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# FP6-2004-INCO-DEV-3
# PRIORITY A.2.3.: Managing Arid and Semi-arid Ecosystems

**First Periodic Activity Report**
**(01.01.2007 – 31.12.2007)**
**January 2008**

**ANNEX 1-3: Task Report on WP1 Activities – Current Land Use Patterns and Impacts**
**Deliverable D1.1 (Lead contractor: UKZN, Due date: November 2007)**

# COMPETE

Competence Platform on Energy Crop and Agroforestry Systems for Arid and Semi-arid Ecosystems - Africa


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# Project Partners

| Partici-pant role | Partici-pant number | Participant name | Participant short name | Country | Date enter project (month) | Date exit project (month) |
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| Partici-pant role | Partici-pant number | Participant name | Participant short name | Country | Date enter project (month) | Date exit project (month) |
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| CR | 47 | Conservation International Foundation (not funded) | CI | USA | 1 | 36 |
| CR | 48 | Foederation Evangelischer Kirchen in Mitteldeutschland | EKMD | DE | 1 | 36 |

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## INTRODUCTION

This work has been conducted in the framework of the project COMPETE (Competence Platform on Energy Crop and Agroforestry Systems for Arid and Semi-arid Ecosystems - Africa), co-funded by the European Commission in the 6th Framework Programme – Specific Measures in Support of International Cooperation (Contract No. INCO-CT- 2006-032448).

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## 1. Objective

COMPETE seeks to enhance sustainable use of renewable natural resources and stimulate bioenergy implementation in the semi arid and arid regions of sub Saharan Africa. The principal objective of this work package was to identify land in these regions where intensification of, or conversion to bioenergy use, will not have detrimental environmental and/or socio-economic impacts.

## 2. Methodological Approach and Data Sources

The first step in the methodology devised to meet this objective was to decide which data source depicting the spatial extent of arid and semi arid regions in Africa, was the most accurate. The range of sources interrogated gave differences in the area of these regions of up to 16%. It was decided to use the WMO and UNEP (2001) delineation of these regions as they appear to be the most accurate (refer Appendix 9, Figure 1). These regions in all sub Saharan countries were digitized and produced as a map which used all the continent's country boundaries as a template (refer Appendix 9, Figure 2). ESRI (2006) Africa and African country shape files were used.

The second step involved sourcing and acquiring high quality Geographic Information Systems (GIS) data sets that categorise spatial and temporal variations in Africa's physiographic parameters, vegetation cover, land use etc. As a precaution against detrimental impacts on biodiversity, all categories of protected areas, closed canopy forests and wetlands were designated as **unavailable** for bioenergy crop production and filtered out from the regions depicted in the base map. UNEP et al. (2006) was used to delineate the International Protected Areas, National Protected Areas (Categories I-VI), and National Protected Areas (Uncategorized), (refer Appendix 9, Figure 5).

The ECJRC's (2003) GLC database (refer Appendix 9, Figure 3) was used to delineate the following forests:- closed deciduous, evergreen lowland, montane and submontane, and wetlands:- mangroves, swamp bush and grassland (refer Appendix 9, Figure 4). The evergreen lowland category included both closed and degraded forest. It could be argued that the latter should not have been filtered out, as there is little prospect of it being rehabilitated and the rural poor would benefit more from it being converted into bioenergy crop production. The GLC database was also used to delineate areas where (i) crops cover more than half the surface, (ii) croplands occur within a matrix of open woody vegetation, (iii) irrigated crops predominate, and (iv) tree crops predominate. In order to avoid food security concerns these areas were also designated as **unavailable** for bioenergy crop production and filtered out from the arid and semi arid regions (refer Appendix 9, Figure 6). Lastly, this database was used to delineate the following areas considered **unsuitable** for bioenergy crop production: cities, bare rock, sandy desert and dunes, stoney desert, and water bodies (refer Appendix 9, Figure 4).

The surfaces remaining as available and/or suitable for bioenergy crop production (refer Appendix 9, Figure 7) are: closed or sparse grassland, open grassland with sparse shrubs, open deciduous shrubland, deciduous shrubland with sparse trees, deciduous woodland, mosaic forest/cropland and mosaic forest/savanna.

Many would argue that the grasslands and woodlands should not be considered more amenable to conversion to biofuel crop production than forests or wetlands, just because they do not enjoy the same level of protection as forests and wetlands accorded by International Conventions. Grasslands and woodlands particularly in sub Sahara's semi arid and arid regions generally have a very high biodiversity and play a very significant role in environmental services and rural livelihoods. Appendix 9, Figures 8, 9 and 10, use the continent's country boundaries and sub Sahara's semi arid and arid regions as a template on which primary roads, primary railroads and populated places are shown, respectively.

Case studies have been made of the following countries: South Africa, Botswana, Zambia, Tanzania, Kenya, Mali, Burkina Faso and Senegal. Each has several different bioenergy initiatives and COMPETE partner representation. A second set of maps used the semi arid and arid regions of each of these countries in turn as a template on which available and suitable areas for bioenergy crop production, roads, railroads, rivers and populated places are sequentially shown and variously labelled (refer Appendices 1-8). BWG's (2007) data on roads, railroads and rivers, and ESRI's (2006) data on populated places were employed. The specific habitat requirements of various bioenergy crops needs to be evaluated in order to identify the best potential candidates in different parts of each country.

Other partners of this work package will now determine (a) if the land identified in these maps is free from legal, cultural, political[1], environmental services and rural livelihood[2], biodiversity[3], and soil[4] constraints against its utilization for bioenergy, (b) if the water resources[5], potential labour market and infrastructure[6] can sustain conversion of this land to bioenergy production, and (c) whether or not the production on cropland filtered out as unavailable is sustainable, or is used, or can be used for bioenergy. Differences in the number of people living in the populated places are not given in the ESRI (2006) data. Partners interrogating potential labour markets[6] will need to source this information. Once they have identified which places are potentially significant in terms of bioenergy production, distribution and utilization, the congested populated places maps produced to date, will be revised.

Once the work package partners input has helped refine the identification of land where intensification of, or conversion to bioenergy use is unlikely to have detrimental environmental and/or socio-economic impacts, Google Earth will be used to survey land use. The work package leader engaged three students to evaluate the efficiency of this tool for this purpose. Research by Baijnath (2005) and Watson (2007) has verified that the Miombo Network's (IGBP/IHDP, 1995) 1 $km^2$ Radiometer data accurately delineate land surfaces in southern Africa which are suitable for sugar cane production.

[1] Task 1.3: UiO
[2] Task 1.7: FAO, UB, Imperial, EUBIA, UCT-ERC, TaTEDO, ENDA-TM, MFC, MU, CENBIO, CAREI, TERI, JGSEE
[3] Task 1.8: UB, UNIVBRIS
[4] Task 1.5: CNR, Imperial
[5] Task 1.4b: UB
[6] Task 1.6: UFH, EUBIA, TaTEDO, ENDA-TM, MFC, MU

After filtering out the protected areas, forested and wetland areas, cultivated and unsuitable areas as described above, each student used Google Earth to examine 90 randomly selected such pixels in Angola, Zambia and Tanzania, respectively. They found about half the pixels in each country had more than 75% of the surface covered by the following signs of human habitation: homesteads, cultivated fields, footpaths, minor roads, earth dams, areas evidently graded to obtain fill material, evidence of deforestation and overgrazing. Local knowledge from the partners of the case study countries, as well as input from the work package partners will be required to assist in deciding whether to classify such surfaces as available for conversion to specific types of bioenergy production or not.

A brief description of the findings of the work package leader's postgraduate student (Ackbar, 2007), may assist Task 1.6 partners with conceptualizing what is required from them. 1 $km^2$ pixels potentially available and suitable for sugar cane production in Angola were identified using the IGBP/IHDP (1995) data and the filtering out procedure described above. As shown in Figure 2.1 below, these pixels are concentrated in three areas. In order to evaluate whether all three areas should be planted up with sugar cane, she had to determine if there is an adequate source of labour in close proximity to each of them. Planting, weeding, burning and harvesting sugar cane are all physically demanding tasks, therefore the status of debilitating conditions such as HIV/Aids, malaria and bilharzia in the potential labour pools was ascertained. She found sugar cane production in all three areas is unlikely to be constrained by labour.

Southern African sugar cane production has two basic types of supply chain, influenced mainly by topography. Where the topography is unsuitable for large vehicles to enter the fields, the cane is loaded into small in-field trailers and subsequently transferred to road vehicles at the loading zone. The "indirect delivery" adds costs compared to "direct delivery" with in-field loading of road vehicles. Where the topography is suitable for direct deliveries, the soil type and conditions may preclude heavy vehicles from entering the field. Some of the harvested cane is delivered in chained bundles but most is delivered loose with grab loading and spiller offloading (Watson et al., 2007). In 2005, 6.2% of the region's cane harvest was delivered by train or tram with the remainder being delivered by road (Davis, 2006). Sugar cane needs to reach the mill as quickly as possible because of rapid sucrose depletion. Another reason why the crop should be grown in close proximity to the mill, is that it has a high bulk to volume ratio hence transporting costs comprise a substantial proportion of total production costs (Watson et al., 2007).

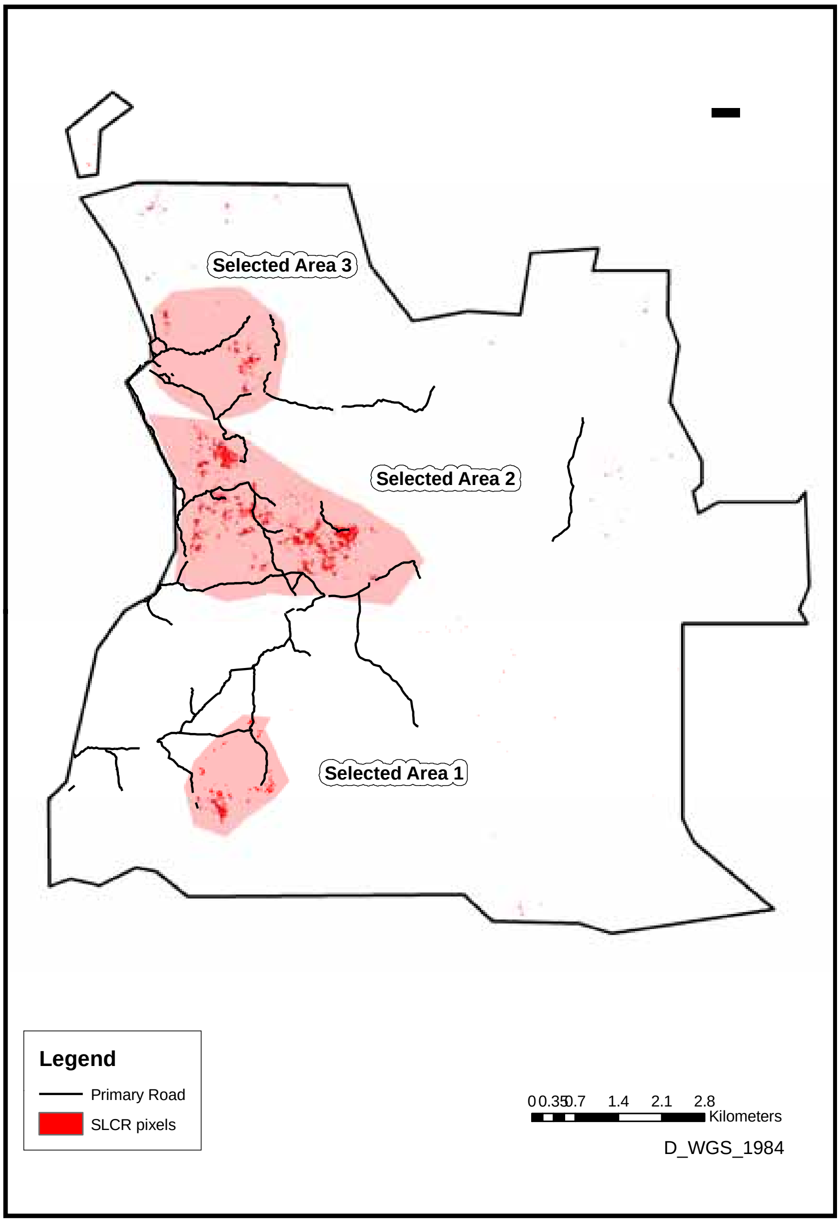


**Figure 2.1: Available and suitable areas for sugar cane production clustered in Angola (Source: Ackbar, 2007).**

Ackbar (2007) assessed the proximity of the pixels to railroads and primary roads in the three areas (as illustrated with area 2 in Figures 2.2 and 2.3, below). If any of these areas are put under sugar cane production, mills will have to be constructed. She concluded that instead of transporting cane to mills outside the areas, each area could sustain four mills from which it would be substantially cheaper to transport bioethanol to the country's main centres.

Task 1.6 partners need to evaluate (a) the contemporary spatial distribution and health status of agricultural labour, (b) the spatial distribution and condition of roads and railroads in relation to transporting products from contemporary agricultural production areas as well as from potential bioenergy crop production areas and (c) whether existing processing plants are adequate or can be modified to process the yields estimated for different types of bioenergy crops. Based on this evaluation they should recommend what new transport and processing infrastructure is needed and where.

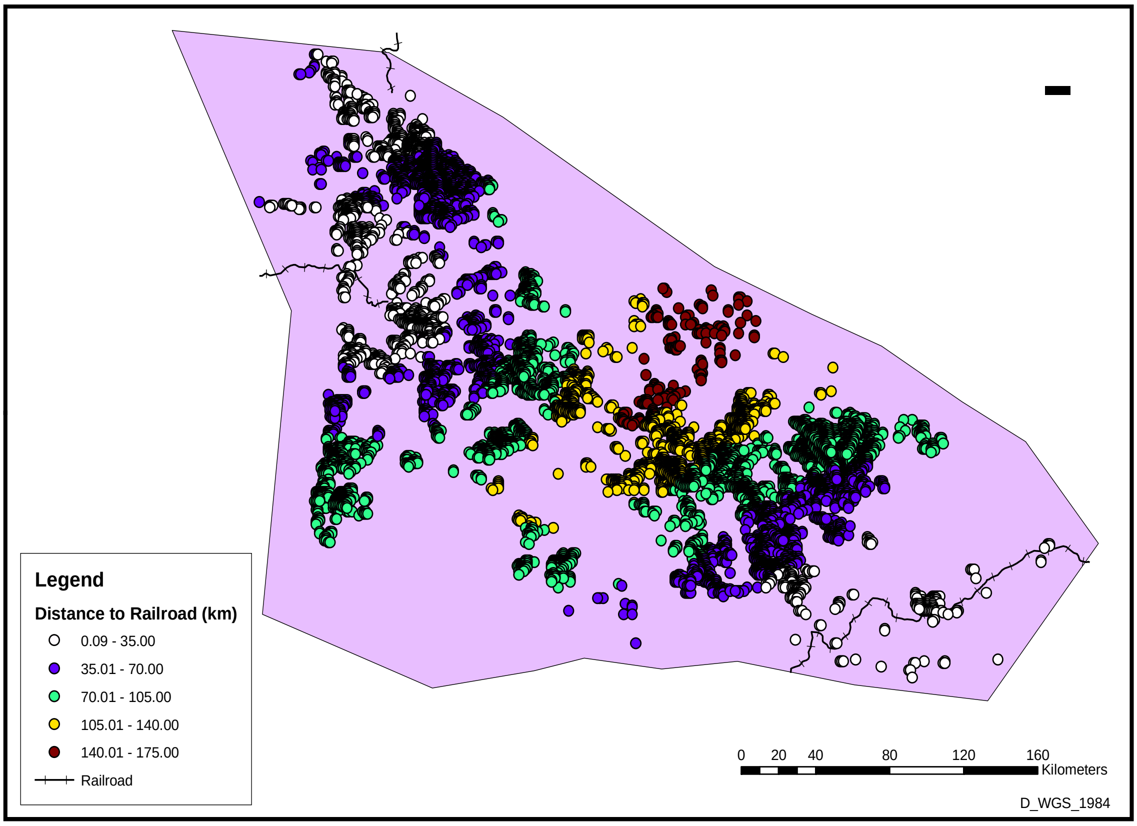


**Figure 2.2: Distances of 1 km$^2$ pixels available and suitable for sugar cane production in Angola's study area 2, to railroads (Source: Ackbar, 2007).**

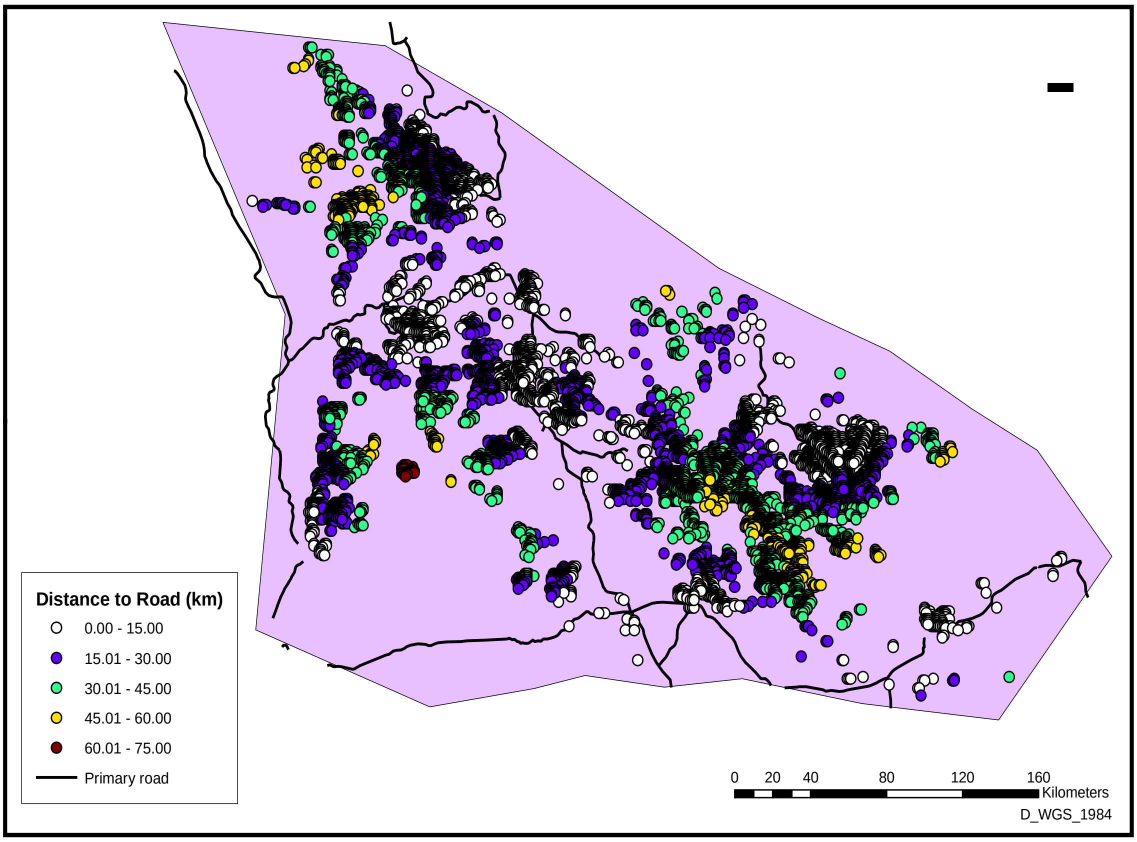


**Figure 2.3: Distances of 1 km$^2$ pixels available and suitable for sugar cane production in Angola's study area 2, to roads (Source: Ackbar, 2007).**

# 3. Country Study of South Africa

## 3.1. Land use in arid and semi arid regions

An overview of the nature of information required for each of the case study countries from partners within them as well as from task leaders and contributors to this work package, is presented below using South Africa as an example.

South Africa's arid and semi arid regions are shown in all figures in Appendix 1. The figure below shows the country's nine provinces.

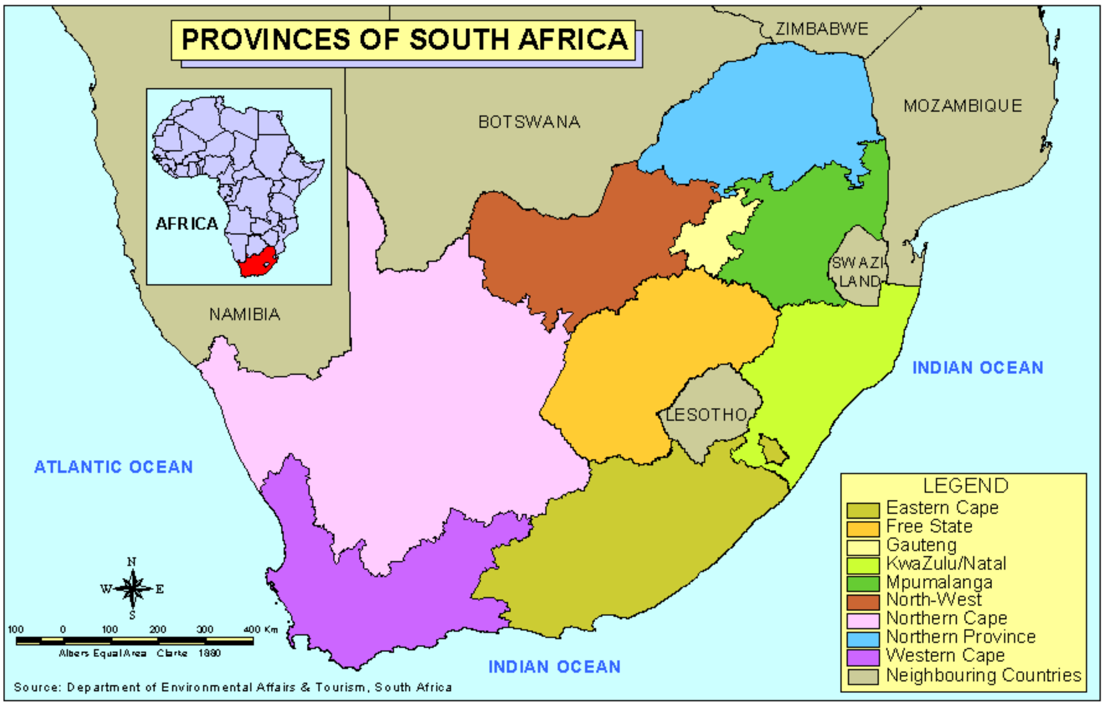


**Figure 3.1.1: South Africa's provinces (Jordaan et al., 2001).**

The arid region predominantly falls in South Africa's Northern Cape and North West provinces. The semi arid region broadly occurs inland of the Drakenberg Mountain Range in the following provinces: Western Cape, Eastern Cape, Free State, Gauteng, Mpumalanga and Northern Province. Northern Province has recently changed its name to Limpopo Province. Appendix 10 shows the land cover, land use, soil types, soil depth and soil leaching status in each of these provinces.

The area that is shown as unavailable and/or unsuitable around Letaba in the north east is the Kruger National Park (refer Appendix 1, Figure SA9, Appendix 10, Limpopo Province and Mpumalanga). This surface in the vicinity of Komatipoort is under irrigated, medium and large scale commercial sugar cane production (refer Appendix 10, Mpumalanga). The land use in the unavailable and/or unsuitable areas north of Brits is primarily conservation, plantation forestry, tea and various fruit tree cultivation (refer Appendix 10, Limpopo and North West provinces). These areas centred around Everton, are under urban, peri-urban, mining, plantation forestry, and maize cultivation (refer Appendix 10, Gauteng and Free State provinces).

The unavailable area north of Rietfontein is part of the Kalahari Gemsbok National Park (refer Appendix 10, Northern Cape). The land use in the unavailable and/or unsuitable areas in the south west and southern coast margin and hinterland is conservation, indigenous and plantation forestry, wheat cultivation and vineyards (refer Appendix 10, Western Cape). The patches of these areas elsewhere are under conservation, irrigated maize, vegetables or fruit trees.

Most of the areas categorised as available and/or suitable for bioenergy crop production in Limpopo Province face legal, cultural and policy constraints. Despite a daily influx of political and economic refugees from Zimbabwe into those white owned commercial farms bordering the Limpopo river, most have not made their land available for land reform under the “willing seller, willing buyer” option. Because land redistribution targets are lagging so far behind, the Government is currently reconsidering this option. Both the refugee influx and uncertainty over the continued right to own land, are likely to undermine the confidence of those wishing to invest in large scale bioenergy crop production. The Kingdom of Venda is situated north west of Thohoyandou. The Sacred Forest around Lake Fundudzi where the royalty is buried, has already been filtered out as unavailable. However, before deciding to convert surrounding land that appears to be available to bioenergy crops, one would need to meet with key traditional figures to ascertain if the land is indeed available. Rural communities in Venda and neighbouring Lebowa are still very traditional. In additional to ruins and burial sites, scattered throughout the landscape are individual trees that have immense cultural value because they are used to hold community meetings under, or have medicinal and/or magical properties.

Most of the semi arid region between Kroonstad and Uniondale is categorised as available and/or suitable for bioenergy crop production. The land use is predominately commercial livestock production. The livestock ranges from cattle, game, cattle and game, cattle and goats, goats, sheep and ostriches, to sheep. The country’s population of sheep has not fluctuated significantly since the early 1990s.

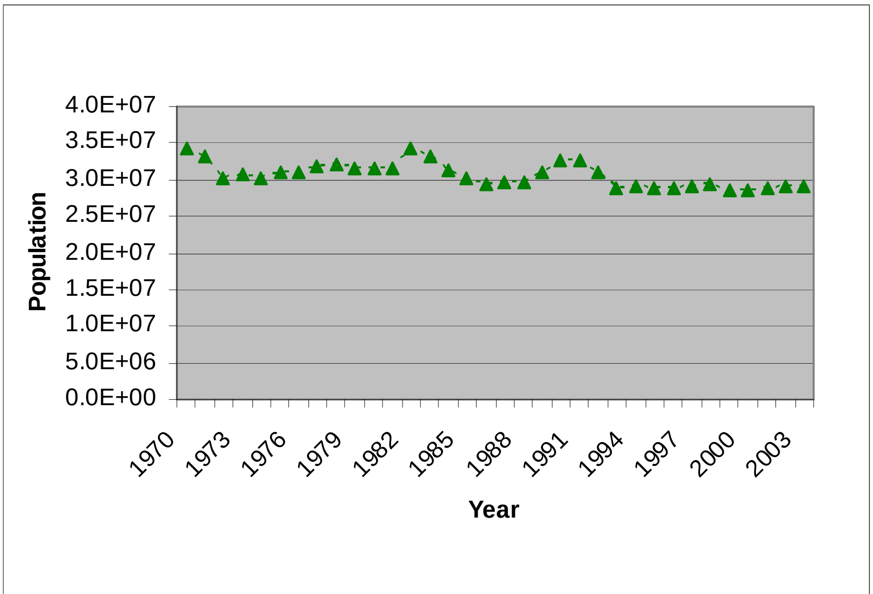


**Figure 3.1.2: South Africa’s Sheep Population (Source: FAOSTAT, 2004).**

By contrast the populations of all the livestock types have steadily increased. In particular, game farming for hunting and/or ecotourism and/or biltong production has increased so rapidly that it has elicited government concern regarding its implications for land reform targets.

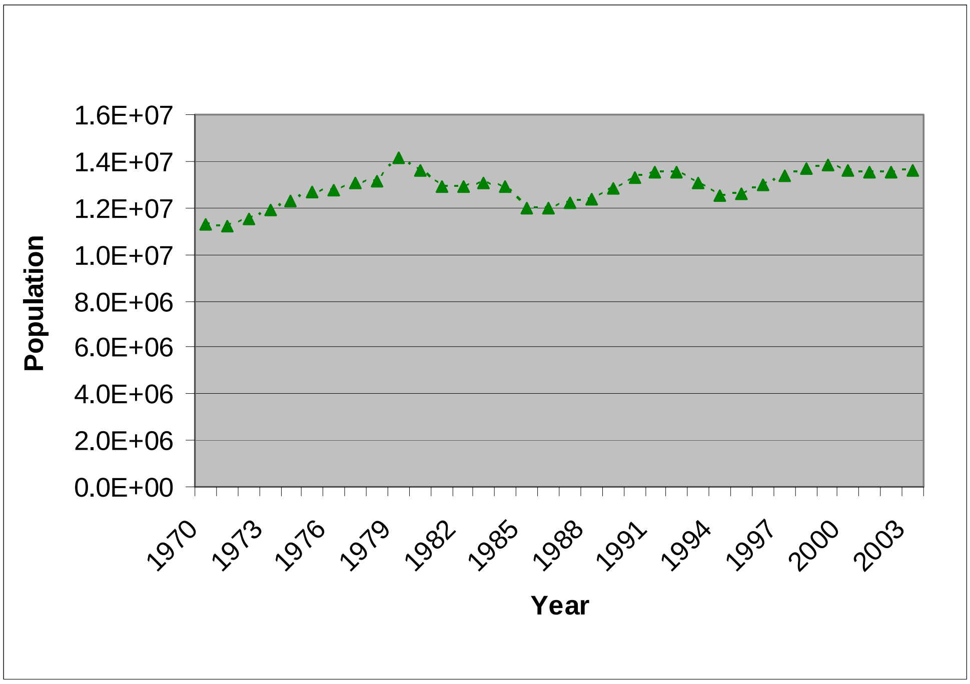


**Figure 3.1.3: South Africa's Cattle Population (Source: FAOSTAT, 2004).**

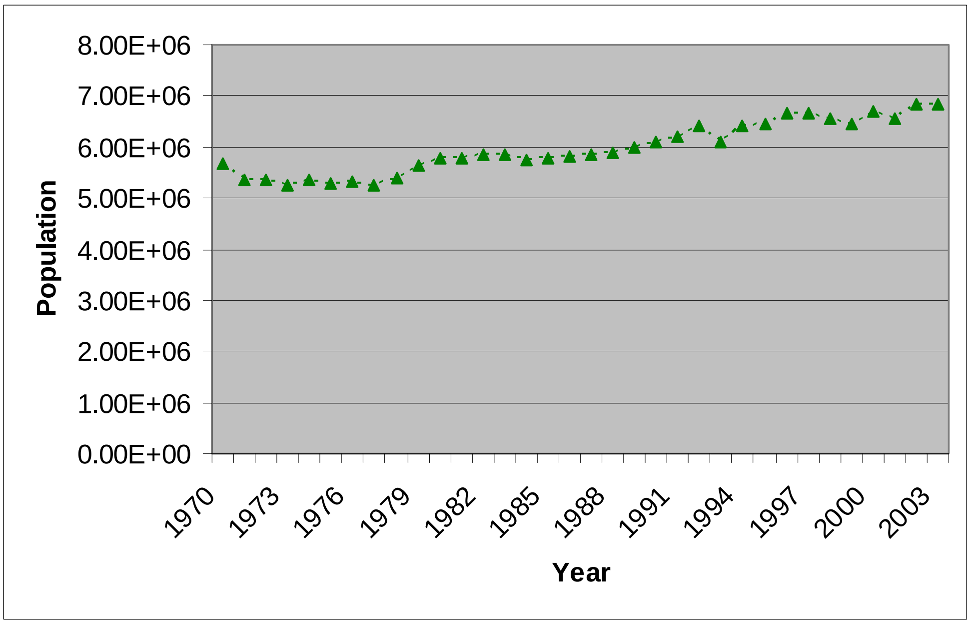


**Figure 3.1.4: South Africa's Goat Population (Source: FAOSTAT, 2004).**

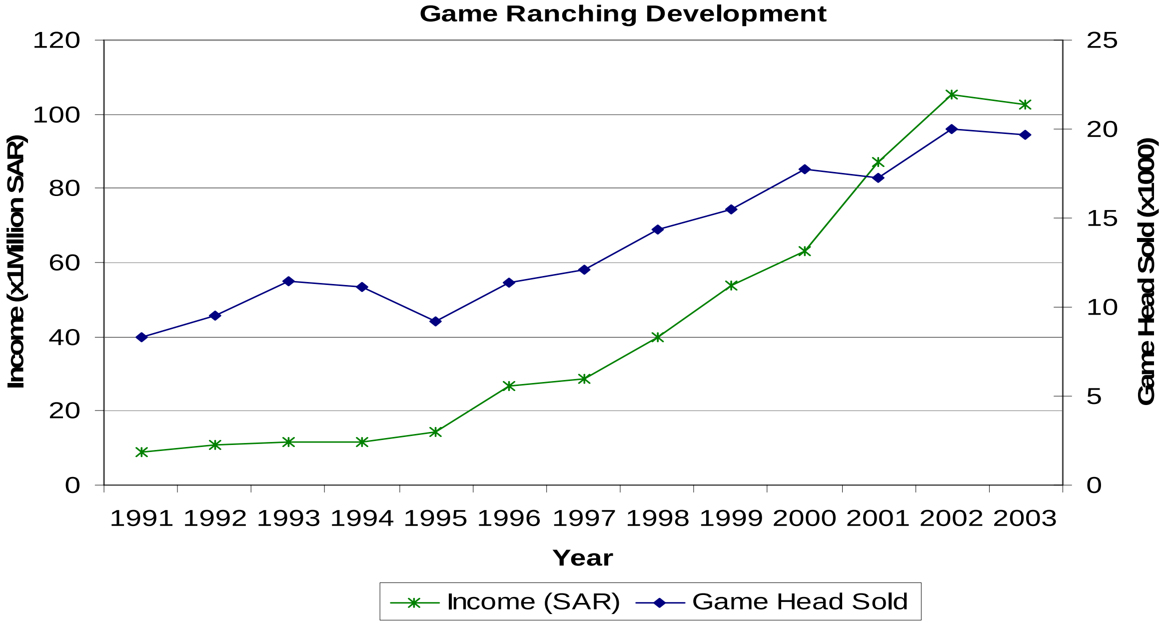


**Figure 3.1.5: Game Ranching Development in South Africa (Source: Hachileka, 2006).**

Most of this area is covered by Arensols derived from Kalahari sands. They generally have a very coarse texture and hence a very high permeability, low water holding capacity and poor fertility. They are consequently not considered suitable for arable use. The extensive land degradation including wind and water erosion and bush encroachment, particularly in the former apartheid "homelands" and communal lands, is generally attributed to overstocking and burning the veld too frequently, and/or too early or too late in the season Garland et al., (1999).

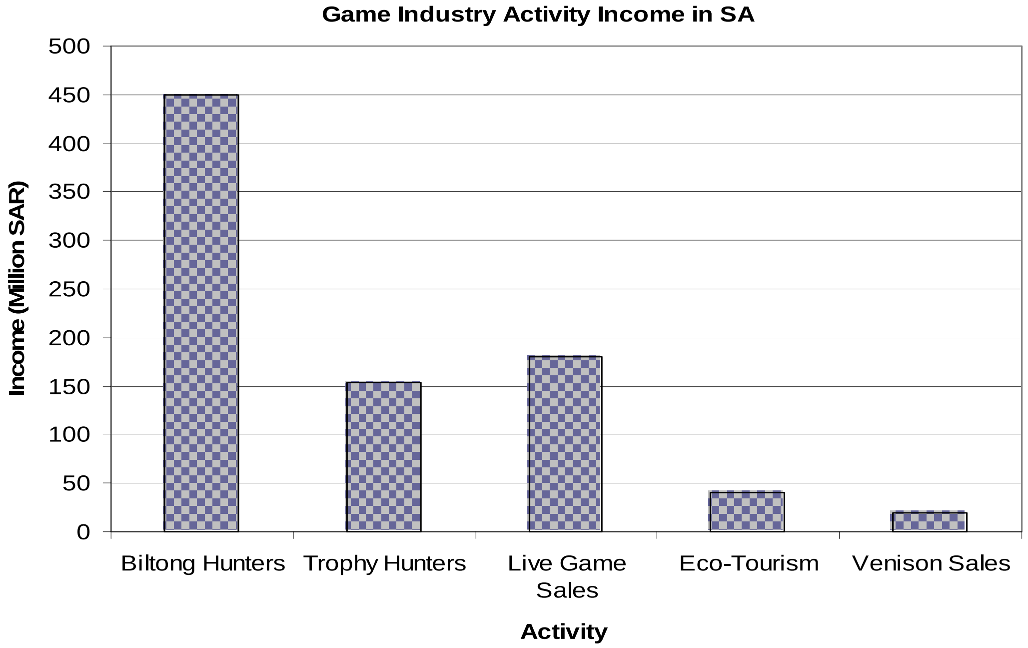


**Figure 3.1.6: Game Industry Activity Income in South Africa (Source: Hachileka, 2006).**

Most of this area between Kroonstad and Uniondale is covered by Arensols derived from Kalahari sands. They generally have a very coarse texture and hence a very high permeability, low water holding capacity and poor fertility. They are consequently not considered suitable for arable use. The extensive land degradation including wind and water erosion and bush encroachment, particularly in the former apartheid “homelands” and communal lands, is generally attributed to overstocking and burning the veld too frequently, and/or too early or too late in the season (Garland et al., 1999).

### 3.2 Traditional Energy Use and Impacts

In 2002, South Africa consumed 12 000 000 $m^3$ of wood fuel (FAOSTAT, 2006). All of this was used in the domestic sector (Batidzirai, 2006), and is equivalent to 0.27 $m^3$ per capita (FAOSTAT, 2006). In the same year 41 000 tonnes of wood charcoal was consumed equivalent to 0.91 $m^3$ per capita (FAOSTAT, 2006). The proportions of this charcoal used by the domestic, commercial and industrial sectors were 31.7, 23.2 and 45.1 percent, respectively (Batidzirai, 2006). According to United Nations Energy Statistics Yearbook for 2002 cited by Johnson and Rosillo-Calle (2007), South Africa has a sizeable international export market for charcoal.

Fuelwood in South Africa is used by households for cooking, heating, lighting, making bricks and brewing beer. Except where trees are scarce, 80 – 99% of rural households use fuelwood to meet their energy needs. Individual members of such households use an average of 687 kg per annum. The gross annual direct use value of fuelwood to rural households averages about EU 222. Many families supplement their income by selling fuelwood. In the Bushbuckridge area of Limpopo province up to half of village households trade in fuelwood. Thriving markets exist in rural areas in close proximity to towns as well as peri-urban areas. Indigenous species particularly of *Acacia* and *Combretum*, are preferred over exotic species. Hard woods are preferred because their coals last longer, yield more heat, and emit less smoke. If there is an abundant supply of wood, dry wood particularly from preferred is collected. As the resource becomes increasing less abundant, dry wood from less favoured species is collected. Where wood is scarce, dry wood from taboo species is collected and live trees are cut (Shackleton et al., 2004). Particularly in areas where wood is scarce, extensive use is made of both animal dung and crop residues. Literature reviewed by the work task leader to date, describe case studies from which it is difficult to extrapolate meaningful statistics and trends because there is no standardisation in the methodologies employed.

