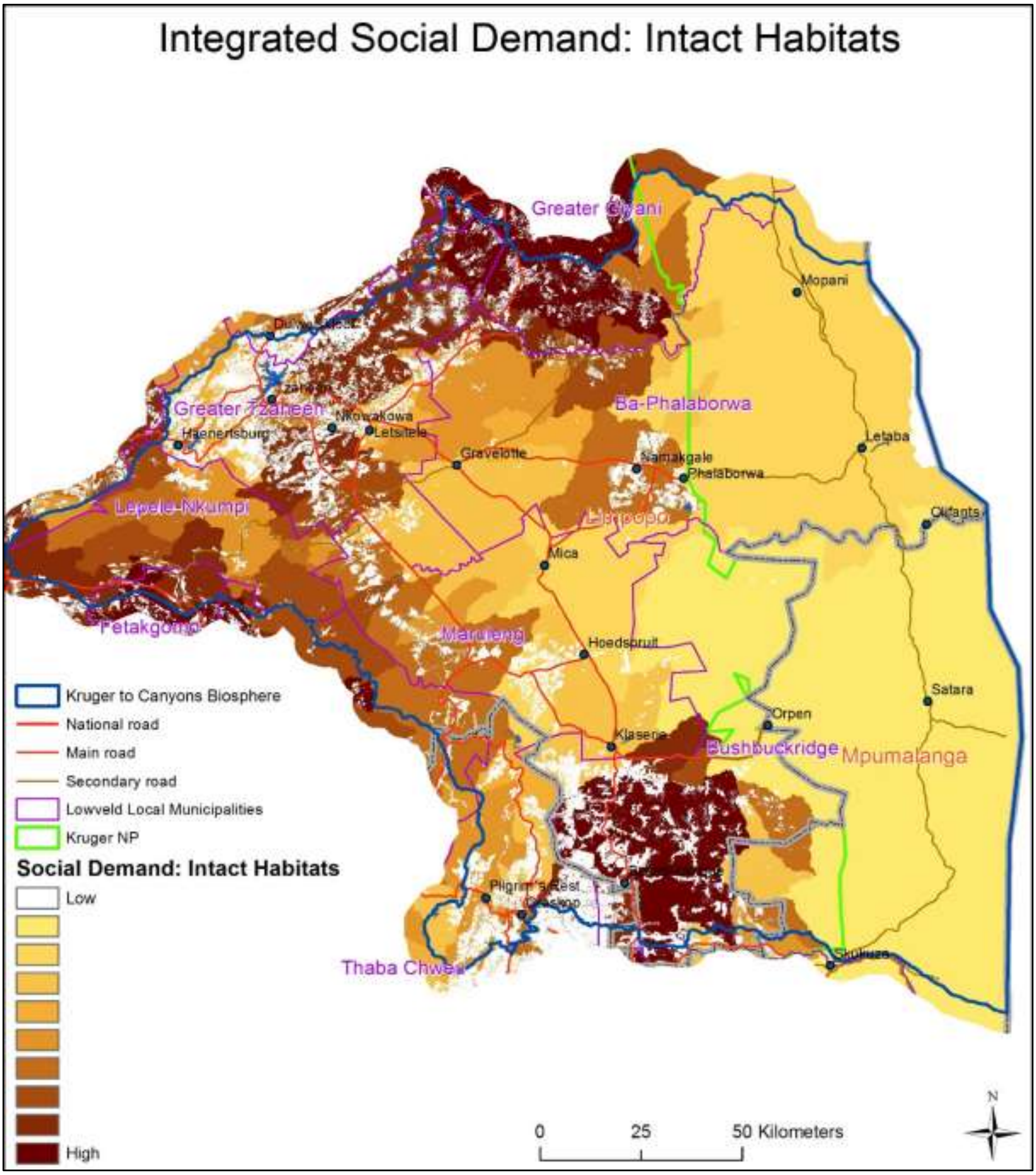

Figure 34: Map of the combined social demand index summarized per quinary catchment. The map shows remaining intact portions of these quinaries and gives a good initial indication of areas of greatest poverty and high natural resource dependence for the area.

6. Overall Spatial Integration

Introduction

As explained in the introduction, we used the concept of Ecosystem-based Adaptation for the overall spatial prioritization. The Convention on Biodiversity defines Ecosystem-based Adaptation as "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change", and the first major international report on Ecosystem-based Adaptation was published by the World Bank in 2009. South Africa's National Climate Change Response White Paper fully supports this approach. In addition to supporting well-functioning landscapes in the long term, some of the areas important for climate change resilience may also provide more specific, immediate benefits that assist directly with human adaptation to the impacts of climate change, known as ecosystem-based adaptation. Ecosystem-based Adaptation has the potential to be both more effective and less costly than engineered solutions, and can be more easily applied in rural landscapes, and implementation efforts can be easily aligned with job creation and other projects with significant social benefits.

Ecosystem-based Adaptation focuses on managing, conserving and restoring ecosystems to buffer humans from the impacts of climate change, instead of relying only on engineered solutions. This approach is suggested to be particularly effective in helping society cope with extreme climate events such as droughts, floods and storms. For example, buffers of natural vegetation along riparian corridors and around wetlands have been shown to mitigate floods, reduce erosion and improve water quality. In many cases Ecosystem-based Adaptation can work hand in hand with engineered adaptation responses.

Ecosystem-based Adaptation requires investing in maintaining and restoring ecological infrastructure, which frequently has the added benefit of creating jobs and contributing to livelihoods, especially in rural economies most at risk from adverse climate change impacts. In some cases ecosystem-based adaptation requires simply that healthy natural ecosystems are left alone to do what they already do best, and ensuring that they are not converted to other land uses. In other cases it requires rehabilitation of impacted ecosystems, for example clearing invasive alien plants in mountain catchments to increase water supply rather than building desalination plants or dams.

Identification of areas important for Ecosystem-based Adaptation

The approach taken in this project to identifying areas important for Ecosystem-based Adaptation is shown in Figure 35. As detailed in the previous chapters, summary layers were developed of:

1.) Ecological Infrastructure
2.) Climate resilience
3.) Biodiversity Priorities
4.) Social Priorities

Each of the layers was produced in a compatible format (e.g. comprehensive coverage across the district, and scoring in a consistent format with lowest value areas scoring 0 and highest value areas scoring 100). The individual layers were then overlaid using an equal weighted approach. Finally, the specific natural and semi-natural portions of these high demand areas were identified by removing irreversibly modified landscapes from the analysis. The initial outcome of this analysis is shown in Figure 36.

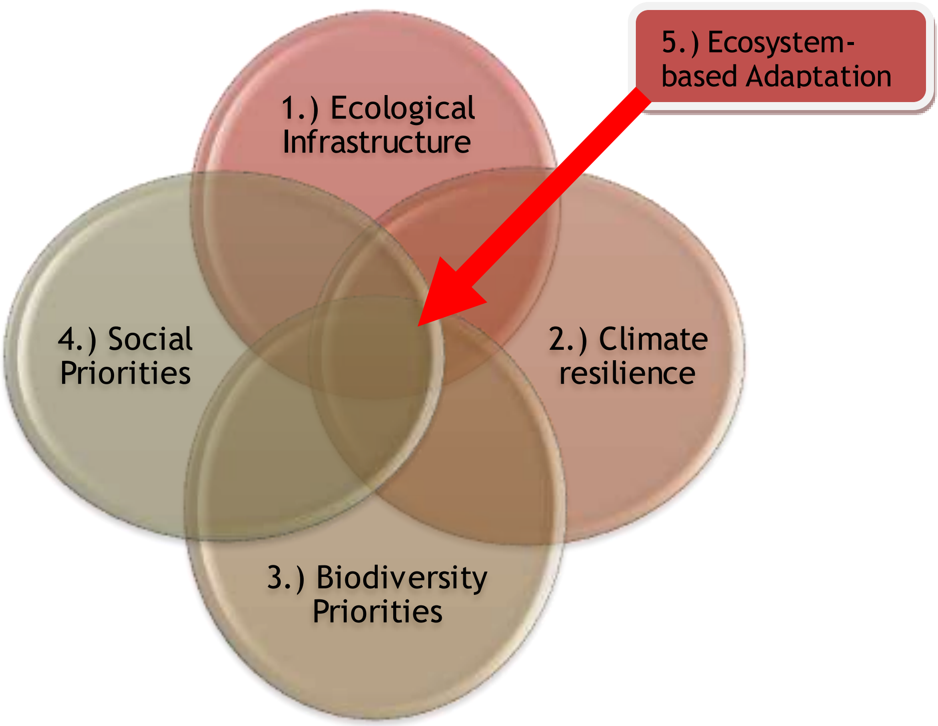

Figure 35: Summary of the analysis process.

Prioritization of areas for implementation activities

The initial spatial analysis presented in Figure 36 represent areas that are 1.) critical for delivering Ecosystem Services (i.e. they are key Ecological Infrastructure), 2.) areas that help ecosystems adapt to climate change impacts and hence support overall system resilience (i.e. the climate change resilience supporting areas), 3.) areas that are important for a range of other biodiversity reasons (Importantly as these areas are critical for supporting viable and robust ecological systems, and it is these systems on which we will depend for ecosystem services and climate change adaptation in the future, it is wrong to see these as environmental priorities only), and 4.) areas that are most important for supporting people who are directly dependent on the environment. The analysis identifies where these areas overlap most strongly, and it is these priority areas for Ecosystem-based Adaptation where we should focus our climate change adaptation activities. Activities that should be prioritized in these areas include:

- These areas should hopefully stimulate discussion on the usefulness of spatial integration methods to bring social, water, biodiversity and climate change issues together in a sensible way. It is our contention that well-managed natural and semi-natural landscapes are the key to long-term resilience of the area's social ecological system. This approach (and its subsequent revisions and full integration with outputs from other components such as systems modelling) will hopefully provide a useful, easy to comprehend (as its spatial and visual), and robust integration of key resilience issues in the Kruger to Canyons Biosphere.
- The areas should be sufficiently included into spatial planning instruments such as Spatial Development Frameworks and other appropriate planning policy (e.g. IDPs).
- The areas should be the focus for Natural Resource Management (NRM) Programmes and other projects securing water services (both for water availability and water quality), restoring and maintaining livestock grazing services as a safety net for the poor, and controlling soil erosion as a way of avoiding infrastructure costs from

damage to roads and dams. Securing ecosystem services is about restoring and protecting resource integrity in the region's water catchments, wetlands, and rivers, and other priority areas.

- The areas should be a focus for activities aimed at conserving landscapes (e.g. community linked stewardship projects).
- These areas could serve to prioritize the geographic focus areas for interventions in the restoration and conservation of scientifically-defined landscapes to ensure ecosystem function as a foundation for climate.
- These areas could be integrated into relevant climate adaptation policy relating to the district (including national, provincial, district and local municipality response strategies). The areas should be integrated into disk risk management strategies for the district and local municipalities.

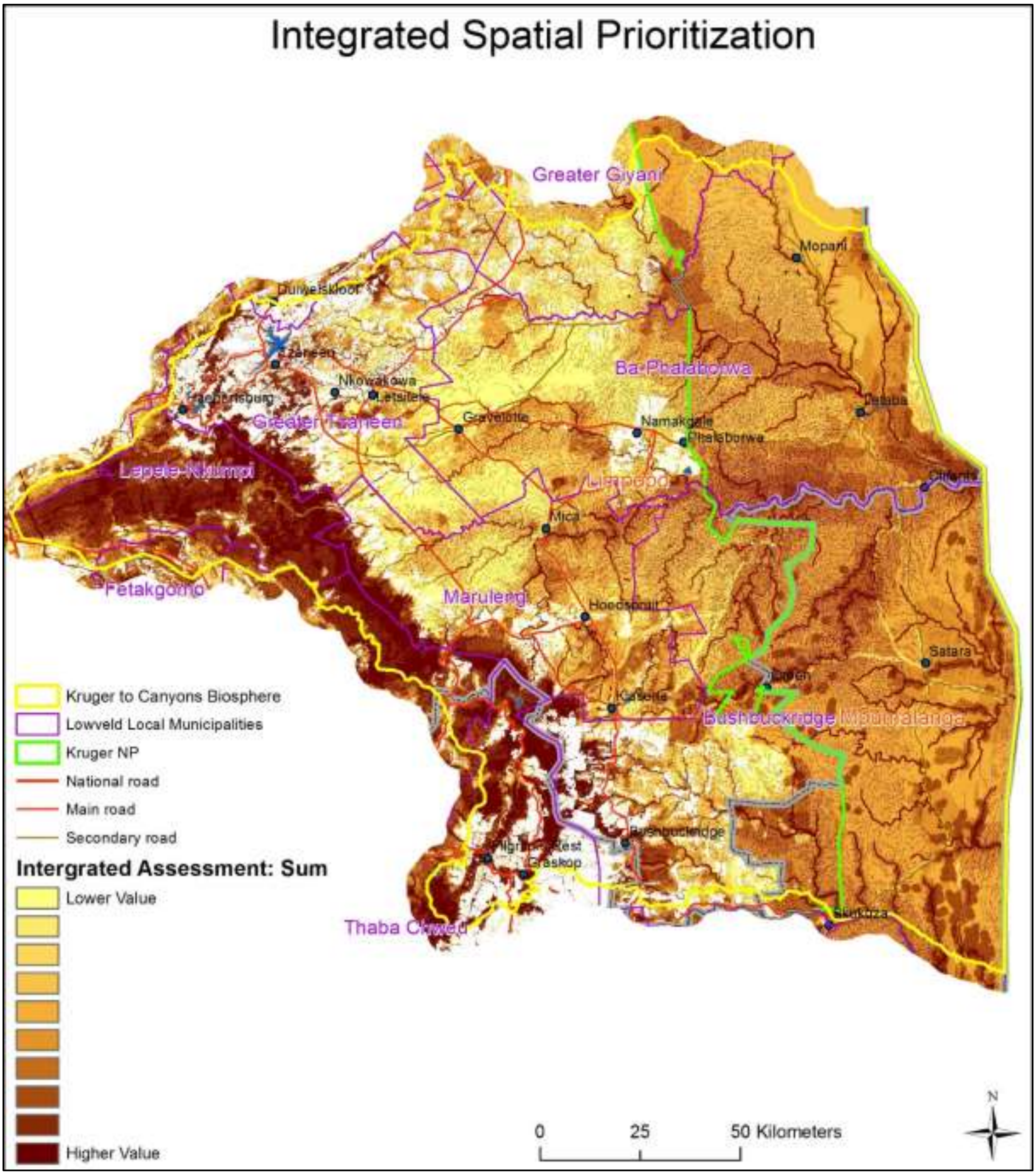

Figure 36: Integrated spatial prioritization for the Kruger to Canyons Biosphere.

7. Priority municipalities, wards and communal rangelands in Tribal Authority Areas

In this chapter we examine the priority areas for Ecosystem-based Adaptation in the Kruger to canyons Biosphere. The priorities are assessed for municipalities, wards and then for Tribal Authority areas. This is designed to provide a rapid summary of priority areas for implementation at a desktop level.

Important issues to note:

- This assessment should be subject to field verification and local implementation issues may suggest a different set of priorities. Nevertheless, this assessment does give an overall indication of priority.
- The assessment reflects mean values across the areas being assessed. Therefore, it is possible that an administrative unit could have a portion of land of very high value and large portions that are low value, and hence receive and overall low value. This does not mean that the high value areas are not extremely important.
- The assessment is strongly linked to intact landcover. It deliberately focusses on units that have both high values in terms of the site level metrics assessed (climate resilience, ecological infrastructure, biodiversity, social demand, and overall Ecosystem-based Adaptation value) and are largely natural or semi-natural. This highlights broader intact and semi-intact landscapes that need to be appropriately managed (e.g. through improved and sustainable rangeland management) to secure overall EbA value of the landscape. It is not designed to highlight small high value fragments as these would tend not to be the focus of CSA's interventions from a climate change perspective.
- We have assumed that natural and semi-natural areas Tribal Authority Areas are used as rangeland. This assumption is likely to be broadly correct, though there may be areas which are not used for reasons of grazing suitability, accessibility, steep slopes or security. We have no way of identifying these areas on a desktop basis.

Approach

The evaluation was based on the underlying indicators covered in earlier sections of the analysis:

- Resilience = Areas important for supporting climate resilience.
- Biodiversity = Biodiversity priorities.
- Ecological infrastructure = Ecological infrastructure priorities.
- Social demand = Overall social demand priorities for intact habitats.
- Overall value/importance for Ecosystem-based Adaptation activities.

In addition, for Tribal Authority Areas we evaluated the adjacency to Protected Areas. We built an equal weighted score based on two underlying calculations:

- Adjacency to Protected Areas. Any Tribal Authority Area which included or shared a boundary with a PA was given a score of 100. We used a 1km search distance to give this value to areas that we very close to PAs but not actually adjacent to them.
- We calculated as average distance for all sites in the K2C from formal Protected Areas. We then indexed the average distance against the Tribal Authority Area

which was furthest overall from a Protected Area. Overall, the Tribal Authority Areas which were closest to Protected Area would get a score of 100.