While most wood is obtained from surrounding forests, woodlands, commercial plantations and woodlots, South Africa’s Working for Water Programme is becoming an increasing source of wood for both fuelwood and charcoal. The Programme is committed to eradicating invasive alien plant species that collectively cover about 8% of the surface area of the country in order to (a) restore the production and flow of water in catchments and rivers respectively, (b) safeguard biodiversity, and (c) generate employment particularly for rural dwellers.

Watson (2002) notes numerous reports from areas scattered throughout South Africa’s arid and semi-arid savanna woodlands of communities claiming that (a) the availability of most resources had recently declined; (b) preferred fuel, building, craft and medicinal species are locally extinct; (c) they expend more effort acquiring smaller quantities of less preferred species; (d) men are more involved in collection; (e) they have reduced the number of meals they cook, switched to fast cooking but less nutritious foods, and/or to burning cow dung; (f) they ignore cultural taboos regarding the harvesting of valuable fruit and medicinal species, and (g) they poach resources from freehold and/or state land. She concluded that while depletion of resources in areas localized around rural villages is becoming more frequent, very extensive depletion is only occurs in the Bushbuckridge area of Limpopo province, elsewhere resources in the savanna woodlands are still abundant. Twine (2002) describes the tear gas, arrests and vehicle impoundment measures resorted to by police in South Africa's Bushbuckridge area to evict fuel wood poachers from private land.

### 3.3 Modern Bioenergy use and potential

The principal potential bioenergy crops in South Africa are sugar cane, sweet sorghum, jatropha, maize, soybeans, and sunflowers. Marrison and Larson (1995 cited by Batidzirai, 2006) estimated that 10,157,000 ha of an energy crop in a marginal region of the country receiving a mean annual precipitation of 482 mm would yield 6.6 dry tonnes per ha per annum with an energy production of 1346 PJ per annum.

### 3.3.1 Sugar Cane

The areas under sugar cane and similar tall grass biomass or potentially suitable for them in southern Africa according to the IGBP/IHDP (1995) 1 $km^2$ resolution data are shown in black in Figure 3.3.1.1, below.

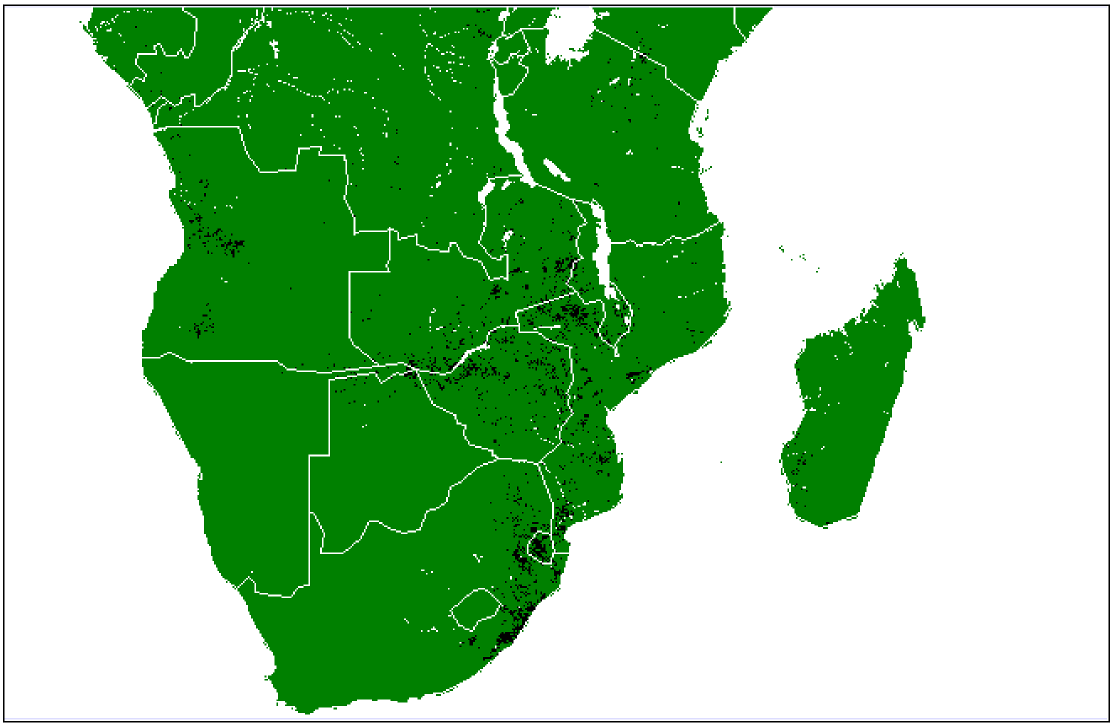

**Figure 3.3.1.1: Areas in southern Africa potentially suitable for sugarcane production shaded black. Derived from IGBP/IHDP (1995).**

In 2005 the South African Sugar Research Institute was mandated by the country's sugar cane growers and millers associations to assess what needs to be put in place for other potential by-products of the crop including ethanol and electricity, to become commercially viable. There has already been earnest work into high biomass varieties, feedstock/transportation/mill scenario modelling, enabling policy negotiations etc. Perhaps it would therefore be more appropriate to categorize the sugar cane surface in the vicinity of Komatipoort noted above, as suitable for bioenergy production. In 2004, South Africa produced 20,419 thousand tons of sugar cane harvested from 326,000 hectares (Johnson and Matsika, 2006). The vast majority of it is grown in the humid coastal zone and coastal hinterland of KwaZulu Natal province and the northern Eastern Cape province, outside the climatic regions focused on in this COMPETE project. Using climate data with a 2 $km^2$ resolution for South Africa, Schulze *et al*. (1997) produced the map shown in Figure 3.3.1.2 below.

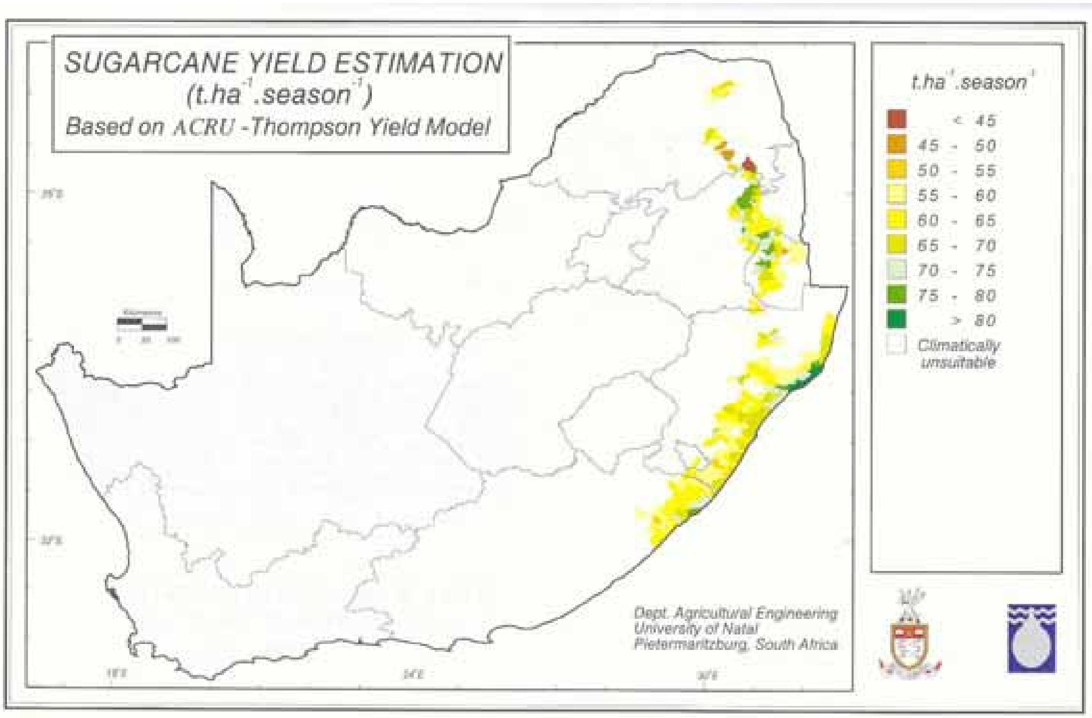


**Figure 3.3.1.2: Estimation of sugar cane yield in South Africa (Source: Schulze *et al*., 1997).**

Optimal growth of sugar cane under rain fed conditions, occurs where the mean annual rainfall ranges between 1200 and 1500 mm. The crop requires a moist soil to germinate or to produce a ratoon. Its water requirement increases until it fully covers the ground then stabilizes through the rest of the rapid growth phase. Drought during this period reduces biomass. However, water stress during the crop's ripening phase arrests vegetative growth and encourages sucrose accumulation in the stalks. Irrigation is essential where the mean annual rainfall is less than 800 mm (Watson et al., 2007). Most the areas climatically suitable for the crop, are already under it. The potential to increase the area under sugarcane in South Africa was assessed by Garland and Watson (2003) based on the proportion of arable land currently under the crop, the land reform and climatic change context, and the potential effect of such expansion on food crops, veld products and irrigation.

They concluded that the potential for medium to large scale and irrigated plantings in South Africa is limited. Although the arable land area has remained about the same since 1995 (refer Figure 3.3.1.3), the area under irrigation increased rapidly in the late 1990's (refer Figure 3.3.1.4). With recent water legislation imposing very stringent conditions for irrigation in anticipation of climate change diminishing the already scarce water resources, unless dry condition varieties are developed, sugar cane is unlikely to be a significant bioenergy feedstock in the country's arid and semi arid regions.

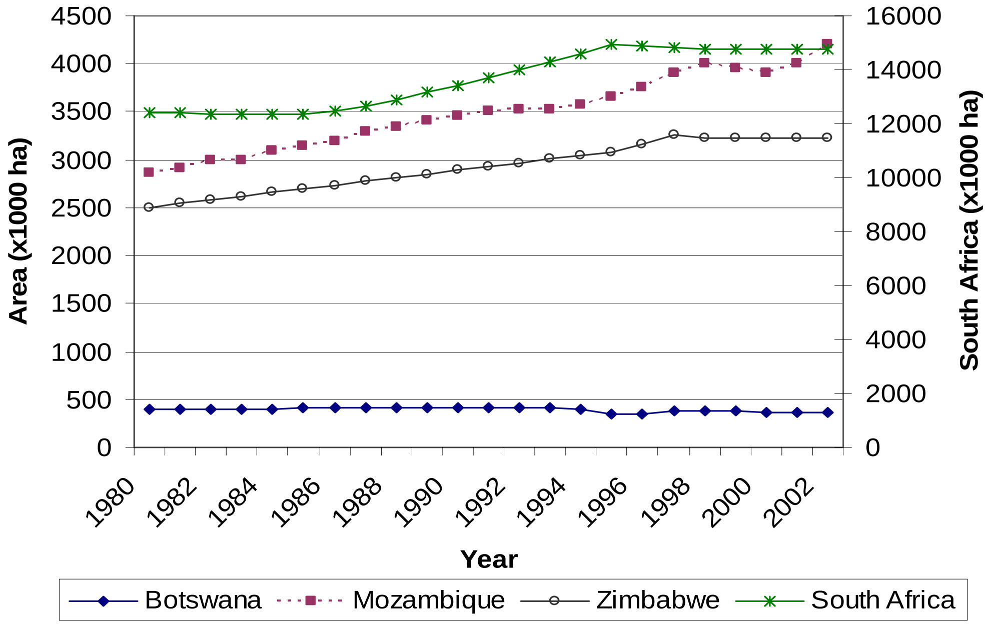


**Figure 3.3.1.3: Arable land area in South Africa and neighbouring countries (Source: Sekhwela et al., 2006).**

Sugar cane bagasse is currently used to heat mill boilers and to generate 400 MW of electricity. The electricity is used by the mill and compound, and "wheeled" to other mills. It is not supplied to the national grid. Deepchand (2000, cited by Batidzirai, 2007) estimated that the country's sugar cane production has the capacity to produce 1,146.5 MW continuous power at 50 kWh/TC, 1834.4 firm power at 44 bars & 80 kWh/TC, and 2522.3 firm power at 82 bars & 110 kWh/TC. According to IEA (2004, cited by Batidzirai, 2007), South Africa distils 126,000 tonnes of ethanol from sugar cane annually which is destined for industrial and pharmaceutical markets.

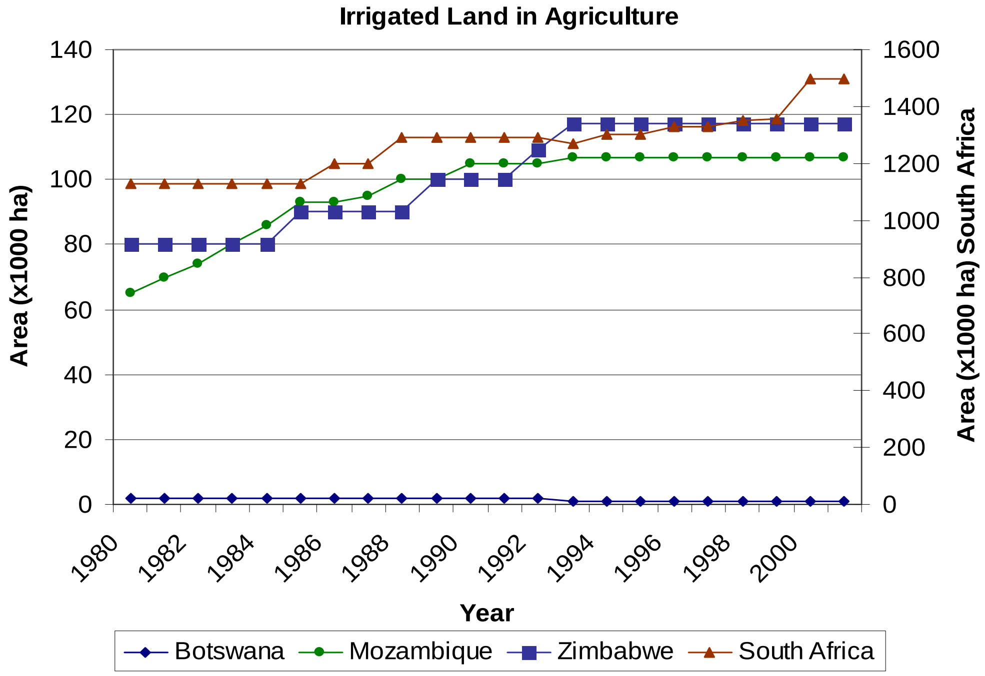


**Figure 3.3.1.4: Area under irrigation in South Africa and neighbouring countries (Source: Sekhwela et al., 2006)**

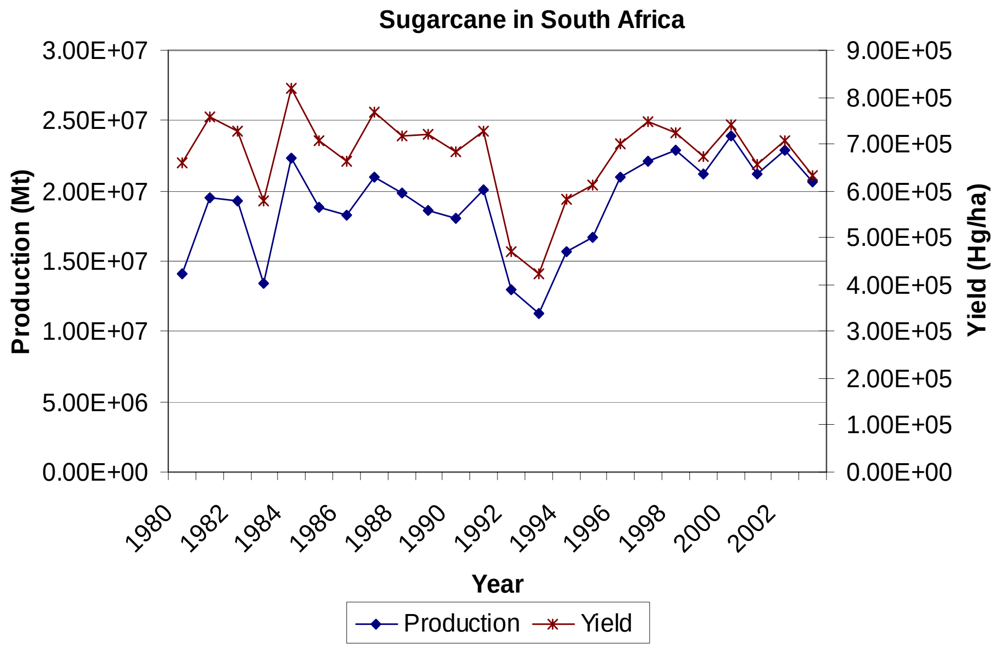


**Figure 3.3.1.5: Sugar cane yield and production in South Africa since 1980 (Source: FAOSTAT, 2004).**

### 3.3.2 Sweet Sorghum

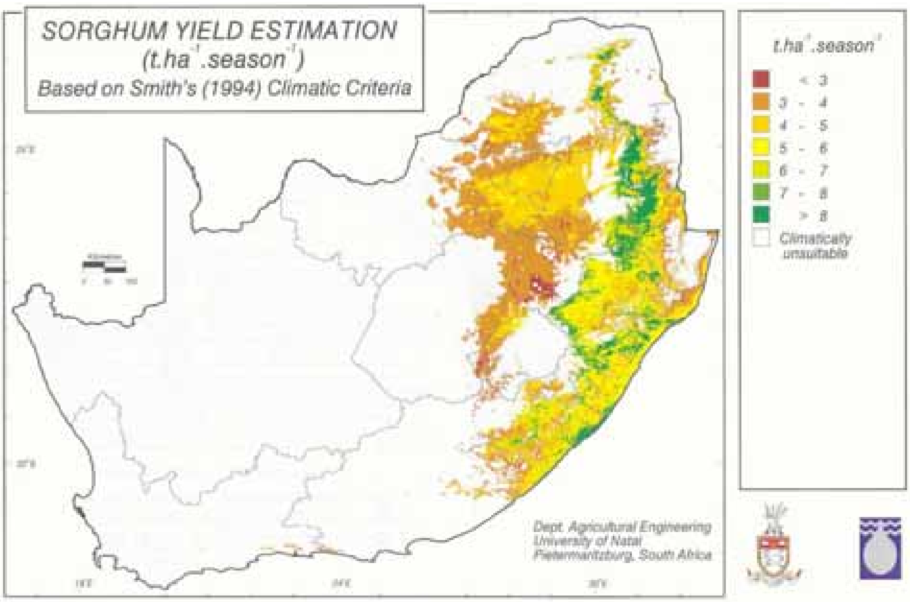


**Figure 3.3.2.1: Areas in South Africa climatically suitable for sweet sorghum production (Schulze *et al*. 1997).**

Using climate data with a 2 $km^2$ resolution for South Africa, Schulze *et al*. (1997) produced Figure 3.3.2.1 shown above. Although this map suggests that sweet sorghum production is not viable in most of the western and central areas of COMPETE's arid and semi arid focus regions, it can be produced in the northern reaches of North West and Free State provinces, and throughout Gauteng. High yields are possible in the lowveld of both Mpumalanga and Limpopo provinces. It is widely grown by small scale and subsistence farmers for food and for distilling alcohol for drinking. Trails to assess its bioenergy potential commenced in the Eastern Cape in 2007.

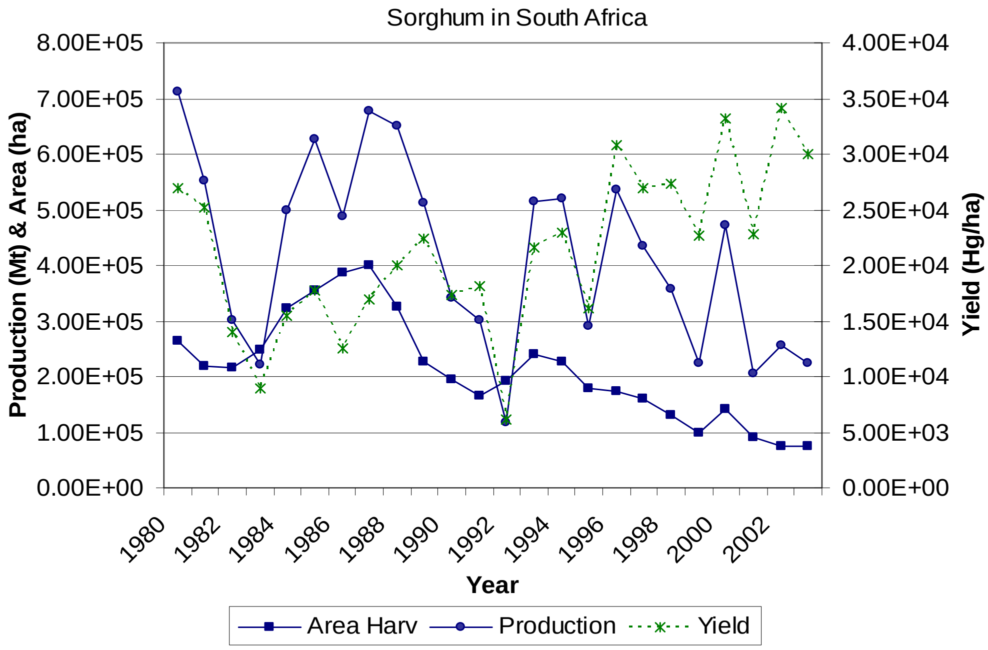


**Figure 3.3.2.2: Sweet sorghum yield and production in South Africa since 1980 (Source: FAOSTAT, 2004).**

### 3.3.3 Jatropha

By 2004, 400 million *Jatropha curcas* trees were planted on 45,000 ha in North West Province, and D1 Oils (a U.K. biodiesel company) had planted 150,000 ha. The Government then called on a moratorium on further commercial planting until it was convinced that (a) the plant was not at risk of becoming an invasive alien, and (b) its toxicity does not pose an environmental and health risk. The "go ahead" to continue commercial plantings was give late in 2007. D1 Oils plans to double the area it has under the crop. In 2007 Emerald Oil International (Pty) Ltd commenced construction of a biodiesel plant in Durban with a 100,000 tons per year capacity. In addition to obtaining feedstock from South Africa, this company will source *Jatropha curcas* seeds in Zimbabwe, Zambia, Malawi and Madagascar. It has an agreement with the KwaZulu Natal Agricultural Extension to facilitate the establishment of an extensive network of Jatropha hedges (Moodley, 2007). Owen Sithole College of Agriculture has a trail project involving 100 plants (Henning, 2006).

### 3.3.4 Maize

In 2006, Ethanol Africa (with Ecofields, Grain Alcohol Investments and Sterling Waterford as key shareholders) became South Africa's first bioethanol producer using surplus maize. Due to increased and improved inputs and improved cultivars, most years the country's maize production exceeds domestic demand – a demand that includes the needs of Botswana, Lesotho, Namibia and Swaziland as part of an agreement of the long standing South African Customs Union. In December 2007, Parliament decreed that maize would no longer be used for this purpose as it was considered a staple food crop.

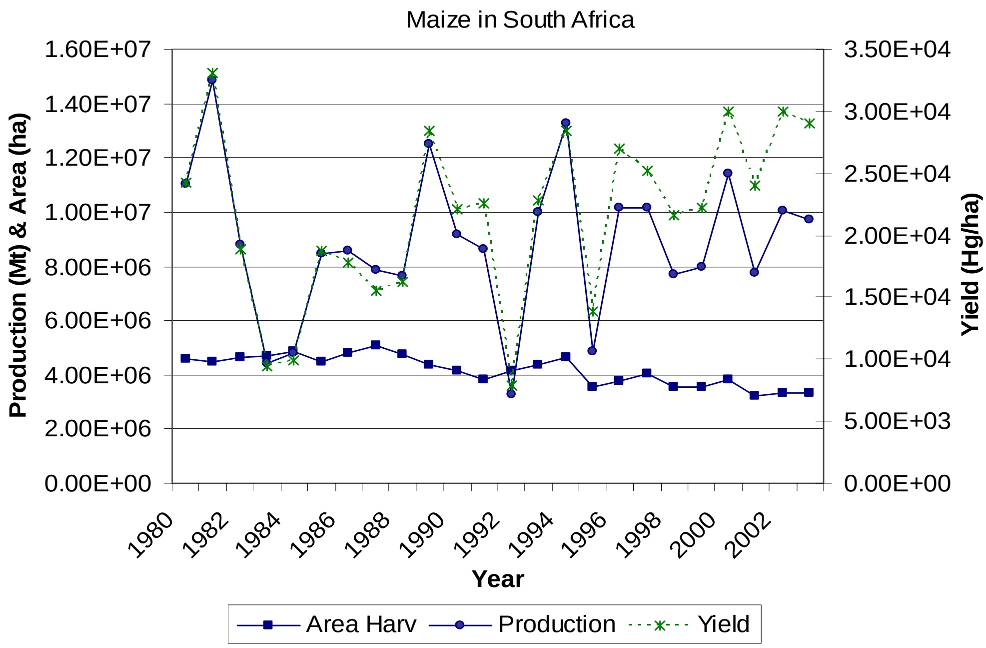


**Figure 3.3.4.1: Maize yield, production and area harvested in South Africa since 1980 (Source: FAOSTAT, 2004).**

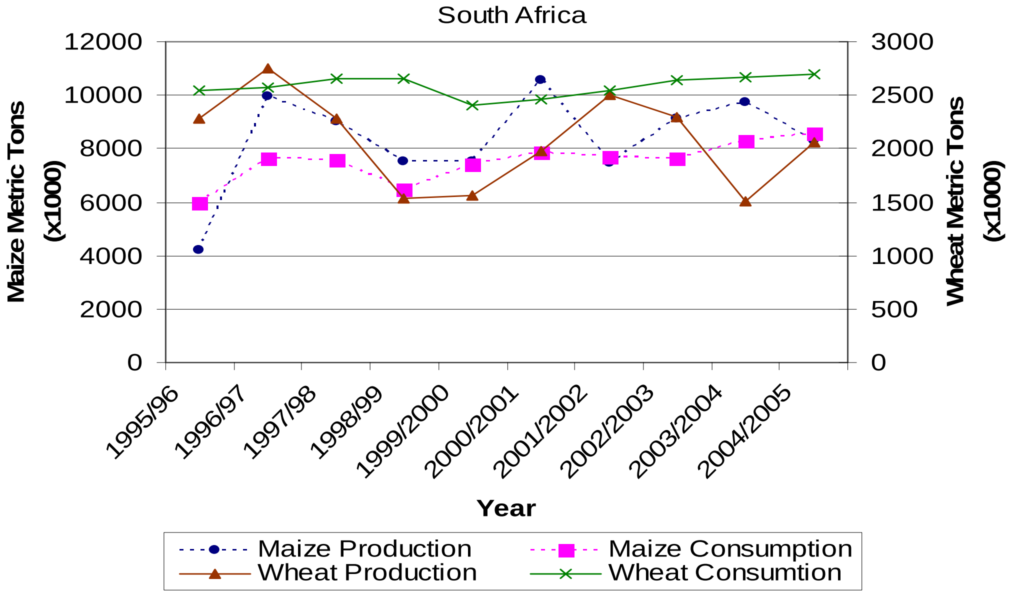


**Figure 3.3.4.2: Production and consumption of wheat and maize in South Africa (Source: Sekhwela et al., 2006).**

### 3.3.5 Other Potential Bioenergy Crops

Production from Oil Palm does not take place in South Africa. Production from Soybeans from 2000 to 2004 was 0.2 million tonnes, and from Sunflowers over the same period, 0.75 million tonnes (FAOSTAT, 2006). Cassava is not widely grown and is used for domestic consumption. No plans to harness the bioenergy potential of any of these crops are know to the leader of this work package.

### 3.3.6 Potential Indigenous Bioenergy Crops

*Pappea capensis* and *Ximenia caffra* (shown in the plates below) are trees indigenous to southern Africa. In 2006, South Africa's Department of Mineral and Energy Affairs suggested that oil from their seeds may have potential for biodiesel production. This suggestion is based on their being able to grow in arid regions and their seeds containing a lot of oil. Individual trees of both species can potentially produce up to 10 kg of seed, 65% of which can be converted into bio-oil or biodiesel. One ha of trees could supply 2400 l of oil, or 1560 l of biodiesel per year. Trees are more cost effective to cultivate than herbaceous crops, as do not need the continuous input of the latter.

The findings of an extensive literature and questionnaire survey carried out by the work package leader's postgraduate student (Sobey, 2007) are described below.

**Plate 3.3.6 a: *Pappea capensis* (Source: Van Wyk and Van Wyk, 1997).**

**Plate 3.3.6 b: *Ximenia caffra* (Source: Van Wyk and Van Wyk, 1997).**

Very little research has been done on the two species. Research into their seed's oil suggests they have some potential as a biofuel. However, no information regarding attempts to cultivate them on any significant scale, were found. *Pappea capensis* is described as being fairly easy to propagate from seed and suitable for Agroforestry. Saplings grow relatively slowly, but as the trees mature their growth rate increases. *Ximenia caffra* is easily propagated from seed and can be propagated vegetatively, but is also slow growing. The seeds of both species contain a yellow, non-drying and highly viscous oil. Exactly how viscous they are is not known.

In order to ascertain whether their oils are suitable as a biofuel, information on their properties were compared with the ranges for an ideal biofuel given by Koerbitz's (2007). No information on *Pappea capensis*'s oil was found. An oil with an iodine value of 12 is very suitable as a biofuel, while a value of 189 is highly unsuitable. The oil of *Ximenia caffra* has a satisfactory iodine value of 83. Iodine values are indicative of stability, the lower the value, the more stable and hence suitable the oil is. Iodine can also be correlated with levels of nitrogen oxides emitted when used. The lower the iodine, the less the emissions. An ideal oil should have an acid value in units of mg KOH/g less than or equal to 0.50. *Ximenia caffra*'s acid value is 2.50.

An ideal oil density is between 860-900 kg/m³ at 15°C. *Ximenia caffra* has a density of 919 kg/m³ at 25°C. In general density decreases with increasing temperature.Therefore, it is anticipated that at 15°C, the oil of *Ximenia caffra*'s oil's will be even denser. Amongst others, Koerbitz (2007) lists fatty acid structure, energy/calorific value, the cold filter plugging point, water content, cetane number, and distillation curve as criteria which need to be met if the oil is to be suitable for use as biofuel. No information on any of them for either species was found.

Literature sources have exhaustive lists of the many uses that one can obtain from the two tree species. They have edible fruits which are consumed by people, insects and animals, as well as being used in the production of alcoholic beverages, vinegar and preserves. Their wood is suitable for the manufacturing of small utensils and implements, and for use as fuel. Their leaves are used as breeding platforms for a variety of butterfly species, and they are also browsed by animals. Once harvested, none of the plant is wasted. Their leaves, roots and bark are used extensively for medicinal purposes. The oil of *Pappea capensis* is used as a purgative, in soap-making and for the oiling of rifles. The oil of *Ximenia caffra* is used mainly in the process of softening hides, as fuel for lamps, and for cosmetic purposes - even to colour and straighten hair. Its fruit has also been identified as containing high amounts of vitamin C (27%), and high potassium and protein levels.

Assuming that with the intensive further research needed, the oils of *Pappea capensis* and *Ximenia caffra* were found to be suitable for biofuel production, the decision whether to cultivate them on a large scale or to rather harvest them from the wild resource, would require an assessment of the socio-economic effects of both options. With the extensive use made of them by the rural poor, it may be preferable not to harvest the wild resource. The wild supply is unlikely to be large enough to sustain commercial venture. While cultivating them seems a better option. By giving these trees a biofuel market value, it may result in the rural poor overexploiting the wild resource for monetary gain. A survey biofuel experts regarding whether to cultivate or harvest the wild resource, was carried out. Opinions did not show marked favour for either option. Most suggested that it would make more sense to cultivate *Jatropha curcas* instead as it reaches maturity in three years and extensive experience from other African countries and in particular India, could be drawn on. With limited knowledge on *Pappea capensis* and *Ximenia caffra*, especially the properties of their seed's oils, neither cultivation nor harvesting of the wild resource should proceed. A concerted effort should be made to determine their oil properties as well as the effects cultivating them or harvesting the wild resource may have on the rural communities who have come to so heavily depend on their products.

### 3.3.7 Densification and Biomethanation

A few companies formed in the late 1990's to produce briquettes using newspapers and sawdust as feedstock. Initially they only supplied the South African barbeque market, but are now also exporting them to Europe for space heating. While the potential of a number of landfills and abattoirs has been recognized, the only landfill gas production initiative that has commenced to date, is in the Ethekwini (Greater Durban) municipality. It is estimated that it will be able to generate 10 MW of electricity for the city. Currently as a consequence of the national energy crisis, power sharing leaves designated supply areas within the city without electricity for two to four hours daily on a rotational timing basis.

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## *Appendix 1 – South Africa*