As almost all Tribal Authority Areas in the Kruger to Canyons Biosphere are relatively close to Protected areas, we have includes this adjacency index for information purposes only. It is not part of the summary metrics per area.

The spatial summary was undertaken of:

- Areas outside of formal Protected Areas. We used the DEA SAPAD database to identify formal declared Protected Areas (both state and private). The assumption is that rangeland interventions would be prioritised near but not in Protected Areas. In some cases, other interventions may be prioritized in Protected Areas (e.g. alien vegetation clearing) especially where land claims have been resolved and where these PAs are now owned and co-managed by local communities. Hence the assessment excludes the values of sites in the PA itself.
- Areas with the Kruger to canyons Biosphere. We evaluated the K2C footprint only. In many cases this is only a portion of the municipality, ward or tribal Authority area.

The analysis areas for municipalities and wards are shown in Figure 37. No separate map is provided for Tribal Authority Areas as the maps from Figure 48 to Figure 53 are sufficiently clear. For Tribal Authority Areas, the areas were given a unique identifying number. These are included in Table 10.

Analysis method:

- The spatial analysis was undertaken as an area based mean across the applicable administrative units.
- Values were indexed/benchmarked against the highest values for that type of administrative unit in the K2C biosphere. Hence, for a metric, a municipality, ward or Tribal Authority area with the highest value would have a score of 100 while units with lower values would have lower scores.
- In addition, we ranked the municipalities, wards or Tribal Authority areas. In this case a low number indicates the highest priority area.

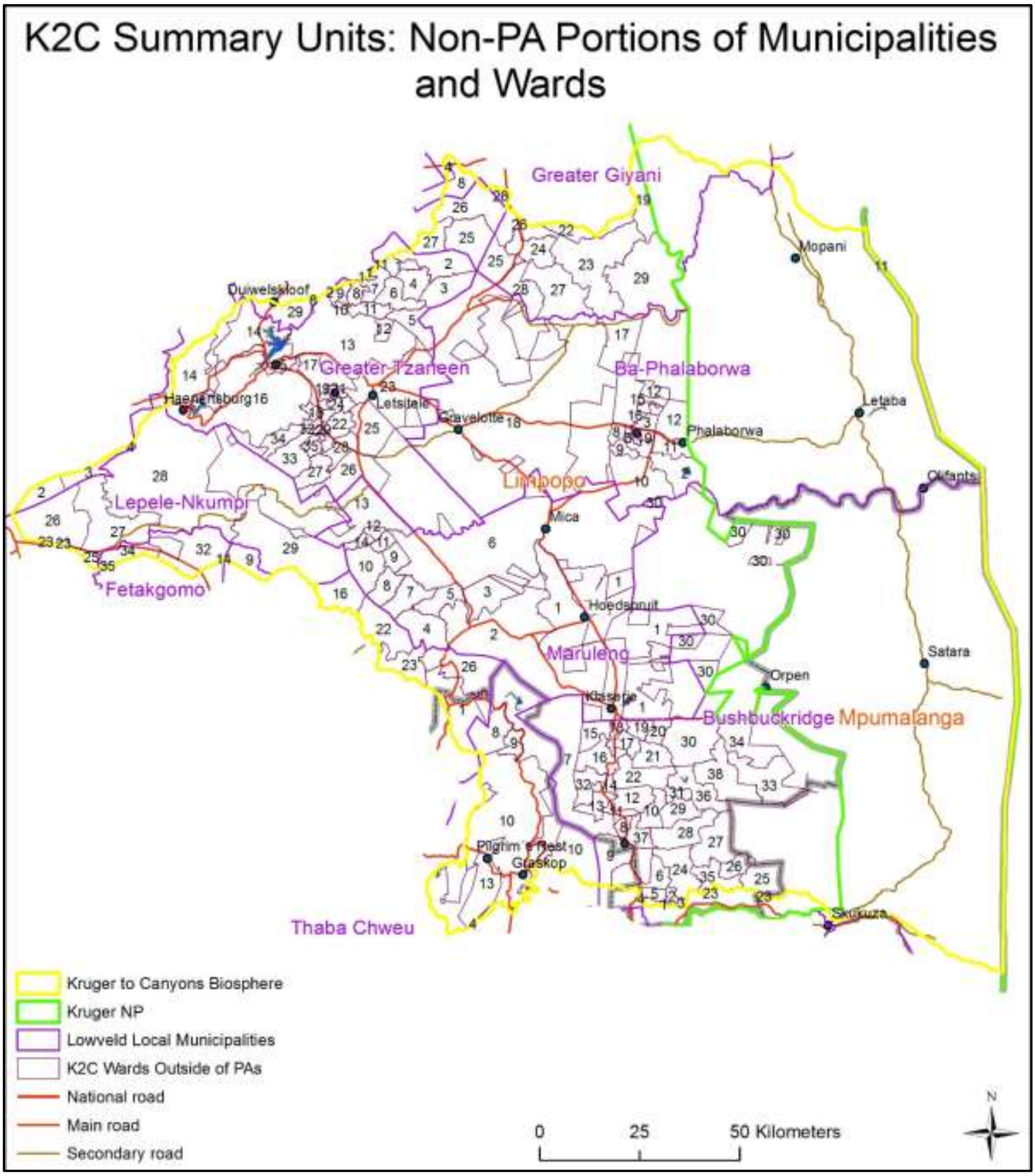

Figure 37: The summary units used were the portions of municipalities and wards that are within the K2C Biosphere that are outside of formally recognized Protected Areas. Note that in many cases this is not the full extent of the municipality or ward as there is only a partial overlap with the biosphere.

Priority municipalities

Maps of the average values of individual summary metrics for municipalities are given in Figure 38 to Figure 41, while the overall value for Ecosystem-based Adaptation is given in Figure 42. The values are summarized in Table 7. The maps and tables highlight to importance of the municipalities which include the escarpment edge. Greater Tubatse and Lepele-Nkumpi are highlighted. The portions of Polokwane that are in the K2C also rank highly. Although it is not a top scoring municipality for any individual metric, Maruleng consistently has moderately high values. Note that municipalities are actually too large a planning unit for this evaluation, and we recommend that the specific wards and Tribal Authority Areas are used.

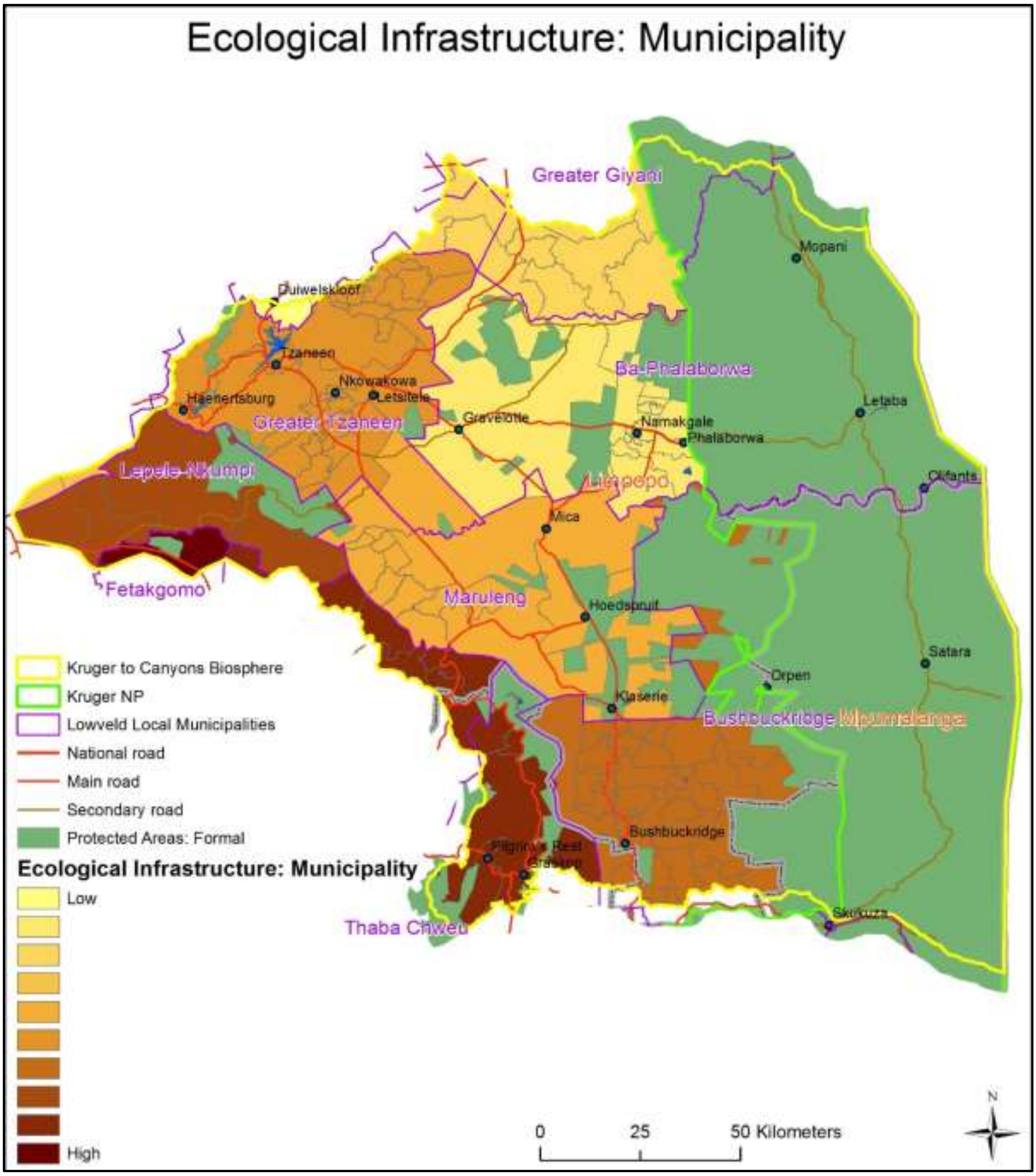

Figure 38: Map showing mean importance for ecological infrastructure for municipalities.

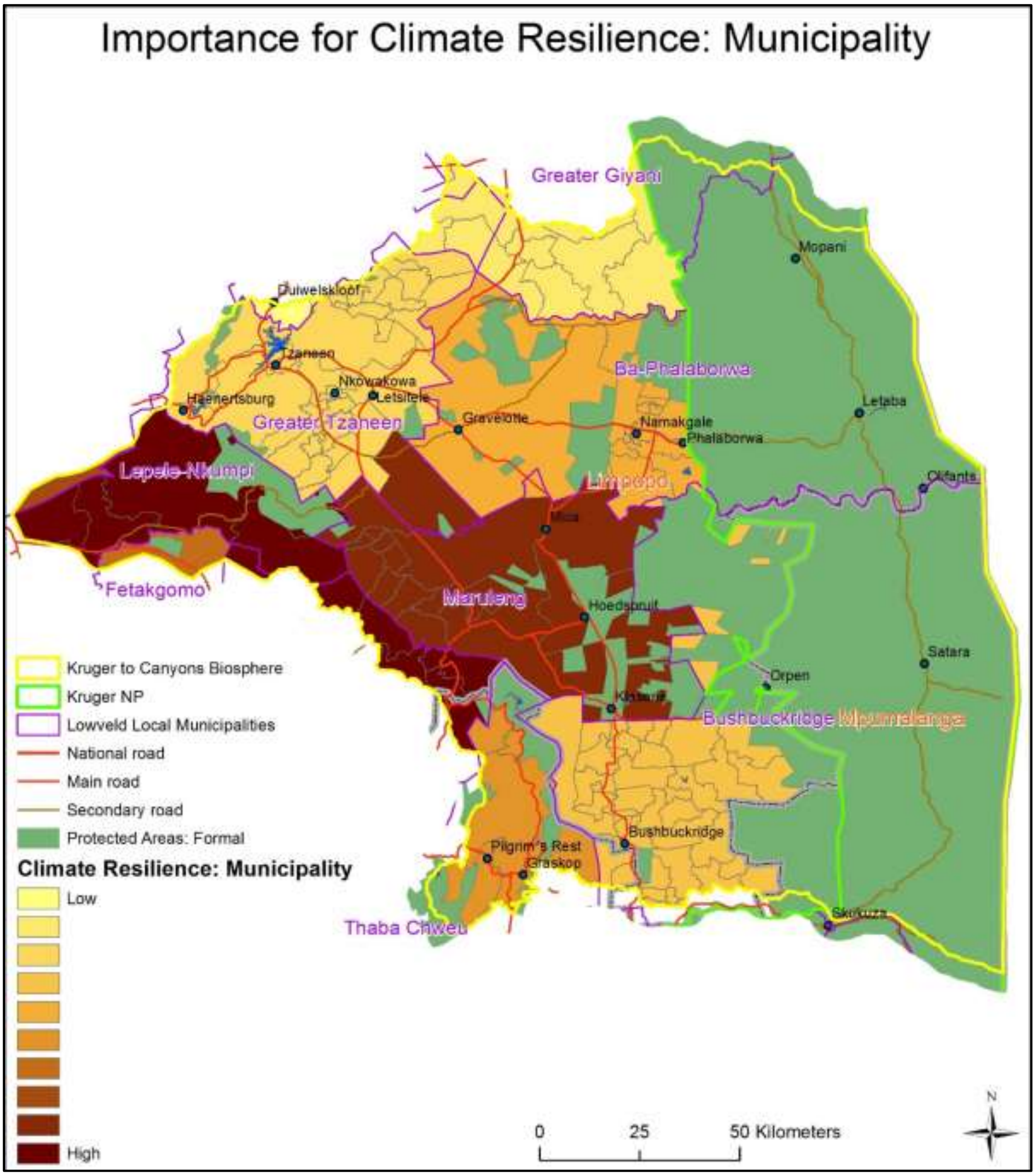

Figure 39: Map showing mean importance for supporting climate change resilience for municipalities.

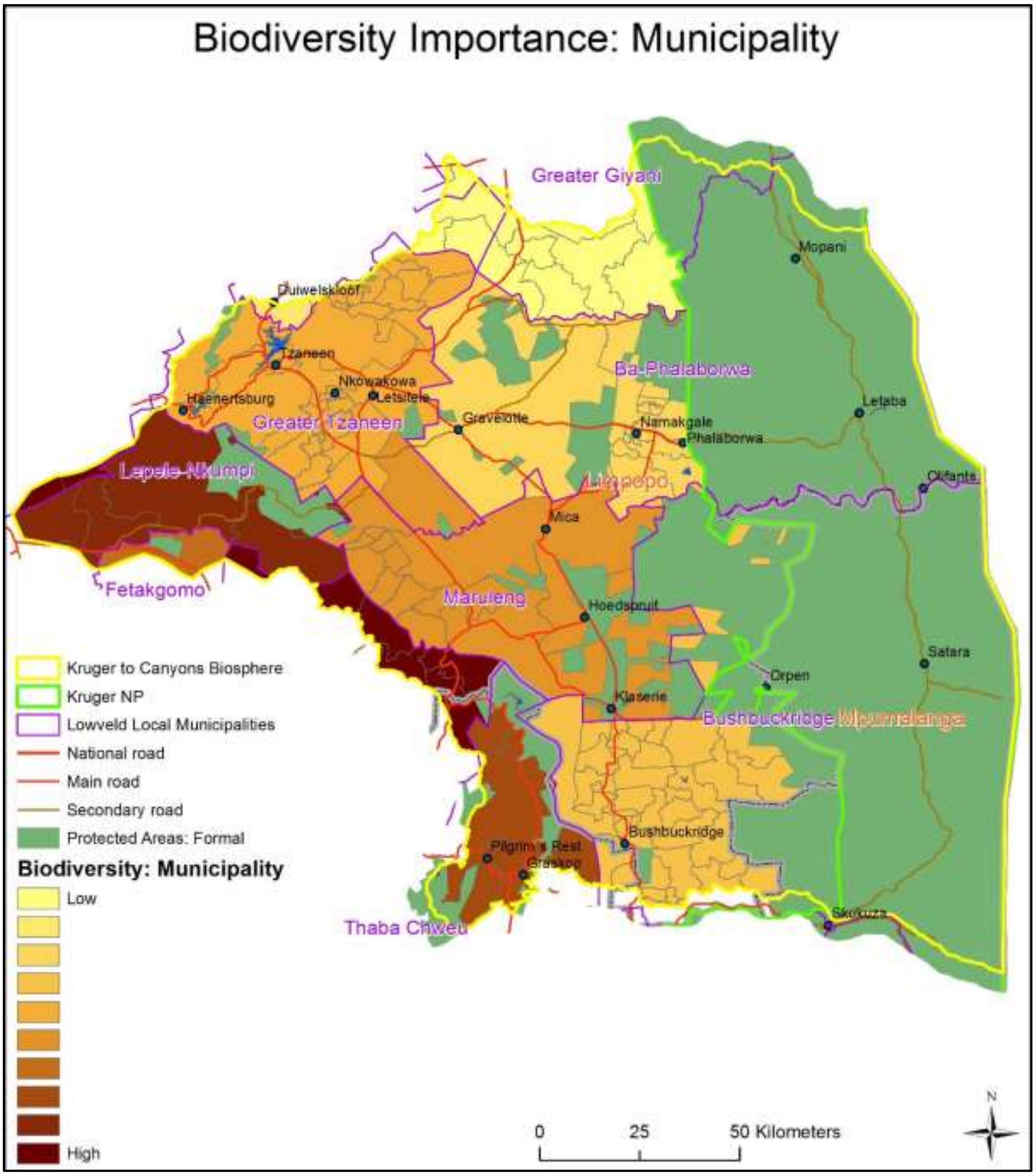

Figure 40: Map showing mean importance for biodiversity for municipalities.