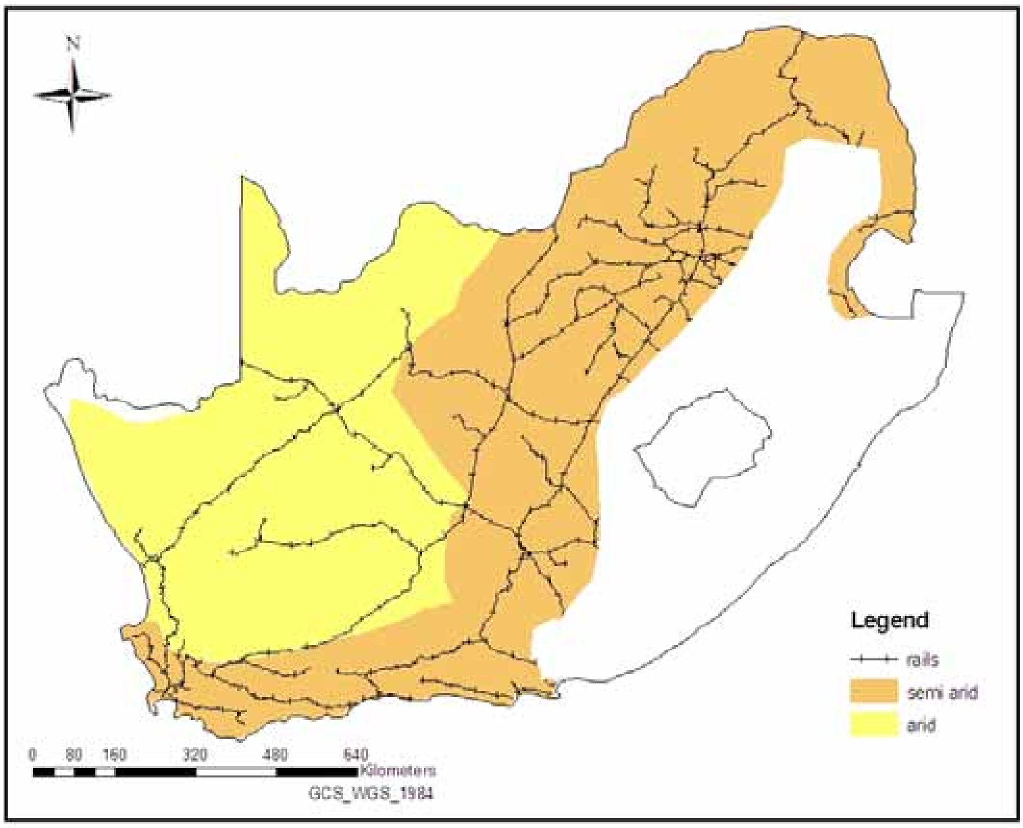



Figure SA1: Railroads in the semi arid and arid regions of South Africa

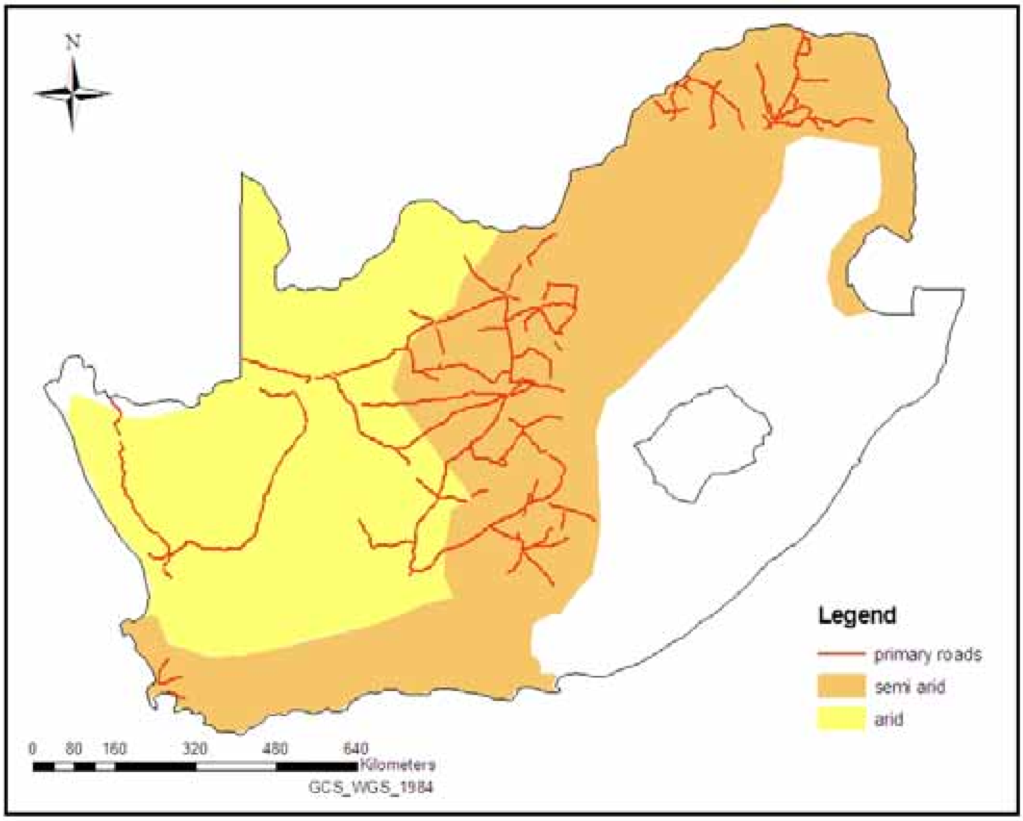



Figure SA2: Primary roads in the semi arid and arid regions of South Africa

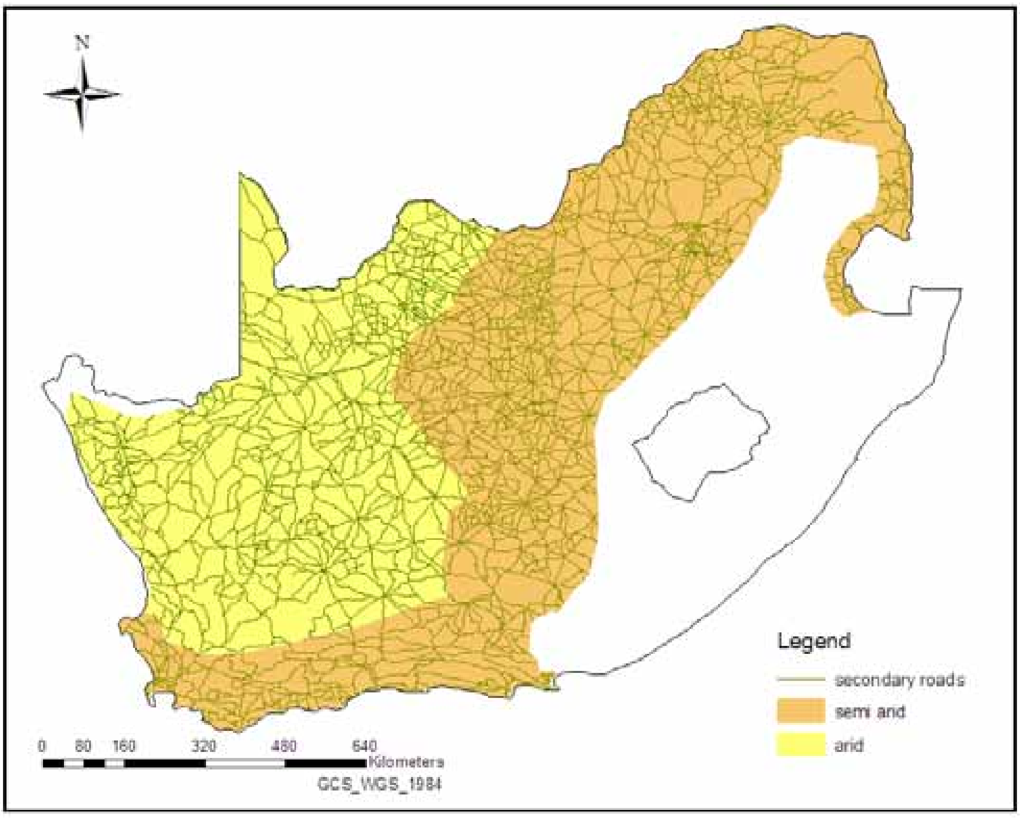



Figure SA3: Secondary roads in the semi arid and arid regions of South Africa

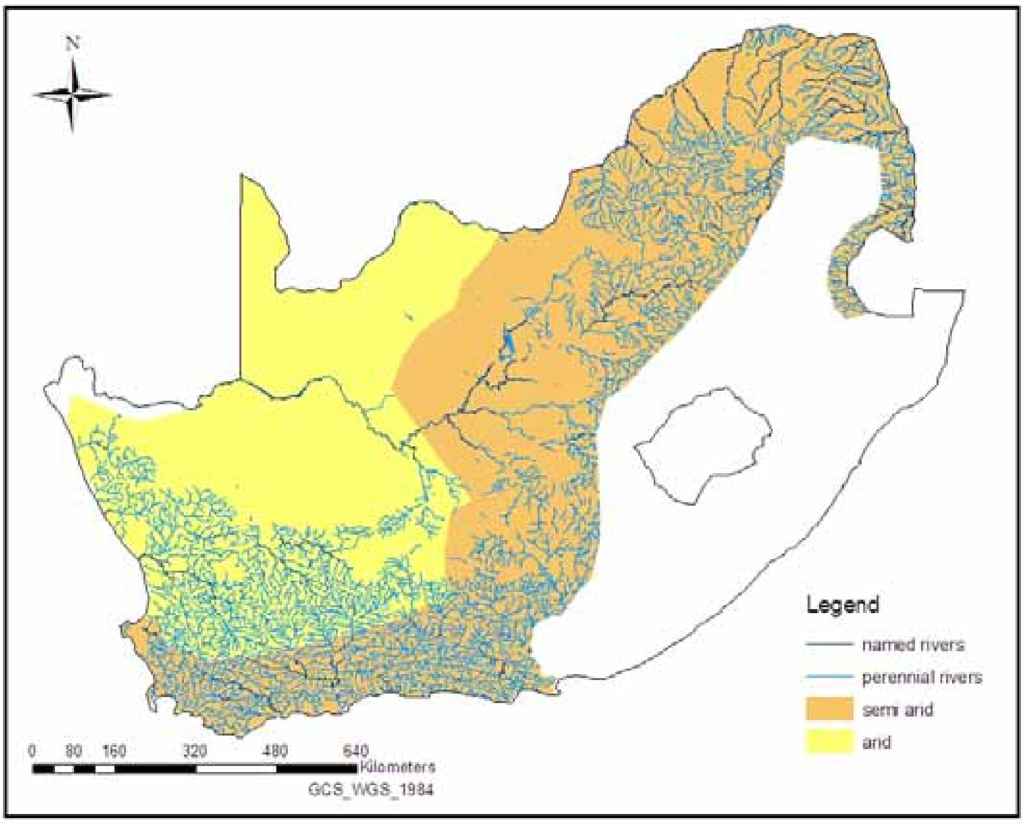



Figure SA4: Perennial rivers in the semi arid and arid regions of South Africa

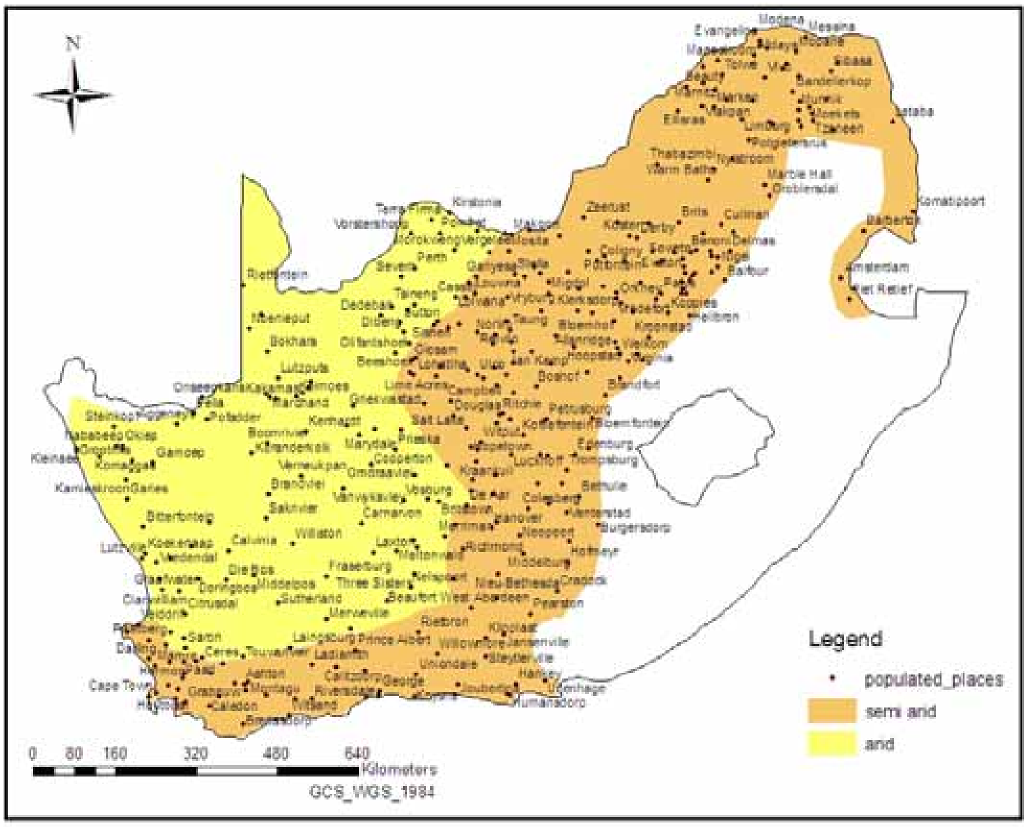



Figure SA5: Populated places in the semi arid and arid regions of South Africa

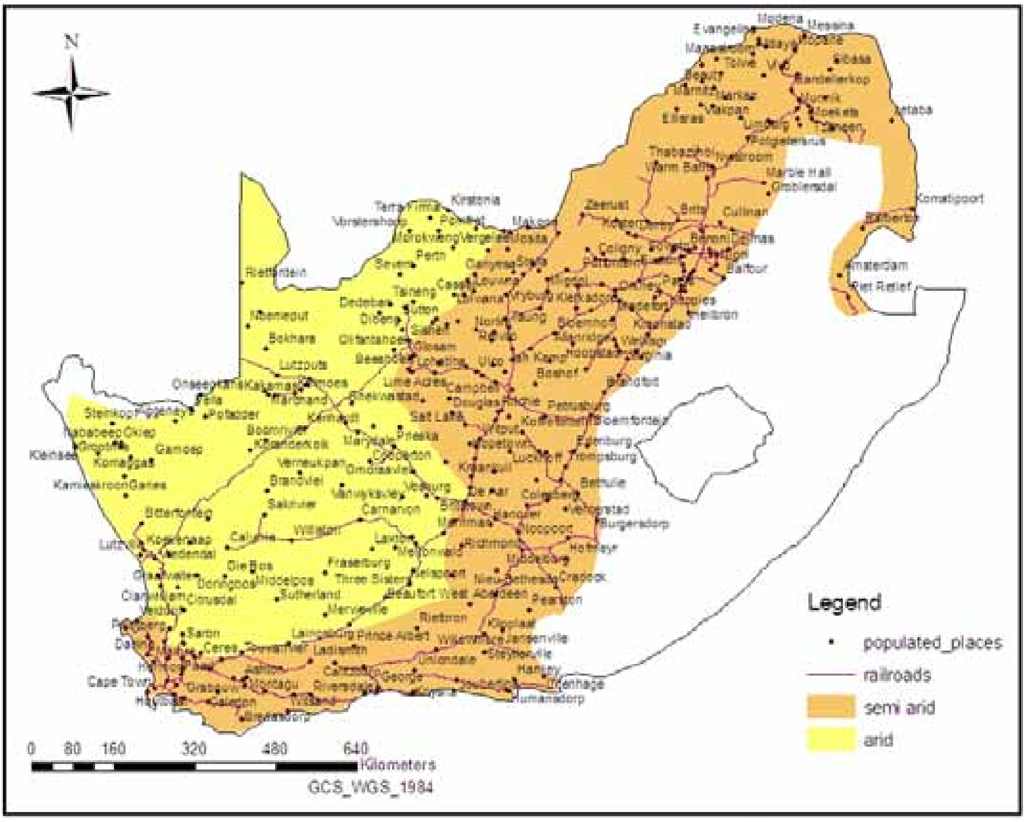



Figure SA6: Populated places in relation to railroads in South Africa's semi arid and arid regions

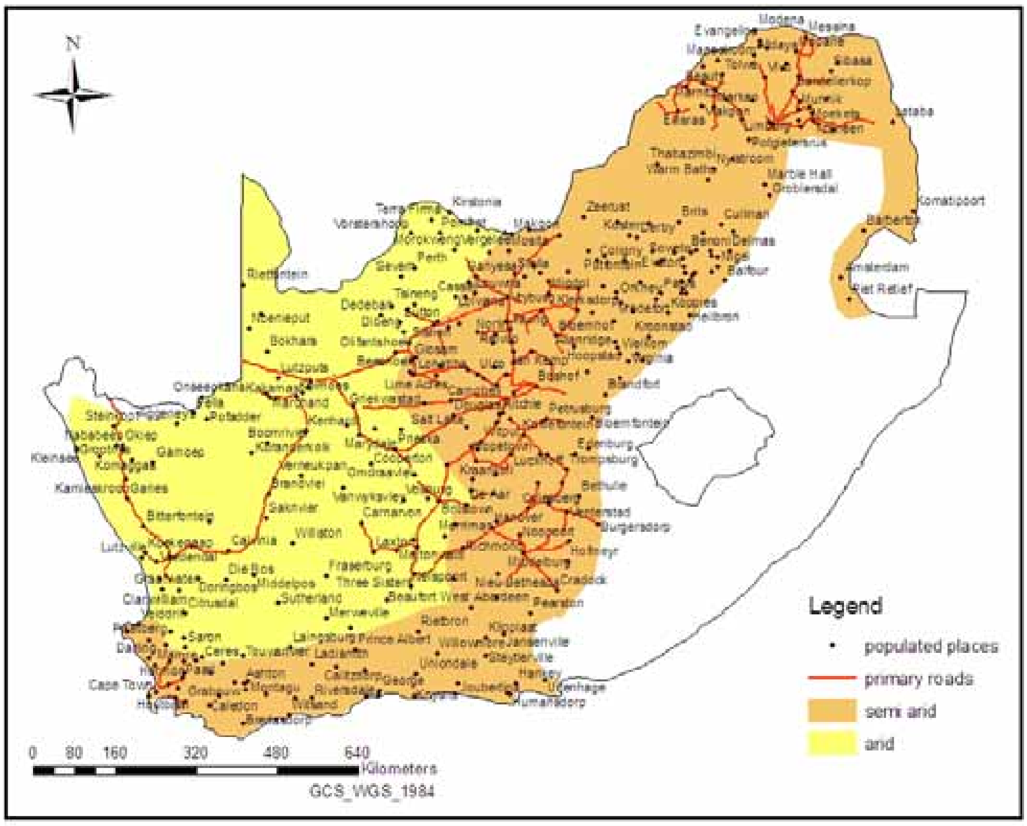



Figure SA7: Populated places in relation to primary roads in South Africa's semi arid and arid regions.

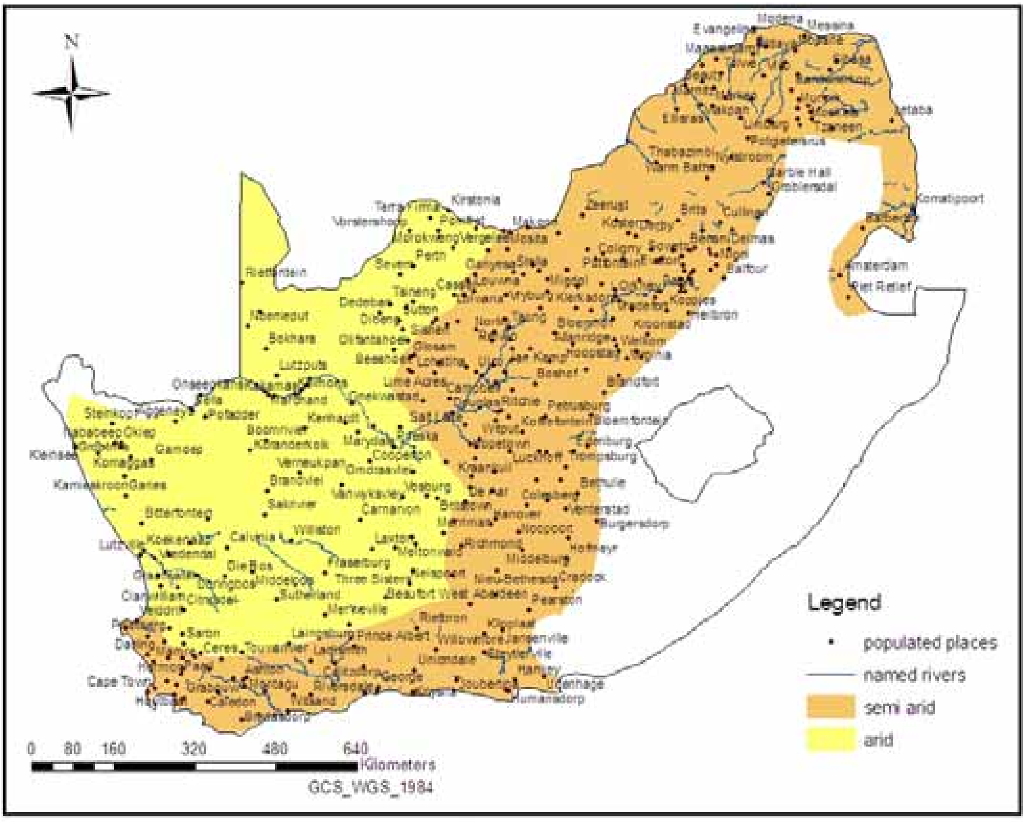



Figure SA8: Populated places in relation to named rivers in South Africa's semi arid and arid regions.

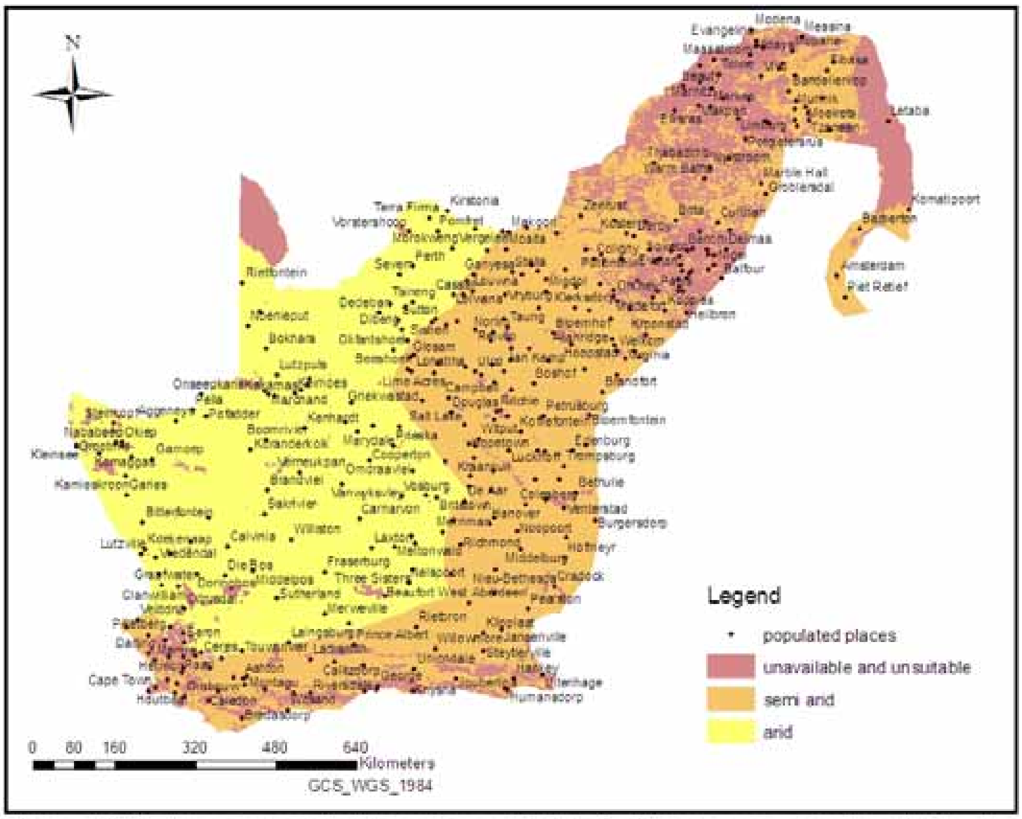



Figure SA9: Areas unavailable and unsuitable for bioenergy crops in relation to populated places in South Africa's semi arid and arid regions

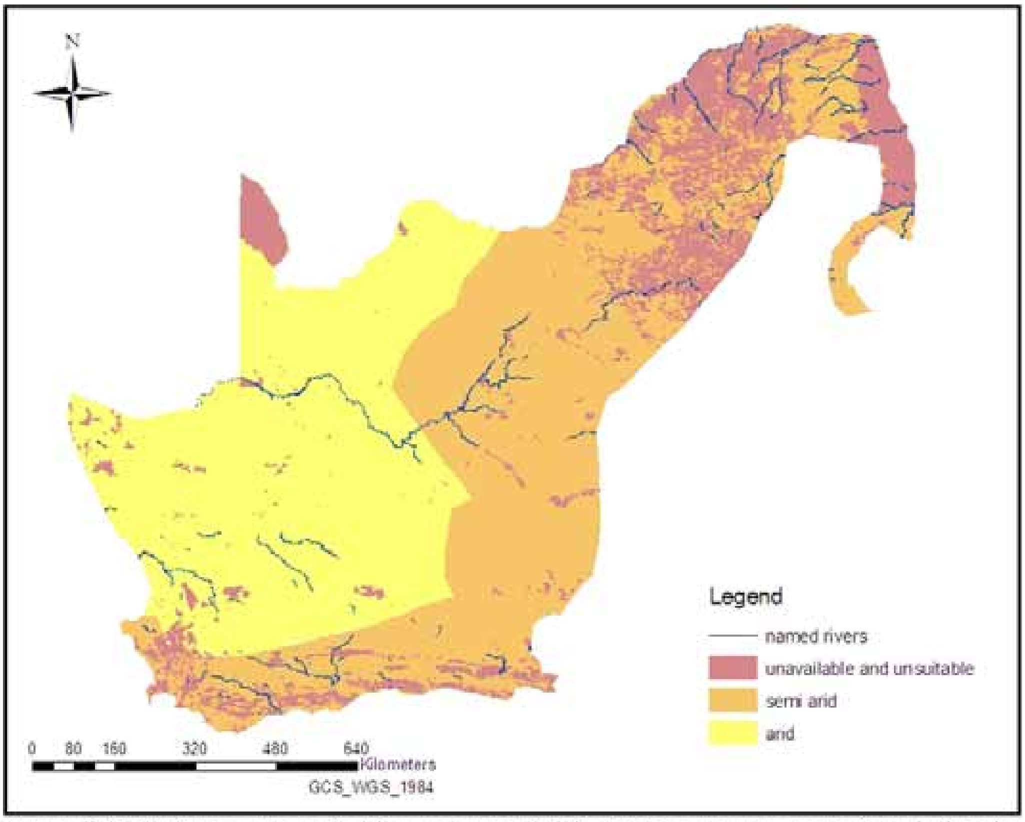



Figure SA10: Areas unavailable and unsuitable for bioenergy crops in relation to named rivers in South Africa's semi arid and arid regions

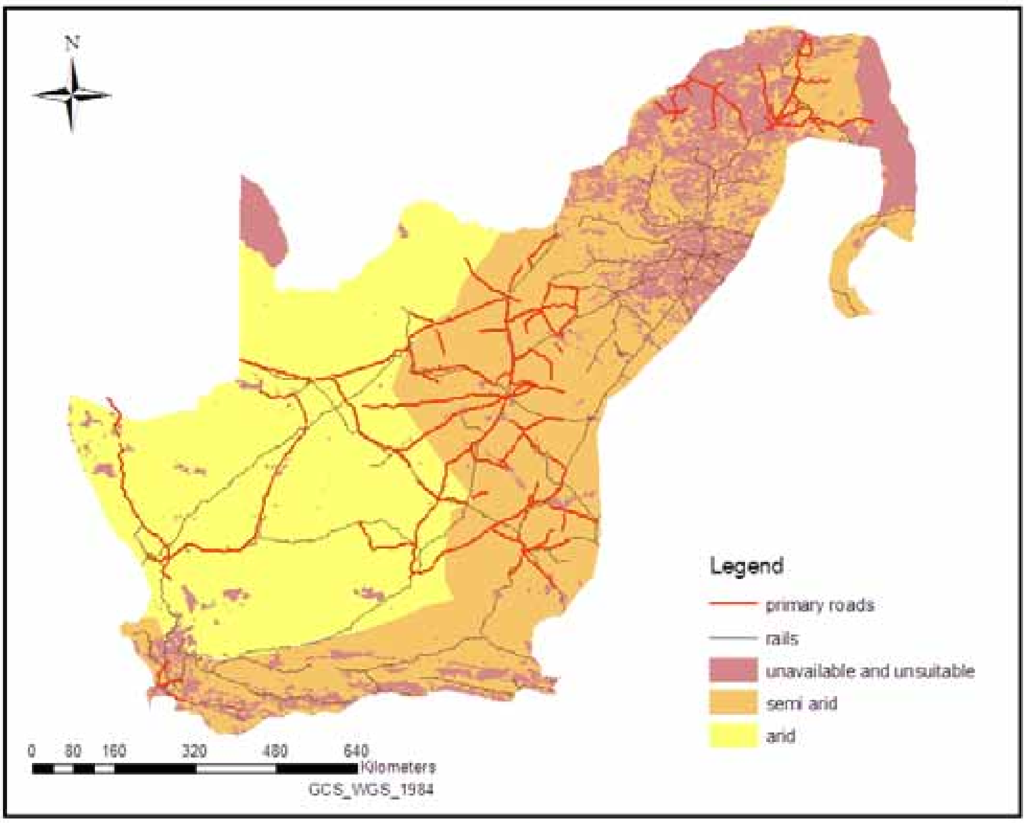



Figure SA11: Areas unavailable and unsuitable for bioenergy crops in relation to railroads and primary roads in South Africa's semi arid and arid regions

## *Appendix 2 – Botswana*

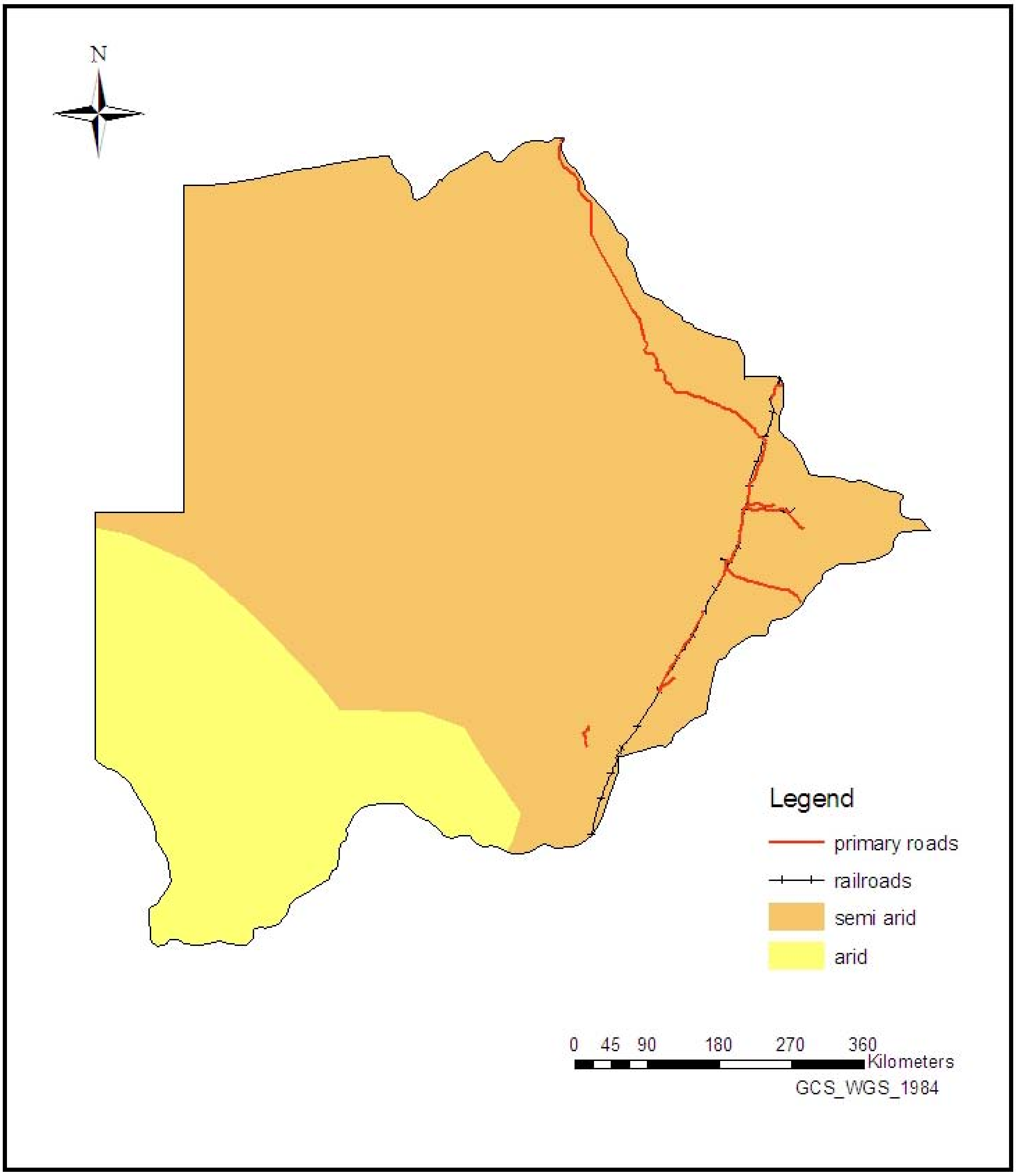



Figure B1: Railroads and primary roads in Botswana's arid and semi arid regions

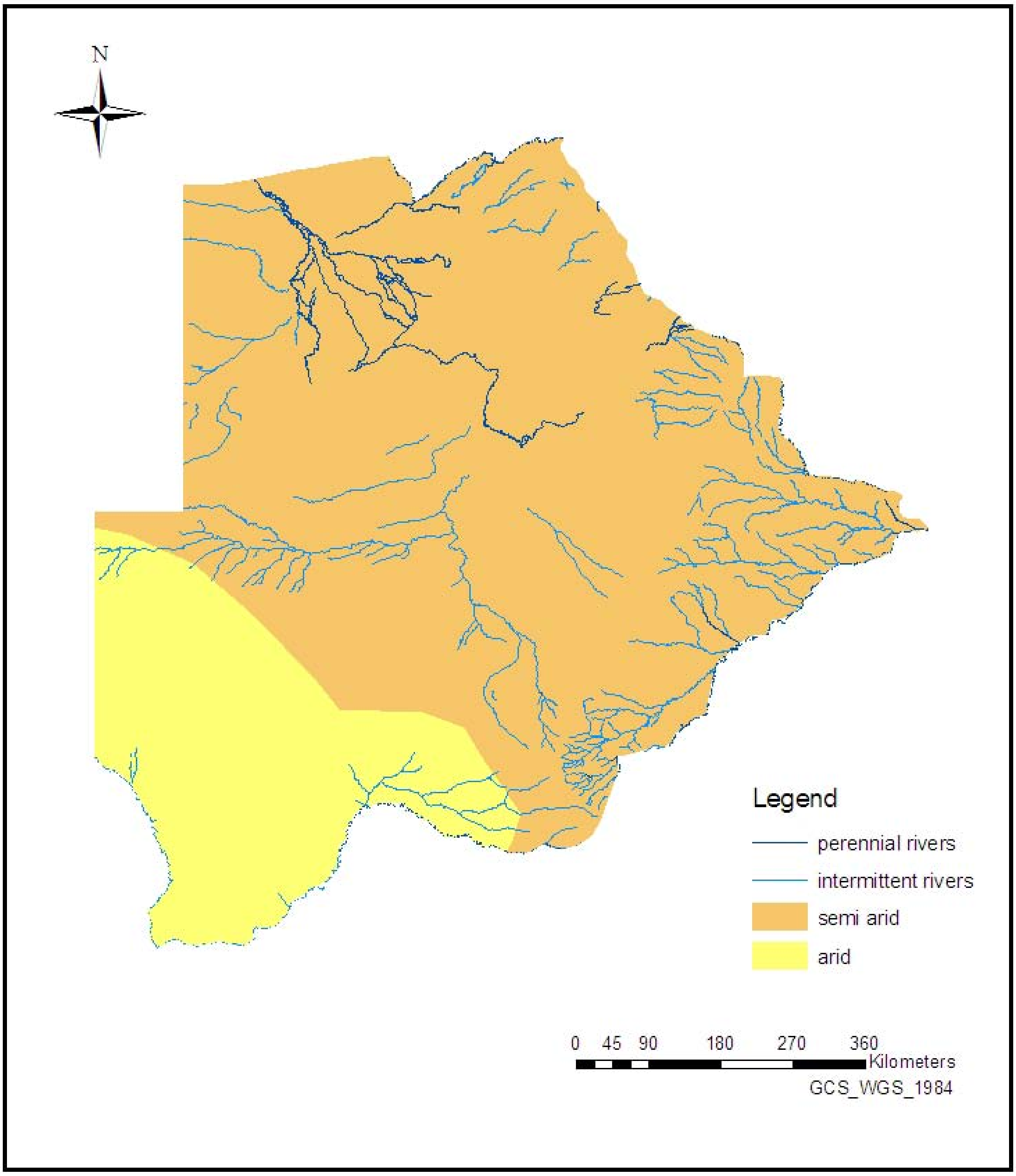



Figure B2: Perennial and intermittent rivers in Botswana's arid and semi arid regions

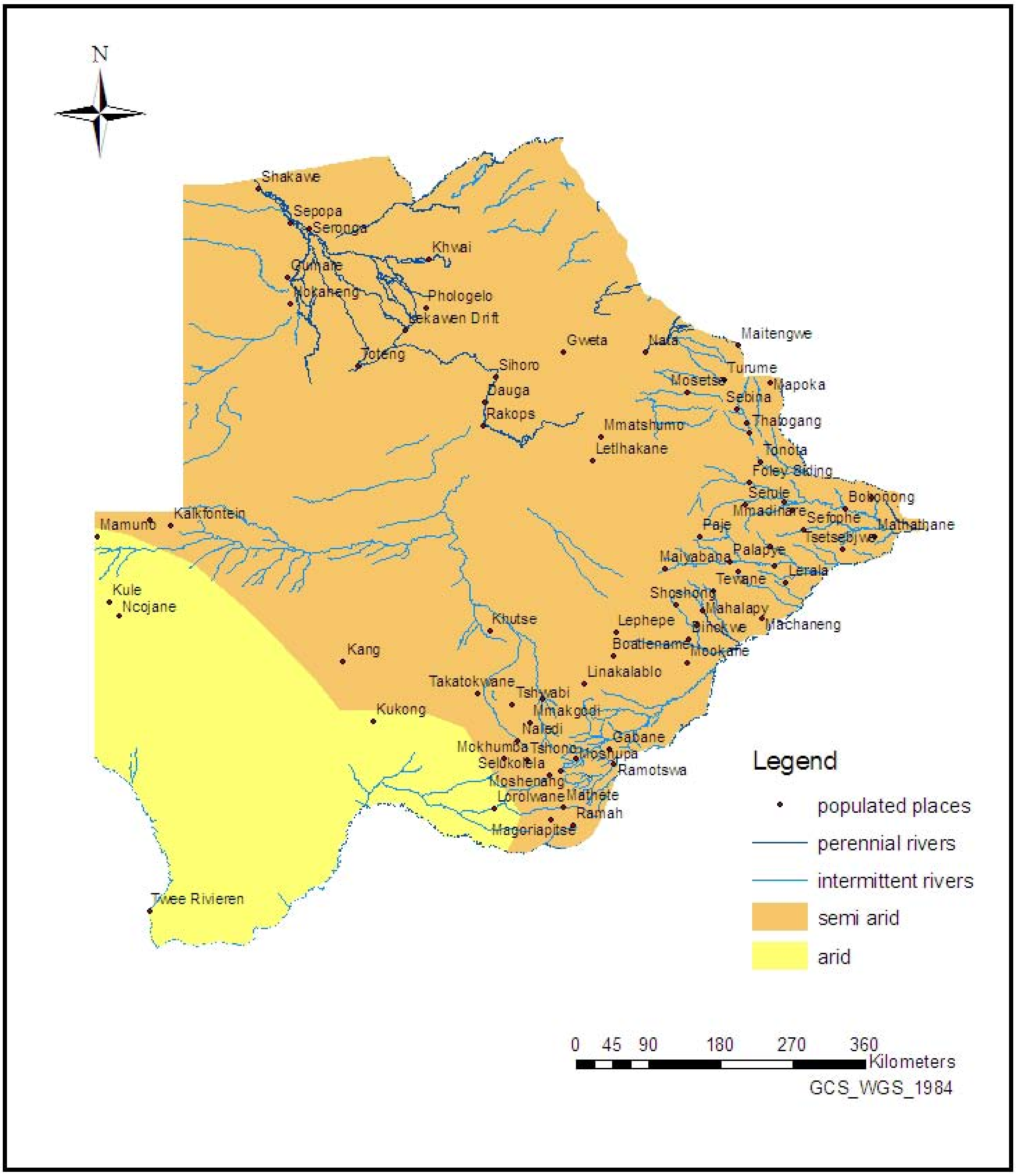



Figure B3: Populated places relative to rivers in Botswana's arid and semi arid regions

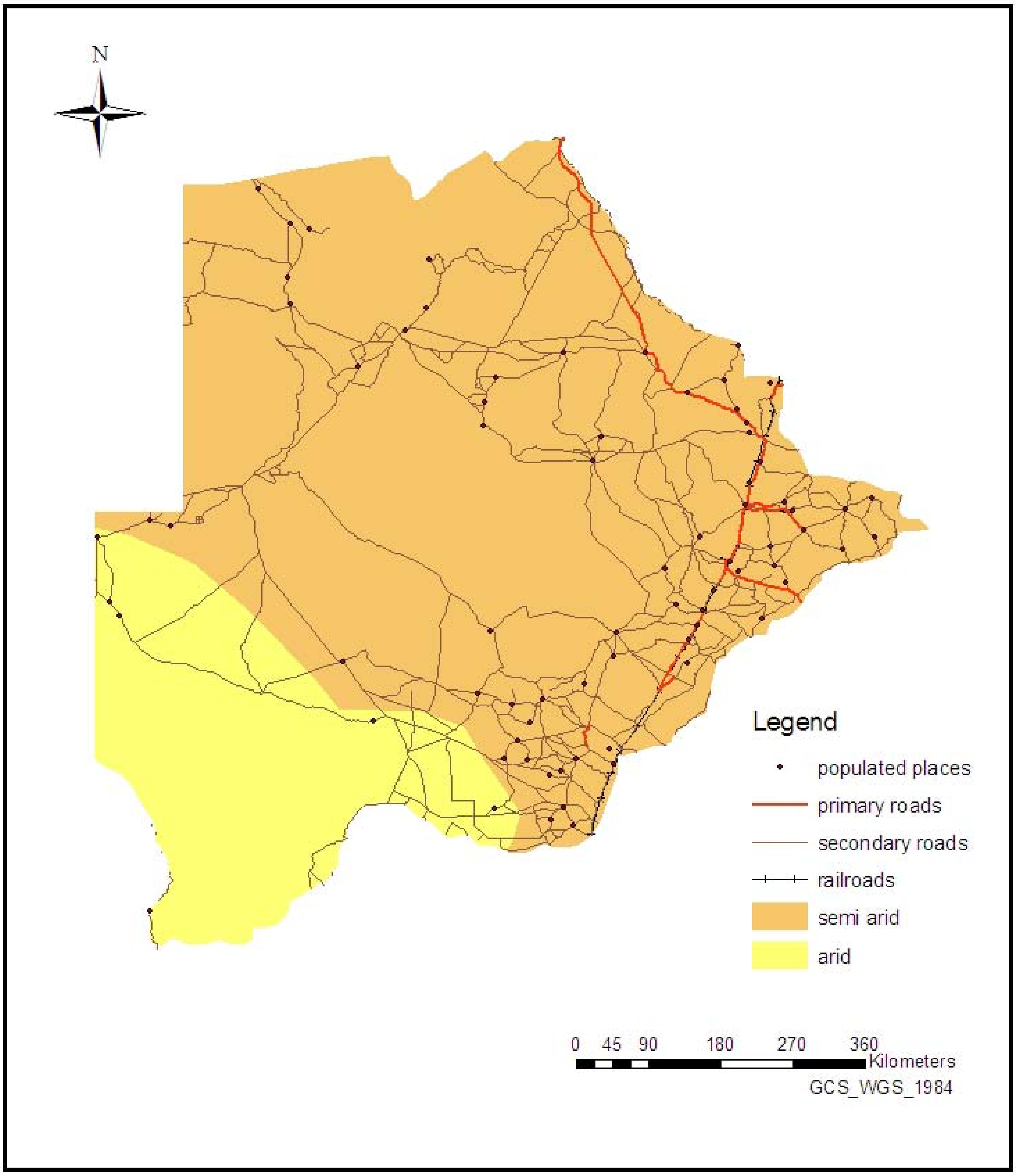



Figure B4: Populated places in relation to roads and railroads in Botswana's arid and semi arid regions

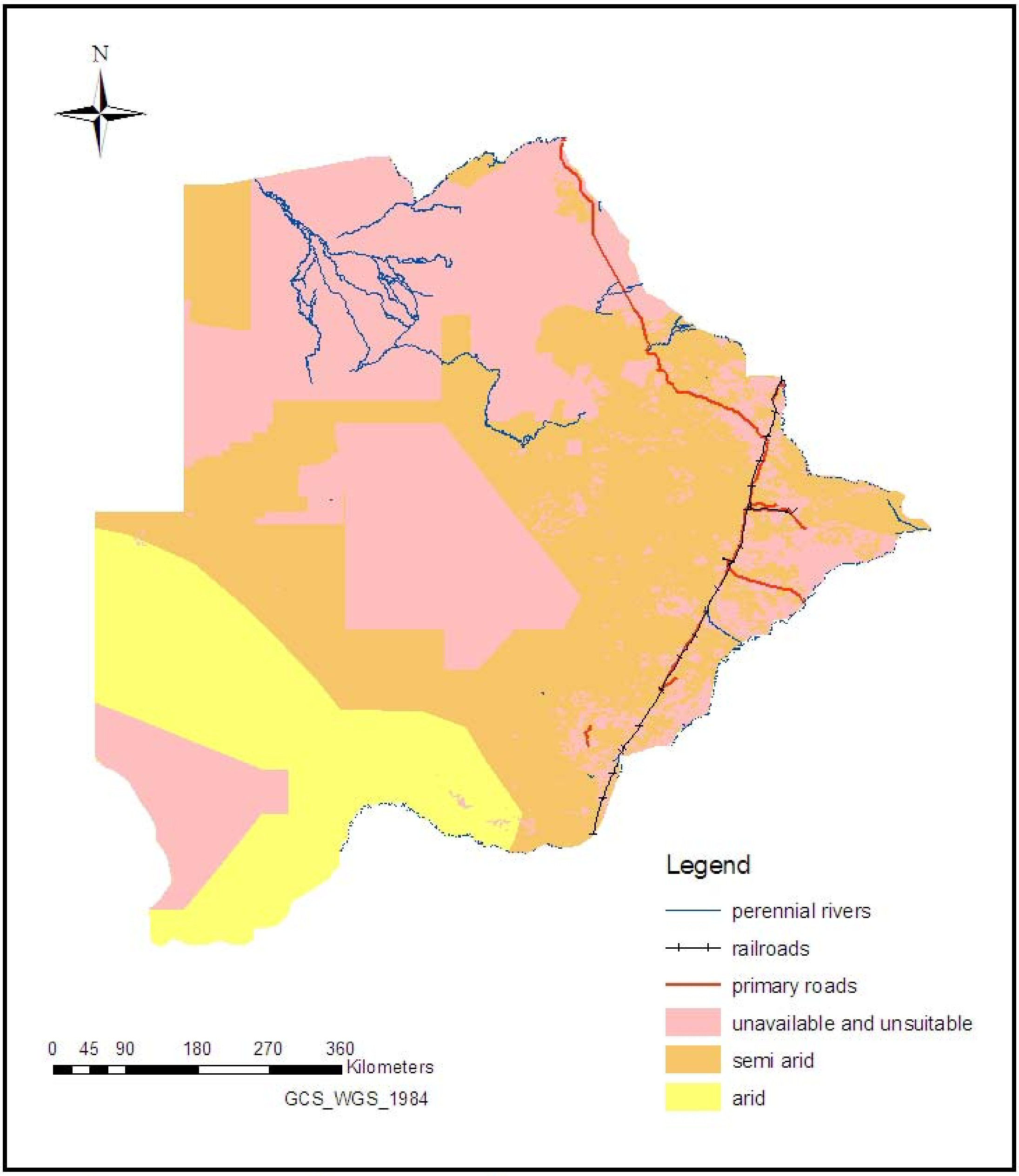



Figure B5: Areas unavailable and unsuitable for bioenergy crops in relation to roads, railroads and perrenial rivers in Botswana's arid and semi arid regions

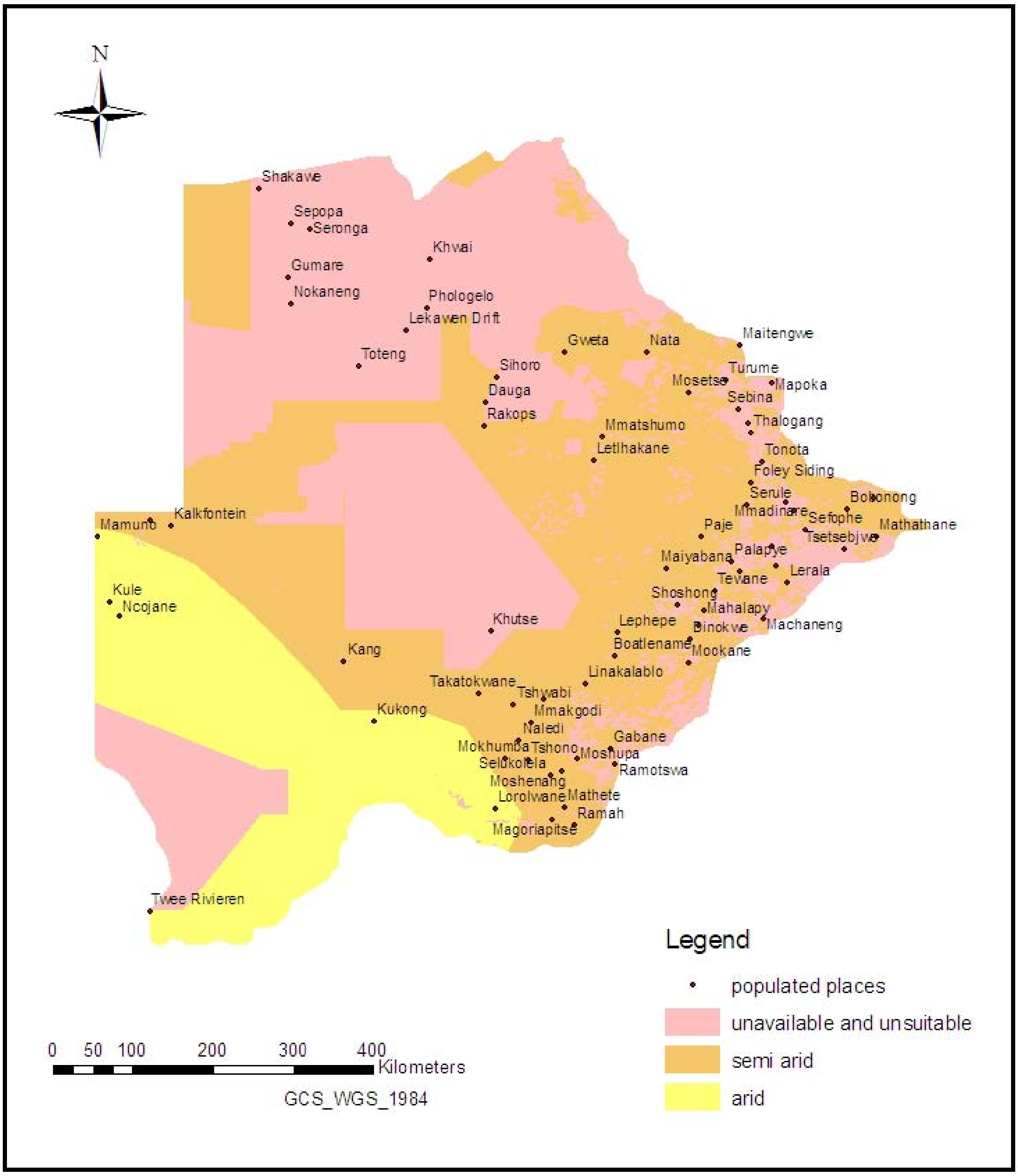



Figure B6: Areas unavailable and unsuitable for bioenergy crops in relation to populated places in Botswana's arid and semi arid regions

## *Appendix 3 – Zambia*

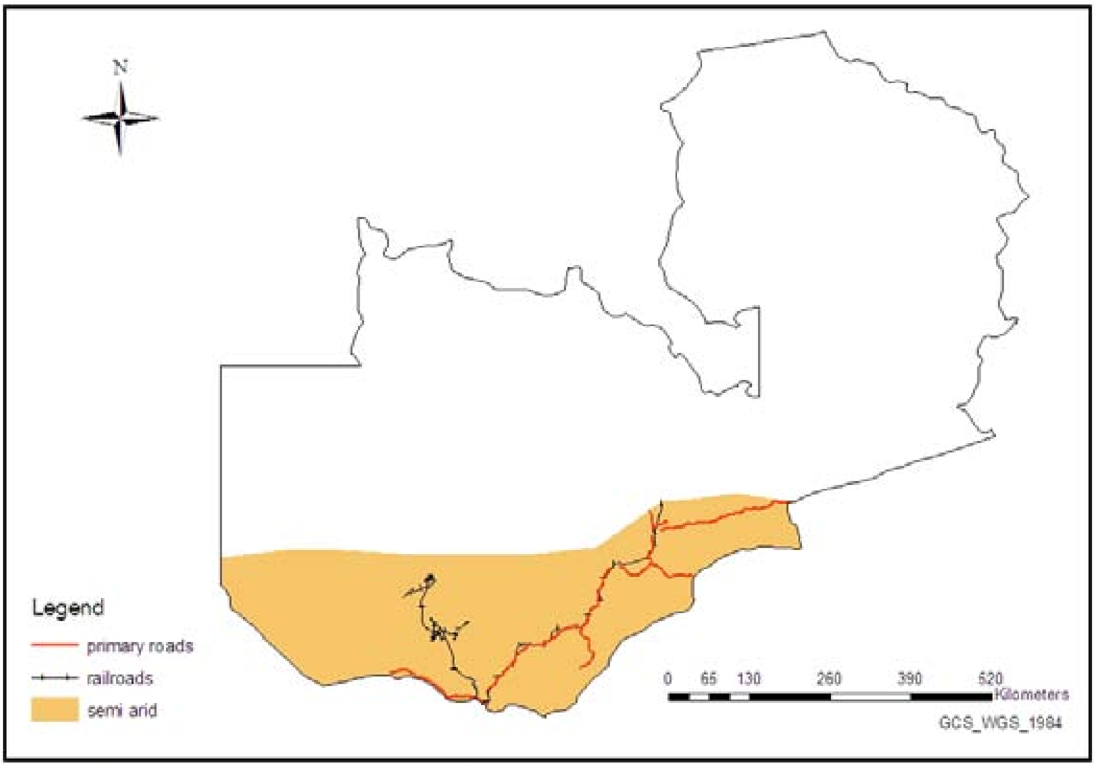



Figure Z1: Primary roads and railroads in Zambia's semi arid region

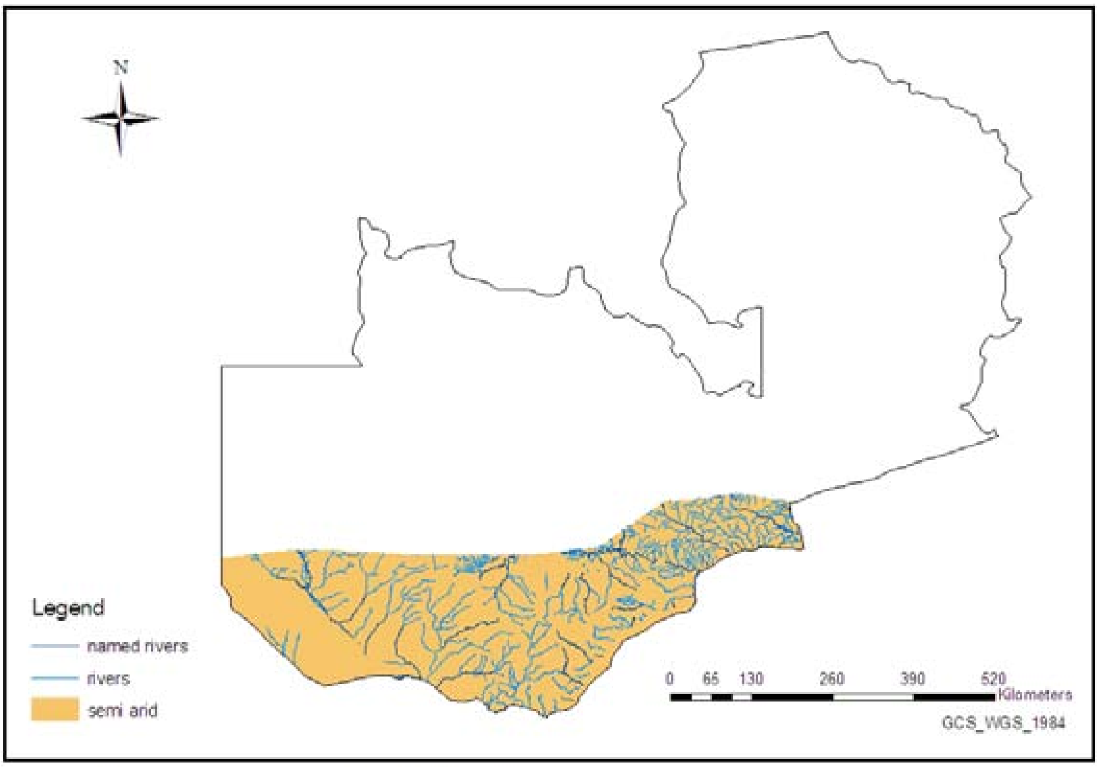



Figure Z2: Rivers in Zambia's semi arid region

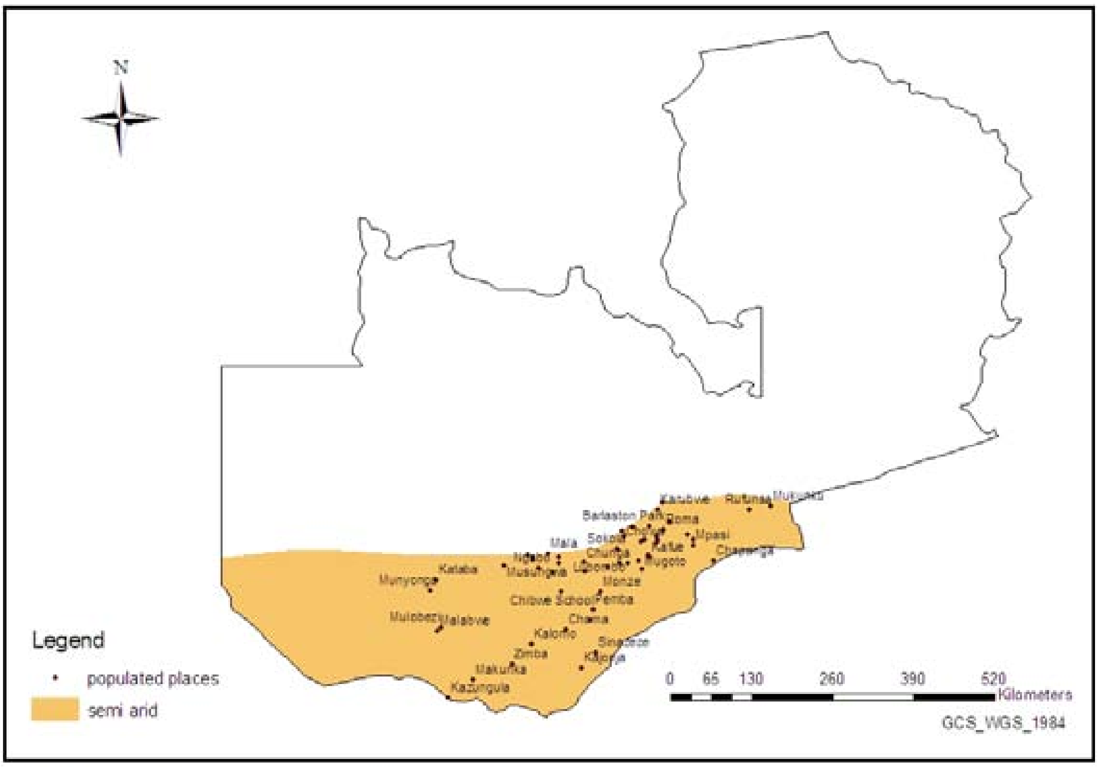



Figure Z3: Populated places in Zambia's semi arid region

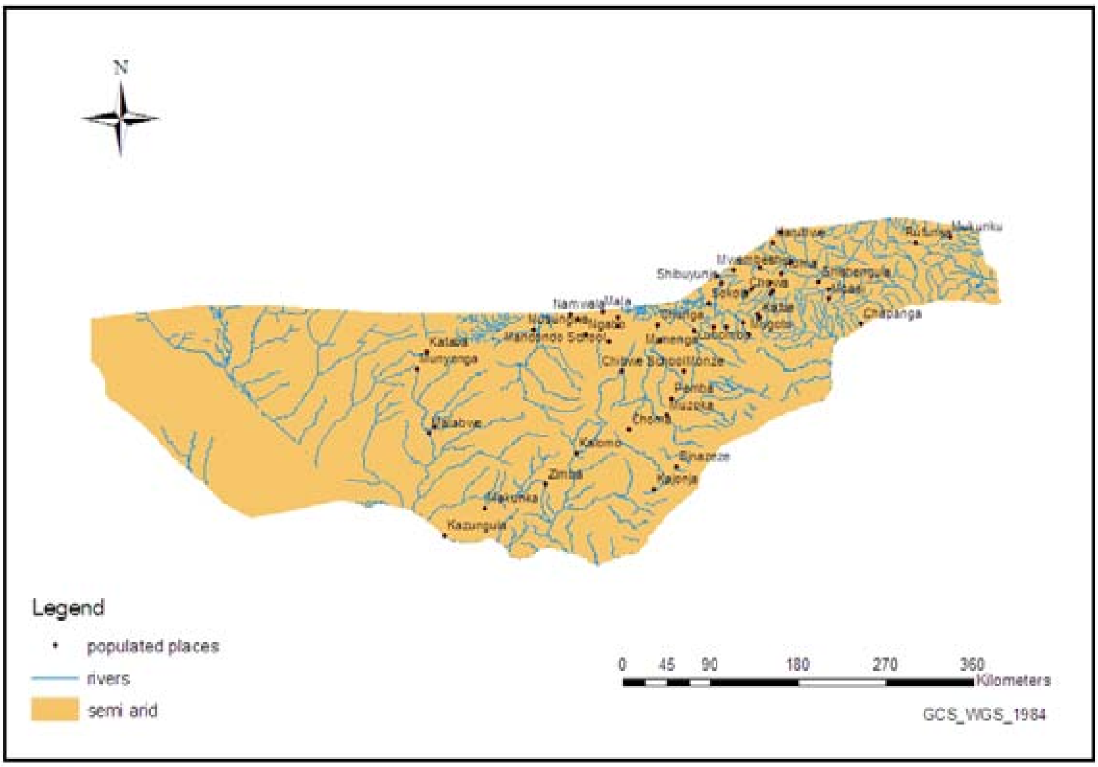



Figure Z4: Populated places in Zambia's semi arid region relative to rivers

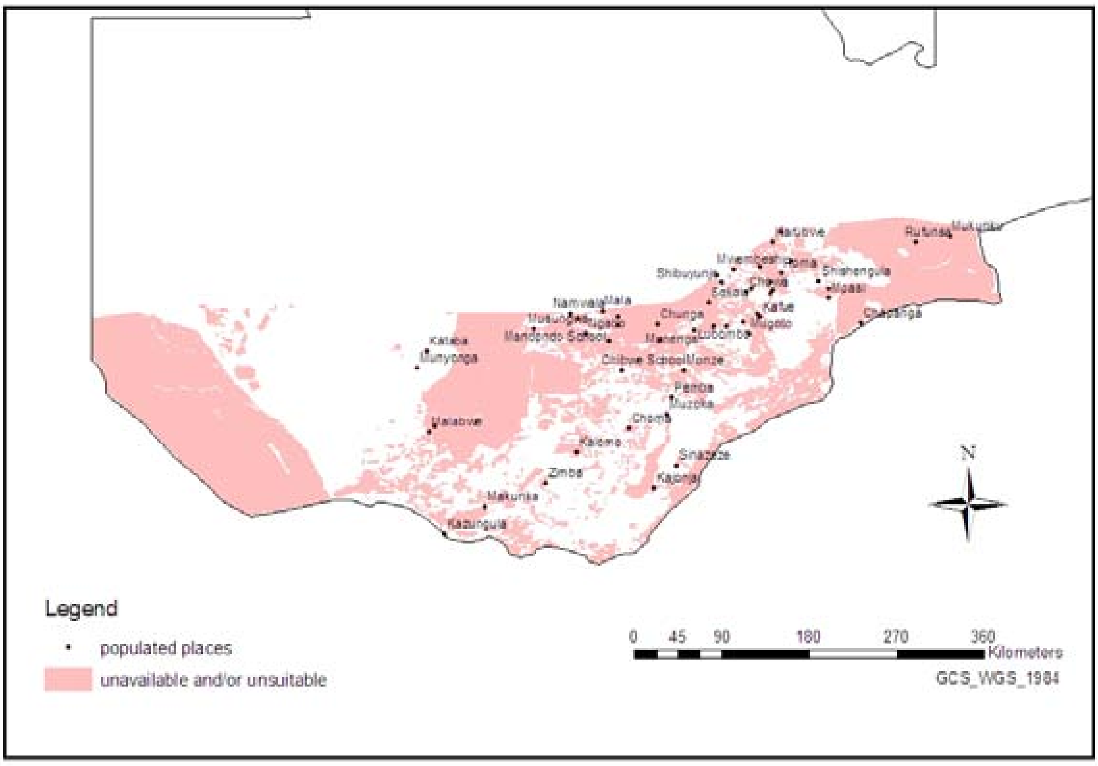



Figure Z5: Areas unavailable and/or unsuitable in Zambia's semi arid region in relation

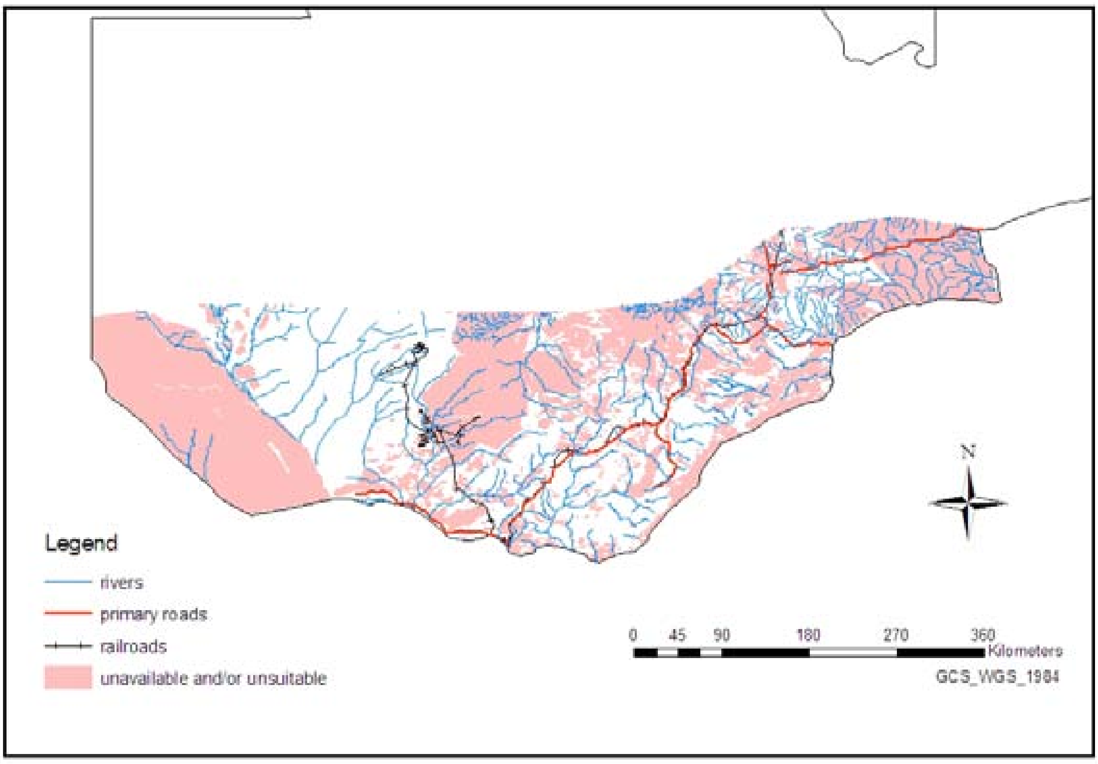



Figure Z6: Areas unavailable and/or unsuitable in Zambia's semi arid region in relation

## *Appendix 4 – Tansania*

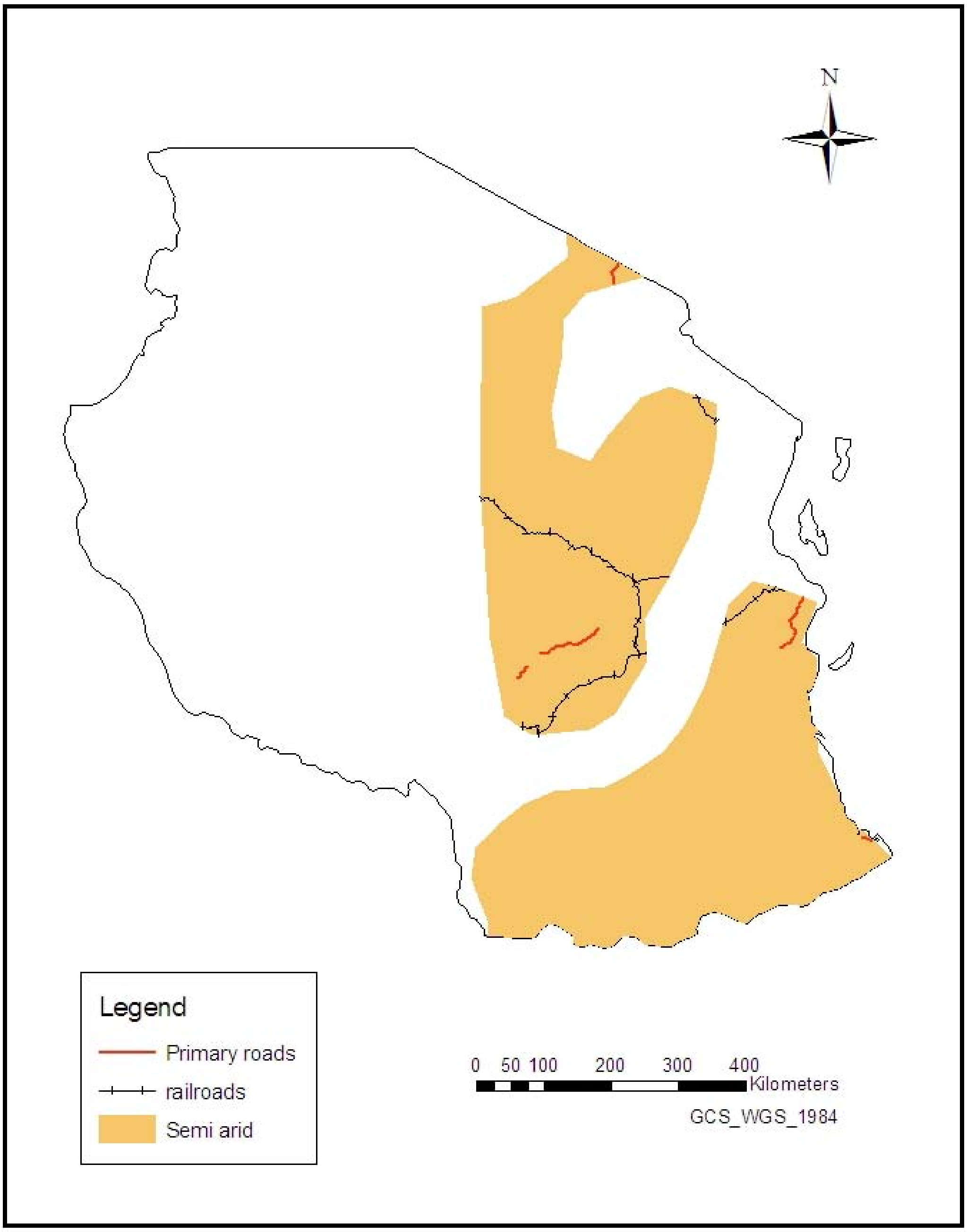



Figure T1: Primary roads and railroads in Tanzania's semi arid regions

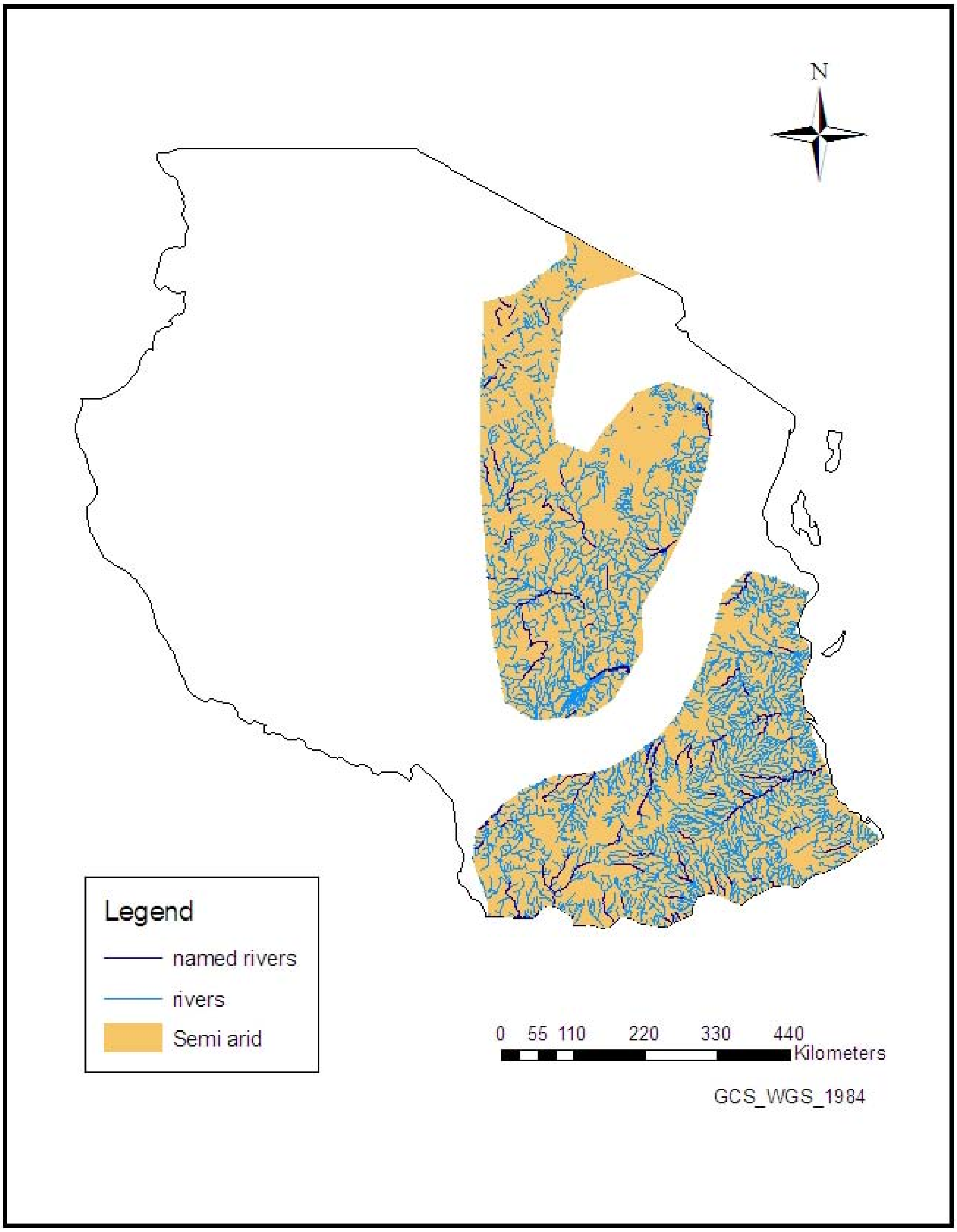



Figure T2: Rivers in Tanzania's semi arid regions

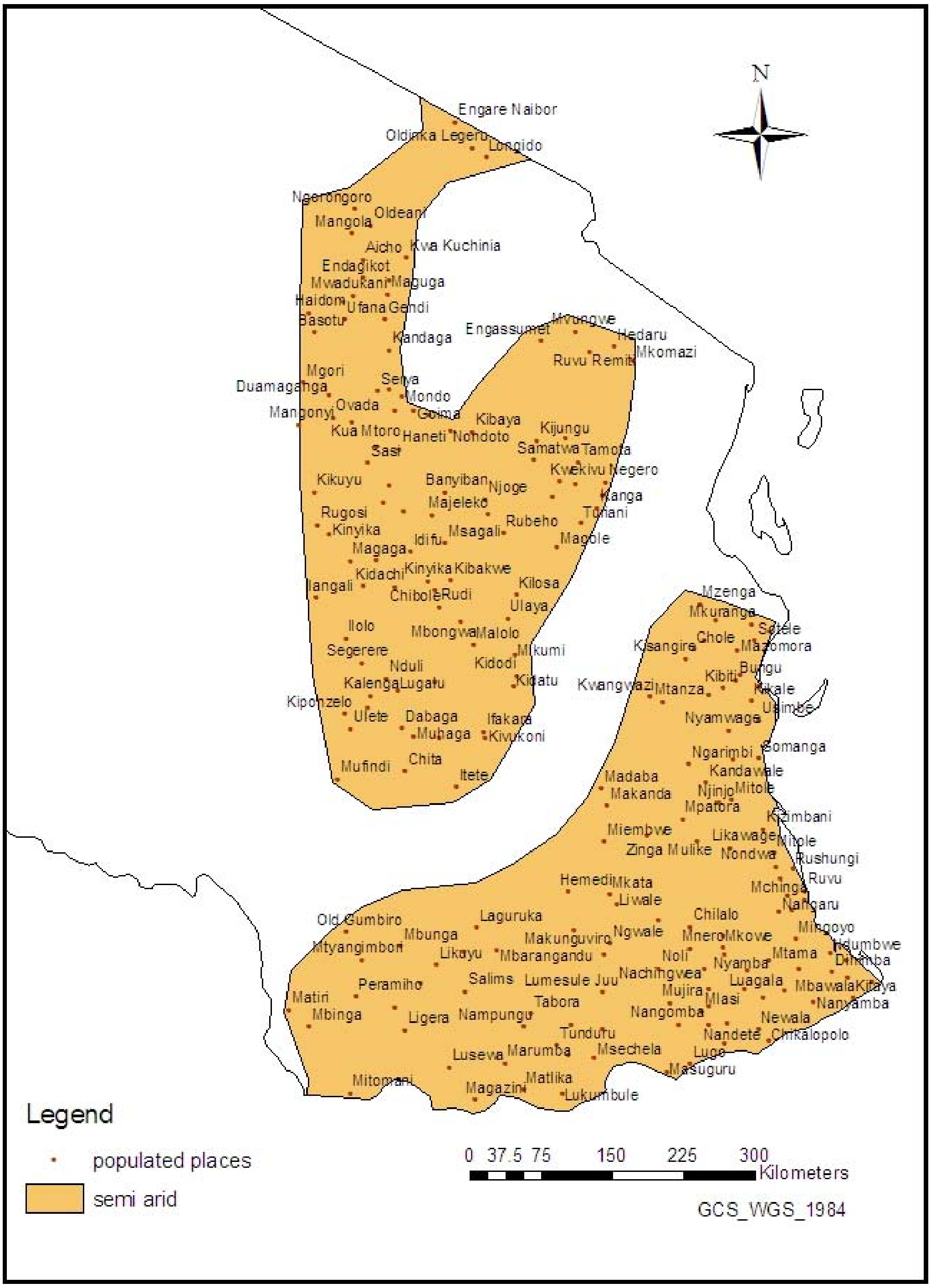



Figure T3: Populated places inTanzania's semi arid regions

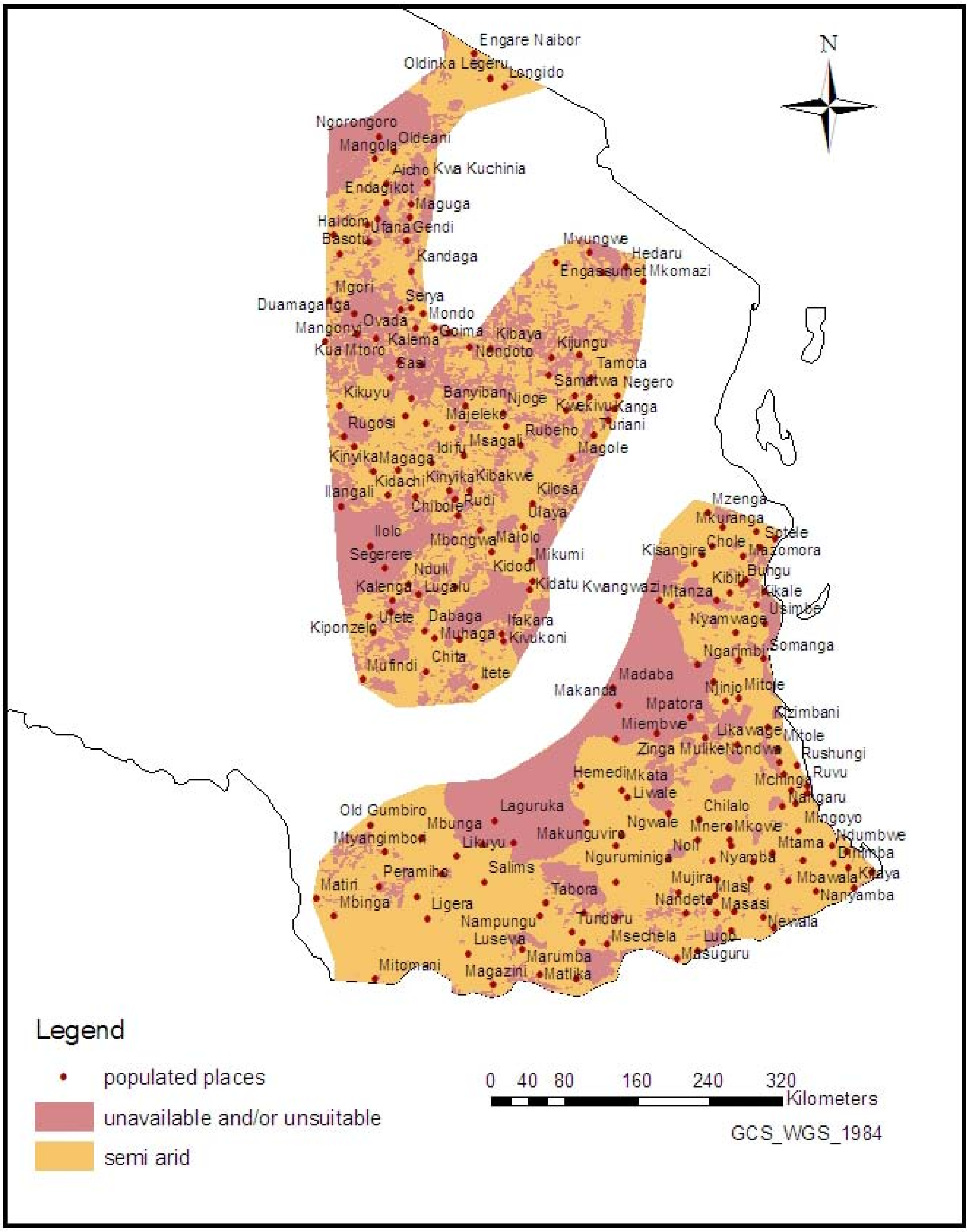



Figure T4: Areas unavailable and/or unsuitable for bioenergy crops in relation to populated places in Tanzania's semi arid regions