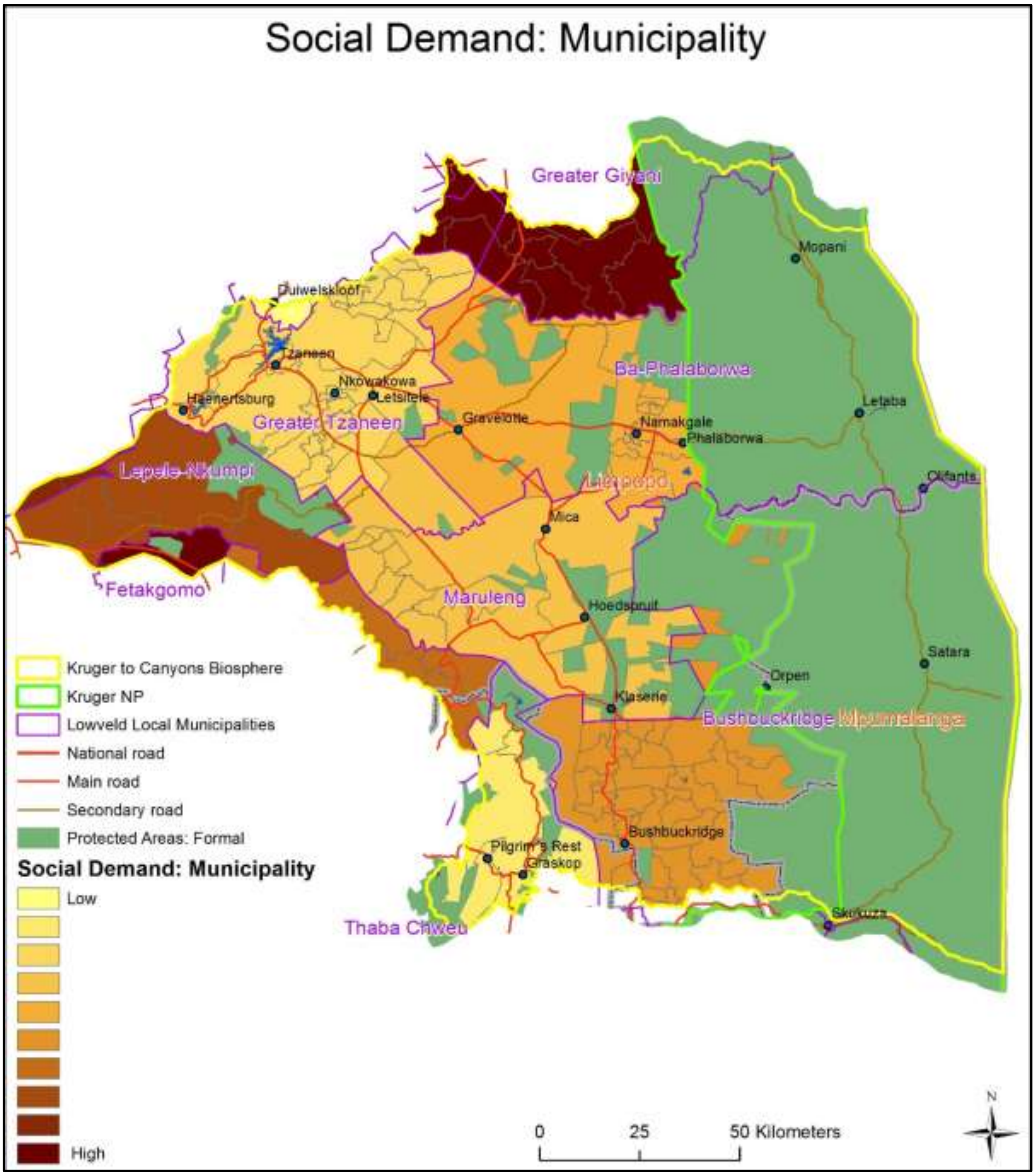

Figure 41: Map showing mean social demand for municipalities.

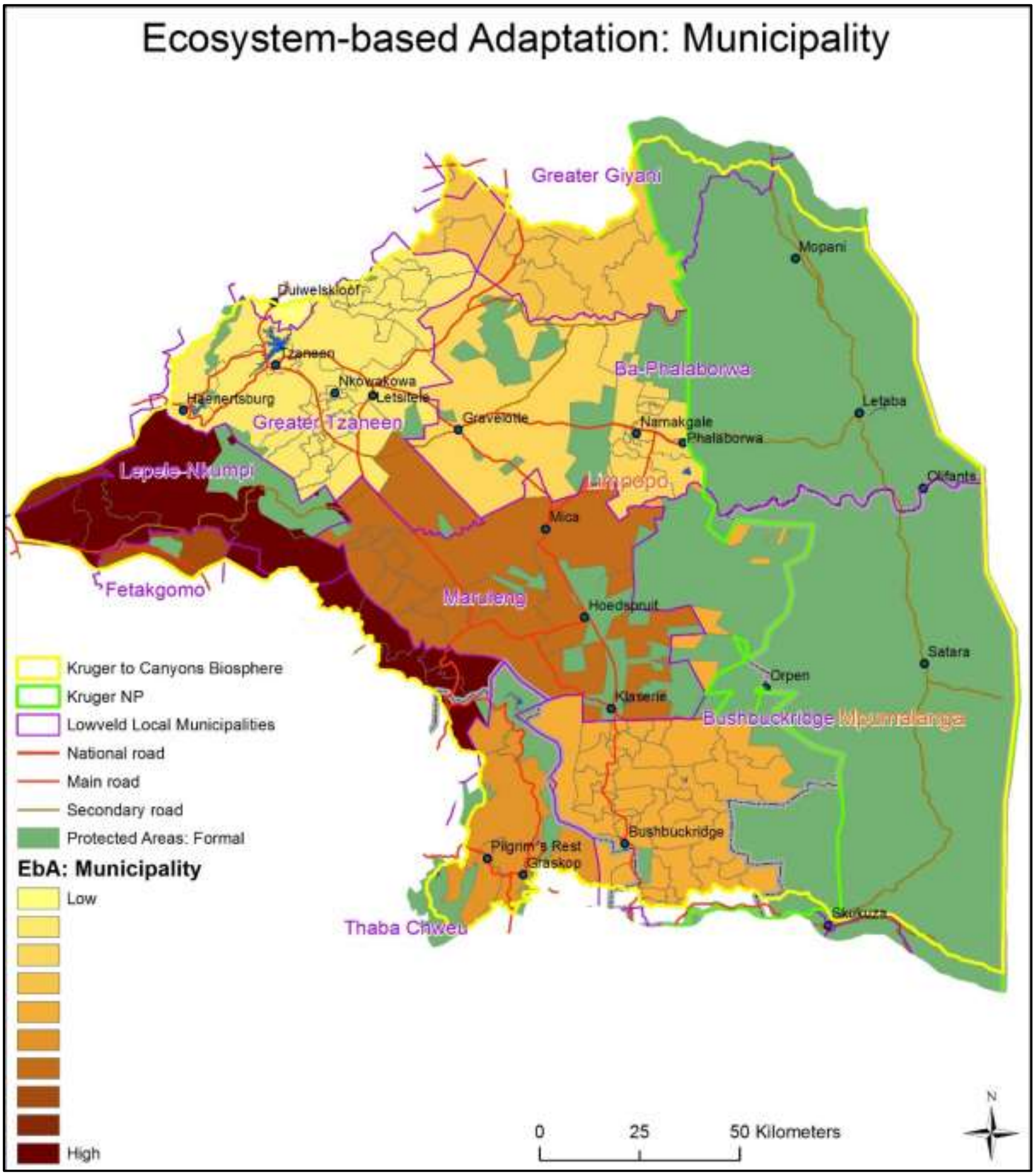

Figure 42: Map showing overall importance for Ecosystem-based Adaptation summarized by municipality.

Table 7: Summary of relative value/importance for Ecosystem-based Adaptation activities of municipalities in the Kruger to Canyons Biosphere. The summary is based on average values across each municipality for each indicator. The value section is indexed against the highest value for a municipality for that metric. The highest value area will have a score of 100, with lower score indicating lower values. In the rank section, we have ranked areas in terms value for that metric. 1 indicates the highest priority area. The indicators relate to the summary values covered in earlier sections of the analysis: Resilience = Areas important for supporting climate resilience; Biodiversity = Biodiversity priorities; Ecological infrastructure = Ecological infrastructure priorities; Social demand = Overall social demand priorities for intact habitats. The Ecosystem-based Adaptation value refers to the overall priority implementation areas for EbA identified in this desktop analysis. This assessment should be subject to field verification and local implementation issues may suggest a different set of priorities. Nevertheless, this assessment does give an overall indication of priority.

	Value					Rank				
Municipality	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation (Overall)	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation (Overall)
Ba-Phalaborwa	19.4	26.6	48.1	69.6	41.0	7	9	10	7	9
Bushbuckridge	16.8	34.9	72.0	80.9	48.0	8	8	5	6	7
Fetakgomo	36.9	51.6	100.0	100.0	69.7	5	5	1	1	4
Greater Giyani	8.4	18.7	59.6	95.8	44.1	10	11	9	2	8
Greater Letaba	1.3	21.0	37.1	18.3	15.7	11	10	11	11	11
Greater Tubatse	100.0	96.8	91.8	87.6	100.0	1	2	2	5	1
Greater Tzaneen	10.5	35.1	65.7	55.9	38.4	9	7	6	9	10
Lepele-Nkumpi	94.5	88.1	74.9	91.2	94.2	2	3	4	4	2
Maruleng	39.9	48.5	64.9	64.7	55.3	3	6	7	8	5
Polokwane	38.8	100.0	59.7	91.5	76.3	4	1	8	3	3
Thaba Chweu	26.8	69.9	85.6	43.2	51.4	6	4	3	10	6

Priority wards

Maps of the average values of individual summary metrics for wards are given in Figure 43 to Figure 46, while the overall value for Ecosystem-based Adaptation is given in Figure 47. The values are summarized in Table 8 (order according to priority for Ecosystem-based Adaptation) and Table 9 (order according to municipal name and ward number). Again, the maps and tables highlight to importance of areas on the escarpment edge. Highest ranked wards tend to be in Greater Tubatse, Lepele-Nkumpi, Maruleng and Polokwane.

If we examine the number of wards which are overall in the top 25: 7 are in Greater Tubatse, 4 are in Lepele-Nkumpi, 3 are in Maruleng and Polokwane, 2 are in Greater Tzaneen and 1 each are in Greater Letaba, Bushbuckridge, Fetakgomo and Thaba Chweu (Table 8).

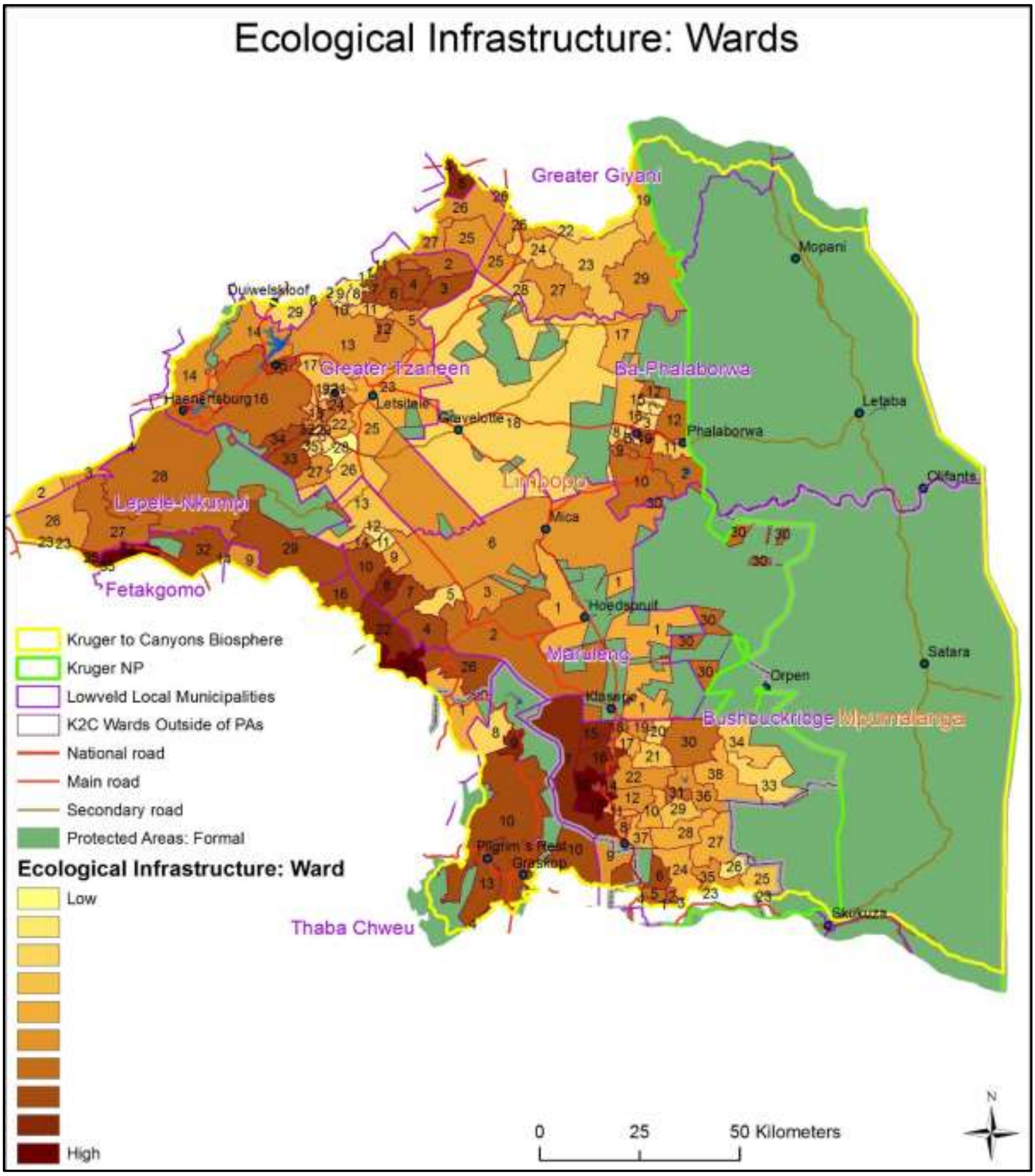

Figure 43: Map showing mean importance for ecological infrastructure summarized by ward.

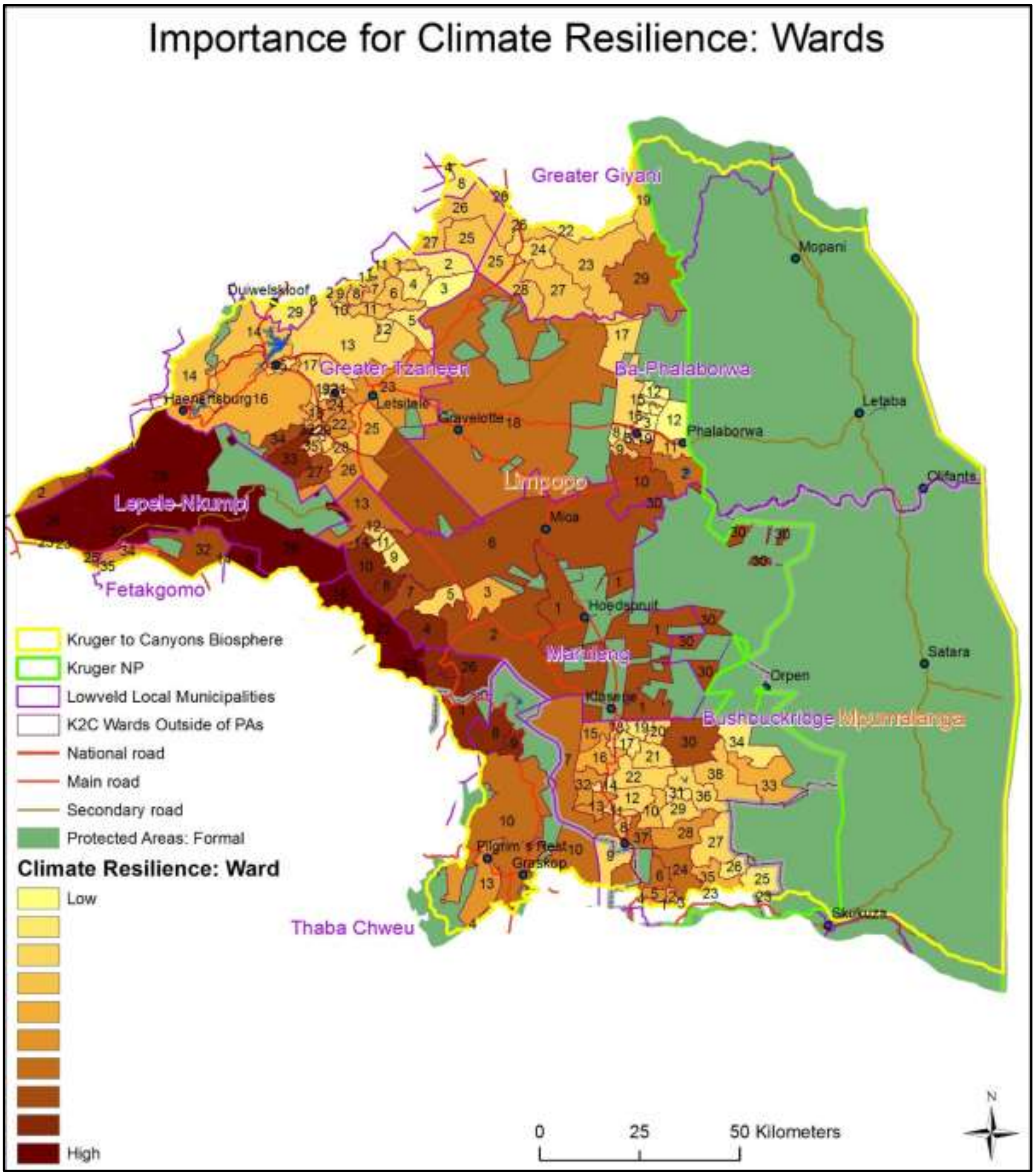

Figure 44: Map showing mean importance for supporting climate change resilience summarized by ward.

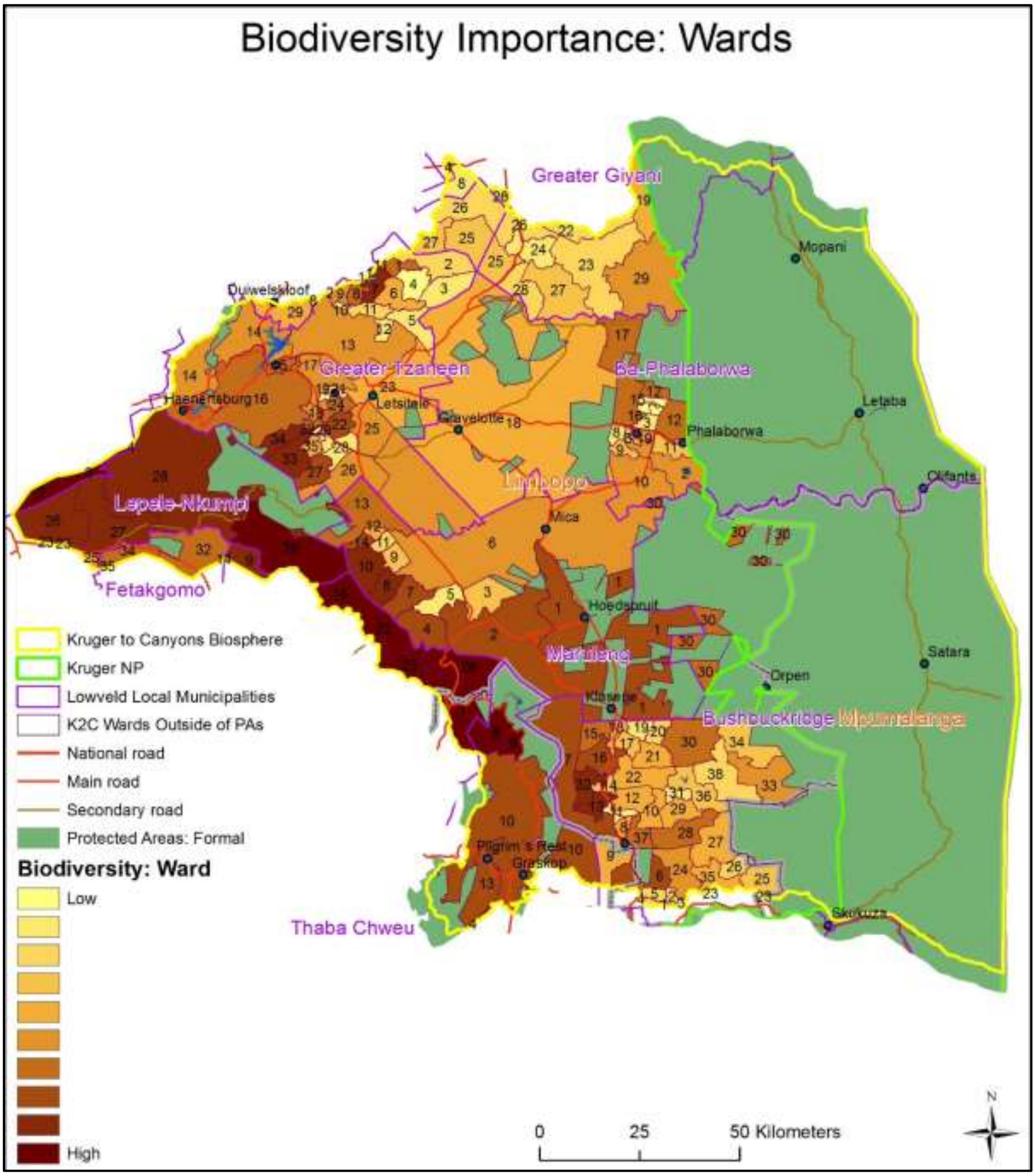

Figure 45: Map showing mean importance for biodiversity for each ward in the Kruger to Canyons Biosphere.

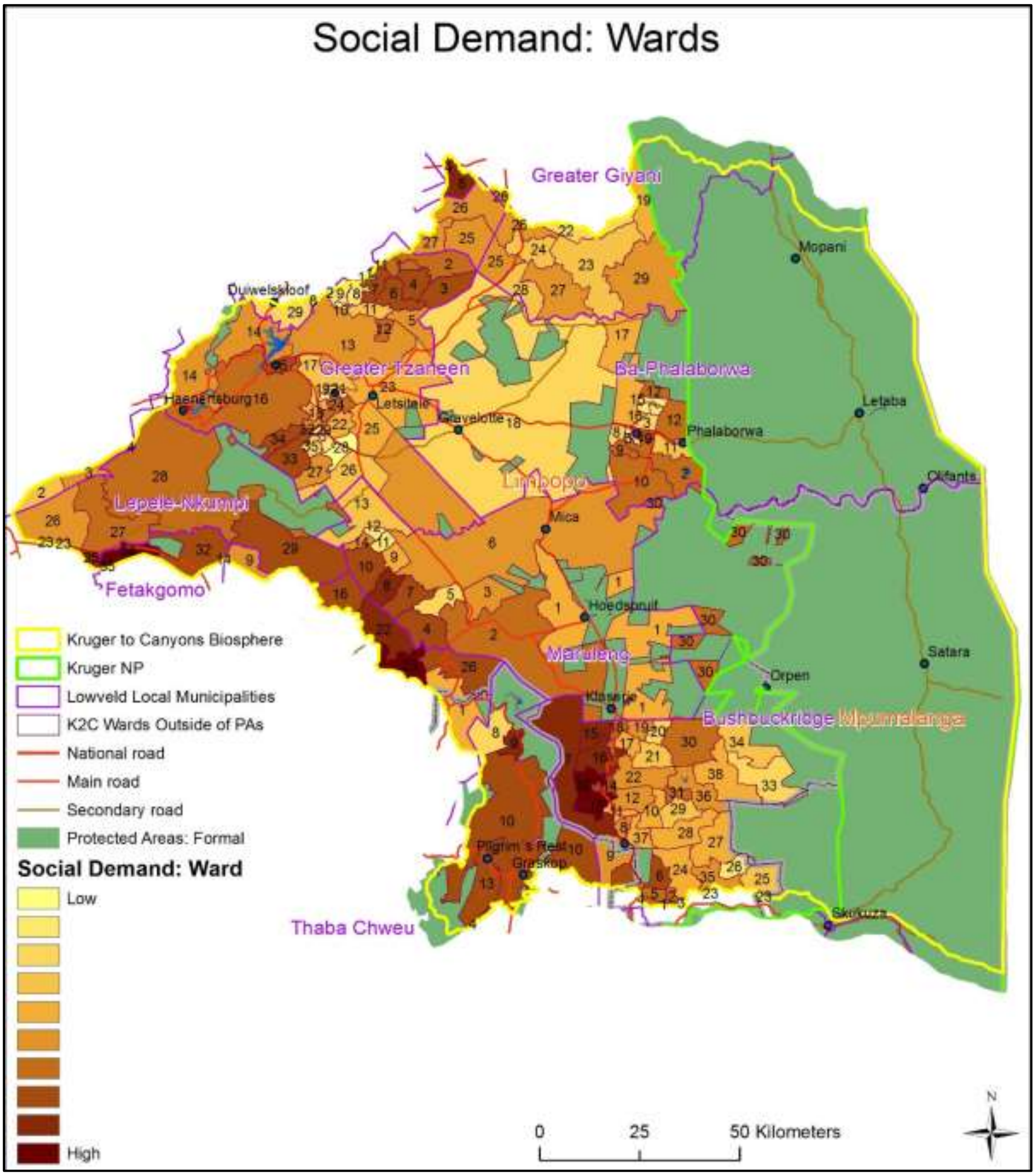

Figure 46: Map showing mean social demand for wards across the Kruger to Canyons Biosphere.

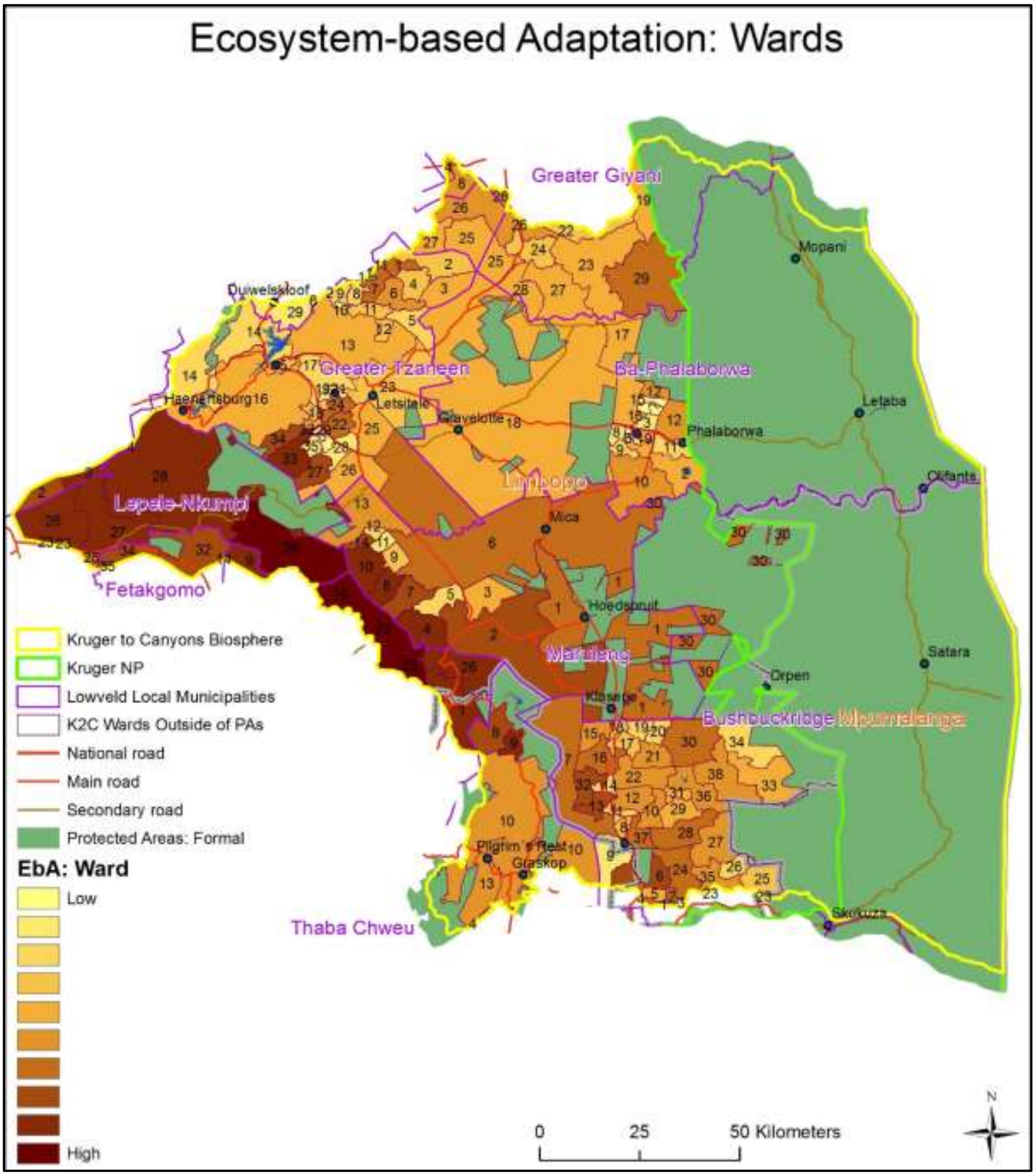

Figure 47: Map showing overall importance for Ecosystem-based Adaptation summarized by ward.

Table 8: Summary of relative value/importance for Ecosystem-based Adaptation activities of wards in the Kruger to Canyons Biosphere. The table is ordered from highest to lowest based on the overall ranking of each ward for Ecosystem-based Adaptation. The summary is based on average values across each ward for each indicator. The value section is indexed against the highest value for a ward for that metric. The highest value area will have a score of 100, with lower score indicating lower values. In the rank section, we have ranked areas in terms value for that metric. 1 indicates the highest priority area. The indicators relate to the summary values covered in earlier sections of the analysis: Resilience = Areas important for supporting climate resilience; Biodiversity = Biodiversity priorities; Ecological infrastructure = Ecological infrastructure priorities; Social demand = Overall social demand priorities for intact habitats. The Ecosystem-based Adaptation value refers to the overall priority implementation areas for EbA identified in this desktop analysis. This assessment should be subject to field verification and local implementation issues may suggest a different set of priorities. Nevertheless, this assessment does give an overall indication of priority.