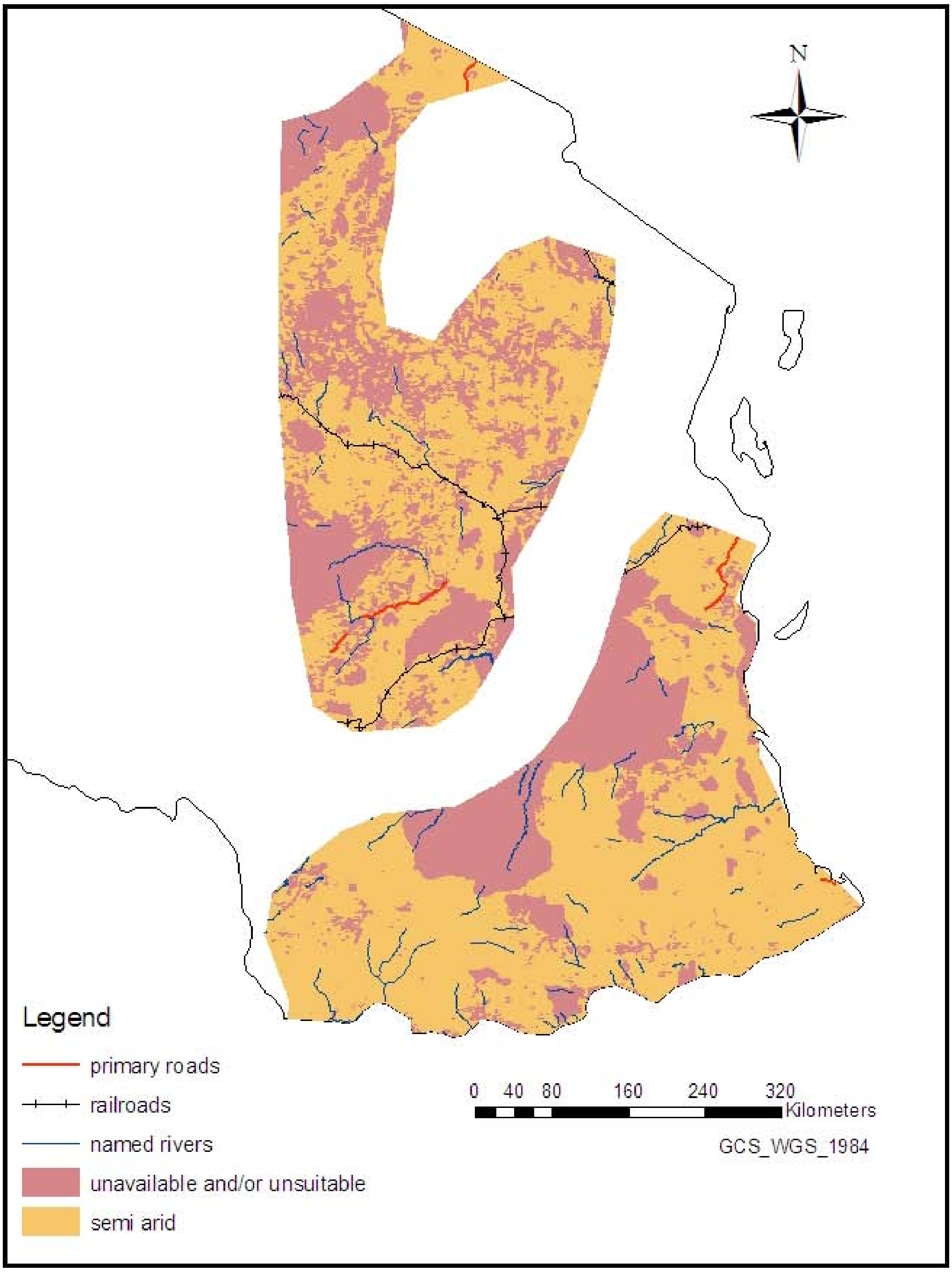



Figure T5: Areas unavailable and/or unsuitable for bioenergy crops relative to primary roads, railroads and named rivers in Tanzania's semi arid regions.

## *Appendix 5 – Kenya*

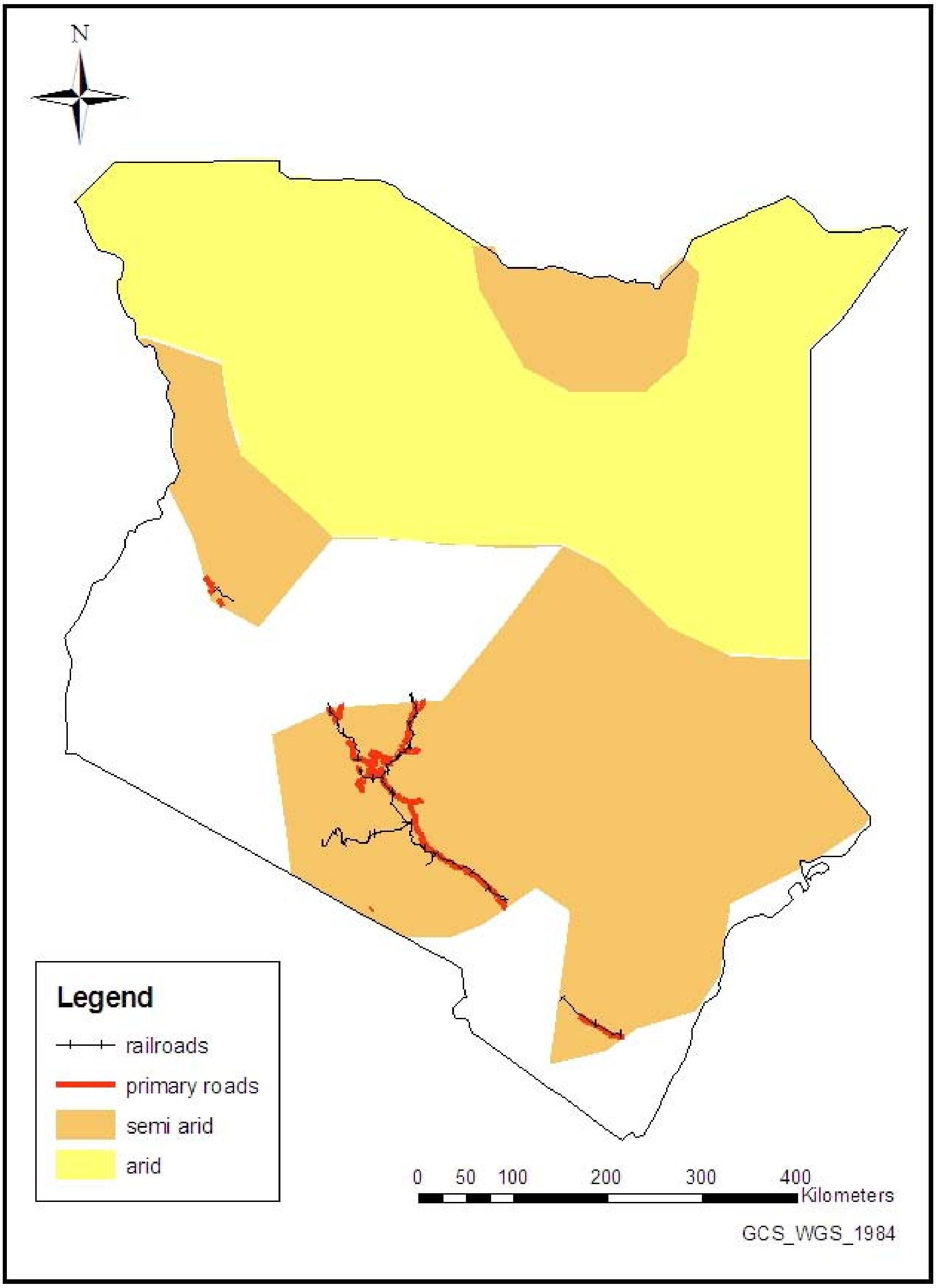



Figure K1: Roads and railroads in arid and semi arid regions of Kenya

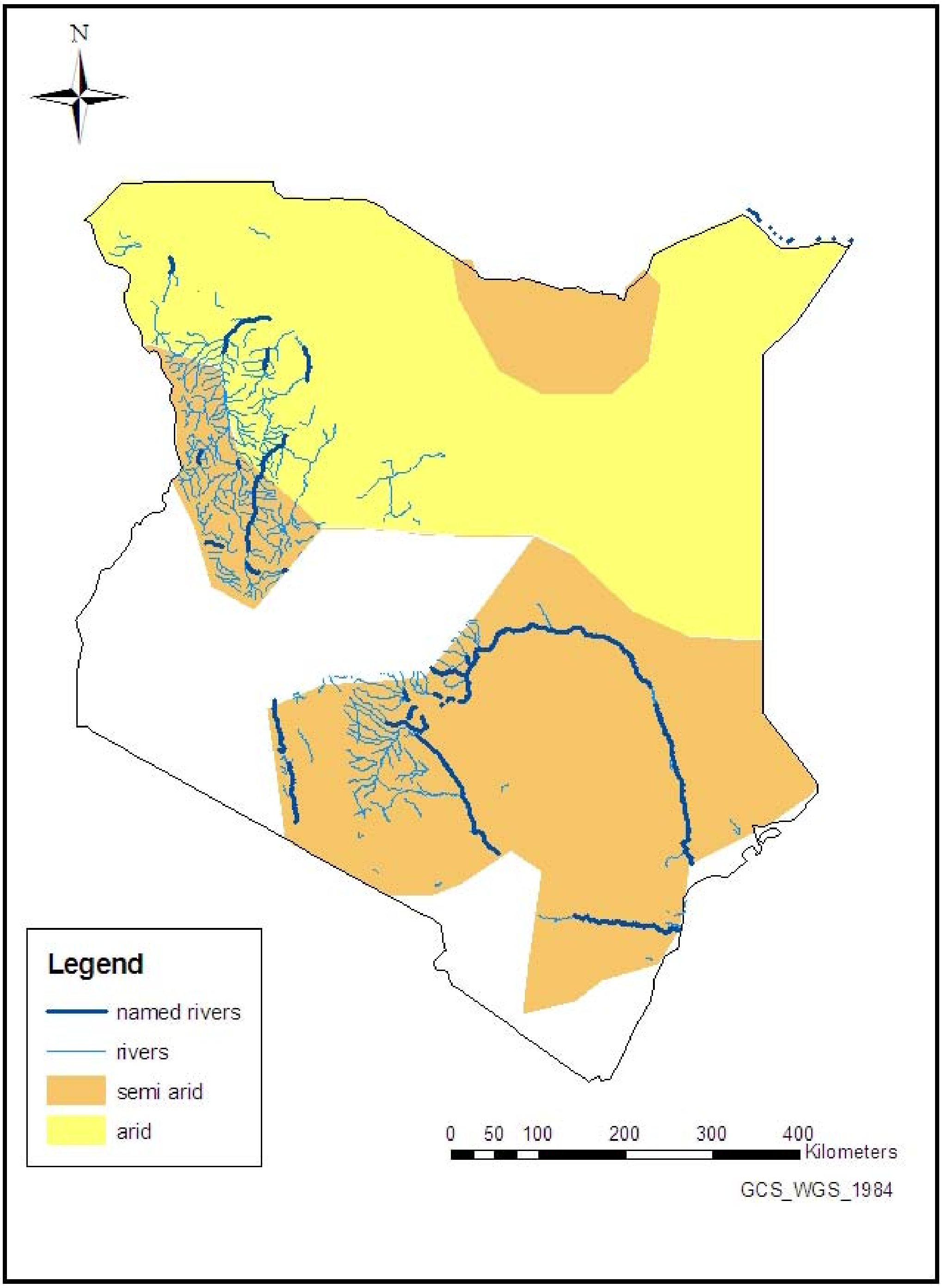



Figure K2: Rivers in arid and semi arid regions of Kenya

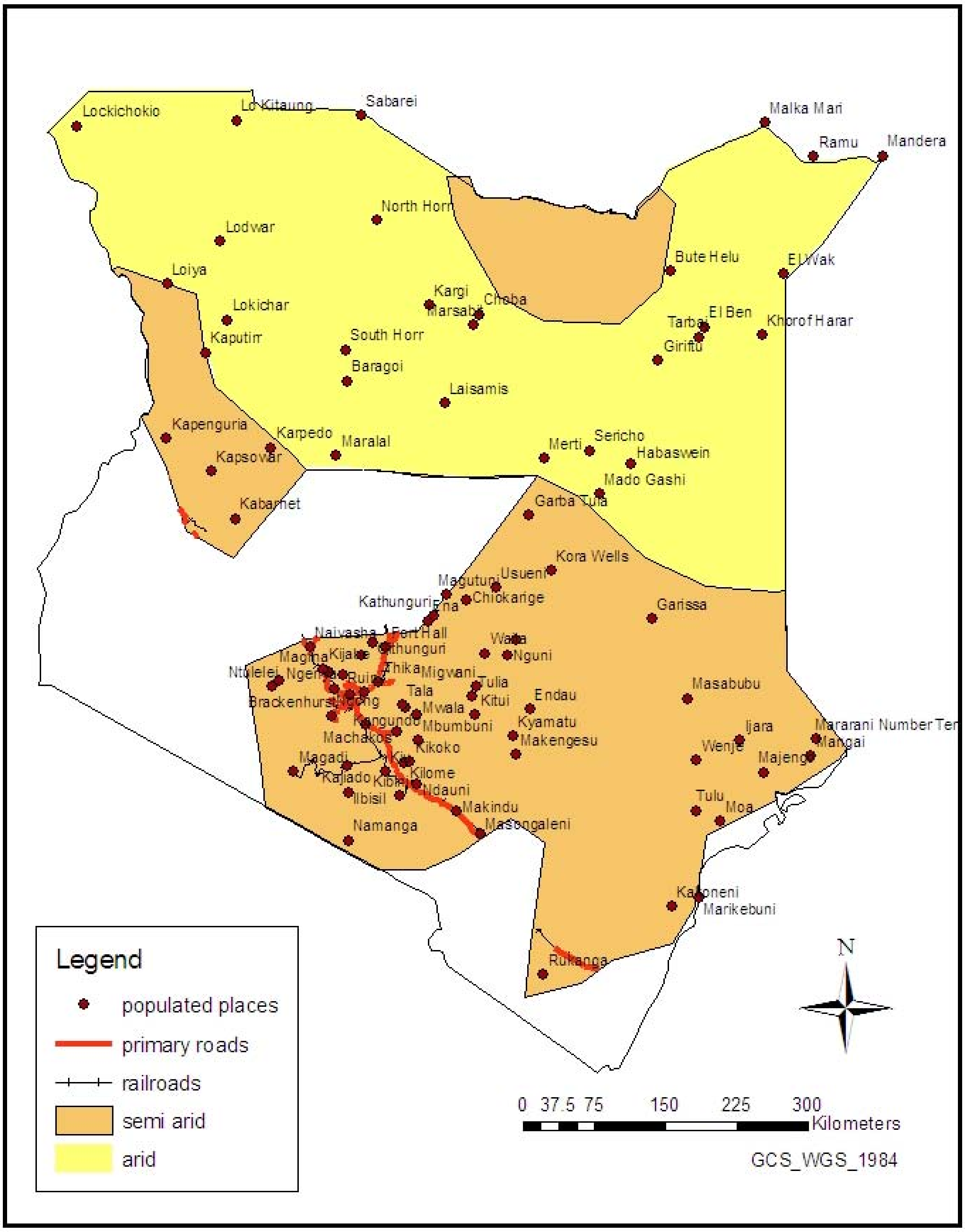



Figure K3: Populated places in arid and semi arid regions in Kenya in relation to primary roads and railroads

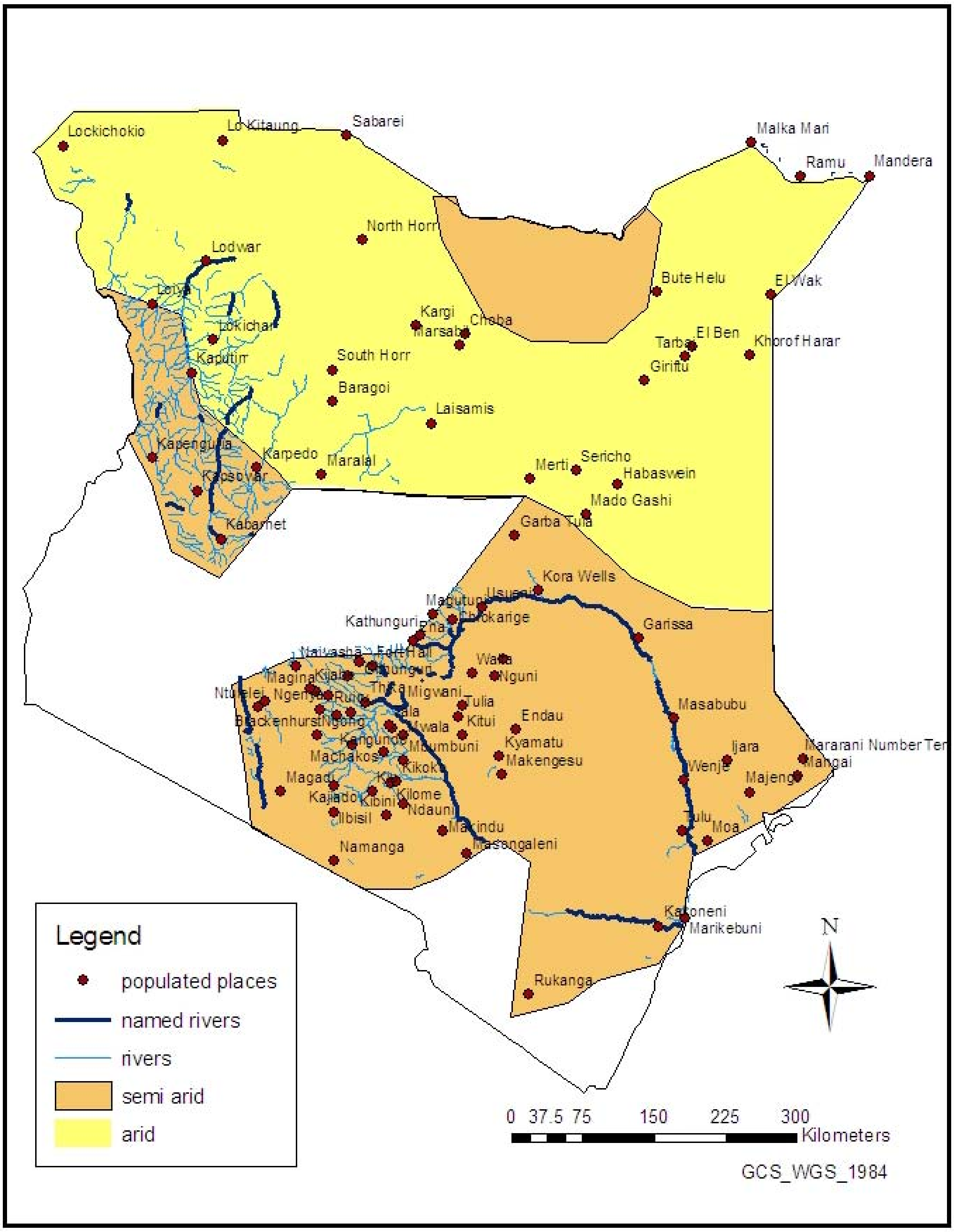



Figure K4: Proximity of populated places in Kenya's arid and semi arid regions to rivers

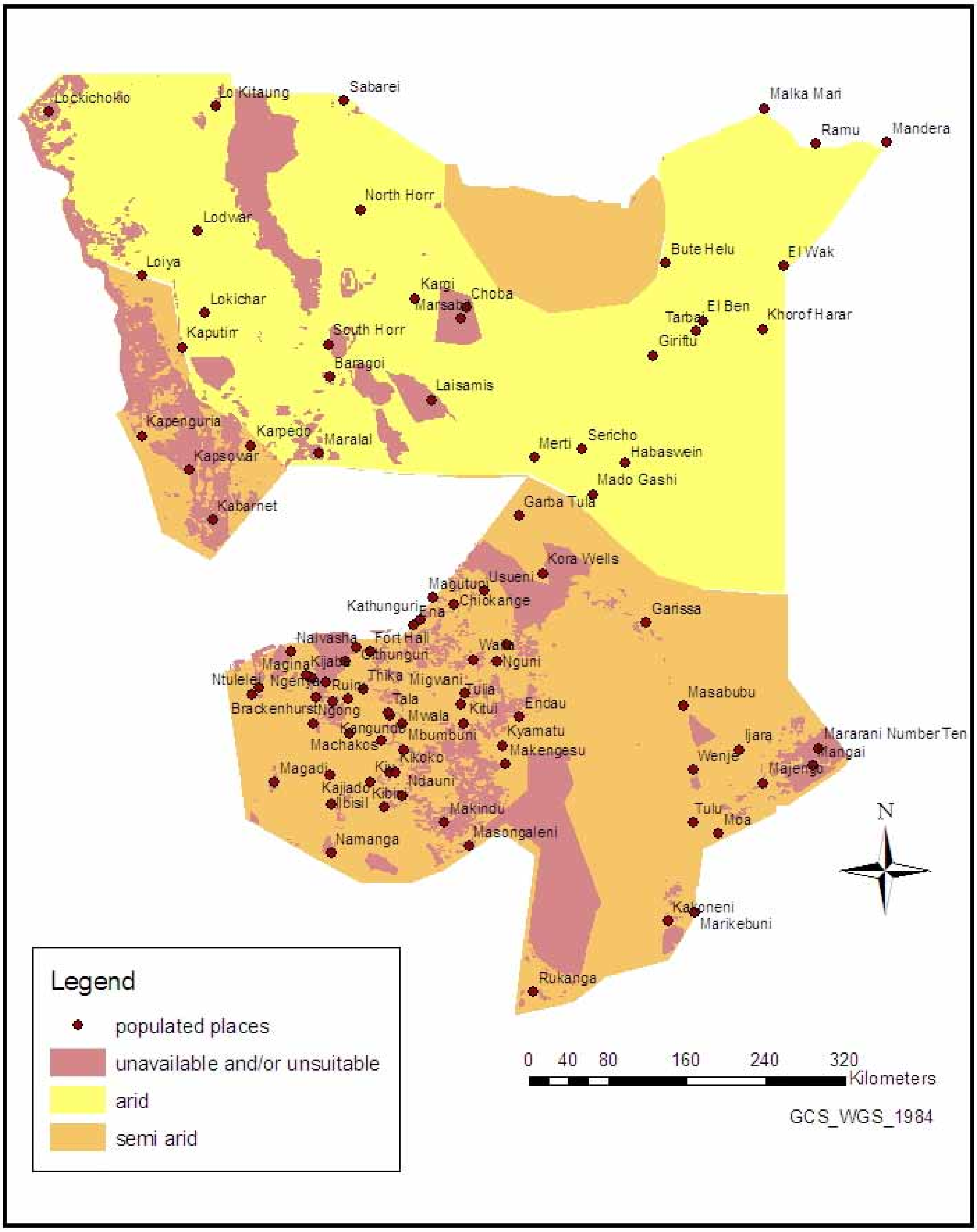



Figure K5: Areas unavailable and/or unsuitable for bioenergy crops relative to populated places in Kenya's arid and semi arid regions

## *Appendix 6 – Mali*

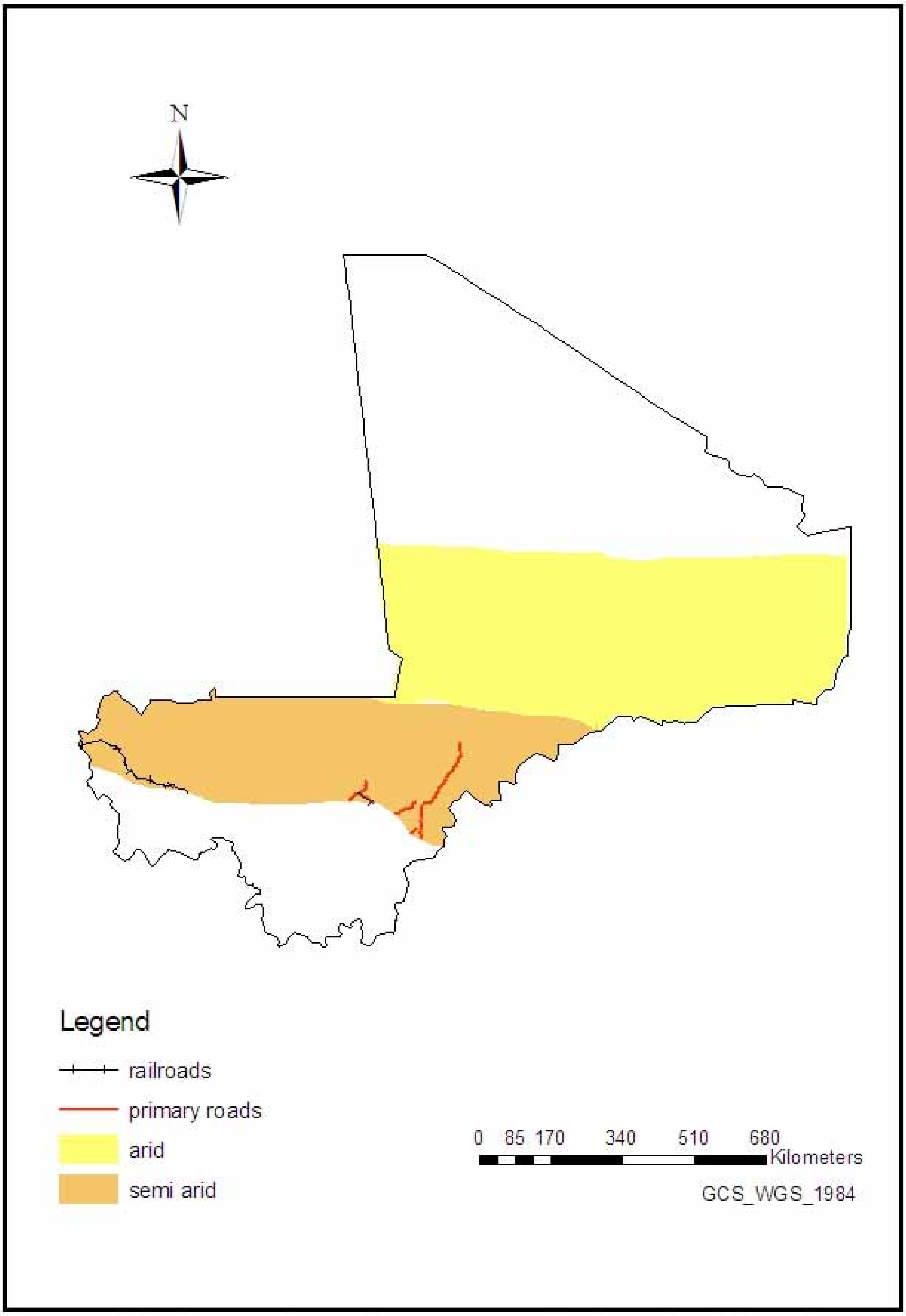



Figure M1: Railroads and primary roads in Mali's arid and semi arid regions

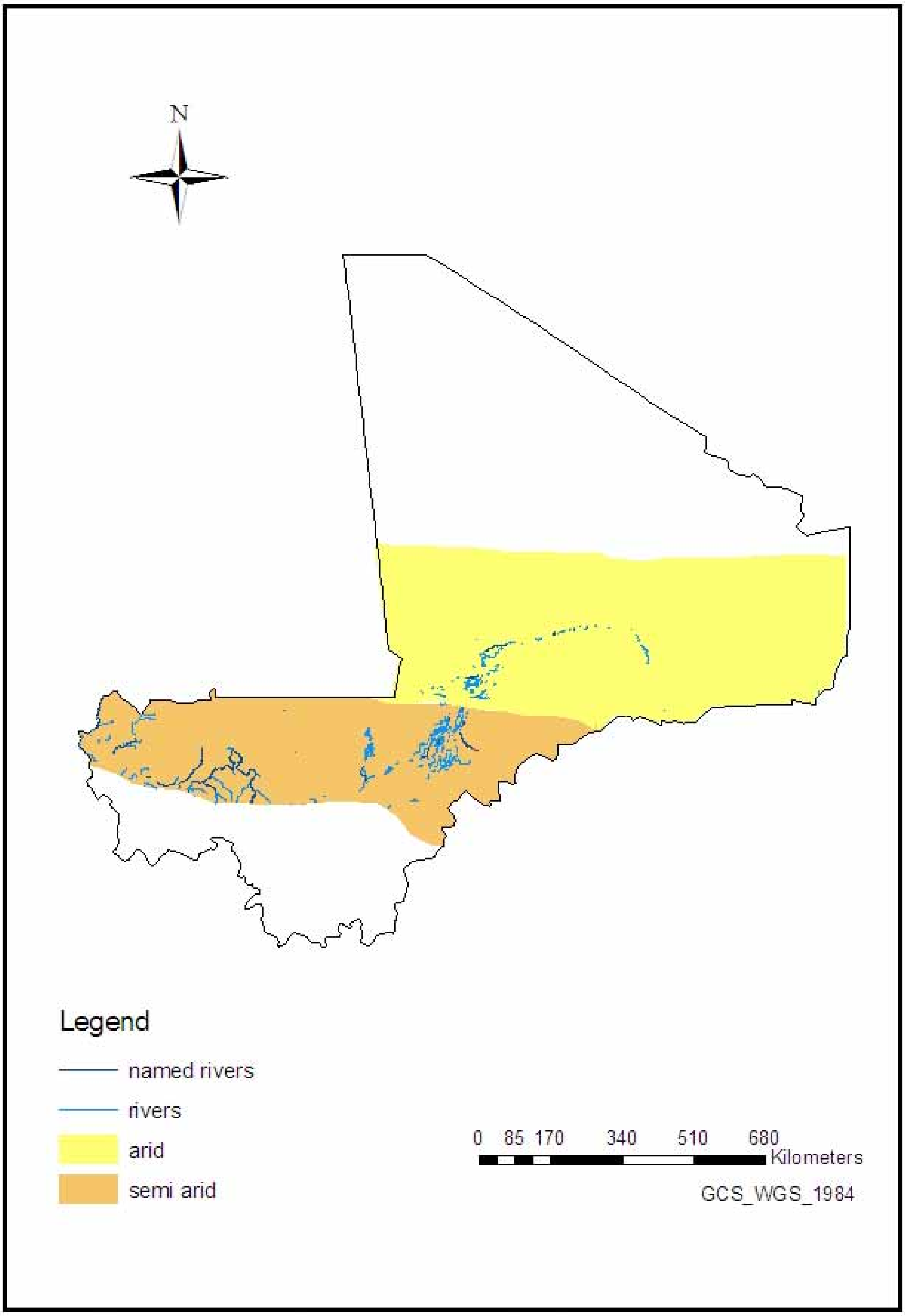



Figure M2: Rivers in Mali's arid and semi arid regions

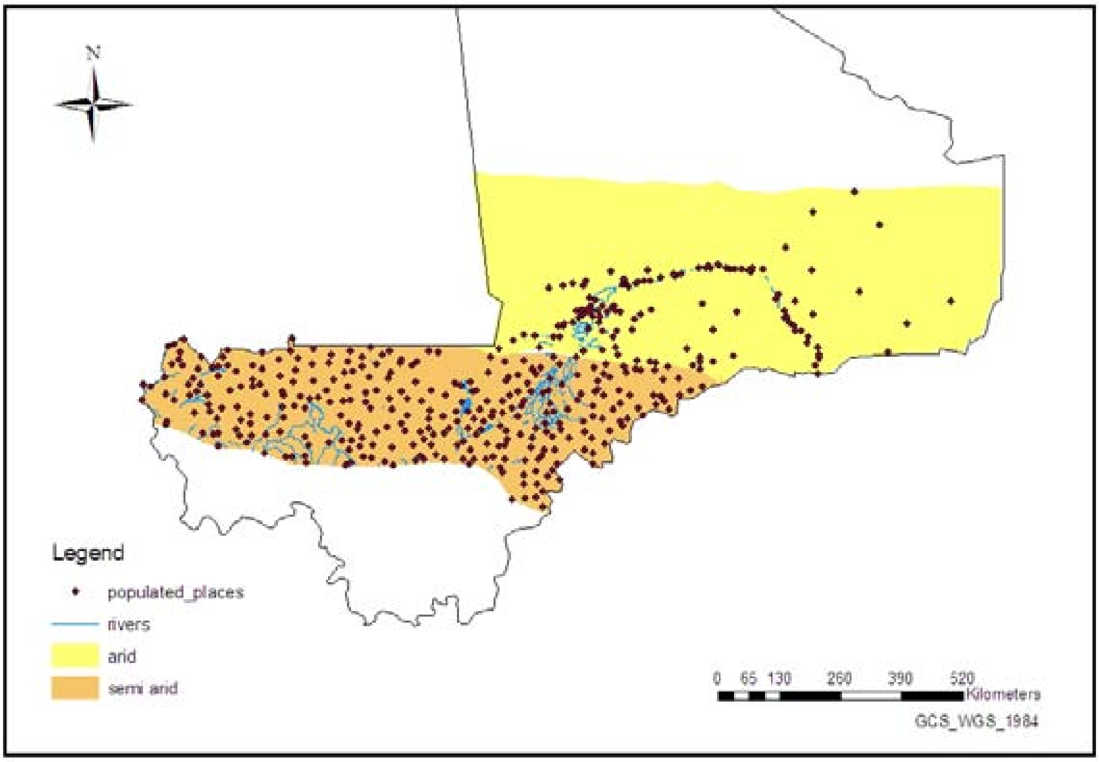



Figure M3: Populated places in Mali's arid and semi arid regions relative to rivers

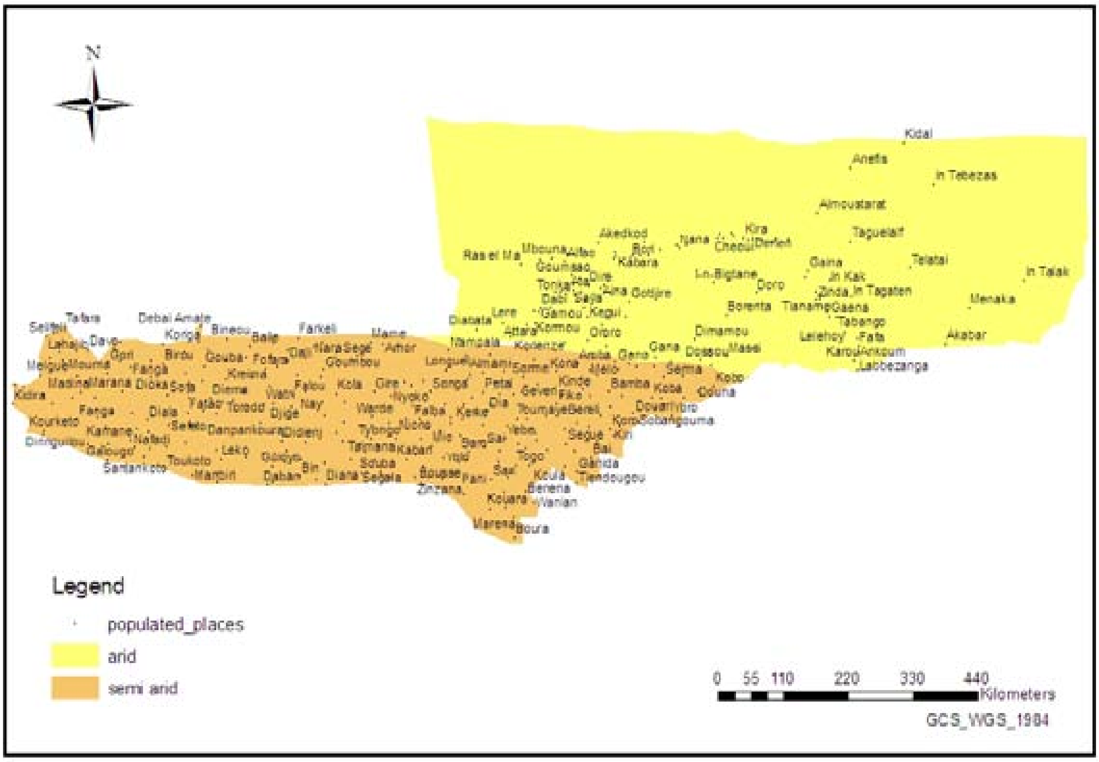



Figure M4: Populated places in Mali's arid and semi arid regions

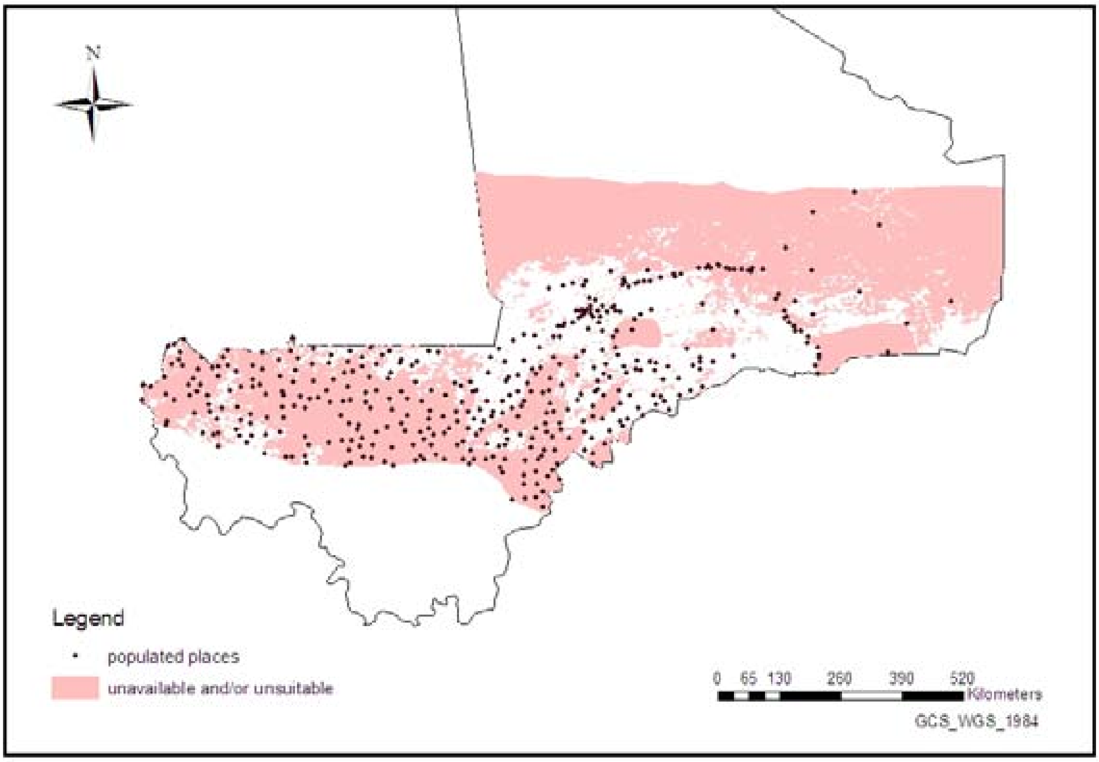



Figure M5: Areas unavailable and/or unsuitable for bioenergy crops in Mali's arid and semi arid

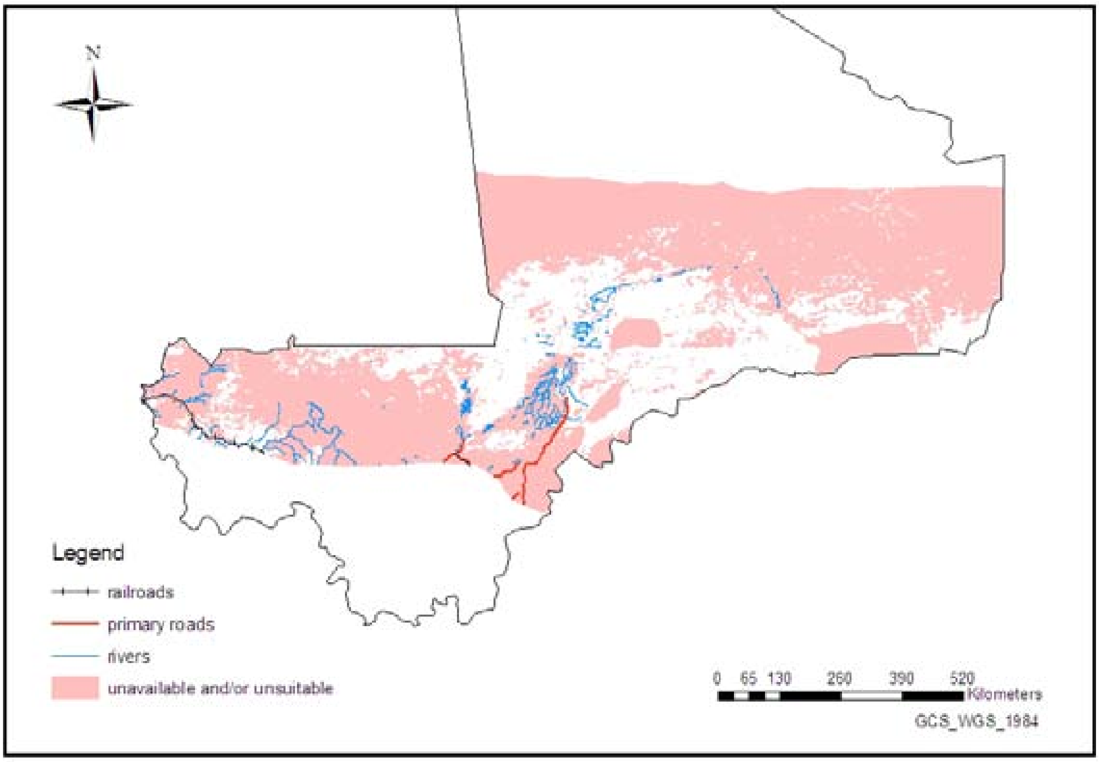



Figure M6: Areas unavailable and/or unsuitable for bioenergy crops in Mali's arid and semi arid

## *Appendix 7 – Burkina Faso*

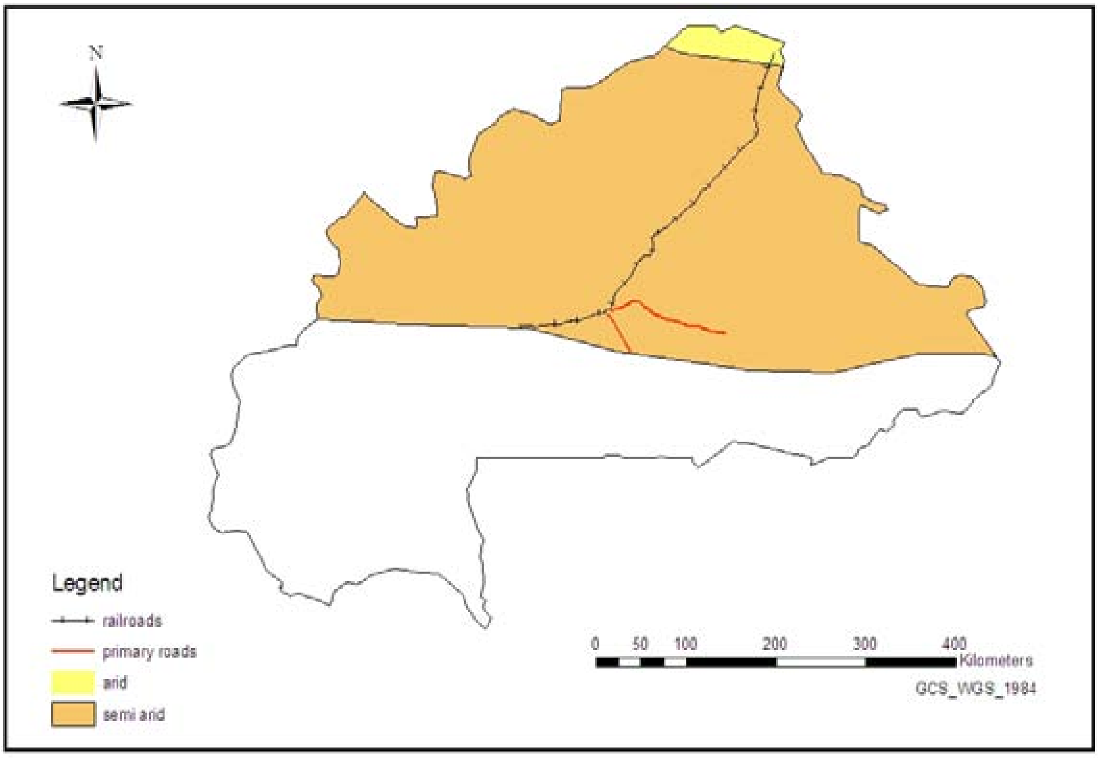



Figure BF1: Railroads and primary roads in Burkina Faso's arid and semi arid regions

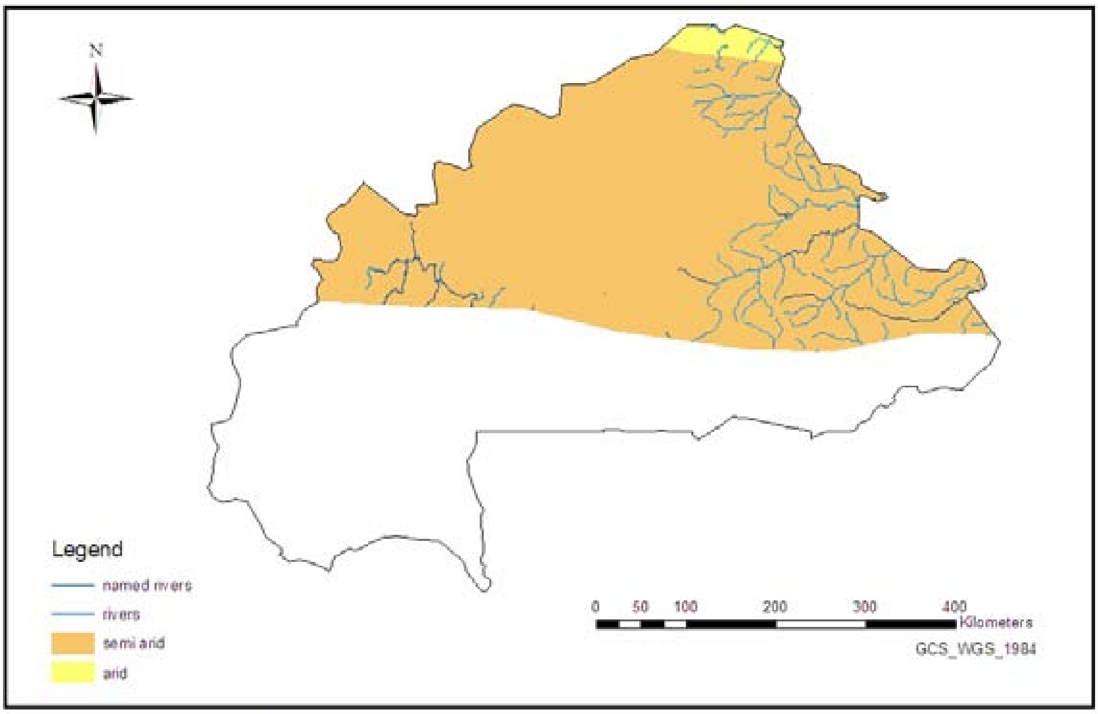



Figure BF2: Rivers in Burkina Faso's arid and semi arid regions

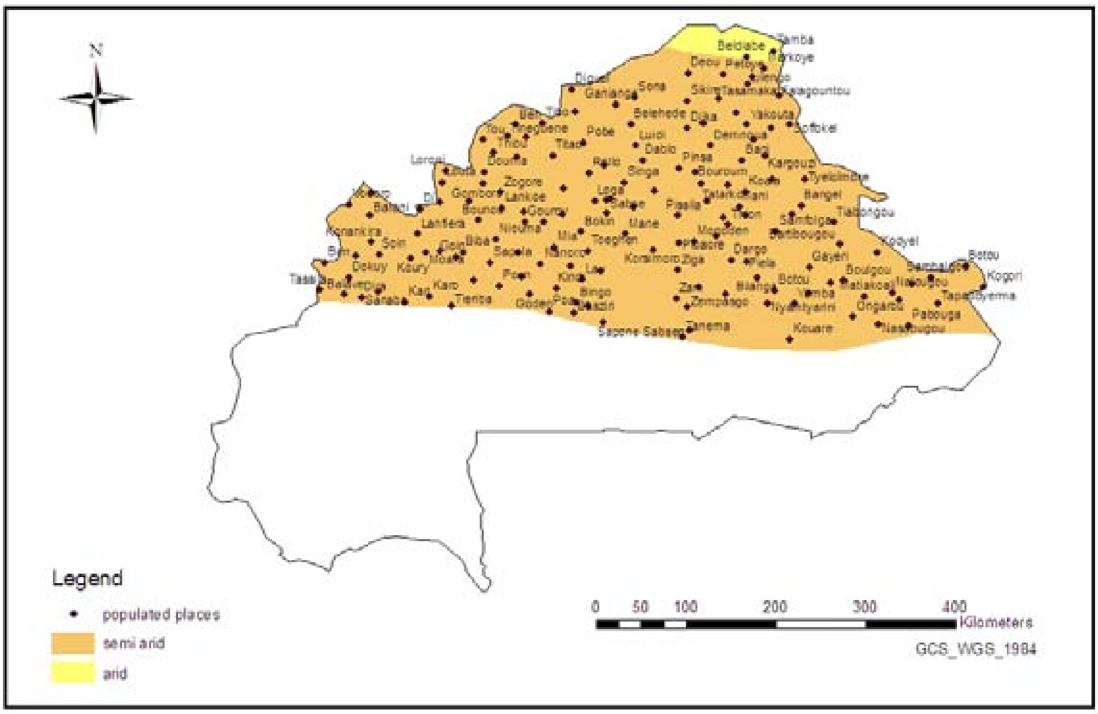



Figure BF3: Populated places in Burkina Faso's arid and semi arid regions

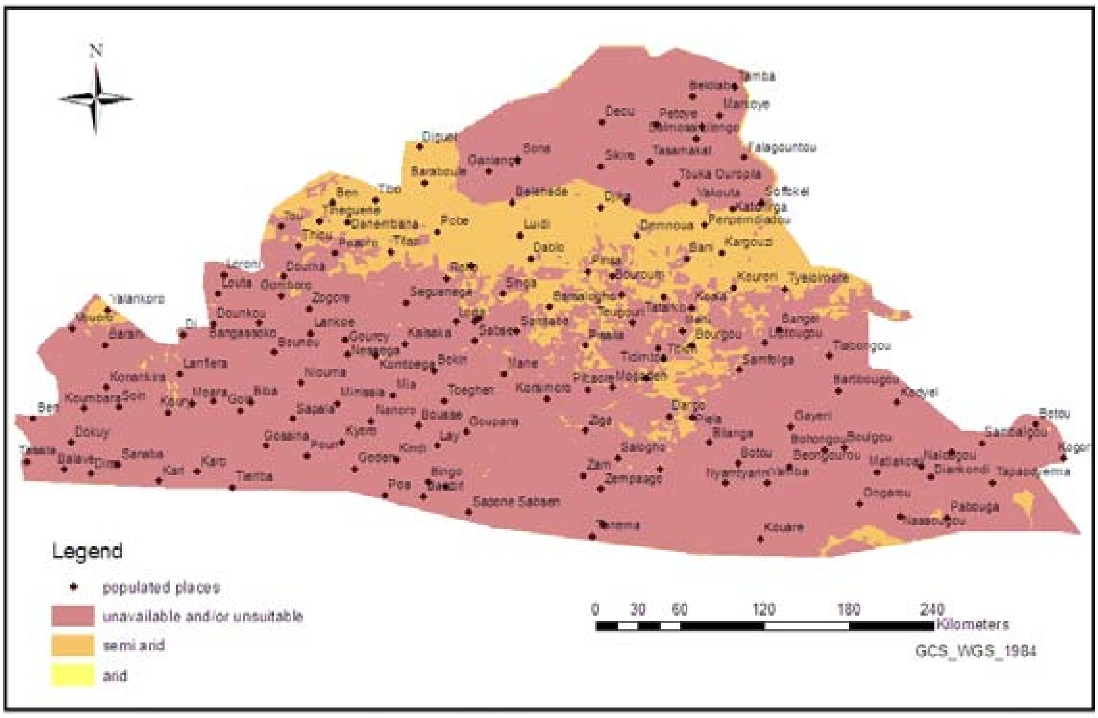



Figure BF4: Areas unavailable and/or unsuitable for bioenergy crops in relation to populated

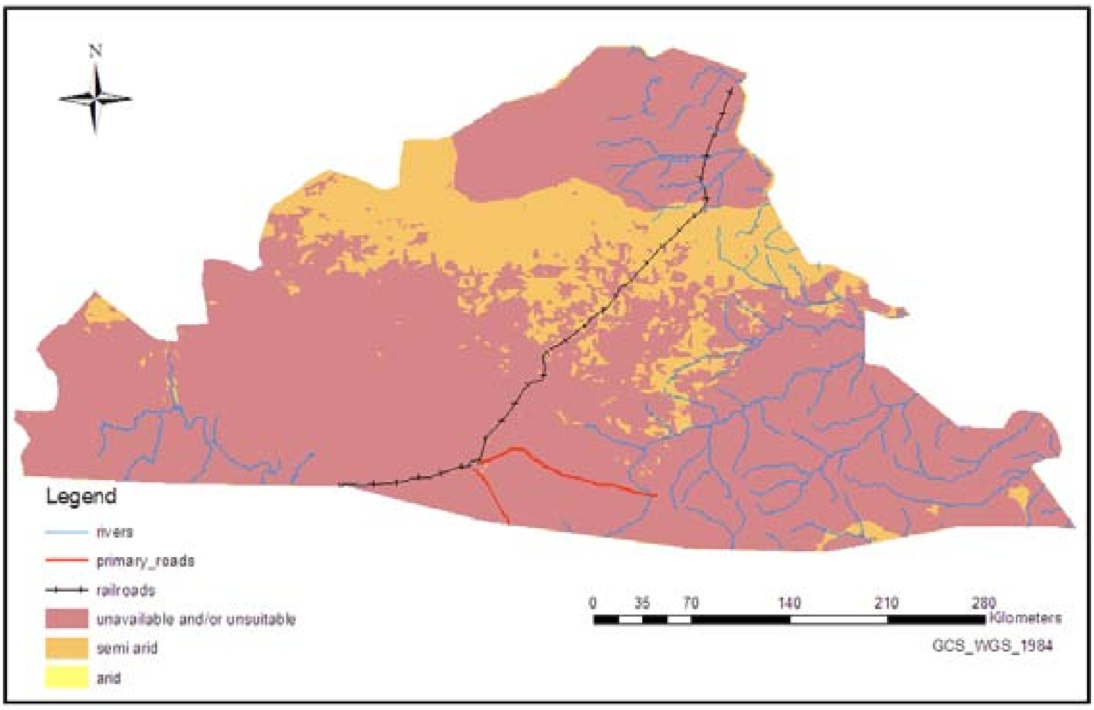



Figure BF5: Areas unavailable and/or unsuitable for bioenergy crops in relation to rivers, primary roads and railroads in Burkina Faso's arid and semi arid regions

## *Appendix 8 – Senegal*

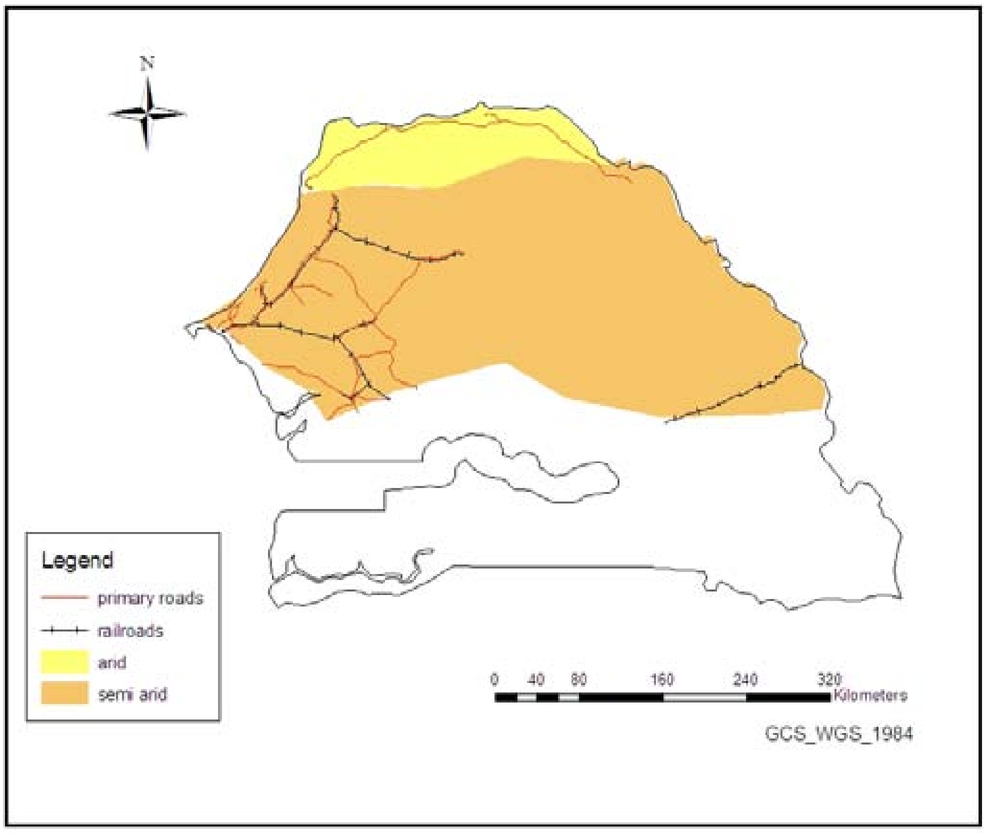



Figure S1: Primary roads, railroads in arid and semi arid regions of Senegal

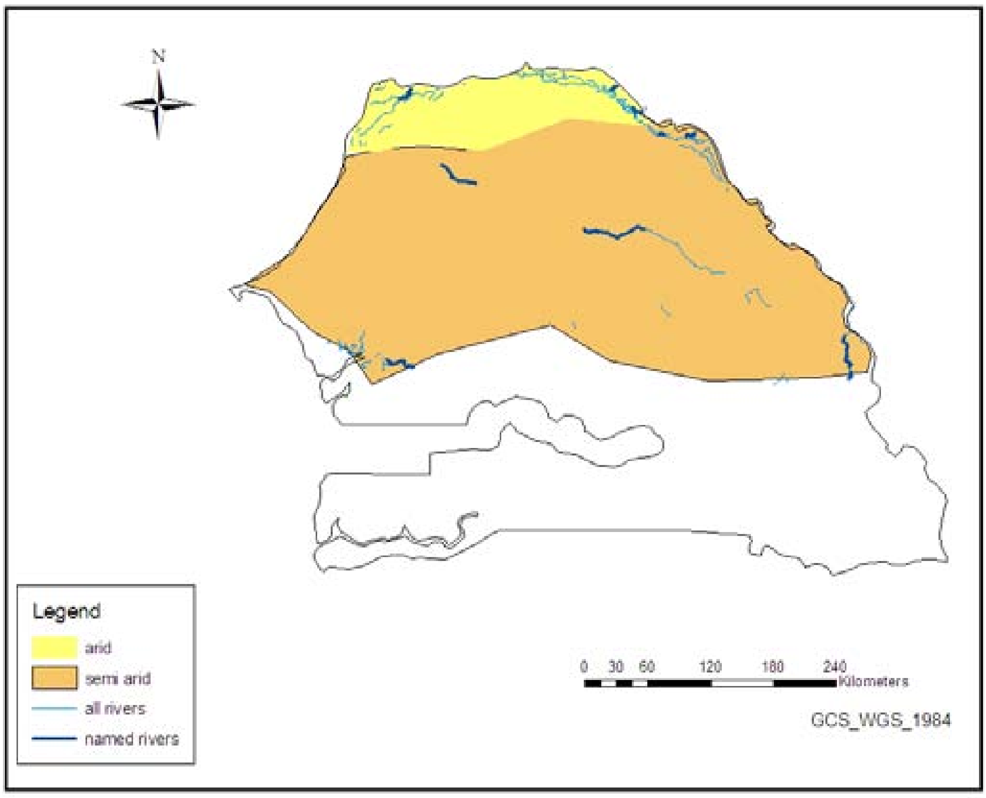



Figure S2: Rivers in arid and semi arid regions of Senegal

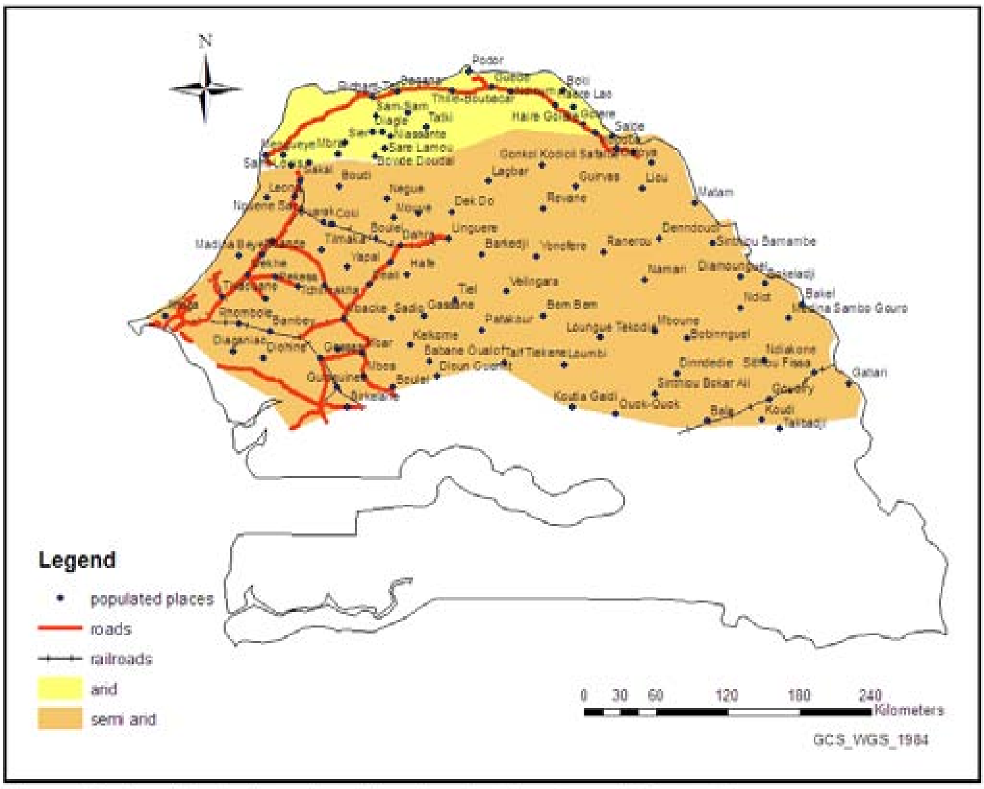



Figure S3: Populated places in arid and semi arid regions in Senegal

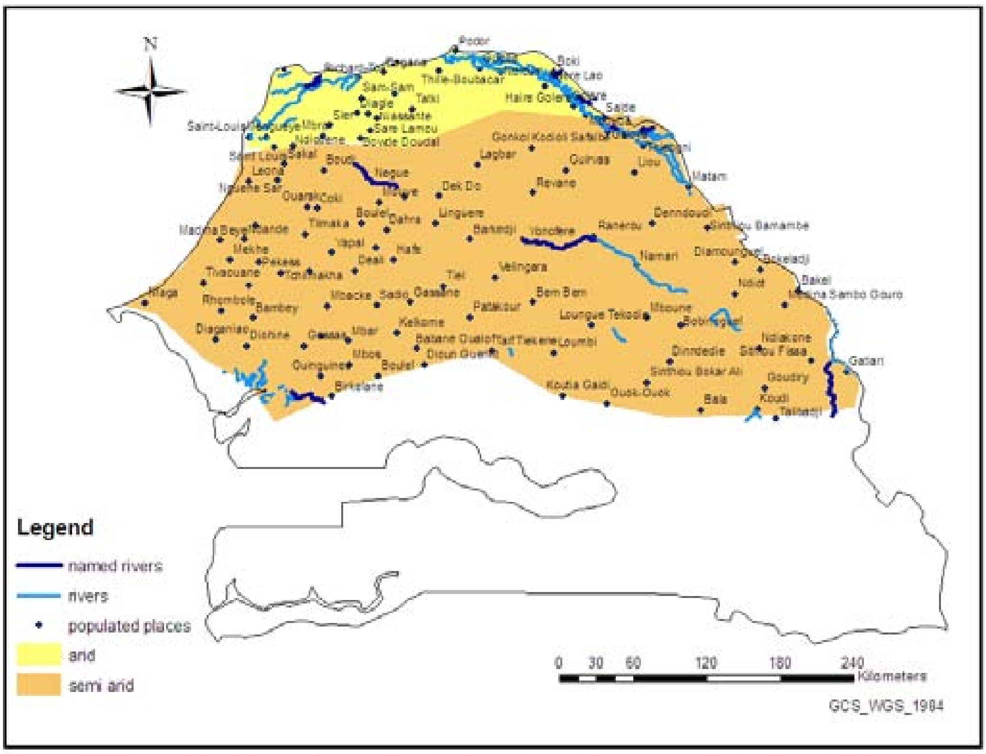



Figure S4: Proximity of rivers to populated places in arid and semi arid regions of Senegal

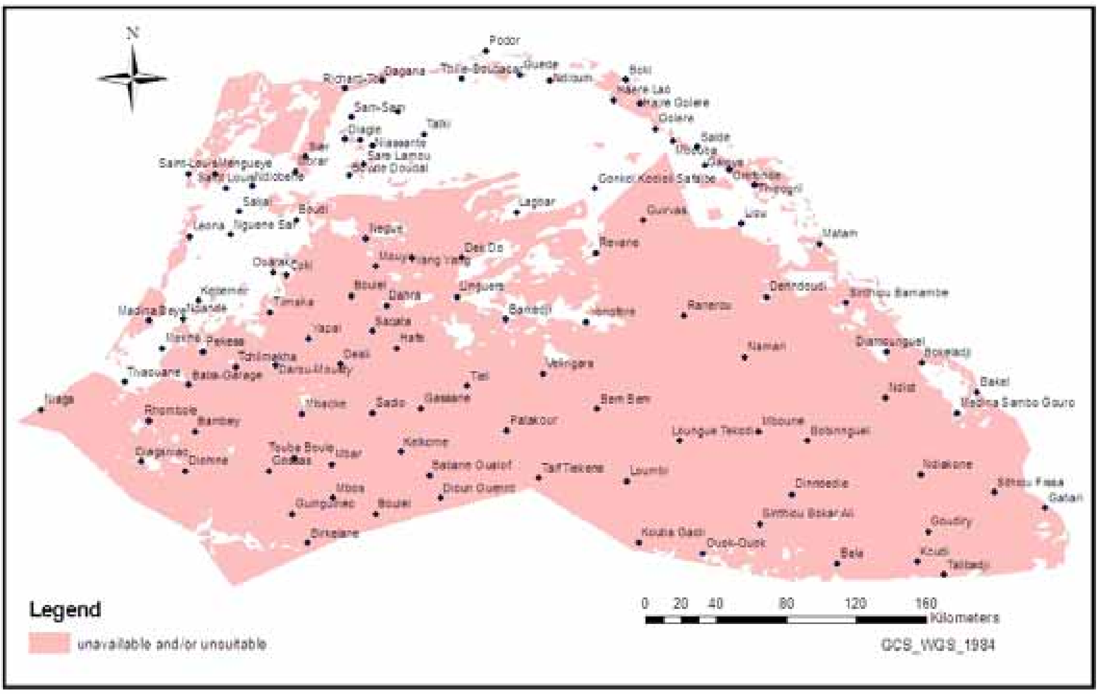



Figure S5: Areas unavailable and/or unsuitable for bioenergy crops relative to populated places in arid and semi arid regions in Senegal

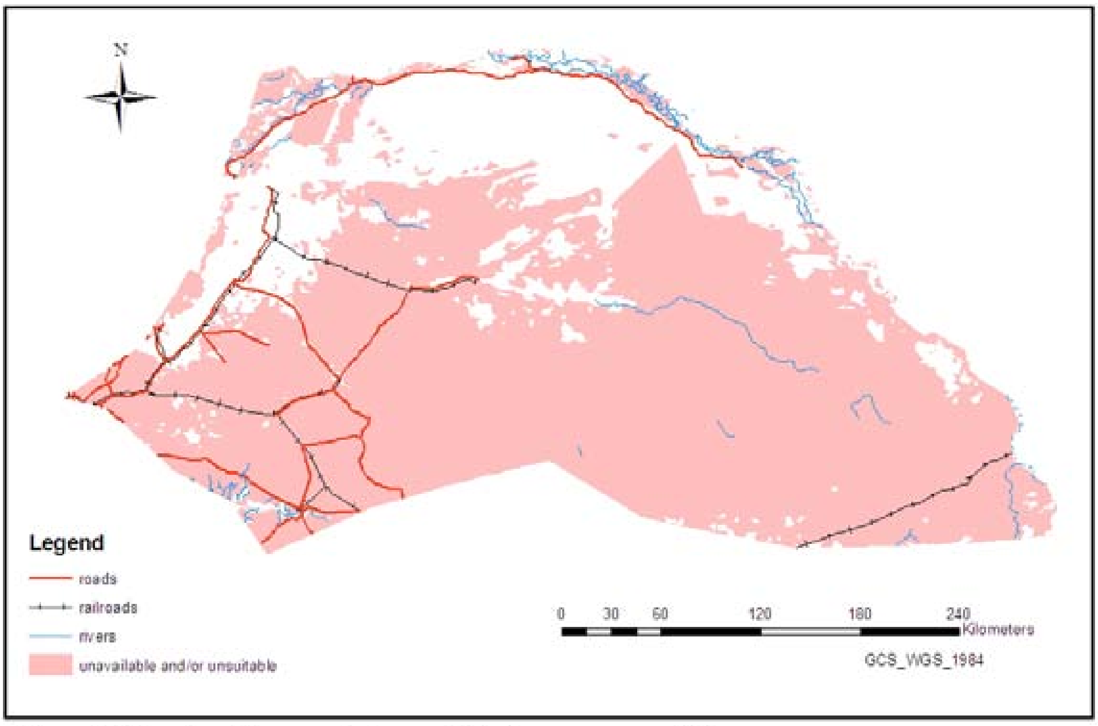
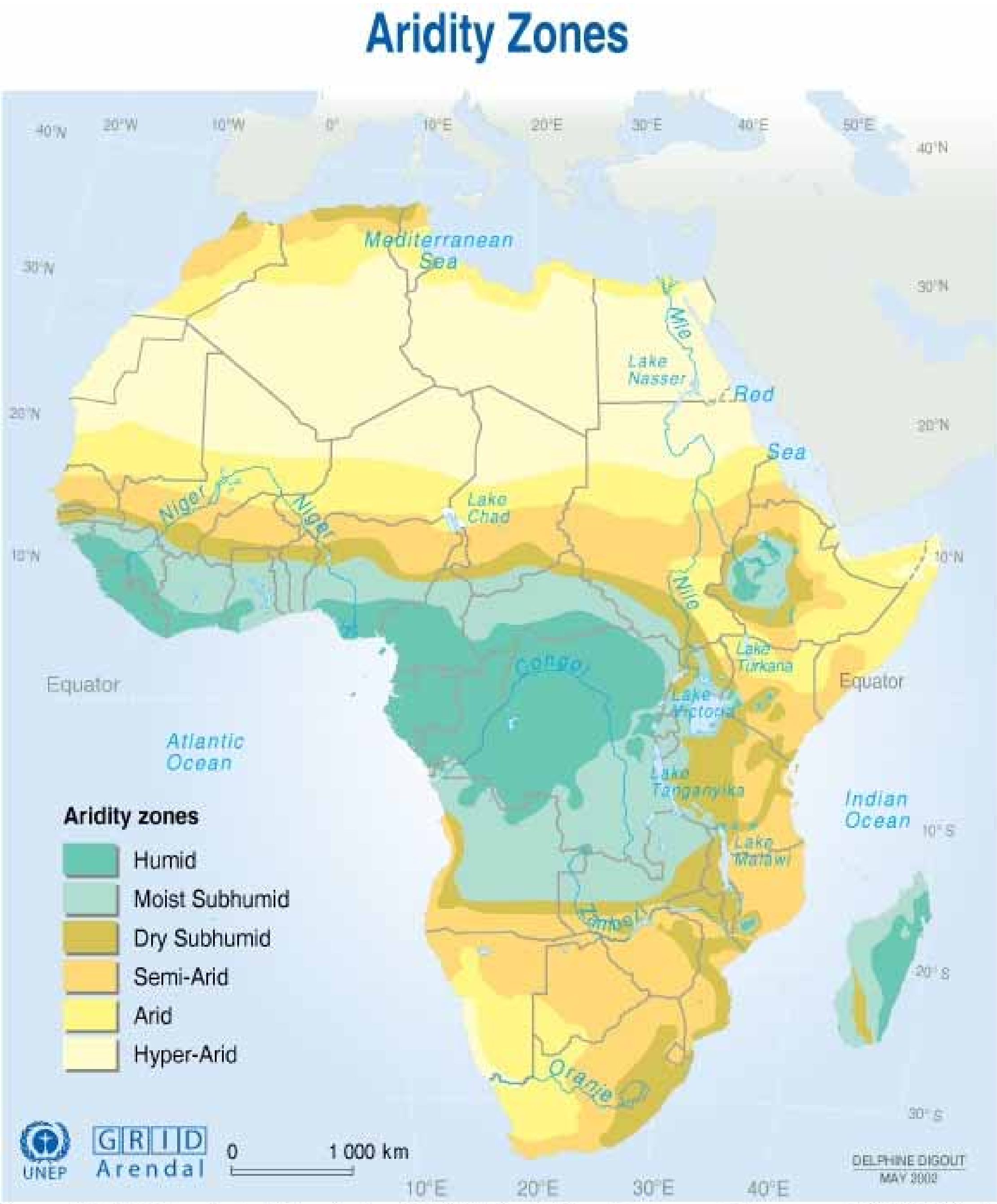



Figure S6: Roads, railways and rivers relative to areas unavailable and/or unsuitable for bioenergy crops in arid and semi arid Senegal

## *Appendix 9 – Africa*




Source: World Meteorological Organization (WMO), United Nations Environment Programme (UNEP), *Climate Change 2001: Impacts, Adaptation, and Vulnerability*, Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).