			Value					Rank				
Municipality	Ward	Area (Ha)	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation
Greater Tubatse	23	7136	94.1	95.9	86.6	86.6	100.0	2	3	5	5	1
Greater Tubatse	22	10857	100.0	91.8	76.3	76.3	99.9	1	6	9	9	2
Greater Tubatse	16	8315	82.6	87.9	66.1	66.1	89.6	3	8	17	17	3
Lepele-Nkumpi	29	28879	73.3	90.7	63.7	63.7	85.7	5	7	22	22	4
Lepele-Nkumpi	26	18074	73.2	76.8	43.5	43.5	80.2	6	16	69	69	5
Lepele-Nkumpi	28	73667	67.1	80.4	46.8	46.8	76.7	8	13	53	53	6
Lepele-Nkumpi	27	19871	70.0	68.2	49.5	49.5	75.9	7	23	42	42	7
Greater Tubatse	9	5098	65.1	68.6	43.1	43.1	75.7	9	20	71	71	8
Greater Tubatse	26	13411	57.8	85.7	64.8	64.8	75.1	10	10	20	20	9
Greater Letaba	6	25	21.3	92.9	79.8	79.8	73.4	33	4	7	7	10
Greater Tzaneen	33	7506	48.1	78.7	62.7	62.7	72.0	13	14	24	24	11
Maruleng	10	8017	53.5	66.4	62.3	62.3	69.7	11	25	25	25	12
Greater Tubatse	1	13860	52.0	87.9	39.0	39.0	68.4	12	9	84	84	13
Maruleng	8	4755	48.0	68.3	72.9	72.9	67.6	14	21	12	12	14
Polokwane	3	4034	34.9	100.0	45.5	45.5	67.5	20	1	57	57	15
Thaba Chweu	9	2788	42.5	98.1	68.1	68.1	66.9	16	2	15	15	16
Greater Tubatse	14	1	81.8	26.6	0.0	0.0	65.7	4	68	151	151	17
Maruleng	4	8843	47.4	63.5	57.9	57.9	64.9	15	26	31	31	18
Polokwane	4	263	17.0	61.6	84.5	84.5	60.8	37	27	6	6	19
Polokwane	2	4881	23.4	83.8	33.4	33.4	60.3	31	12	102	102	20
Greater Tzaneen	34	4005	26.2	75.6	66.0	66.0	60.0	27	17	18	18	21
Bushbuckridge	32	4907	13.3	68.3	91.1	91.1	59.0	43	22	4	4	22
Fetakgomo	32	13904	33.1	47.6	55.5	55.5	58.9	23	40	36	36	23
Thaba Chweu	8	8297	42.4	84.8	27.6	27.6	58.6	17	11	114	114	24
Bushbuckridge	13	3440	9.4	70.8	93.5	93.5	58.5	54	18	3	3	25
Bushbuckridge	6	7223	24.5	55.6	63.1	63.1	56.8	30	33	23	23	26
Fetakgomo	34	5181	11.9	43.5	96.5	96.5	55.7	45	47	2	2	27
Thaba Chweu	4	30	9.2	92.6	56.7	56.7	54.9	55	5	32	32	28
Fetakgomo	35	383	3.3	50.0	100.0	100.0	54.4	90	39	1	1	29
Maruleng	7	6539	31.8	53.9	58.5	58.5	54.2	24	34	30	30	30
Greater Tzaneen	27	4808	35.8	60.4	44.8	44.8	53.5	19	29	60	60	31
Maruleng	14	1656	38.1	58.6	45.9	45.9	52.5	18	32	54	54	32

			Value					Rank				
Municipality	Ward	Area (Ha)	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation ...	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation
Maruleng	2	56914	33.8	61.0	47.4	47.4	52.1	22	28	46	46	33
Bushbuckridge	30	30583	34.1	44.7	48.2	48.2	50.3	21	42	44	44	34
Lepele-Nkumpi	25	1673	19.4	30.7	74.1	74.1	49.9	34	63	10	10	35
Bushbuckridge	28	8763	11.3	39.6	40.4	40.4	49.5	48	50	81	81	36
Greater Tzaneen	7	3611	4.4	69.5	64.4	64.4	49.2	78	19	21	21	37
Bushbuckridge	16	6733	5.8	51.0	74.0	74.0	47.5	64	37	11	11	38
Greater Giyani	29	26912	16.4	34.9	45.5	45.5	46.6	39	56	56	56	39
Bushbuckridge	24	8495	15.6	28.9	38.1	38.1	46.1	42	65	91	91	40
Bushbuckridge	37	3774	15.9	39.7	40.4	40.4	45.6	41	49	82	82	41
Greater Tzaneen	22	3684	11.5	52.5	40.9	40.9	45.5	47	36	79	79	42
Greater Letaba	11	3	0.0	77.9	15.0	15.0	45.0	140	15	138	138	43
Maruleng	1	51250	28.5	50.8	38.9	38.9	44.9	26	38	86	86	44
Bushbuckridge	7	27204	24.7	53.6	76.6	76.6	44.8	29	35	8	8	45
Maruleng	6	130469	28.8	34.8	42.9	42.9	43.8	25	57	72	72	46
Greater Tzaneen	24	2769	10.7	47.3	47.3	47.3	43.1	51	41	47	47	47
Bushbuckridge	2	1734	7.2	10.7	47.1	47.1	42.9	60	114	50	50	48
Greater Tzaneen	1	2658	4.7	38.6	51.4	51.4	42.7	74	51	39	39	49
Greater Letaba	1	8	0.9	67.5	38.5	38.5	42.3	122	24	88	88	50
Bushbuckridge	22	8098	2.7	23.5	44.8	44.8	42.1	97	76	61	61	51
Lepele-Nkumpi	23	497	22.3	24.9	23.9	23.9	41.7	32	73	124	124	52
Thaba Chweu	10	63355	17.6	59.4	60.0	60.0	40.7	36	31	27	27	53
Bushbuckridge	15	4234	11.6	37.8	67.4	67.4	40.6	46	52	16	16	54
Greater Tzaneen	6	5318	4.4	22.6	59.0	59.0	40.6	79	77	29	29	55
Bushbuckridge	35	5329	5.8	19.0	45.5	45.5	39.7	65	87	58	58	56
Bushbuckridge	36	7897	2.3	17.8	45.7	45.7	39.4	103	91	55	55	57
Ba-Phalaborwa	10	16358	26.0	26.8	47.3	47.3	39.4	28	67	48	48	58
Greater Giyani	4	1261	0.5	8.4	70.4	70.4	39.0	133	122	13	13	59
Thaba Chweu	13	15800	11.0	60.4	62.2	62.2	38.6	50	30	26	26	60
Bushbuckridge	12	5352	3.0	18.9	44.7	44.7	38.3	92	88	62	62	61
Bushbuckridge	21	5122	2.8	20.9	34.8	34.8	38.1	96	82	99	99	62
Greater Giyani	8	4130	0.7	6.8	70.4	70.4	38.0	131	126	14	14	63
Greater Letaba	2	106	11.1	44.0	24.8	24.8	37.9	49	45	122	122	64
Ba-Phalaborwa	12	9017	0.4	44.7	48.1	48.1	37.4	136	43	45	45	65
Bushbuckridge	23	182	12.3	25.5	32.4	32.4	37.2	44	72	104	104	66
Bushbuckridge	10	4156	4.9	20.4	38.9	38.9	37.1	71	84	85	85	67
Bushbuckridge	27	10084	2.8	22.1	36.1	36.1	37.1	93	79	95	95	68
Bushbuckridge	38	12320	5.2	11.6	38.3	38.3	36.8	69	108	89	89	69
Maruleng	13	16291	17.6	36.1	32.8	32.8	36.5	35	55	103	103	70
Greater Giyani	26	11375	4.7	10.8	44.0	44.0	36.5	75	112	64	64	71
Greater Giyani	26	7494	4.7	10.8	44.0	44.0	36.5	75	112	64	64	71

			Value					Rank				
Municipality	Ward	Area (Ha)	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation ...	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation
Bushbuckridge	5	1766	10.3	10.7	47.2	47.2	35.9	52	115	49	49	73
Greater Tzaneen	25	9764	7.3	30.7	37.8	37.8	35.8	59	62	92	92	74
Greater Giyani	21	70	0.0	6.7	25.1	25.1	35.8	140	128	119	119	75
Bushbuckridge	29	5008	3.3	20.0	35.0	35.0	35.6	89	85	98	98	76
Ba-Phalaborwa	17	19372	2.1	36.2	36.4	36.4	35.4	104	54	94	94	77
Greater Tzaneen	26	12315	10.1	30.5	33.5	33.5	35.3	53	64	101	101	78
Greater Giyani	27	4824	4.1	14.2	41.3	41.3	35.2	81	98	77	77	79
Greater Giyani	27	14787	4.1	14.2	41.3	41.3	35.2	81	98	77	77	79
Ba-Phalaborwa	2	10425	16.8	32.4	46.8	46.8	35.1	38	59	52	52	81
Greater Giyani	23	25820	3.8	12.3	31.4	31.4	34.9	85	106	106	106	82
Ba-Phalaborwa	18	167349	16.0	21.8	29.0	29.0	34.6	40	80	111	111	83
Greater Giyani	25	10046	3.7	13.0	43.5	43.5	34.5	87	103	67	67	84
Greater Giyani	25	6697	3.7	13.0	43.5	43.5	34.5	87	103	67	67	84
Ba-Phalaborwa	19	1281	0.5	31.4	56.2	56.2	34.3	134	61	33	33	86
Bushbuckridge	31	1855	1.8	7.4	52.4	52.4	34.1	108	125	37	37	87
Greater Giyani	28	7593	4.8	11.5	31.2	31.2	33.3	73	109	107	107	88
Maruleng	3	8189	6.2	14.2	43.1	43.1	33.1	62	100	70	70	89
Greater Giyani	19	7811	4.2	23.7	38.2	38.2	32.7	80	75	90	90	90
Bushbuckridge	33	12632	8.5	26.2	28.1	28.1	32.2	57	70	113	113	91
Greater Tzaneen	32	1000	6.0	43.7	41.4	41.4	31.8	63	46	74	74	92
Greater Tzaneen	13	35195	2.7	28.5	41.4	41.4	31.6	99	66	75	75	93
Greater Tzaneen	16	45942	7.6	44.4	51.6	51.6	31.5	58	44	38	38	94
Greater Tzaneen	3	7159	0.0	4.3	65.1	65.1	31.4	140	138	19	19	95
Greater Giyani	22	5521	1.3	11.4	24.2	24.2	30.7	114	110	123	123	96
Greater Tzaneen	23	28726	9.2	20.6	40.5	40.5	30.5	56	83	80	80	97
Greater Tzaneen	15	2408	1.3	41.3	55.6	55.6	29.4	113	48	35	35	98
Bushbuckridge	17	2685	0.9	15.4	37.4	37.4	29.2	123	96	93	93	99
Maruleng	9	3197	1.4	16.8	39.2	39.2	28.6	112	94	83	83	100
Greater Tzaneen	11	3266	5.3	9.3	29.4	29.4	27.8	68	117	110	110	101
Bushbuckridge	25	6826	1.2	14.2	34.6	34.6	27.8	117	97	100	100	102
Bushbuckridge	18	2170	2.8	22.5	48.6	48.6	27.7	95	78	43	43	103
Greater Tzaneen	18	2001	6.4	26.4	38.5	38.5	27.1	61	69	87	87	104
Greater Giyani	24	7093	2.8	8.1	30.3	30.3	27.1	94	123	108	108	105
Greater Tzaneen	2	8536	0.8	8.8	49.7	49.7	27.0	124	120	41	41	106
Bushbuckridge	8	1544	3.7	21.1	43.9	43.9	26.8	86	81	66	66	107
Greater Tzaneen	4	4796	0.7	3.3	59.6	59.6	26.4	128	141	28	28	108
Greater Tzaneen	12	1964	1.2	6.3	50.2	50.2	25.8	118	131	40	40	109
Bushbuckridge	14	1583	1.7	17.1	56.1	56.1	25.2	110	92	34	34	110
Bushbuckridge	34	9692	1.2	15.4	31.6	31.6	25.0	116	95	105	105	111
Ba-Phalaborwa	11	4470	3.8	16.9	30.1	30.1	24.6	84	93	109	109	112

			Value					Rank				
Municipality	Ward	Area (Ha)	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation ...	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation
Ba-Phalaborwa	9	1870	5.4	13.6	46.9	46.9	24.5	67	102	51	51	113
Greater Tzaneen	5	5987	0.8	5.8	41.5	41.5	24.3	125	132	73	73	114
Greater Tzaneen	8	2018	5.6	37.1	15.2	15.2	24.3	66	53	135	135	115
Greater Tzaneen	17	8162	3.2	26.1	35.3	35.3	24.1	91	71	97	97	116
Greater Tzaneen	9	1954	4.9	33.2	17.5	17.5	23.0	70	58	131	131	117
Maruleng	5	5298	2.4	6.7	24.9	24.9	22.6	101	129	121	121	118
Greater Tzaneen	14	30918	4.7	32.2	41.4	41.4	22.1	77	60	76	76	119
Bushbuckridge	20	2567	2.1	11.0	21.7	21.7	22.1	105	111	126	126	120
Bushbuckridge	26	3120	0.7	9.1	20.1	20.1	21.1	132	118	128	128	121
Bushbuckridge	19	2635	1.2	4.3	45.2	45.2	20.6	115	137	59	59	122
Maruleng	12	1206	2.6	24.1	17.7	17.7	20.1	100	74	130	130	123
Bushbuckridge	11	1777	2.7	3.9	36.0	36.0	19.6	98	139	96	96	124
Maruleng	11	1939	1.6	10.6	18.6	18.6	18.7	111	116	129	129	125
Bushbuckridge	9	7959	1.9	19.5	44.5	44.5	18.5	107	86	63	63	126
Greater Tzaneen	28	4087	4.8	6.8	10.2	10.2	18.5	72	127	146	146	127
Greater Tzaneen	35	1800	4.1	18.9	26.9	26.9	18.3	83	89	117	117	128
Greater Tzaneen	21	671	2.4	11.7	28.4	28.4	17.1	102	107	112	112	129
Ba-Phalaborwa	8	1684	1.0	5.2	26.9	26.9	15.1	120	134	116	116	130
Ba-Phalaborwa	3	1731	0.0	5.4	25.1	25.1	14.0	140	133	120	120	131
Greater Tzaneen	30	340	0.8	6.6	26.9	26.9	13.1	127	130	115	115	132
Ba-Phalaborwa	6	348	0.0	8.9	23.4	23.4	13.0	140	119	125	125	133
Greater Letaba	29	7496	0.8	18.7	25.2	25.2	12.7	126	90	118	118	134
Ba-Phalaborwa	7	330	0.0	13.8	15.9	15.9	10.9	140	101	134	134	135
Greater Tzaneen	29	1082	1.9	7.9	11.0	11.0	10.5	106	124	145	145	136
Ba-Phalaborwa	1	275	1.1	12.9	15.1	15.1	10.0	119	105	137	137	137
Greater Tzaneen	19	523	1.8	3.6	12.1	12.1	9.0	109	140	143	143	138
Ba-Phalaborwa	13	649	0.0	3.2	17.4	17.4	7.9	140	142	132	132	139
Greater Letaba	8	325	0.7	8.6	14.3	14.3	7.3	130	121	139	139	140
Bushbuckridge	4	174	1.0	4.6	20.2	20.2	7.1	121	136	127	127	141
Bushbuckridge	1	113	0.7	1.1	17.1	17.1	6.5	129	148	133	133	142
Bushbuckridge	3	463	0.4	2.0	15.2	15.2	6.5	135	146	136	136	143
Greater Tzaneen	20	465	0.0	2.0	13.0	13.0	6.4	139	144	140	140	144
Ba-Phalaborwa	15	1198	0.0	2.6	12.4	12.4	6.0	140	143	142	142	145
Ba-Phalaborwa	4	118	0.0	4.8	5.0	5.0	5.4	140	135	149	149	146
Ba-Phalaborwa	16	774	0.0	1.4	12.0	12.0	4.3	140	147	144	144	147
Greater Tzaneen	10	471	0.2	1.0	7.0	7.0	3.5	138	149	148	148	148
Ba-Phalaborwa	14	137	0.0	0.9	12.9	12.9	3.2	140	150	141	141	149
Ba-Phalaborwa	5	175	0.0	0.8	4.7	4.7	2.1	140	151	150	150	150
Greater Tzaneen	31	319	0.2	2.0	8.6	8.6	1.9	137	145	147	147	151

Table 9: Summary of relative value/importance for Ecosystem-based Adaptation activities of wards in the Kruger to Canyons Biosphere. The table is in alphabetical and numerical order based on municipality name and ward numbers. The summary is based on average values across each ward for each indicator. The value section is indexed against the highest value for a ward for that metric. The highest value area will have a score of 100, with lower score indicating lower values. In the rank section, we have ranked areas in terms value for that metric. 1 indicates the highest priority area. The indicators relate to the summary values covered in earlier sections of the analysis: Resilience = Areas important for supporting climate resilience; Biodiversity = Biodiversity priorities; Ecological infrastructure = Ecological infrastructure priorities; Social demand = Overall social demand priorities for intact habitats. The Ecosystem-based Adaptation value refers to the overall priority implementation areas for EbA identified in this desktop analysis. This assessment should be subject to field verification and local implementation issues may suggest a different set of priorities. Nevertheless, this assessment does give an overall indication of priority.

			Value					Rank				
Municipality	Ward	Area (Ha)	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation (Overall)	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation (Overall)
Ba-Phalaborwa	1	275	1.1	12.9	15.1	15.1	10.0	119	105	137	137	137
Ba-Phalaborwa	2	10425	16.8	32.4	46.8	46.8	35.1	38	59	52	52	81
Ba-Phalaborwa	3	1731	0.0	5.4	25.1	25.1	14.0	140	133	120	120	131
Ba-Phalaborwa	4	118	0.0	4.8	5.0	5.0	5.4	140	135	149	149	146
Ba-Phalaborwa	5	175	0.0	0.8	4.7	4.7	2.1	140	151	150	150	150
Ba-Phalaborwa	6	348	0.0	8.9	23.4	23.4	13.0	140	119	125	125	133
Ba-Phalaborwa	7	330	0.0	13.8	15.9	15.9	10.9	140	101	134	134	135
Ba-Phalaborwa	8	1684	1.0	5.2	26.9	26.9	15.1	120	134	116	116	130
Ba-Phalaborwa	9	1870	5.4	13.6	46.9	46.9	24.5	67	102	51	51	113
Ba-Phalaborwa	10	16358	26.0	26.8	47.3	47.3	39.4	28	67	48	48	58
Ba-Phalaborwa	11	4470	3.8	16.9	30.1	30.1	24.6	84	93	109	109	112
Ba-Phalaborwa	12	9017	0.4	44.7	48.1	48.1	37.4	136	43	45	45	65
Ba-Phalaborwa	13	649	0.0	3.2	17.4	17.4	7.9	140	142	132	132	139
Ba-Phalaborwa	14	137	0.0	0.9	12.9	12.9	3.2	140	150	141	141	149
Ba-Phalaborwa	15	1198	0.0	2.6	12.4	12.4	6.0	140	143	142	142	145
Ba-Phalaborwa	16	774	0.0	1.4	12.0	12.0	4.3	140	147	144	144	147
Ba-Phalaborwa	17	19372	2.1	36.2	36.4	36.4	35.4	104	54	94	94	77
Ba-Phalaborwa	18	167349	16.0	21.8	29.0	29.0	34.6	40	80	111	111	83
Ba-Phalaborwa	19	1281	0.5	31.4	56.2	56.2	34.3	134	61	33	33	86
Bushbuckridge	1	113	0.7	1.1	17.1	17.1	6.5	129	148	133	133	142
Bushbuckridge	2	1734	7.2	10.7	47.1	47.1	42.9	60	114	50	50	48
Bushbuckridge	3	463	0.4	2.0	15.2	15.2	6.5	135	146	136	136	143
Bushbuckridge	4	174	1.0	4.6	20.2	20.2	7.1	121	136	127	127	141
Bushbuckridge	5	1766	10.3	10.7	47.2	47.2	35.9	52	115	49	49	73
Bushbuckridge	6	7223	24.5	55.6	63.1	63.1	56.8	30	33	23	23	26
Bushbuckridge	7	27204	24.7	53.6	76.6	76.6	44.8	29	35	8	8	45
Bushbuckridge	8	1544	3.7	21.1	43.9	43.9	26.8	86	81	66	66	107
Bushbuckridge	9	7959	1.9	19.5	44.5	44.5	18.5	107	86	63	63	126
Bushbuckridge	10	4156	4.9	20.4	38.9	38.9	37.1	71	84	85	85	67
Bushbuckridge	11	1777	2.7	3.9	36.0	36.0	19.6	98	139	96	96	124
Bushbuckridge	12	5352	3.0	18.9	44.7	44.7	38.3	92	88	62	62	61
Bushbuckridge	13	3440	9.4	70.8	93.5	93.5	58.5	54	18	3	3	25

			Value					Rank				
Municipality	Ward	Area (Ha)	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation (Overall)	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation (Overall)
Bushbuckridge	14	1583	1.7	17.1	56.1	56.1	25.2	110	92	34	34	110
Bushbuckridge	15	4234	11.6	37.8	67.4	67.4	40.6	46	52	16	16	54
Bushbuckridge	16	6733	5.8	51.0	74.0	74.0	47.5	64	37	11	11	38
Bushbuckridge	17	2685	0.9	15.4	37.4	37.4	29.2	123	96	93	93	99
Bushbuckridge	18	2170	2.8	22.5	48.6	48.6	27.7	95	78	43	43	103
Bushbuckridge	19	2635	1.2	4.3	45.2	45.2	20.6	115	137	59	59	122
Bushbuckridge	20	2567	2.1	11.0	21.7	21.7	22.1	105	111	126	126	120
Bushbuckridge	21	5122	2.8	20.9	34.8	34.8	38.1	96	82	99	99	62
Bushbuckridge	22	8098	2.7	23.5	44.8	44.8	42.1	97	76	61	61	51
Bushbuckridge	23	182	12.3	25.5	32.4	32.4	37.2	44	72	104	104	66
Bushbuckridge	24	8495	15.6	28.9	38.1	38.1	46.1	42	65	91	91	40
Bushbuckridge	25	6826	1.2	14.2	34.6	34.6	27.8	117	97	100	100	102
Bushbuckridge	26	3120	0.7	9.1	20.1	20.1	21.1	132	118	128	128	121
Bushbuckridge	27	10084	2.8	22.1	36.1	36.1	37.1	93	79	95	95	68
Bushbuckridge	28	8763	11.3	39.6	40.4	40.4	49.5	48	50	81	81	36
Bushbuckridge	29	5008	3.3	20.0	35.0	35.0	35.6	89	85	98	98	76
Bushbuckridge	30	30583	34.1	44.7	48.2	48.2	50.3	21	42	44	44	34
Bushbuckridge	31	1855	1.8	7.4	52.4	52.4	34.1	108	125	37	37	87
Bushbuckridge	32	4907	13.3	68.3	91.1	91.1	59.0	43	22	4	4	22
Bushbuckridge	33	12632	8.5	26.2	28.1	28.1	32.2	57	70	113	113	91
Bushbuckridge	34	9692	1.2	15.4	31.6	31.6	25.0	116	95	105	105	111
Bushbuckridge	35	5329	5.8	19.0	45.5	45.5	39.7	65	87	58	58	56
Bushbuckridge	36	7897	2.3	17.8	45.7	45.7	39.4	103	91	55	55	57
Bushbuckridge	37	3774	15.9	39.7	40.4	40.4	45.6	41	49	82	82	41
Bushbuckridge	38	12320	5.2	11.6	38.3	38.3	36.8	69	108	89	89	69
Fetakgomo	32	13904	33.1	47.6	55.5	55.5	58.9	23	40	36	36	23
Fetakgomo	34	5181	11.9	43.5	96.5	96.5	55.7	45	47	2	2	27
Fetakgomo	35	383	3.3	50.0	100.0	100.0	54.4	90	39	1	1	29
Greater Giyani	4	1261	0.5	8.4	70.4	70.4	39.0	133	122	13	13	59
Greater Giyani	8	4130	0.7	6.8	70.4	70.4	38.0	131	126	14	14	63
Greater Giyani	19	7811	4.2	23.7	38.2	38.2	32.7	80	75	90	90	90
Greater Giyani	21	70	0.0	6.7	25.1	25.1	35.8	140	128	119	119	75
Greater Giyani	22	5521	1.3	11.4	24.2	24.2	30.7	114	110	123	123	96
Greater Giyani	23	25820	3.8	12.3	31.4	31.4	34.9	85	106	106	106	82
Greater Giyani	24	7093	2.8	8.1	30.3	30.3	27.1	94	123	108	108	105
Greater Giyani	25	10046	3.7	13.0	43.5	43.5	34.5	87	103	67	67	84
Greater Giyani	25	6697	3.7	13.0	43.5	43.5	34.5	87	103	67	67	84
Greater Giyani	26	11375	4.7	10.8	44.0	44.0	36.5	75	112	64	64	71
Greater Giyani	26	7494	4.7	10.8	44.0	44.0	36.5	75	112	64	64	71
Greater Giyani	27	4824	4.1	14.2	41.3	41.3	35.2	81	98	77	77	79

			Value					Rank				
Municipality	Ward	Area (Ha)	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation (Overall)	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation (Overall)
Greater Giyani	27	14787	4.1	14.2	41.3	41.3	35.2	81	98	77	77	79
Greater Giyani	28	7593	4.8	11.5	31.2	31.2	33.3	73	109	107	107	88
Greater Giyani	29	26912	16.4	34.9	45.5	45.5	46.6	39	56	56	56	39
Greater Letaba	1	8	0.9	67.5	38.5	38.5	42.3	122	24	88	88	50
Greater Letaba	2	106	11.1	44.0	24.8	24.8	37.9	49	45	122	122	64
Greater Letaba	6	25	21.3	92.9	79.8	79.8	73.4	33	4	7	7	10
Greater Letaba	8	325	0.7	8.6	14.3	14.3	7.3	130	121	139	139	140
Greater Letaba	11	3	0.0	77.9	15.0	15.0	45.0	140	15	138	138	43
Greater Letaba	29	7496	0.8	18.7	25.2	25.2	12.7	126	90	118	118	134
Greater Tubatse	1	13860	52.0	87.9	39.0	39.0	68.4	12	9	84	84	13
Greater Tubatse	9	5098	65.1	68.6	43.1	43.1	75.7	9	20	71	71	8
Greater Tubatse	14	1	81.8	26.6	0.0	0.0	65.7	4	68	151	151	17
Greater Tubatse	16	8315	82.6	87.9	66.1	66.1	89.6	3	8	17	17	3
Greater Tubatse	22	10857	100.0	91.8	76.3	76.3	99.9	1	6	9	9	2
Greater Tubatse	23	7136	94.1	95.9	86.6	86.6	100.0	2	3	5	5	1
Greater Tubatse	26	13411	57.8	85.7	64.8	64.8	75.1	10	10	20	20	9
Greater Tzaneen	1	2658	4.7	38.6	51.4	51.4	42.7	74	51	39	39	49
Greater Tzaneen	2	8536	0.8	8.8	49.7	49.7	27.0	124	120	41	41	106
Greater Tzaneen	3	7159	0.0	4.3	65.1	65.1	31.4	140	138	19	19	95
Greater Tzaneen	4	4796	0.7	3.3	59.6	59.6	26.4	128	141	28	28	108
Greater Tzaneen	5	5987	0.8	5.8	41.5	41.5	24.3	125	132	73	73	114
Greater Tzaneen	6	5318	4.4	22.6	59.0	59.0	40.6	79	77	29	29	55
Greater Tzaneen	7	3611	4.4	69.5	64.4	64.4	49.2	78	19	21	21	37
Greater Tzaneen	8	2018	5.6	37.1	15.2	15.2	24.3	66	53	135	135	115
Greater Tzaneen	9	1954	4.9	33.2	17.5	17.5	23.0	70	58	131	131	117
Greater Tzaneen	10	471	0.2	1.0	7.0	7.0	3.5	138	149	148	148	148
Greater Tzaneen	11	3266	5.3	9.3	29.4	29.4	27.8	68	117	110	110	101
Greater Tzaneen	12	1964	1.2	6.3	50.2	50.2	25.8	118	131	40	40	109
Greater Tzaneen	13	35195	2.7	28.5	41.4	41.4	31.6	99	66	75	75	93
Greater Tzaneen	14	30918	4.7	32.2	41.4	41.4	22.1	77	60	76	76	119
Greater Tzaneen	15	2408	1.3	41.3	55.6	55.6	29.4	113	48	35	35	98
Greater Tzaneen	16	45942	7.6	44.4	51.6	51.6	31.5	58	44	38	38	94
Greater Tzaneen	17	8162	3.2	26.1	35.3	35.3	24.1	91	71	97	97	116
Greater Tzaneen	18	2001	6.4	26.4	38.5	38.5	27.1	61	69	87	87	104
Greater Tzaneen	19	523	1.8	3.6	12.1	12.1	9.0	109	140	143	143	138
Greater Tzaneen	20	465	0.0	2.0	13.0	13.0	6.4	139	144	140	140	144
Greater Tzaneen	21	671	2.4	11.7	28.4	28.4	17.1	102	107	112	112	129
Greater Tzaneen	22	3684	11.5	52.5	40.9	40.9	45.5	47	36	79	79	42
Greater Tzaneen	23	28726	9.2	20.6	40.5	40.5	30.5	56	83	80	80	97
Greater Tzaneen	24	2769	10.7	47.3	47.3	47.3	43.1	51	41	47	47	47

			Value					Rank				
Municipality	Ward	Area (Ha)	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation (Overall)	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Ecosystem-based Adaptation (Overall)
Greater Tzaneen	25	9764	7.3	30.7	37.8	37.8	35.8	59	62	92	92	74
Greater Tzaneen	26	12315	10.1	30.5	33.5	33.5	35.3	53	64	101	101	78
Greater Tzaneen	27	4808	35.8	60.4	44.8	44.8	53.5	19	29	60	60	31
Greater Tzaneen	28	4087	4.8	6.8	10.2	10.2	18.5	72	127	146	146	127
Greater Tzaneen	29	1082	1.9	7.9	11.0	11.0	10.5	106	124	145	145	136
Greater Tzaneen	30	340	0.8	6.6	26.9	26.9	13.1	127	130	115	115	132
Greater Tzaneen	31	319	0.2	2.0	8.6	8.6	1.9	137	145	147	147	151
Greater Tzaneen	32	1000	6.0	43.7	41.4	41.4	31.8	63	46	74	74	92
Greater Tzaneen	33	7506	48.1	78.7	62.7	62.7	72.0	13	14	24	24	11
Greater Tzaneen	34	4005	26.2	75.6	66.0	66.0	60.0	27	17	18	18	21
Greater Tzaneen	35	1800	4.1	18.9	26.9	26.9	18.3	83	89	117	117	128
Lepele-Nkumpi	23	497	22.3	24.9	23.9	23.9	41.7	32	73	124	124	52
Lepele-Nkumpi	25	1673	19.4	30.7	74.1	74.1	49.9	34	63	10	10	35
Lepele-Nkumpi	26	18074	73.2	76.8	43.5	43.5	80.2	6	16	69	69	5
Lepele-Nkumpi	27	19871	70.0	68.2	49.5	49.5	75.9	7	23	42	42	7
Lepele-Nkumpi	28	73667	67.1	80.4	46.8	46.8	76.7	8	13	53	53	6
Lepele-Nkumpi	29	28879	73.3	90.7	63.7	63.7	85.7	5	7	22	22	4
Maruleng	1	51250	28.5	50.8	38.9	38.9	44.9	26	38	86	86	44
Maruleng	2	56914	33.8	61.0	47.4	47.4	52.1	22	28	46	46	33
Maruleng	3	8189	6.2	14.2	43.1	43.1	33.1	62	100	70	70	89
Maruleng	4	8843	47.4	63.5	57.9	57.9	64.9	15	26	31	31	18
Maruleng	5	5298	2.4	6.7	24.9	24.9	22.6	101	129	121	121	118
Maruleng	6	130469	28.8	34.8	42.9	42.9	43.8	25	57	72	72	46
Maruleng	7	6539	31.8	53.9	58.5	58.5	54.2	24	34	30	30	30
Maruleng	8	4755	48.0	68.3	72.9	72.9	67.6	14	21	12	12	14
Maruleng	9	3197	1.4	16.8	39.2	39.2	28.6	112	94	83	83	100
Maruleng	10	8017	53.5	66.4	62.3	62.3	69.7	11	25	25	25	12
Maruleng	11	1939	1.6	10.6	18.6	18.6	18.7	111	116	129	129	125
Maruleng	12	1206	2.6	24.1	17.7	17.7	20.1	100	74	130	130	123
Maruleng	13	16291	17.6	36.1	32.8	32.8	36.5	35	55	103	103	70
Maruleng	14	1656	38.1	58.6	45.9	45.9	52.5	18	32	54	54	32
Polokwane	2	4881	23.4	83.8	33.4	33.4	60.3	31	12	102	102	20
Polokwane	3	4034	34.9	100.0	45.5	45.5	67.5	20	1	57	57	15
Polokwane	4	263	17.0	61.6	84.5	84.5	60.8	37	27	6	6	19
Thaba Chweu	4	30	9.2	92.6	56.7	56.7	54.9	55	5	32	32	28
Thaba Chweu	8	8297	42.4	84.8	27.6	27.6	58.6	17	11	114	114	24
Thaba Chweu	9	2788	42.5	98.1	68.1	68.1	66.9	16	2	15	15	16
Thaba Chweu	10	63355	17.6	59.4	60.0	60.0	40.7	36	31	27	27	53
Thaba Chweu	13	15800	11.0	60.4	62.2	62.2	38.6	50	30	26	26	60

Priority community rangelands and tribal authority areas

Finally, we evaluated the Ecosystem-based Adaptation value of the 46 tribal authority areas in the Kruger to Canyons Biosphere. As we have no direct measure of areas used as communal rangelands, we have assumed that all tribal authority controlled areas which are in a natural or semi-natural state are used as rangelands. Maps of the average values of individual summary metrics for tribal authority areas are given in Figure 48 to Figure 51, while the overall value for Ecosystem-based Adaptation is given in Figure 52 . The additional element of proximity to Protected Areas is shown in Figure 53, but as almost all tribal authority areas in the Kruger to Canyons Biosphere are near Protected Areas, we do not feel that this is a useful measure. The values are summarized in Table 10. The highest vale EbA areas are on the escarpment edge, particularly in the areas of the Ba-Kgwete-Ba-Kgautswane, Roka-Motshana, Mogane, Mafefe, Bakgaga-Ba-Mphahlele, Roka (Malepe), Maja Bakgaga, Dinkwanyane and Ditlou-Ntshong.