**Figure 1: Aridity Zones in Africa**

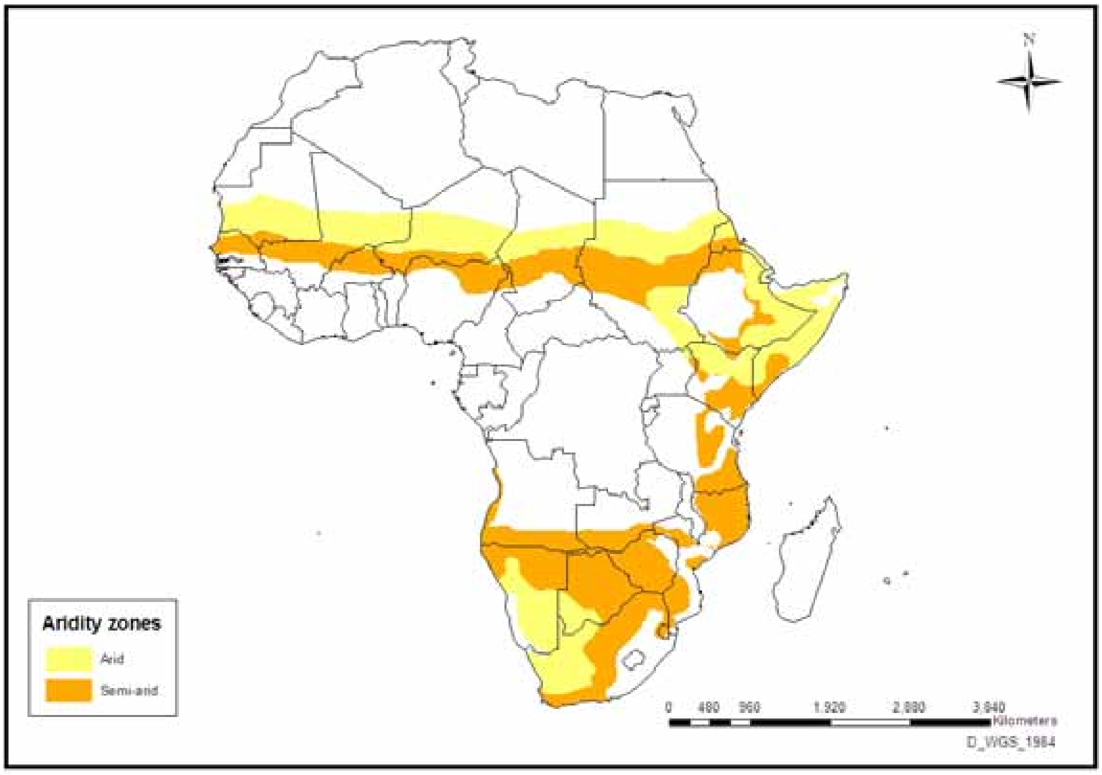



**Figure 2: Arid and semi-arid areas in African countries**

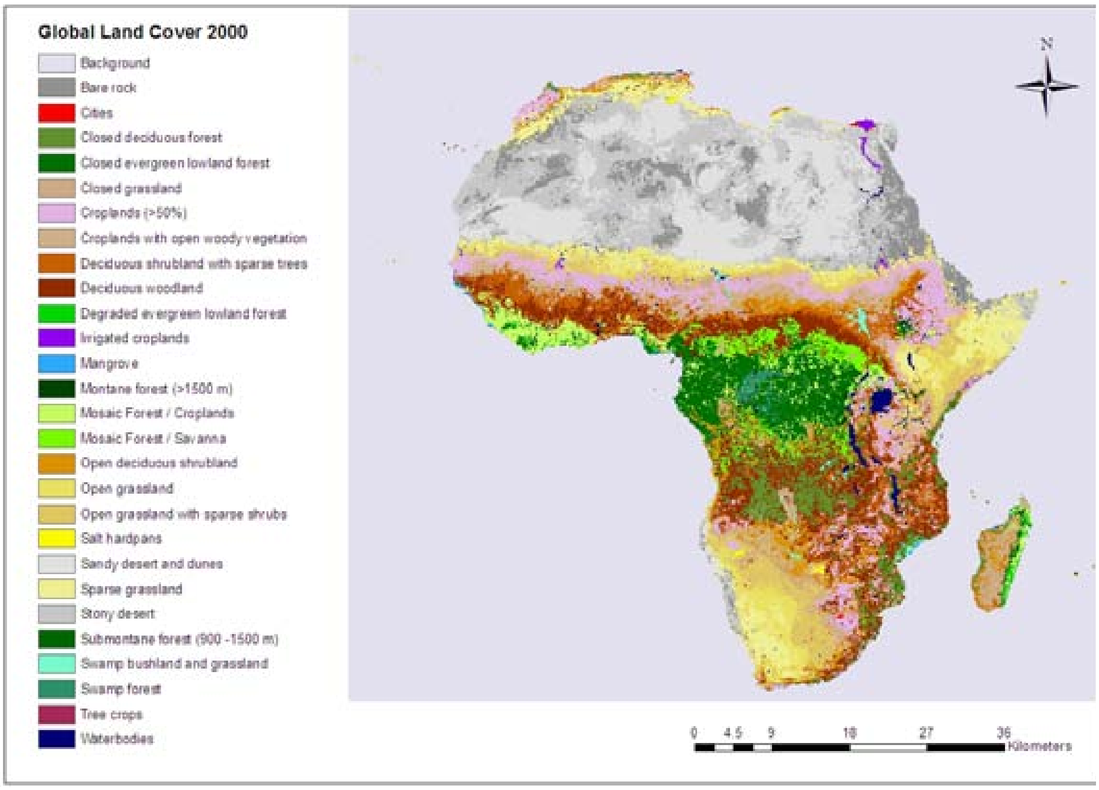



**Figure 3: Spatial extent of Global Land Covers in Africa**

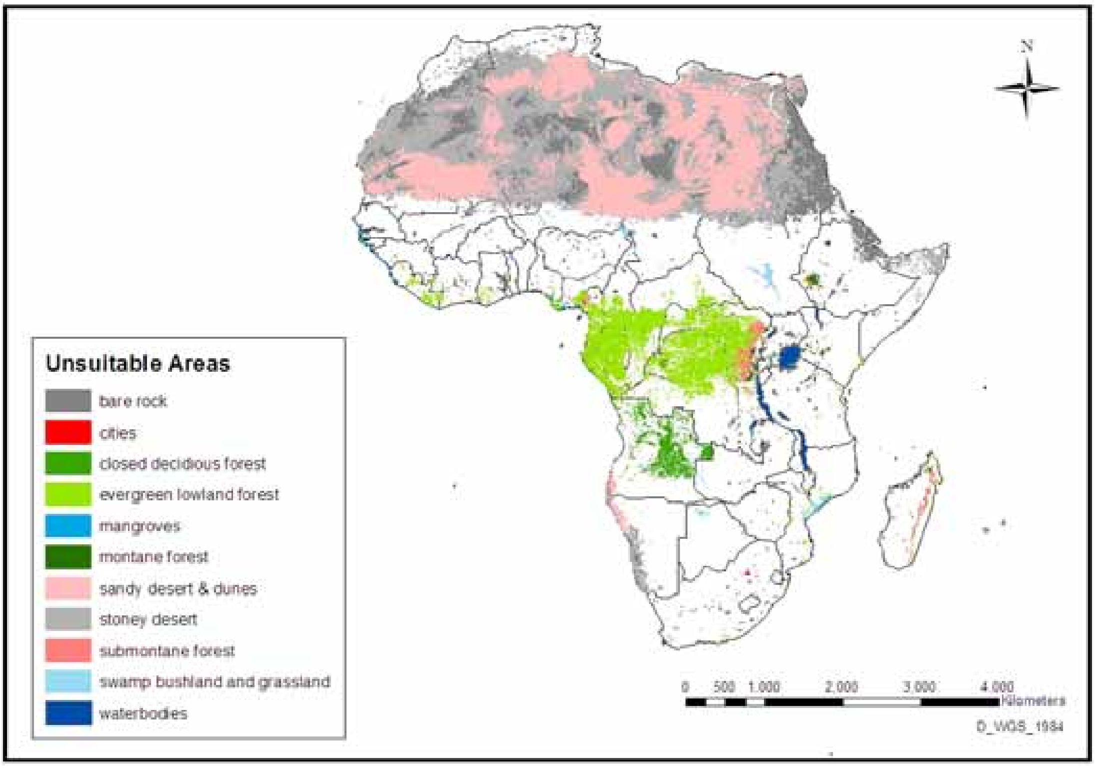



**Figure 4: Land covers unsuitable for bioenergy crops in Africa**

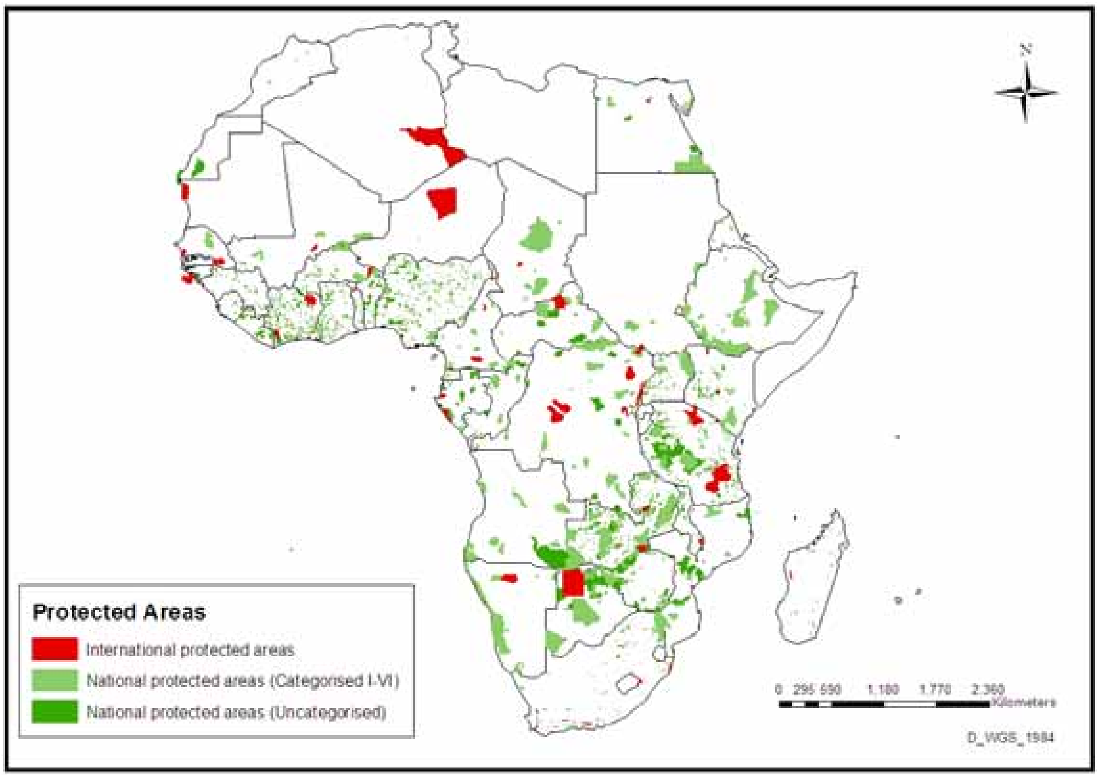



**Figure 5: Protected areas unavailable for bioenergy crops**

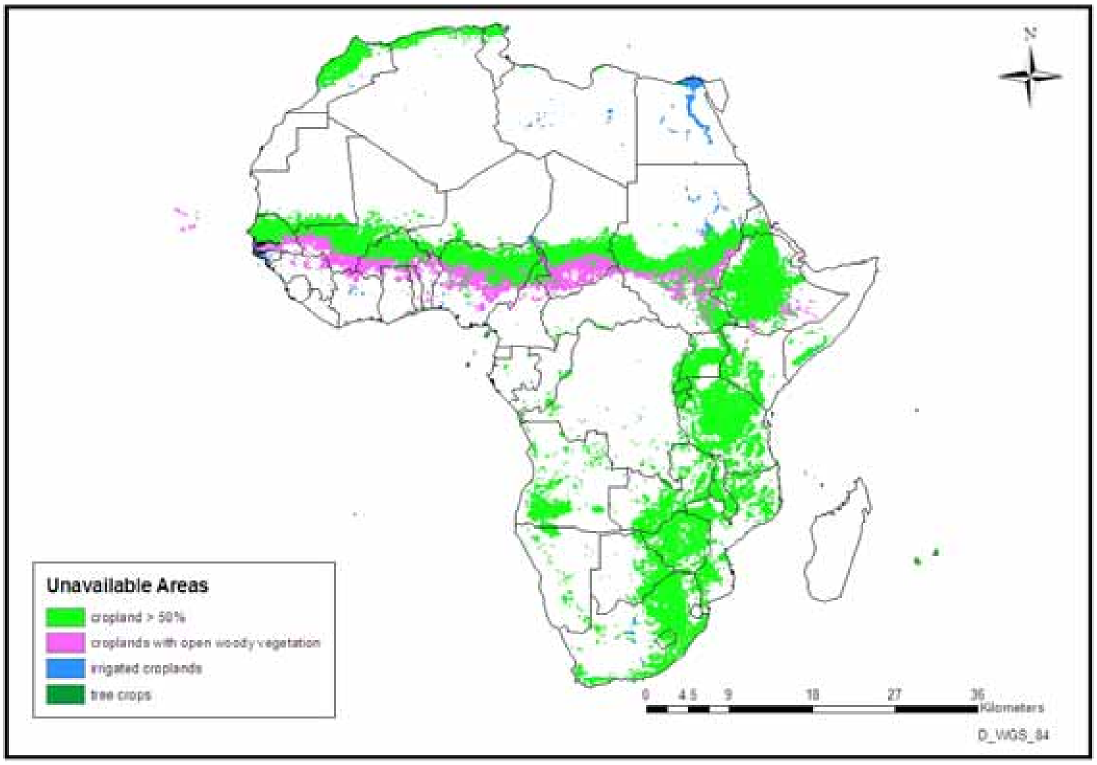



**Figure 6: Areas under food or cash crops unavailable for bioenergy crops**

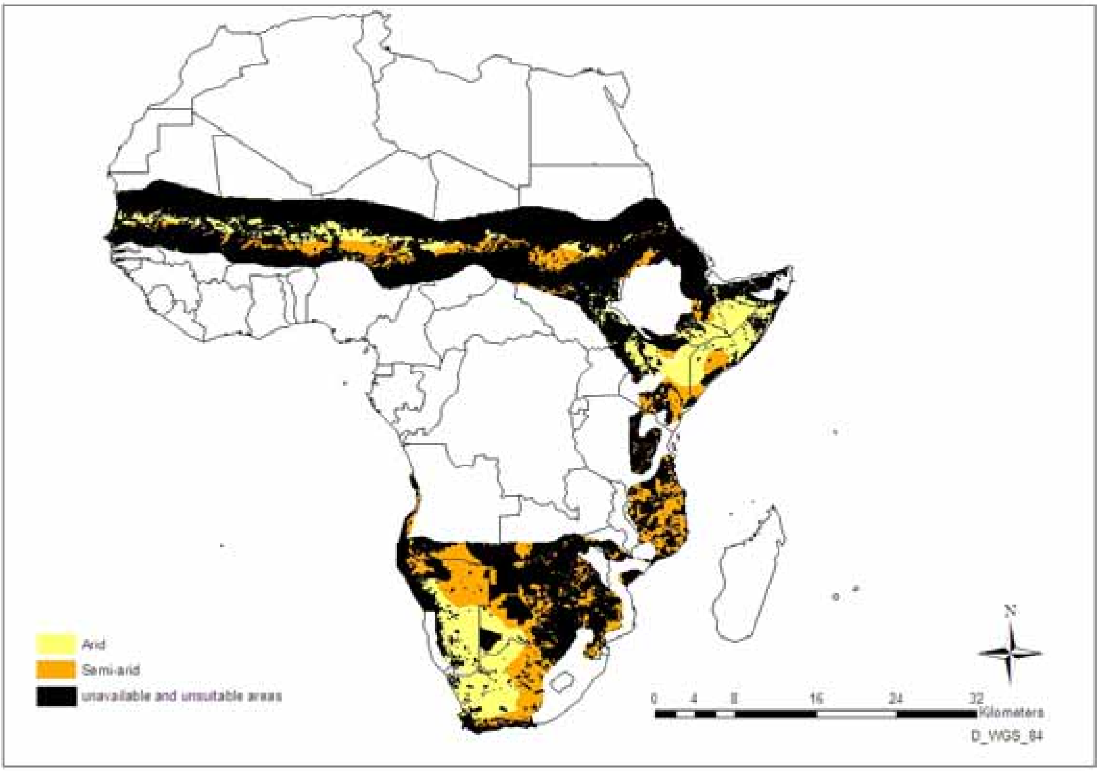



**Figure 7: Unsuitable/unavailable areas for Bioenergy crops in sub-Sahara's arid/semi-arid regions.**

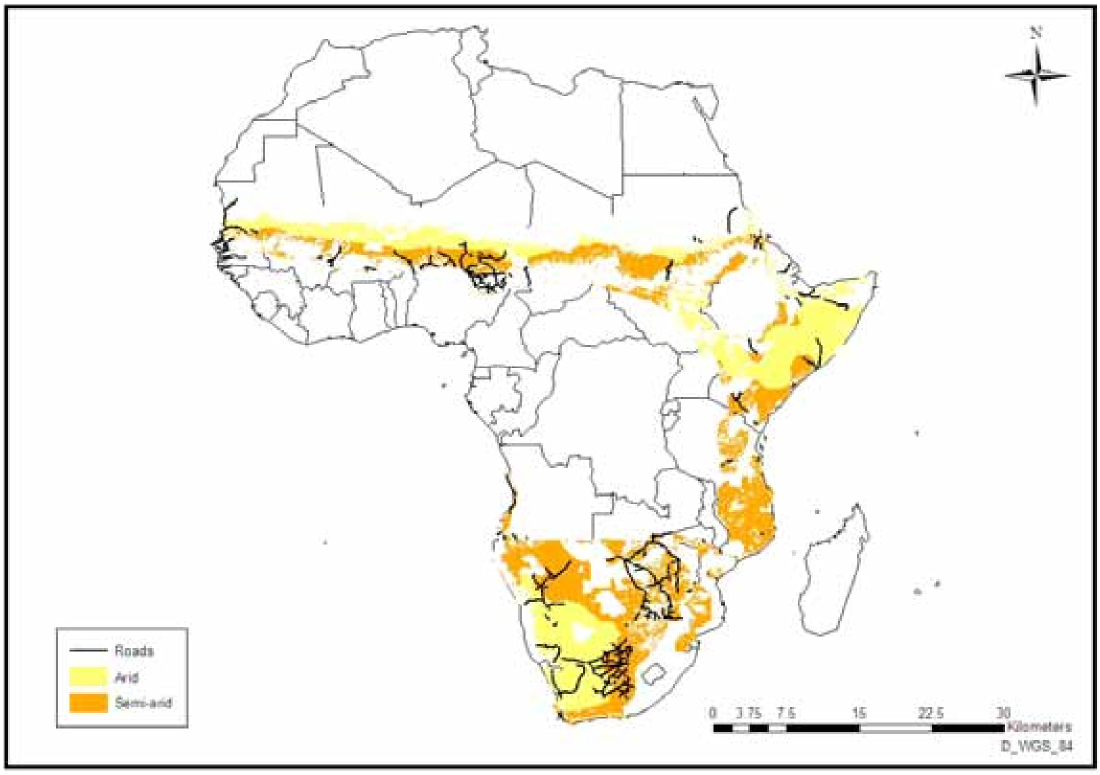



**Figure 8: Primary roads in arid and semi-arid sub-Saharan Africa**

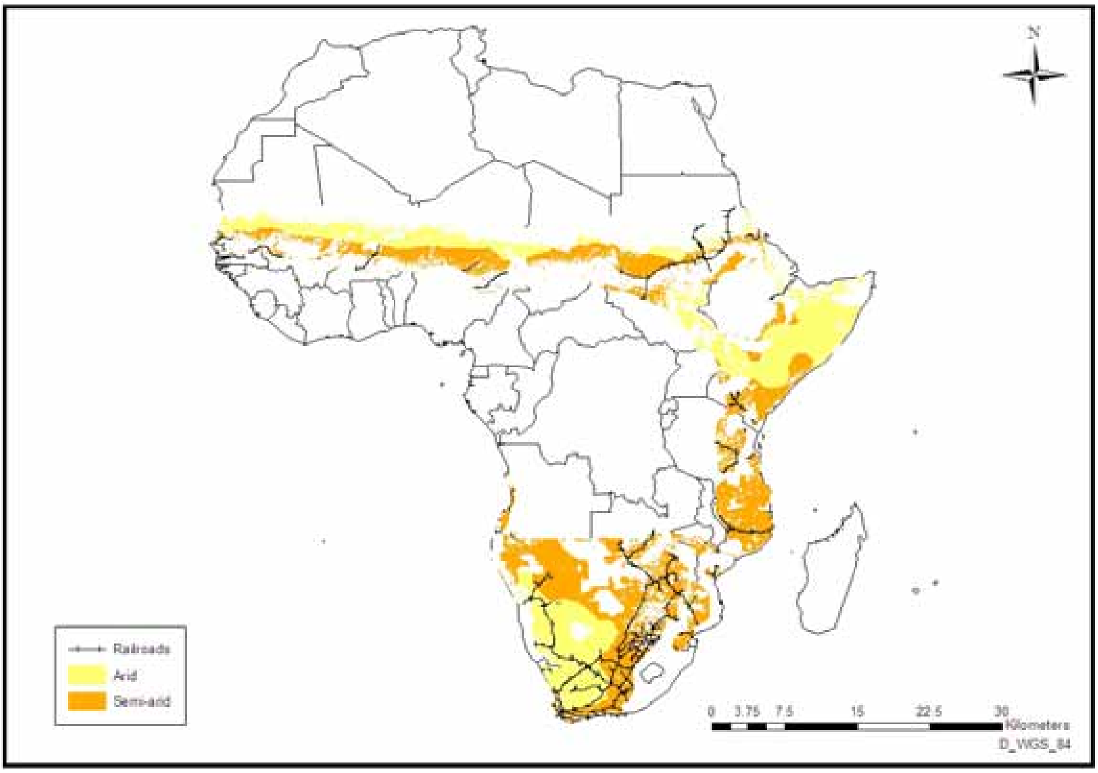



**Figure 9: Railway lines in arid and semi-arid sub-Saharan Africa**

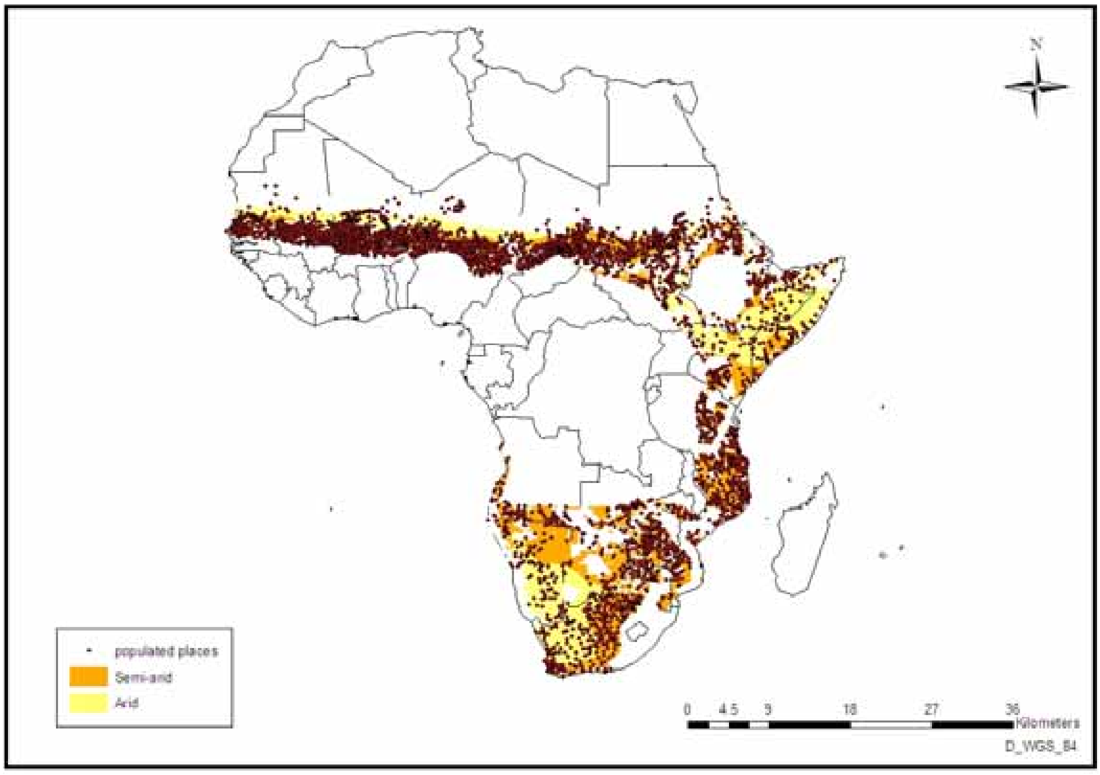
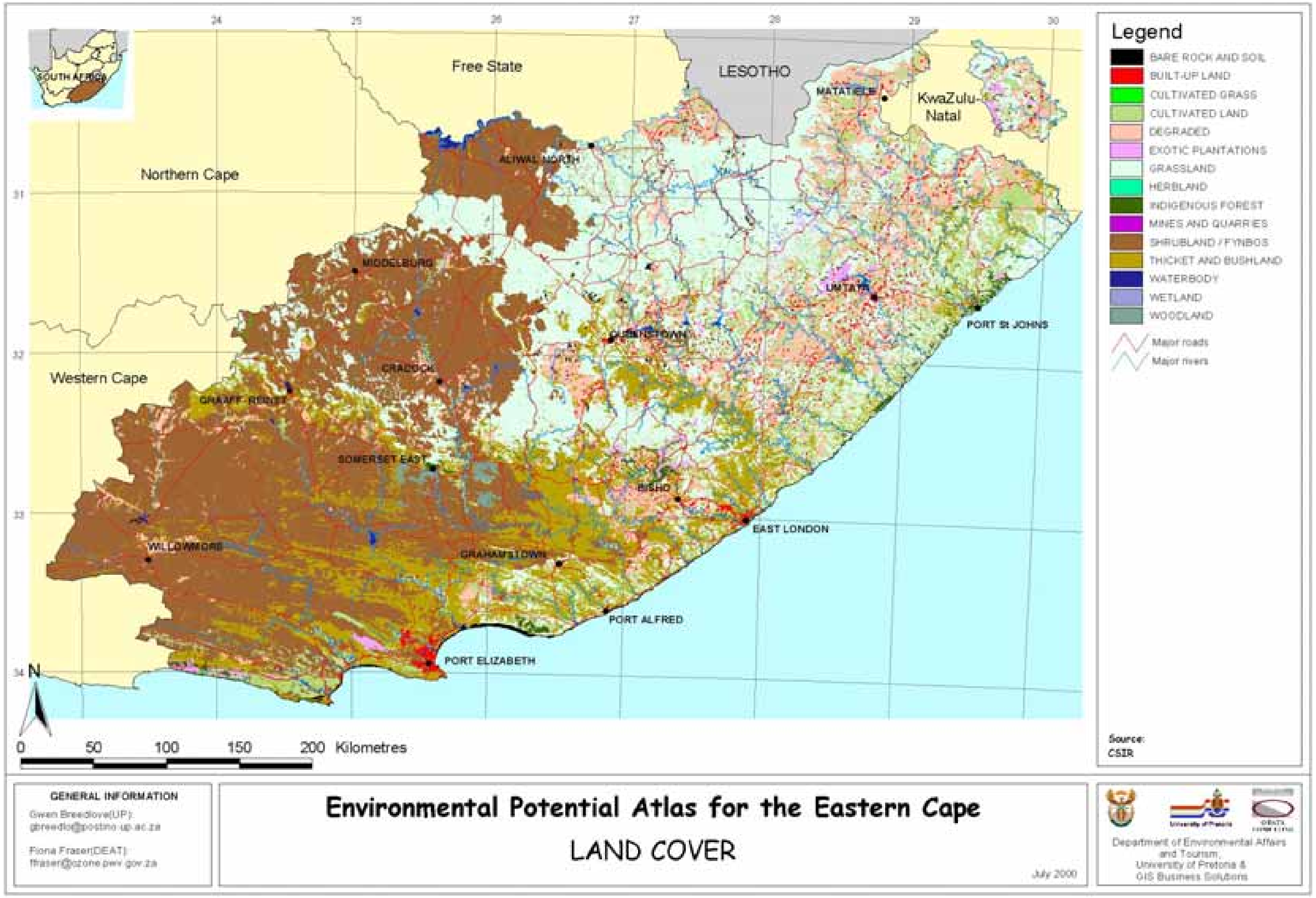
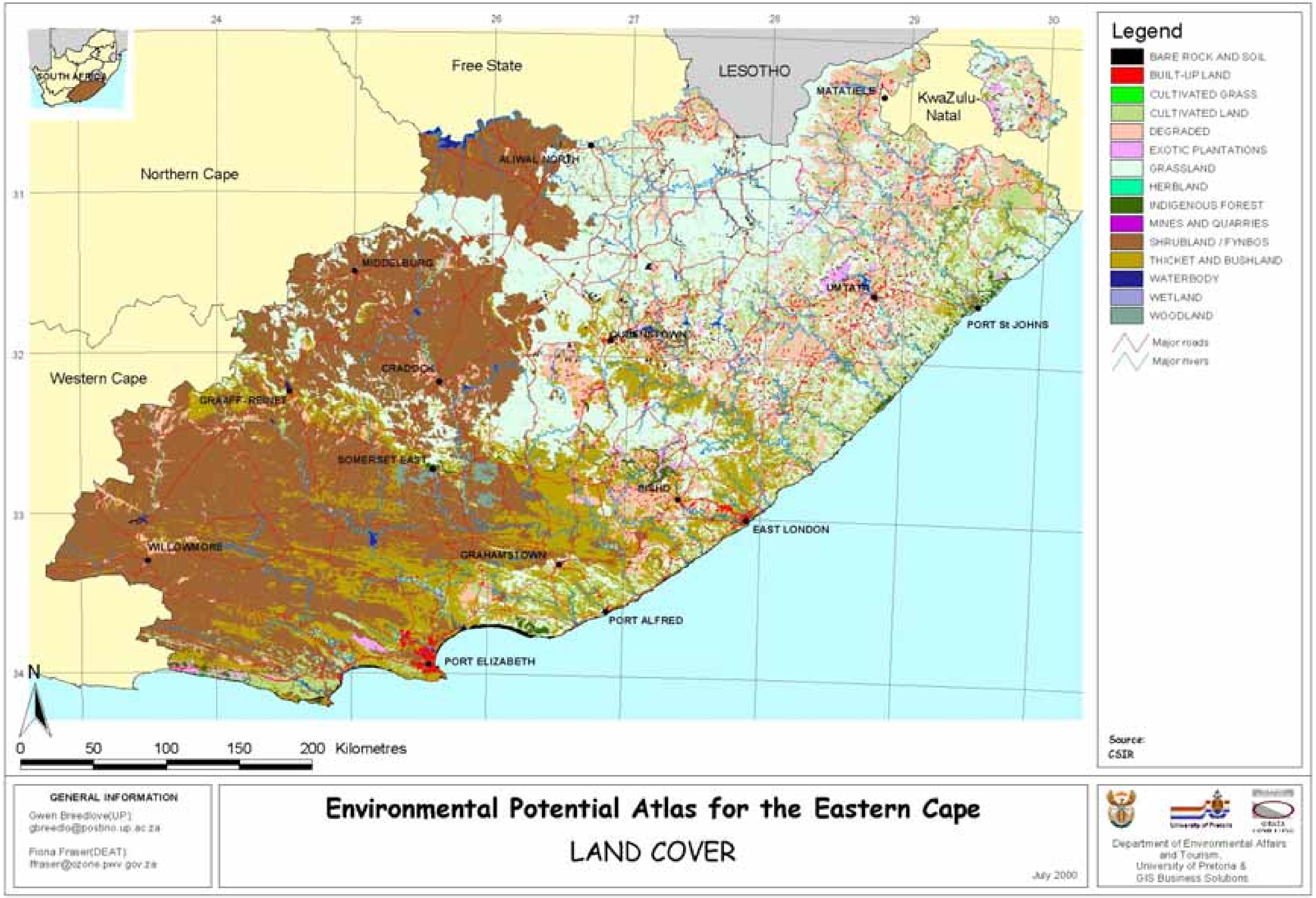


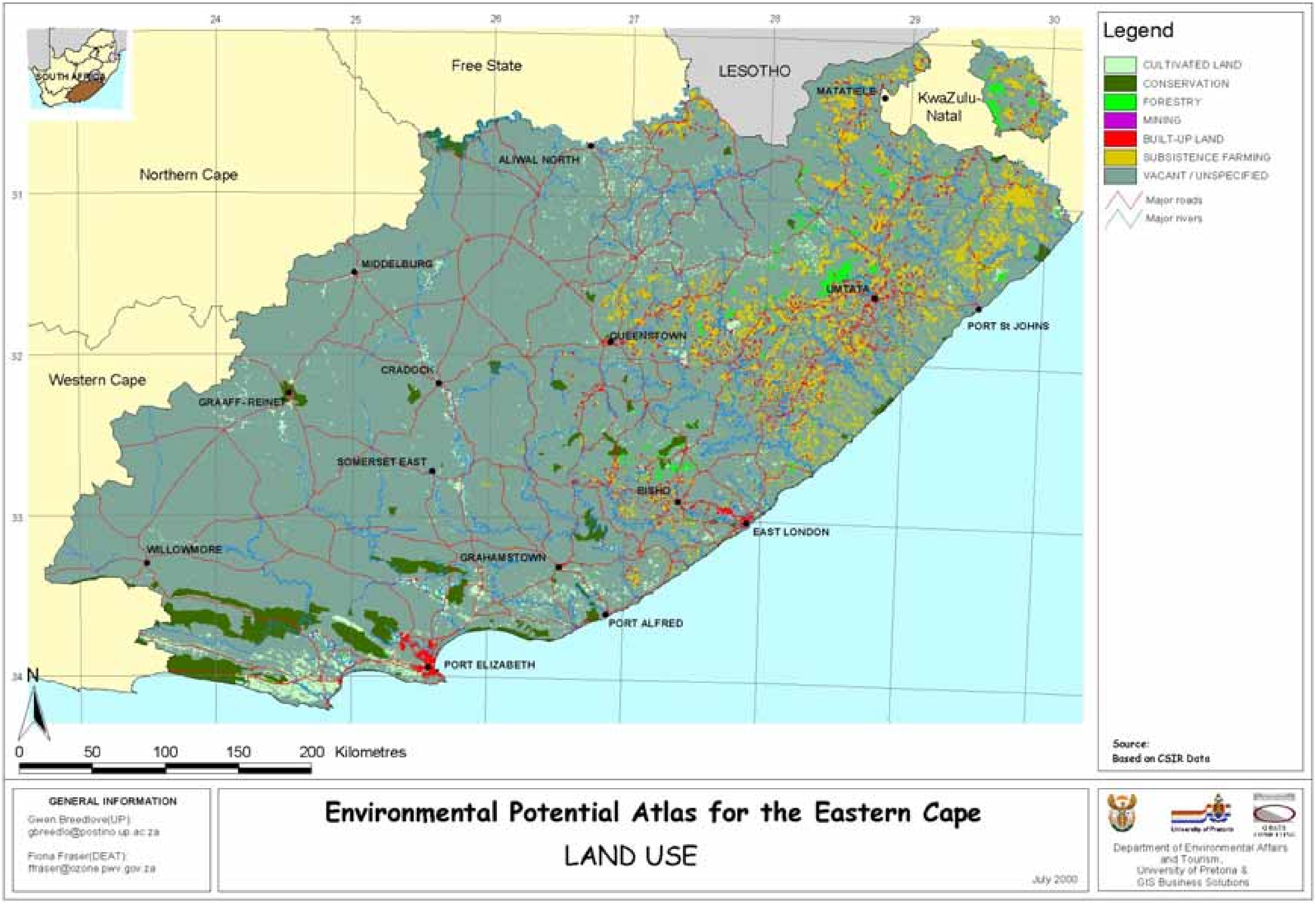

**Figure 10: Populated places in arid and semi-arid sub-Saharan Africa**

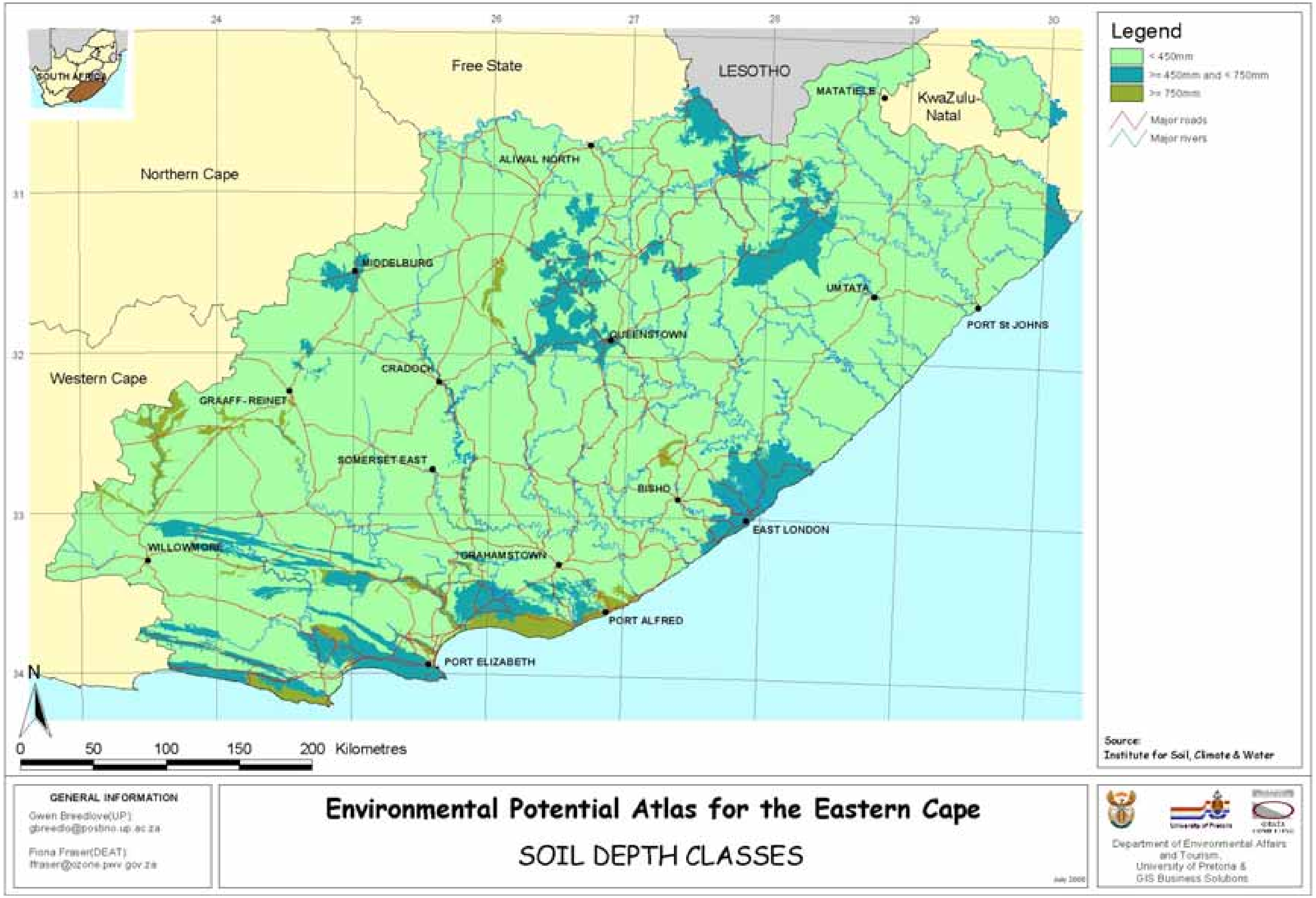
## *Appendix 10 – South Africa (detailled)*