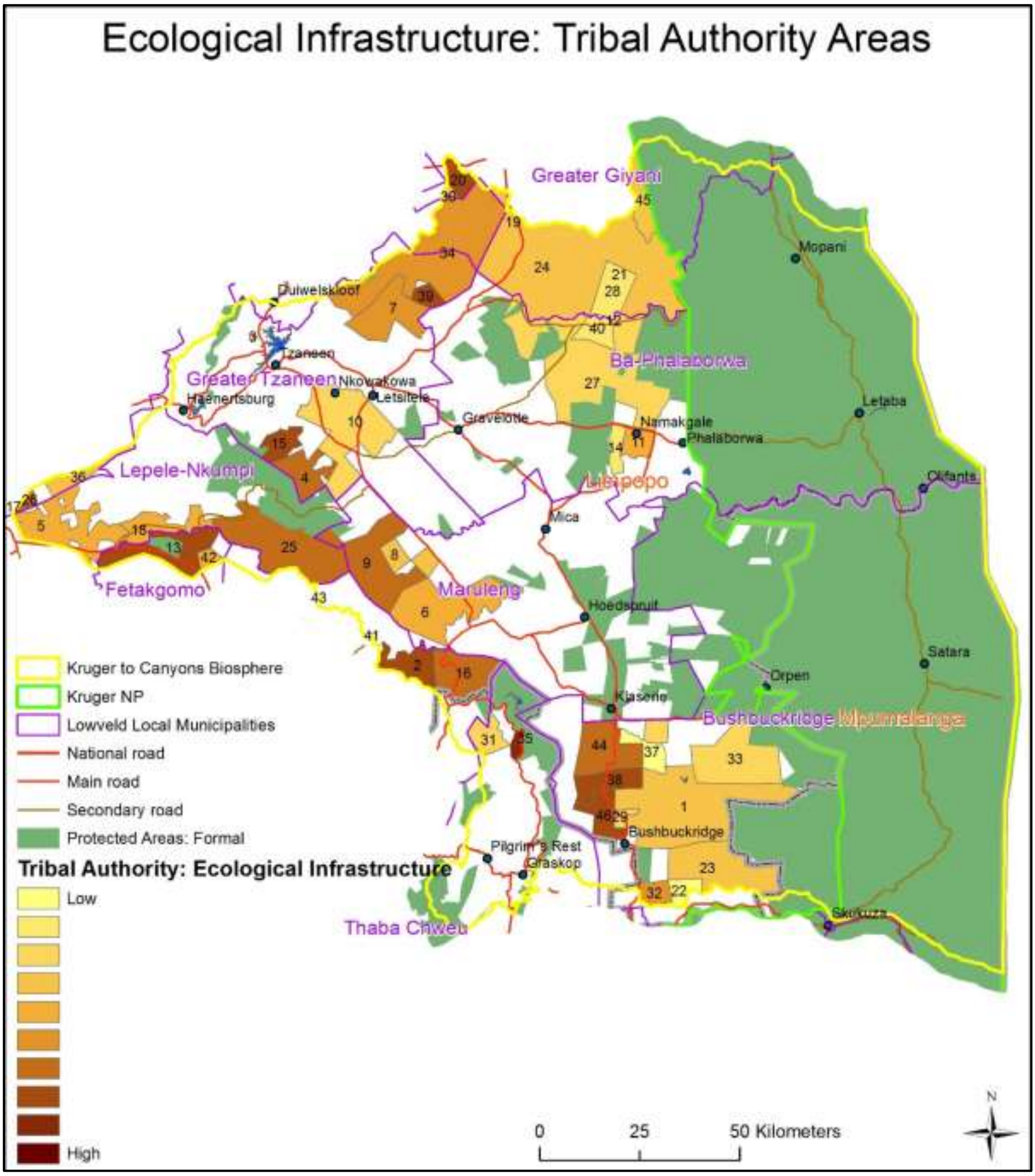

Figure 48: Map showing mean importance for ecological infrastructure for areas controlled by tribal authorities. The numbers link to Table 10.

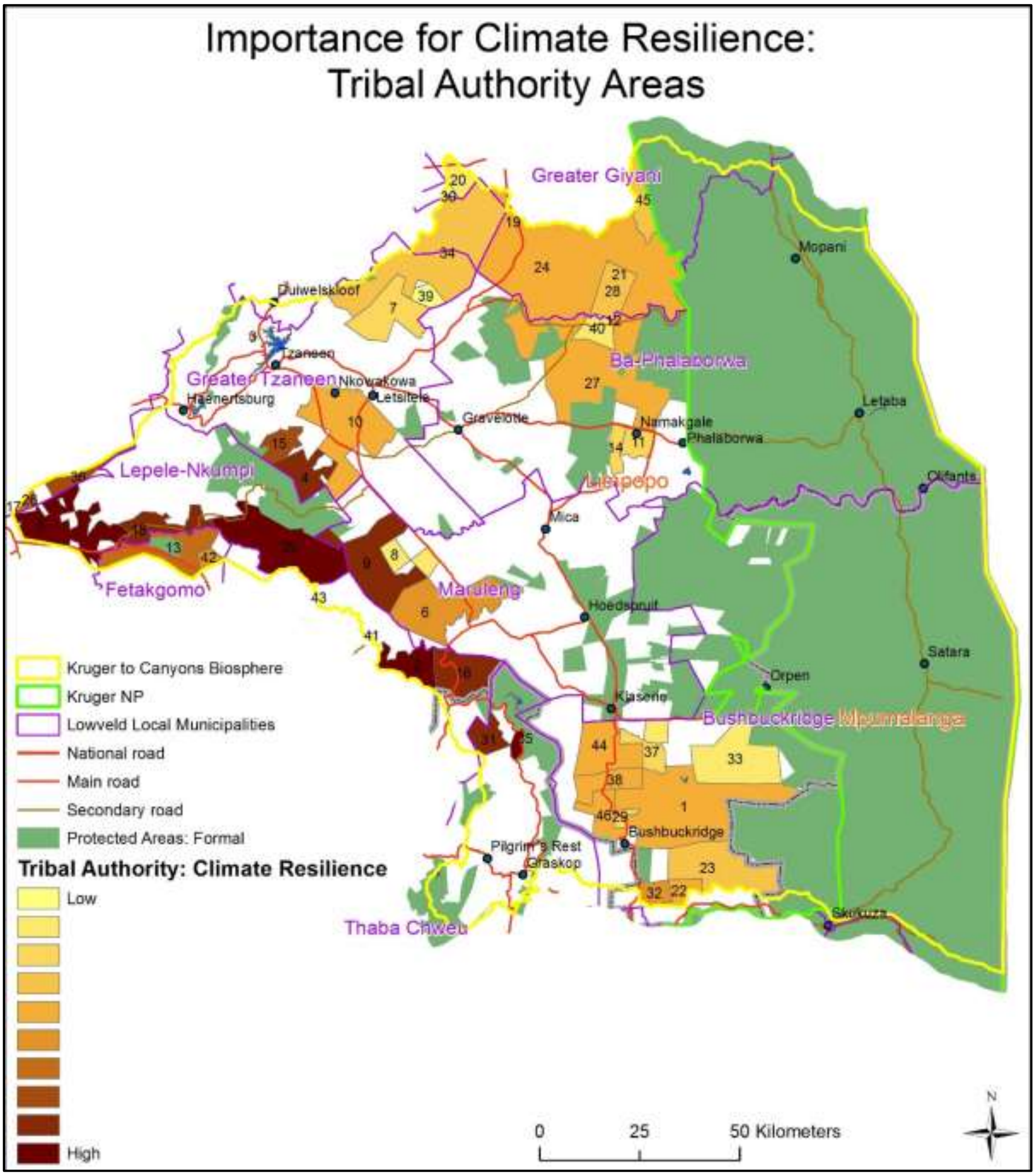

Figure 49: Map showing mean importance for supporting climate change resilience for areas controlled by tribal authorities. The numbers link to Table 10.

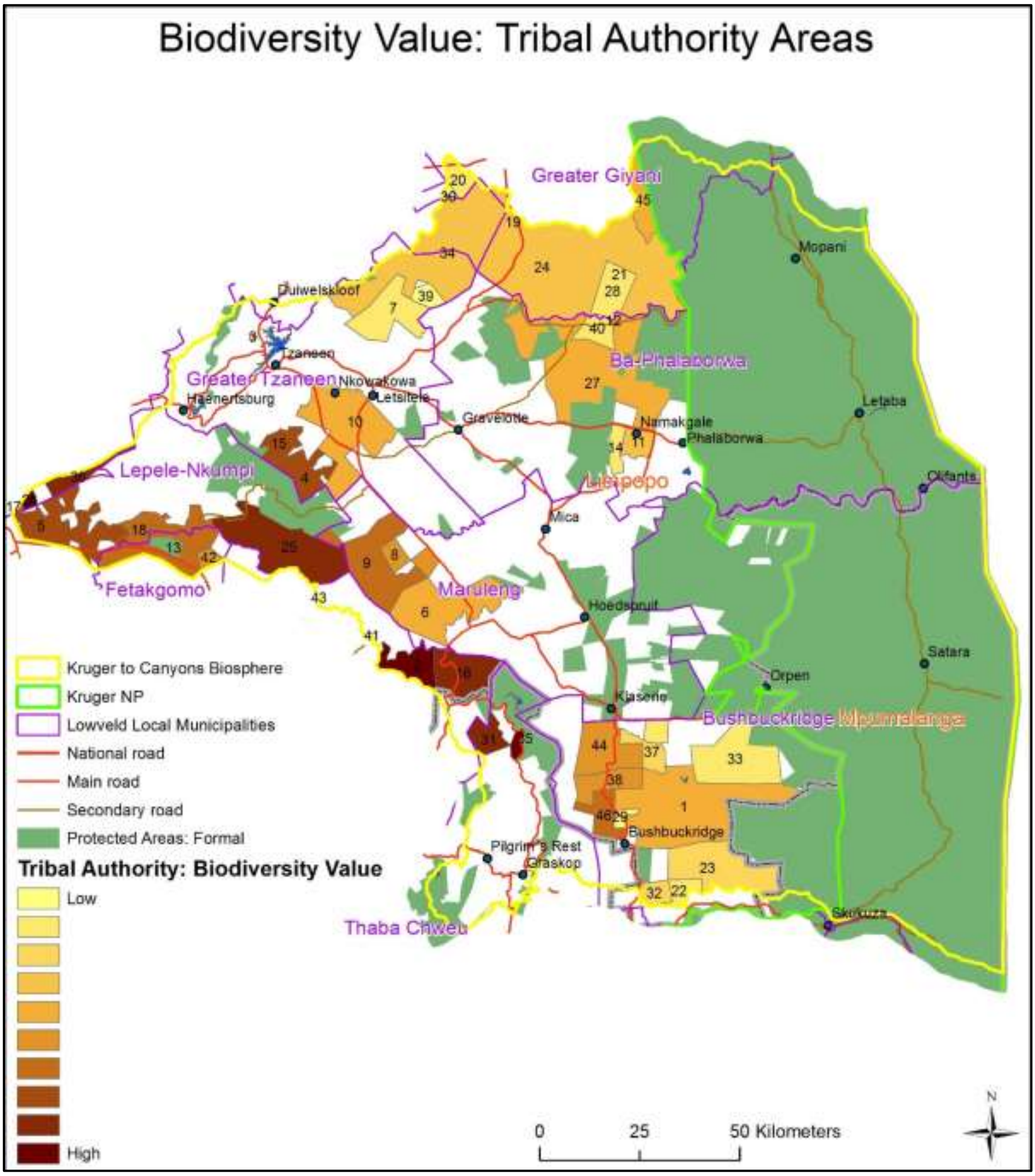

Figure 50: Map showing mean importance for biodiversity for areas controlled by tribal authorities. The numbers link to Table 10.

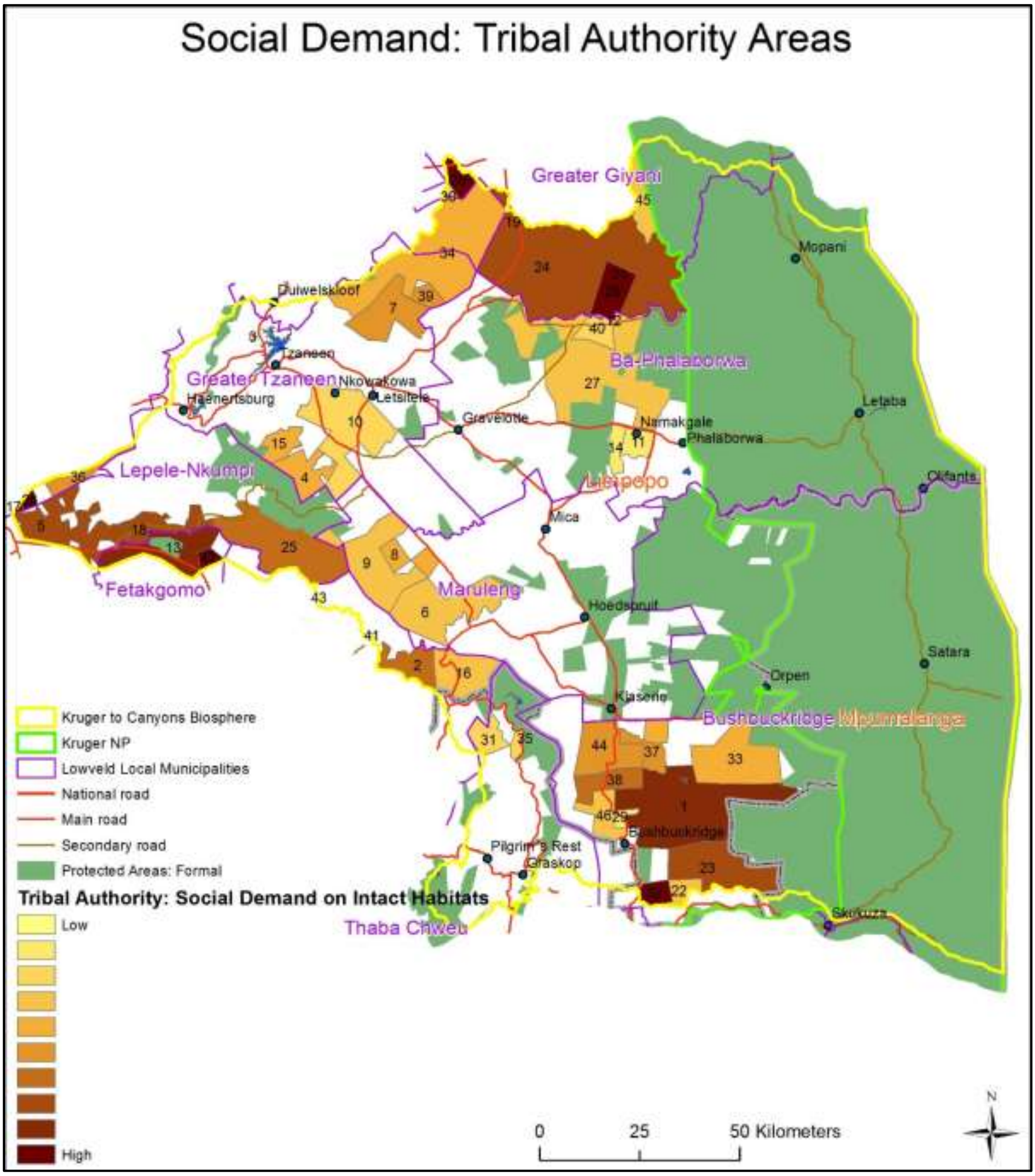

Figure 51: Map showing mean social demand for areas controlled by tribal authorities. The numbers link to Table 10.

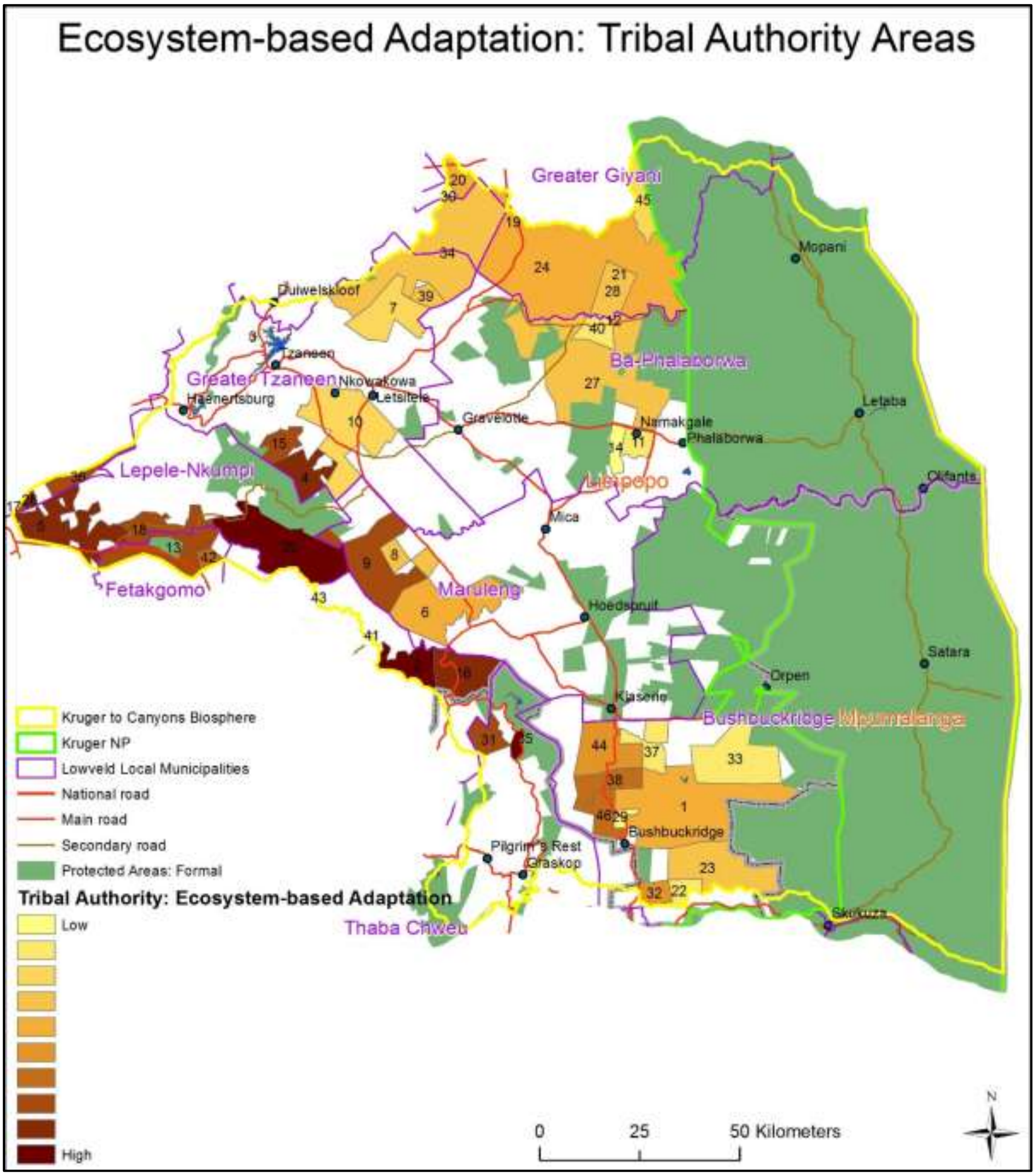

Figure 52: Map showing overall importance for Ecosystem-based Adaptation for areas controlled by tribal authorities. The numbers link to Table 10.

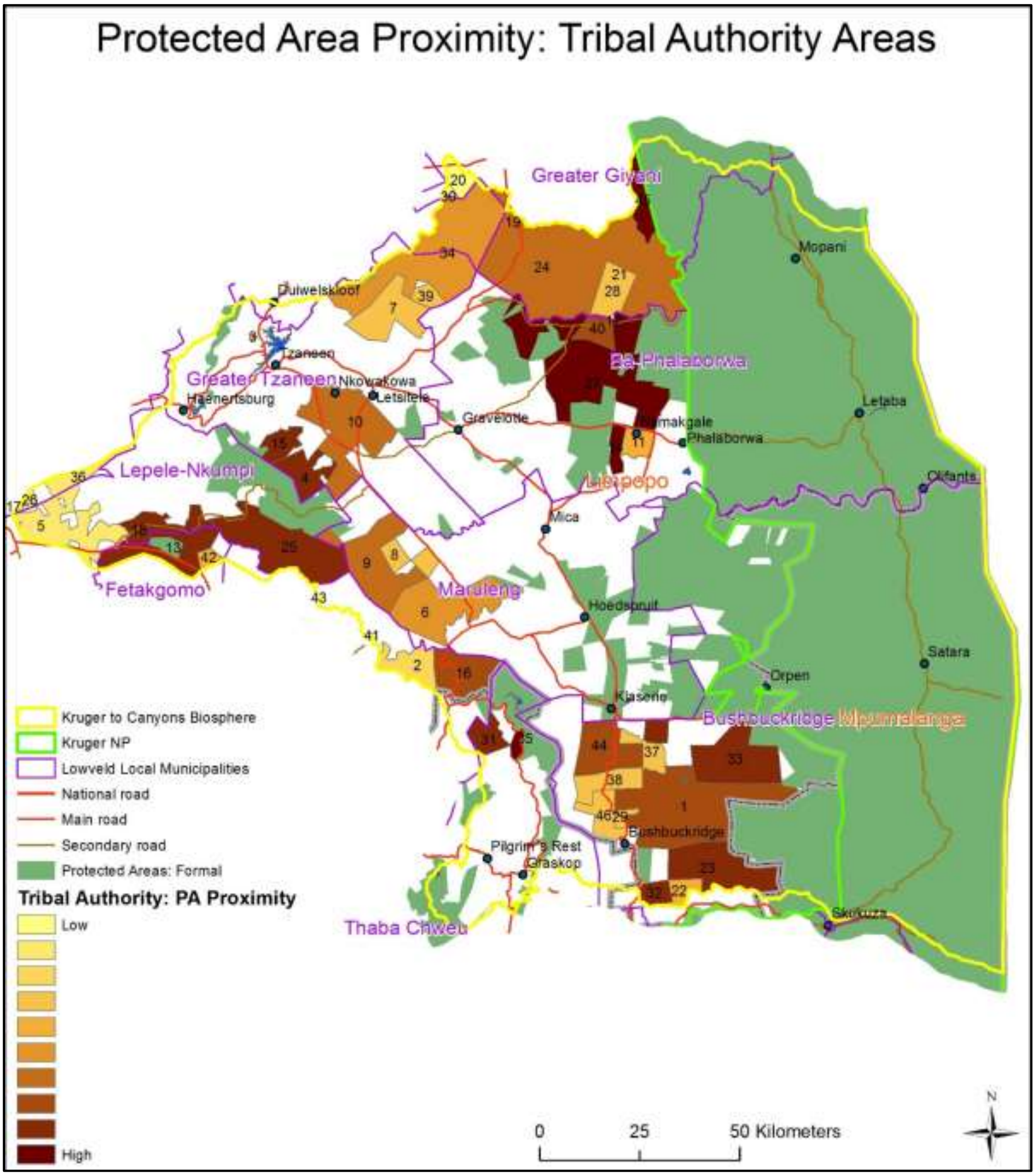

Figure 53: Map proximity to Protected Areas of areas controlled by tribal authorities. The numbers identify specific communities and link to Table 10.

Table 10: Summary of tribal authority controlled areas of relative value/importance for Ecosystem-based Adaptation activities. Tribal Authority number refers to the area identifier on the maps in this section. Summary is based on average values across each tribal authority area for each indicator. The value section is indexed against the highest value for a tribal authority area for that metric. The highest value area will have a score of 100, with lower score indicating lower values. In the rank section, we have ranked areas in terms value for that metric. 1 indicates the highest priority area. The indicators relate to the summary values covered in earlier sections of the analysis: Resilience = Areas important for supporting climate resilience; Biodiversity = Biodiversity priorities; Ecological infrastructure = Ecological infrastructure priorities; Social demand = Overall social demand priorities for intact habitats; Protected area proximity is a composite measure based on adjacency to formal protected areas and average distance to protected areas compared to other tribal authority areas in the K2C. The Ecosystem-based Adaptation value refers to the overall priority implementation areas for EbA identified in this desktop analysis. This assessment should be subject to field verification and local implementation issues may suggest a different set of priorities. Nevertheless, this assessment does give an overall indication of priority.

			Value						Rank					
Tribal Authority Name	Number	Area (ha)	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Protected Area Proximity	Ecosystem-based Adaptation (Overall)	Resilience	Biodiversity	Ecological Infrastructure	Social Demand	Protected Area Proximity	Ecosystem-based Adaptation (Overall)
Amashangana	1	52,163	7.7	23.9	21.5	92.4	86.5	40.8	23	25	30	7	17	24
Ba-Kgwete-Ba-Kgautswane	2	9,814	100.0	93.3	47.7	82.1	21.0	100.0	1	3	5	17	39	1
Bahanawa-Ba-Kiwi	3	177	1.5	15.1	18.6	16.1	39.9	14.0	38	34	35	46	24	46
Bakgaga	4	9,521	59.3	72.4	29.5	73.9	94.6	70.4	5	9	18	23	6	8
Bakgaga-Ba-Mphahlele	5	23,284	76.3	64.6	24.7	88.0	14.2	76.8	4	11	24	10	41	5
Bakoni Ba Mamietja	6	26,915	18.8	28.8	23.4	68.0	77.2	40.4	17	23	27	36	21	25
Baloyi	7	16,853	3.6	11.1	25.7	75.3	33.0	33.1	34	39	22	21	31	34
Banareng-Ba-Letsoalo	8	6,309	0.8	42.0	21.1	71.1	32.9	37.8	40	19	31	29	32	27
Banareng Ba Sekororo	9	24,843	43.7	54.7	29.9	68.6	81.9	58.8	10	14	16	34	19	16
Bankuna	10	33,204	7.6	27.9	18.1	59.4	81.1	32.1	24	24	37	40	20	36
Baphalaborwa Ba Nakome	11	5,327	3.4	18.2	24.2	41.5	38.4	25.1	35	30	25	44	25	40
Baphalaborwa Ba Seloane	12	31	4.8	23.7	79.5	72.0	35.8	55.7	30	26	3	27	27	17
Baroka-Ba-Nkwana	13	18,557	27.5	49.0	40.7	91.2	93.9	60.9	14	17	8	8	8	14
Bashai_Ditlou	14	3,958	2.8	7.7	16.1	34.6	97.7	17.2	36	41	41	45	2	45
Bathlabine	15	5,943	34.5	70.4	39.0	72.6	93.1	63.4	11	10	11	25	9	12
Dinkwanyane	16	16,064	53.1	81.8	31.3	68.6	88.3	69.9	7	7	15	33	16	9
Ditlou-Macidi	17	357	26.4	51.8	29.8	94.4	13.1	59.2	15	16	17	5	42	15
Ditlou-Ntshong	18	9,590	53.1	55.9	23.7	87.8	92.0	65.3	6	13	26	11	10	10
Dzumeri	19	2,482	0.3	19.0	11.5	88.6	15.5	32.6	43	29	46	9	40	35
Hlaneki	20	4,595	0.8	7.5	40.5	95.0	0.0	41.4	39	42	9	4	46	23
Homu	21	370	0.0	3.7	26.2	46.5	30.7	22.5	45	44	21	43	34	42
Hoxana	22	4,162	7.3	11.5	13.0	69.8	40.0	27.9	25	37	45	31	23	39
Jongilanga	23	25,929	4.9	16.5	20.7	86.4	91.8	36.1	29	32	32	13	11	29
Mabunda	24	94,156	8.8	19.5	20.6	86.7	84.2	38.5	22	28	33	12	18	26
Mafefe	25	32,668	80.5	85.9	34.1	82.6	90.7	86.1	3	6	13	16	13	4
Maja	26	1,171	25.1	94.6	31.8	94.3	12.8	71.3	16	2	14	6	43	7
Majeje	27	73,743	7.1	32.5	17.4	69.6	96.4	35.9	27	22	39	32	4	30
Makhuva	28	9,666	5.8	10.7	14.9	95.4	31.8	35.3	28	40	43	3	33	31
Malele	29	1,748	3.9	3.1	18.4	49.4	34.4	19.9	33	45	36	42	29	44
Mamaila	30	675	0.0	2.7	21.9	53.3	5.2	21.7	45	46	28	41	45	43
Mashilane	31	6,269	52.6	87.4	17.1	61.7	94.3	65.0	8	5	40	37	7	11
Mathibela	32	4,573	15.6	15.6	26.6	100.0	94.9	44.4	19	33	20	1	5	21
Mnisi	33	28,492	0.8	11.7	17.8	73.0	91.3	28.6	41	36	38	24	12	37
Modjadji	34	55,513	4.6	17.3	28.4	72.0	77.2	35.1	32	31	19	28	22	32
Mogane	35	5,364	83.8	100.0	57.2	59.6	100.0	93.0	2	1	4	39	1	3
Molepo	36	5,214	29.9	89.2	21.9	76.1	9.7	62.9	13	4	29	19	44	13
Moletele	37	5,354	2.4	14.7	13.7	74.9	34.5	28.6	37	35	44	22	28	38
Moreipuso	38	9,051	9.0	43.7	40.3	84.0	30.1	50.3	21	18	10	15	35	19
Nyavana	39	3,228	0.0	5.1	43.7	78.8	28.9	37.5	44	43	6	18	36	28
Phalaborwa	40	5,594	0.6	11.3	15.8	61.0	88.5	24.9	42	38	42	38	15	41
Roka-Motshana	41	184	46.6	81.5	100.0	84.1	22.4	96.4	9	8	1	14	38	2
Roka(Makgalanotho)	42	2,211	18.8	36.9	24.7	96.7	37.3	50.6	18	21	23	2	26	18
Roka(Malepe)	43	135	31.6	64.1	90.3	72.2	25.3	76.2	12	12	2	26	37	6
Setlhare	44	16,655	7.1	39.4	35.0	76.0	89.1	44.2	26	20	12	20	14	22
Shiviti	45	7,840	4.6	22.8	20.5	68.4	96.9	33.2	31	27	34	35	3	33
Thabakgolo	46	8,451	9.2	51.9	41.9	70.1	33.4	49.0	20	15	7	30	30	20

8. Conclusions and way forward

The current rapid analysis identified a set of areas which we see as the key areas for **Ecosystem-based Adaptation** in the Kruger to Canyons Biosphere. The project went through a process of identifying:

- **Ecological infrastructure.** The analysis and mapping process identified the key areas specific areas of natural and semi-natural habitat important for delivering ecosystem services to the people of the district. The analysis focussed on water related ecosystem services linked to the quantity and quality of water supply, the control of soil erosion and reduction of sediment inputs into systems, and areas important for reducing flood risk. The analysis focussed on the key question: Which areas are important Ecological Infrastructure for helping people adapt and supplying key ecosystem services?
- **The areas supporting climate change resilience.** The analysis process identified the key features which support overall climate change resilience for environmental systems in the district. The analysis focussed on the key question: Which areas are important for the environment to adapt to climate change?
- **A set of environmental priorities.** Independent of climate change, there are a range of key biodiversity assets and priority areas which underpin all ecosystem services across the district. An intact and functional landscape is critical to supporting society. Therefore, we have identified a set of overall spatial biodiversity priorities for the district. The analysis focussed on the key question: Which areas are important for other environmental reasons?
- **Social priorities.** As the project is heavily focussed on the link between human/social needs and the environment, we have identified the social priority areas where people are most directly dependent on the environment for the delivery of ecosystem services. The analysis examined both general poverty pressure and specific environmental dependency. The analysis focussed on the question: Where is there most social need for intact Ecosystem Services?

Based on these building blocks, the project identified the areas of overlap, where social need, biodiversity climate resilience and ecological infrastructure intersect. These areas are initial priority areas for Ecosystem-based Adaptation to climate change impacts. This analysis can nevertheless be used to:

- Highlight key areas for Ecosystem-based Adaptation where social, water, biodiversity and climate change issues overlap. Well-managed natural and semi-natural landscapes are the key to long-term resilience of the biosphere. This approach will hopefully provide a useful, easy to comprehend, and robust integration of key resilience issues in the Kruger to Canyons Biosphere.
- The areas should inform the revision of the zoning for the Kruger to Canyons Biosphere.
- The areas should be sufficiently included into spatial planning instruments such as Spatial Development Frameworks and other appropriate planning policy (e.g. IDPs). Avoiding inappropriate development of these areas will be critical to the long-term ability of the K2C social-ecological system to adapt to climate change impacts.
- The areas should be the focus for Natural Resource Management (NRM) Programmes and other projects securing water services (both for water availability and water quality), restoring and maintaining livestock grazing services as a safety net for the poor, and controlling soil erosion as a way of avoiding infrastructure costs from damage to roads and dams. Securing ecosystem services is about restoring and protecting resource integrity in the region's water catchments, wetlands, and rivers, and other priority areas.
- The areas should be a focus for activities aimed at conserving landscapes (e.g. community linked stewardship projects).

- These areas could be integrated into relevant climate adaptation policy relating to the district (including national, provincial, district and local municipality response strategies). The areas should be integrated into disk risk management strategies for the district and local municipalities.

Although the current analysis represents a thorough desktop view of the Kruger to Canyons Biosphere, it is critical to note:

- This assessment should be subject to field verification and local implementation issues may suggest a different set of priorities. Nevertheless, this assessment does give an overall indication of priority.
- The assessment reflects mean values across the areas being assessed. Therefore, it is possible that an administrative unit could have a portion of land of very high value and large portions that are low value, and hence receive and overall low value. This does not mean that the high value areas are not extremely important.
- The assessment focusses on units that have both high values in terms of the site level metrics assessed (climate resilience, ecological infrastructure, biodiversity, social demand, and overall Ecosystem-based Adaptation value) and are largely natural or semi-natural. This highlights broader intact and semi-intact landscapes that need to be appropriately managed (e.g. through improved and sustainable rangeland management) to secure overall EbA value of the landscape. It is not designed to highlight small high value fragments as these would tend not to be the focus of CSA's interventions from a climate change perspective.