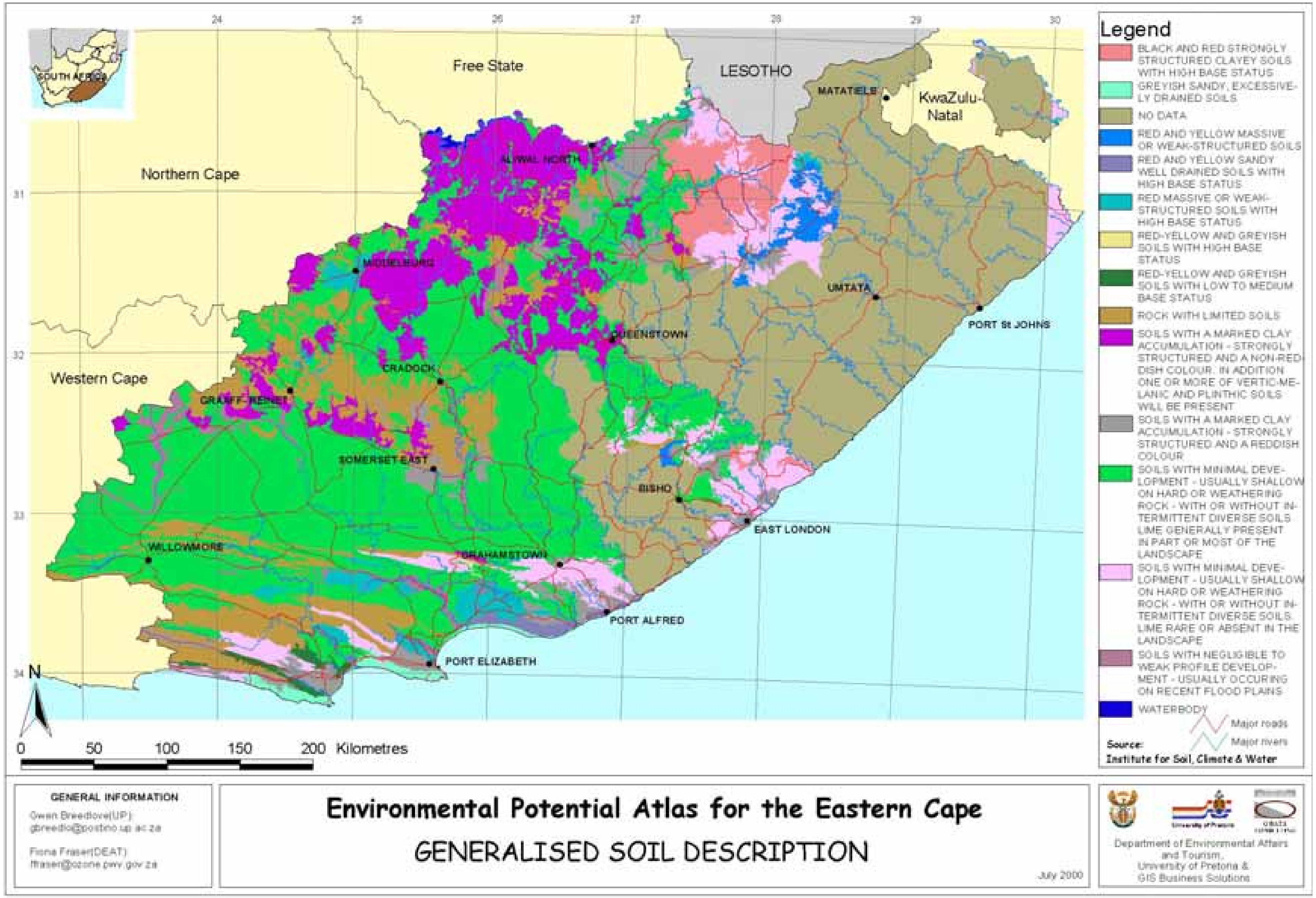
### Eastern Cape Province




Free State
LESOTHO
KwaZulu-Natal
Northern Cape
Western Cape
SOUTH AFRICA
MATATIELE
ALIWAL NORTH
MIDDELBURG
CRADOCK
GRAAFF-REINET
QUEENSTOWN
UMTATA
PORT St JOHNS
SOMERSET EAST
BISHO
EAST LONDON
WILLOWMORE
GRAHAMSTOWN
PORT ALFRED
PORT ELIZABETH
N
0 50 100 150 200 Kilometres
Legend
BARE ROCK AND SOIL
BUILT-UP LAND
CULTIVATED GRASS
CULTIVATED LAND
DEGRADED
EXOTIC PLANTATIONS
GRASSLAND
HERBLAND
INDIGENOUS FOREST
MINES AND QUARRIES
SHRUBLAND / FYNBOS
THICKET AND BUSHLAND
WATERBODY
WETLAND
WOODLAND
Major roads
Major rivers
Source:
CSIR
GENERAL INFORMATION
Gwen Breedlove(UP)
gbreedlo@postino.up.ac.za
Fiona Fraser(DEAT)
ffraser@ozone.pwv.gov.za
Environmental Potential Atlas for the Eastern Cape
LAND COVER
July 2000
Department of Environmental Affairs and Tourism,
University of Pretoria &
GIS Business Solutions


Legend
CULTIVATED LAND
CONSERVATION
FORESTRY
MINING
BUILT-UP LAND
SUBSISTENCE FARMING
VACANT / UNSPECIFIED
Major roads
Major rivers
Free State
LESOTHO
KwaZulu-Natal
Northern Cape
Western Cape
SOUTH AFRICA
MATATIELE
ALIWAL NORTH
MIDDELBURG
UMTATA
PORT St JOHNS
QUEENSTOWN
CRADOCK
GRAAFF-REINET
SOMERSET EAST
BISHO
EAST LONDON
WILLOWMORE
GRAHAMSTOWN
PORT ALFRED
PORT ELIZABETH
N
0 50 100 150 200 Kilometres
Source:
Based on CSIR Data
GENERAL INFORMATION
Gwen Breedlove(UP):
gbreedlo@postino.up.ac.za
Fiona Fraser(DEAT):
ffraser@ozone.pwv.gov.za
Environmental Potential Atlas for the Eastern Cape
LAND USE
July 2000
Department of Environmental Affairs and Tourism, University of Pretoria & GIS Business Solutions


Legend
< 450mm
>= 450mm and < 750mm
>= 750mm
Major roads
Major rivers
SOUTH AFRICA
Free State
LESOTHO
KwaZulu-Natal
Northern Cape
Western Cape
MATATIELE
ALIWAL NORTH
MIDDELBURG
UMTATA
PORT St JOHNS
QUEENSTOWN
CRADOCK
GRAAFF-REINET
SOMERSET EAST
BISHO
EAST LONDON
WILLOWMORE
GRAHAMSTOWN
PORT ALFRED
PORT ELIZABETH
N
0 50 100 150 200 Kilometres
Source:
Institute for Soil, Climate & Water
GENERAL INFORMATION
Gwen Breedlove(UP):
gbreedlo@postino.up.ac.za
Fiona Fraser(DEAT):
ffraser@ozone.pwv.gov.za
Environmental Potential Atlas for the Eastern Cape
SOIL DEPTH CLASSES
Department of Environmental Affairs and Tourism, University of Pretoria & GIS Business Solutions


Free State
LESOTHO
KwaZulu-Natal
Northern Cape
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SOUTH AFRICA
MATATIELE
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QUEENSTOWN
UMTATA
PORT St JOHNS
CRADOCK
GRAAFF-REINET
SOMERSET EAST
BISHO
EAST LONDON
WILLOWMORE
GRAHAMSTOWN
PORT ALFRED
PORT ELIZABETH
N
0 50 100 150 200 Kilometres
Legend
BLACK AND RED STRONGLY STRUCTURED CLAYEY SOILS WITH HIGH BASE STATUS
GREYISH SANDY, EXCESSIVELY DRAINED SOILS
NO DATA
RED AND YELLOW MASSIVE OR WEAK-STRUCTURED SOILS
RED AND YELLOW SANDY WELL DRAINED SOILS WITH HIGH BASE STATUS
RED MASSIVE OR WEAK-STRUCTURED SOILS WITH HIGH BASE STATUS
RED-YELLOW AND GREYISH SOILS WITH HIGH BASE STATUS
RED-YELLOW AND GREYISH SOILS WITH LOW TO MEDIUM BASE STATUS
ROCK WITH LIMITED SOILS
SOILS WITH A MARKED CLAY ACCUMULATION - STRONGLY STRUCTURED AND A NON-REDDISH COLOUR. IN ADDITION ONE OR MORE OF VERTIC-MELANIC AND PLINTHIC SOILS WILL BE PRESENT
SOILS WITH A MARKED CLAY ACCUMULATION - STRONGLY STRUCTURED AND A REDDISH COLOUR
SOILS WITH MINIMAL DEVELOPMENT - USUALLY SHALLOW ON HARD OR WEATHERING ROCK - WITH OR WITHOUT INTERMITTENT DIVERSE SOILS LIME GENERALLY PRESENT IN PART OR MOST OF THE LANDSCAPE
SOILS WITH MINIMAL DEVELOPMENT - USUALLY SHALLOW ON HARD OR WEATHERING ROCK - WITH OR WITHOUT INTERMITTENT DIVERSE SOILS. LIME RARE OR ABSENT IN THE LANDSCAPE
SOILS WITH NEGLIGIBLE TO WEAK PROFILE DEVELOPMENT - USUALLY OCCURING ON RECENT FLOOD PLAINS
WATERBODY
Major roads
Major rivers
Source:
Institute for Soil, Climate & Water
GENERAL INFORMATION
Gwen Breedlove(UP):
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Fiona Fraser(DEAT):
ffraser@ozone.pwv.gov.za
Environmental Potential Atlas for the Eastern Cape
GENERALISED SOIL DESCRIPTION
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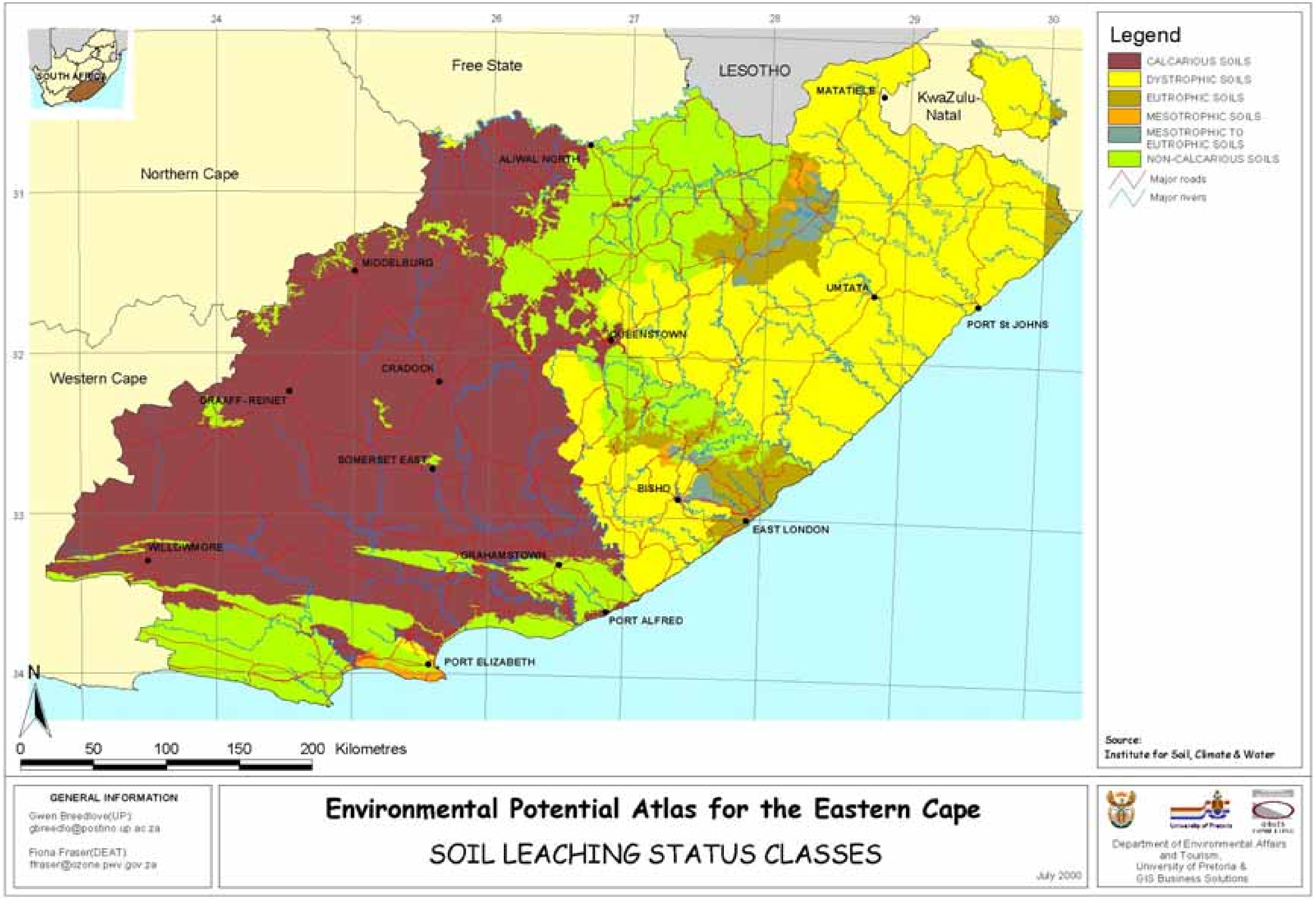
GIS Business Solutions


Legend
CALCARIOUS SOILS
DYSTROPHIC SOILS
EUTROPHIC SOILS
MESOTROPHIC SOILS
MESOTROPHIC TO EUTROPHIC SOILS
NON-CALCARIOUS SOILS
Major roads
Major rivers
Free State
LESOTHO
KwaZulu-Natal
Northern Cape
Western Cape
SOUTH AFRICA
MATATIELE
ALIWAL NORTH
MIDDELBURG
UMTATA
PORT St JOHNS
QUEENSTOWN
CRADOCK
GRAAFF-REINET
SOMERSET EAST
BISHO
EAST LONDON
WILLOWMORE
GRAHAMSTOWN
PORT ALFRED
PORT ELIZABETH
N
0 50 100 150 200 Kilometres
Source:
Institute for Soil, Climate & Water
GENERAL INFORMATION
Gwen Breedlove(UP)
gbreedlo@postino.up.ac.za
Fiona Fraser(DEAT)
ffraser@ozone.pwv.gov.za
Environmental Potential Atlas for the Eastern Cape
SOIL LEACHING STATUS CLASSES
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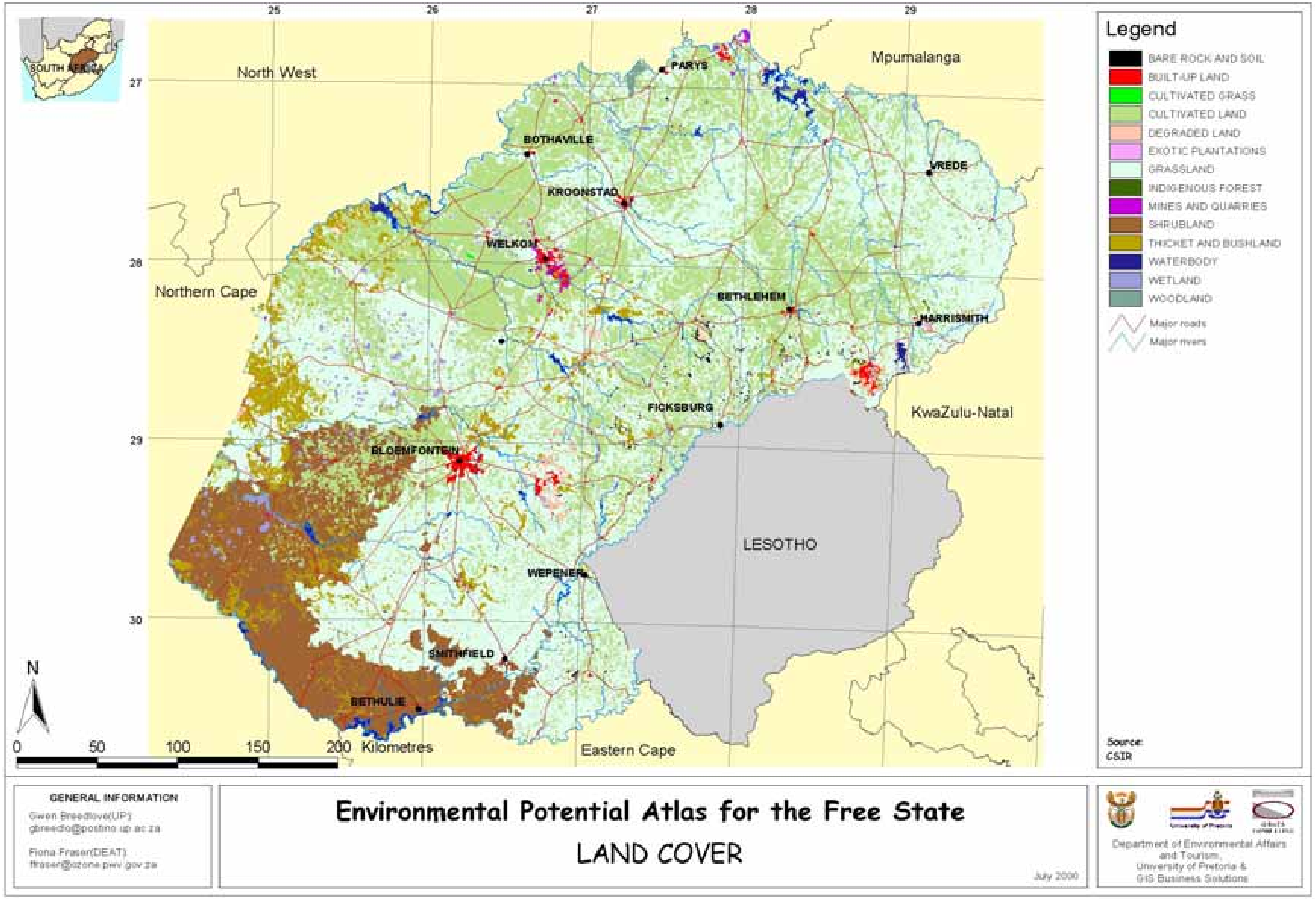
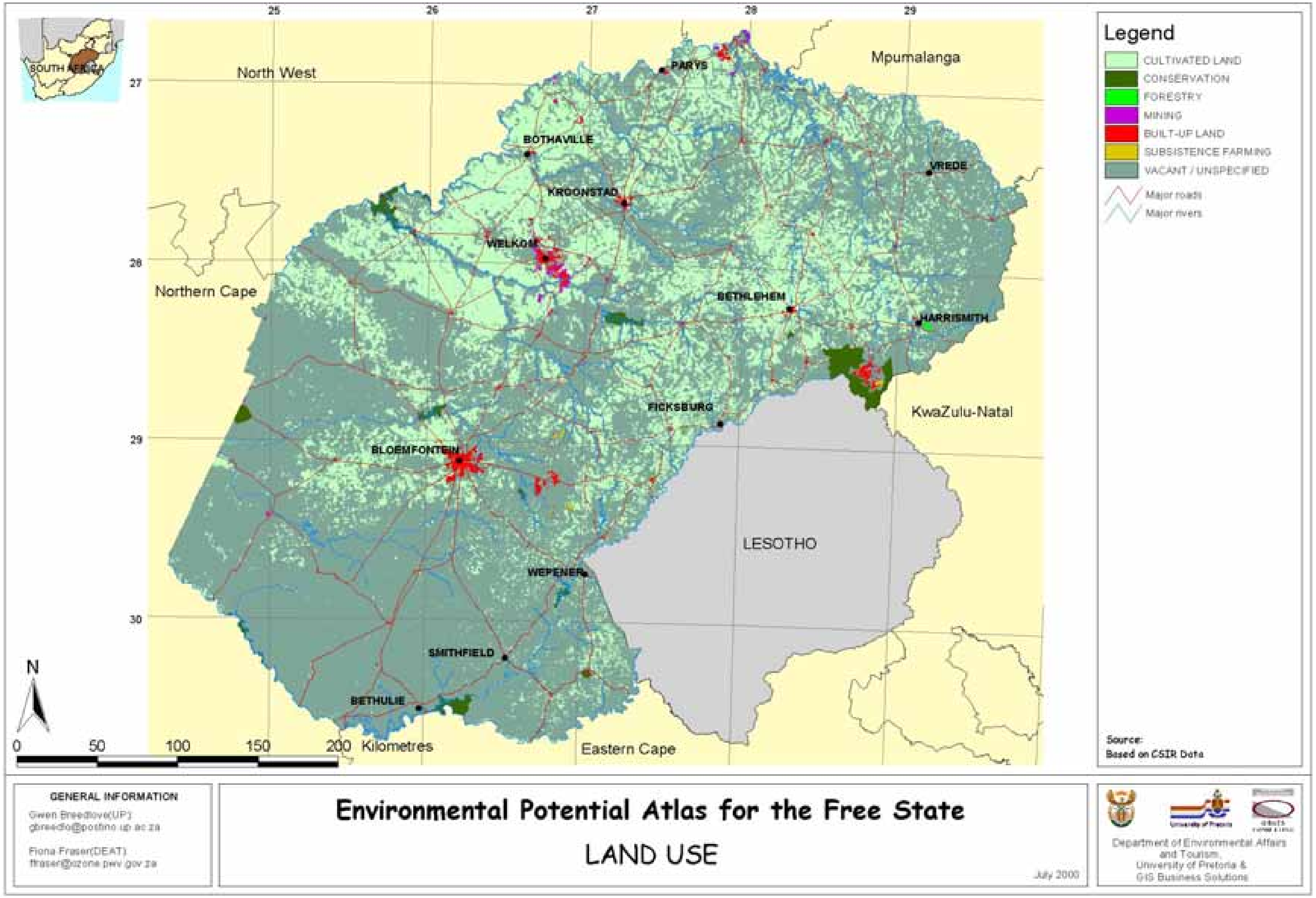
GIS Business Solutions

**Eastern Cape Province**

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CULTIVATED LAND
CONSERVATION
FORESTRY
MINING
BUILT-UP LAND
SUBSISTENCE FARMING
VACANT / UNSPECIFIED
Major roads
Major rivers
Source:
Based on CSIR Data
North West
Mpumalanga
Northern Cape
KwaZulu-Natal
LESOTHO
Eastern Cape
SOUTH AFRICA
PARYS
BOTHAVILLE
VREDE
KROONSTAD
WELKOM
BETHLEHEM
HARRISMITH
FICKSBURG
BLOEMFONTEIN
WEPENER
SMITHFIELD
BETHULIE
N
0 50 100 150 200 Kilometres
GENERAL INFORMATION
Gwen Breedlove(UP)
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Fiona Fraser(DEAT)
ffraser@ozone.pwv.gov.za
Environmental Potential Atlas for the Free State
LAND USE
July 2000
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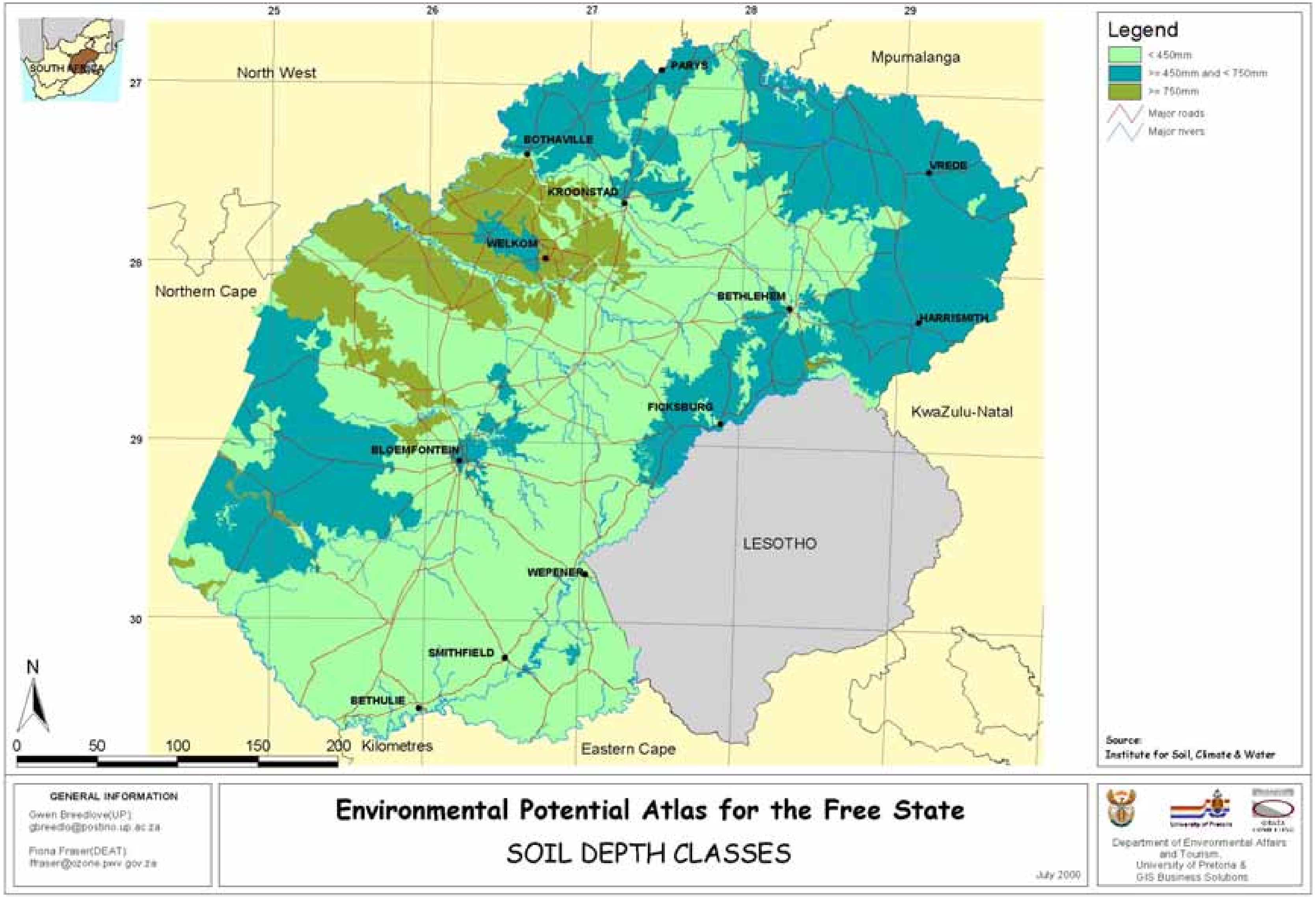
Legend
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>= 450mm and < 750mm
>= 750mm
Major roads
Major rivers
North West
Mpumalanga
Northern Cape
KwaZulu-Natal
LESOTHO
Eastern Cape
PARYS
BOTHAVILLE
VREDE
KROONSTAD
WELKOM
BETHLEHEM
HARRISMITH
FICKSBURG
BLOEMFONTEIN
WEPENER
SMITHFIELD
BETHULIE
SOUTH AFRICA
N
0 50 100 150 200 Kilometres
25 26 27 28 29
27 28 29 30
Source:
Institute for Soil, Climate & Water
GENERAL INFORMATION
Gwen Breedlove(UP):
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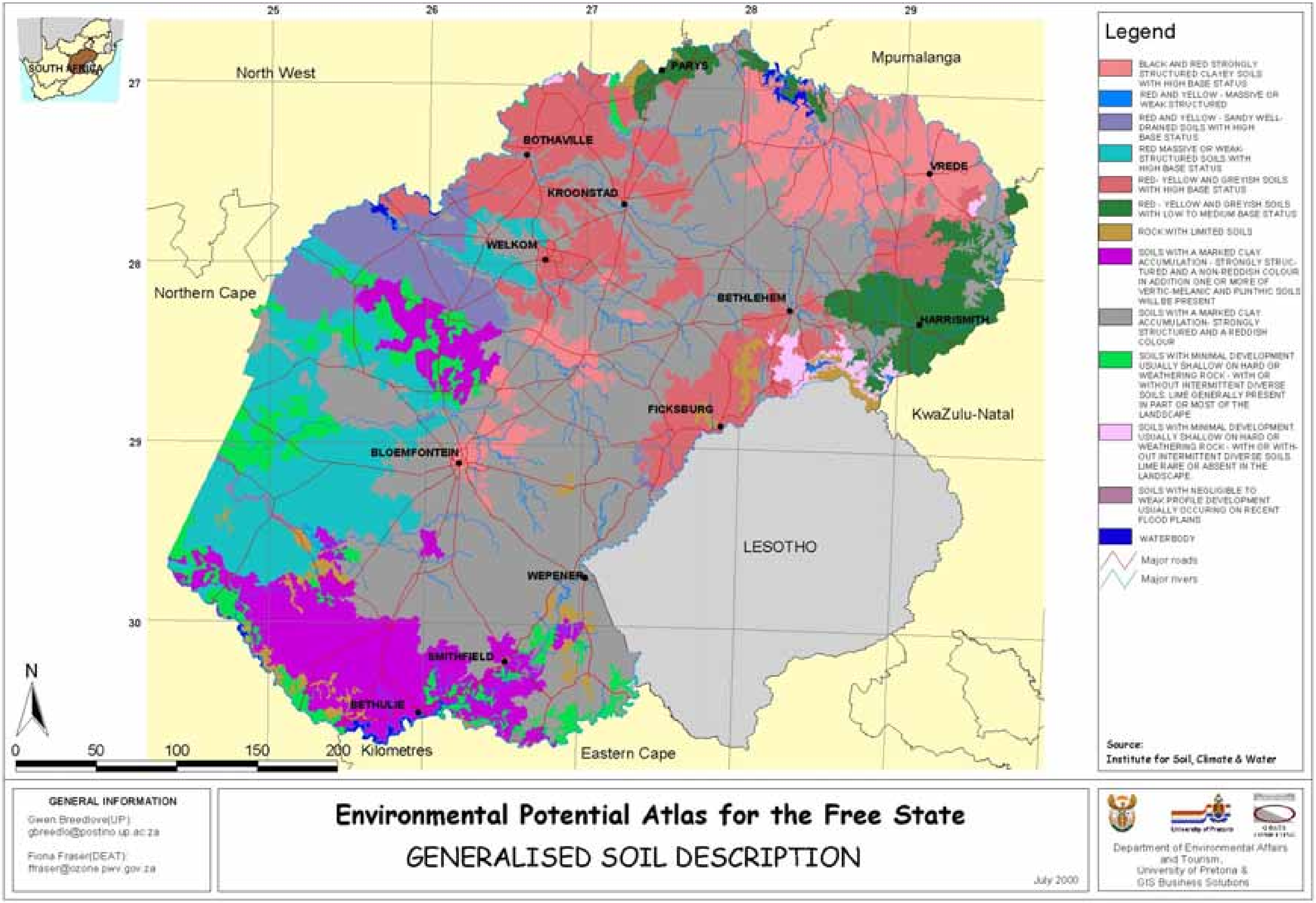

North West
Mpumalanga
Northern Cape
KwaZulu-Natal
LESOTHO
Eastern Cape
SOUTH AFRICA
PARYS
BOTHAVILLE
KROONSTAD
VREDE
WELKOM
BETHLEHEM
HARRISMITH
FICKSBURG
BLOEMFONTEIN
WEPENER
SMITHFIELD
BETHULIE
N
0 50 100 150 200 Kilometres
Legend
BLACK AND RED STRONGLY STRUCTURED CLAYEY SOILS WITH HIGH BASE STATUS
RED AND YELLOW - MASSIVE OR WEAK STRUCTURED
RED AND YELLOW - SANDY WELL-DRAINED SOILS WITH HIGH BASE STATUS
RED MASSIVE OR WEAK STRUCTURED SOILS WITH HIGH BASE STATUS
RED- YELLOW AND GREYISH SOILS WITH HIGH BASE STATUS
RED - YELLOW AND GREYISH SOILS WITH LOW TO MEDIUM BASE STATUS
ROCK WITH LIMITED SOILS
SOILS WITH A MARKED CLAY ACCUMULATION - STRONGLY STRUCTURED AND A NON-REDDISH COLOUR IN ADDITION ONE OR MORE OF VERTIC-MELANIC AND PLINTHIC SOILS WILL BE PRESENT
SOILS WITH A MARKED CLAY ACCUMULATION- STRONGLY STRUCTURED AND A REDDISH COLOUR
SOILS WITH MINIMAL DEVELOPMENT USUALLY SHALLOW ON HARD OR WEATHERING ROCK - WITH OR WITHOUT INTERMITTENT DIVERSE SOILS. LIME GENERALLY PRESENT IN PART OR MOST OF THE LANDSCAPE
SOILS WITH MINIMAL DEVELOPMENT USUALLY SHALLOW ON HARD OR WEATHERING ROCK - WITH OR WITHOUT INTERMITTENT DIVERSE SOILS LIME RARE OR ABSENT IN THE LANDSCAPE
SOILS WITH NEGLIGIBLE TO WEAK PROFILE DEVELOPMENT USUALLY OCCURING ON RECENT FLOOD PLAINS
WATERBODY
Major roads
Major rivers
Source:
Institute for Soil, Climate & Water
GENERAL INFORMATION
Gwen Breedlove(UP): gbreedlo@postino.up.ac.za
Fiona Fraser(DEAT): ffraser@ozone.pwv.gov.za
Environmental Potential Atlas for the Free State
GENERALISED SOIL DESCRIPTION
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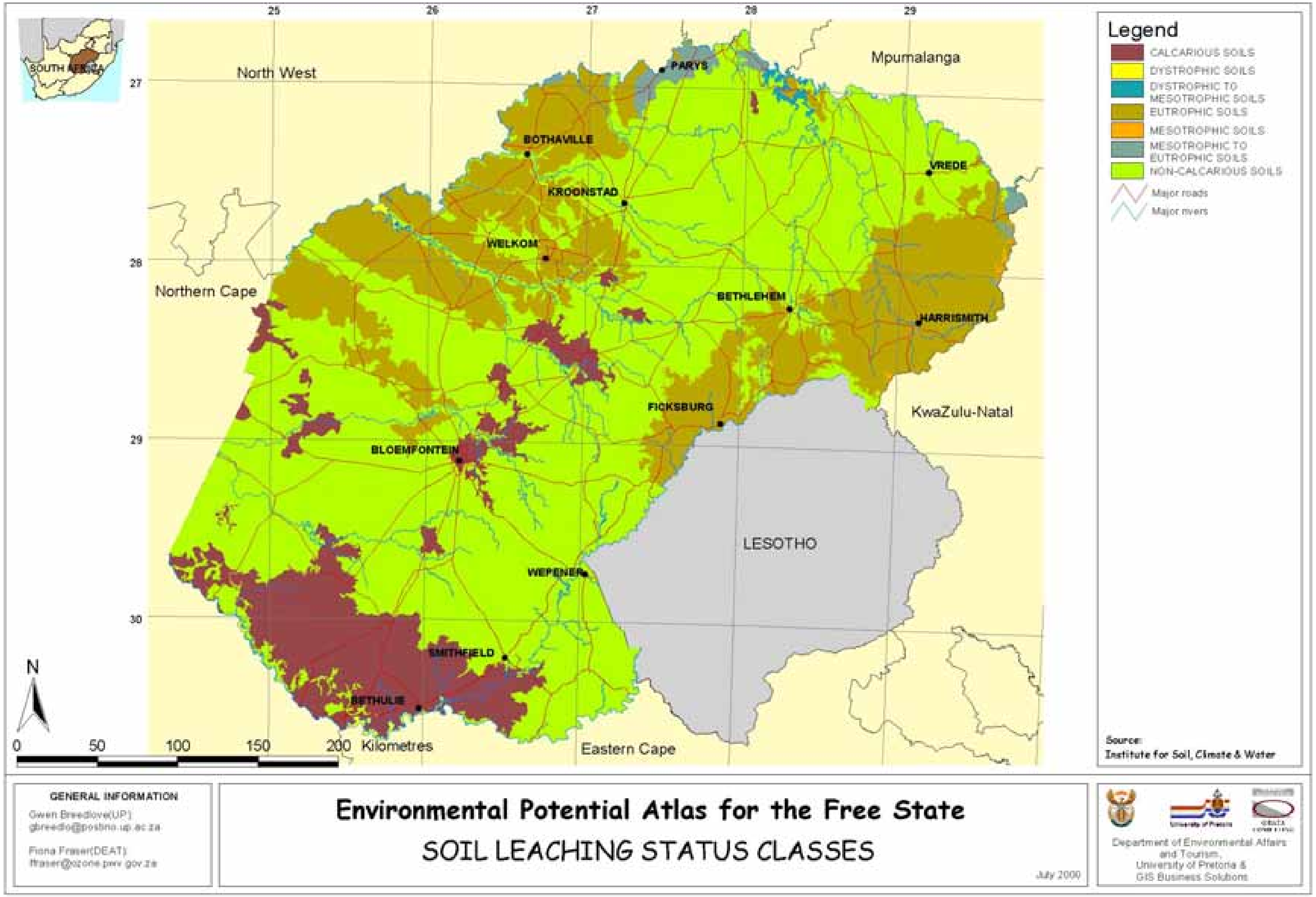
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CALCARIOUS SOILS
DYSTROPHIC SOILS
DYSTROPHIC TO MESOTROPHIC SOILS
EUTROPHIC SOILS
MESOTROPHIC SOILS
MESOTROPHIC TO EUTROPHIC SOILS
NON-CALCARIOUS SOILS
Major roads
Major rivers
Source: Institute for Soil, Climate & Water
North West
Mpumalanga
Northern Cape
KwaZulu-Natal
LESOTHO
Eastern Cape
PARYS
BOTHAVILLE
KROONSTAD
VREDE
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BETHLEHEM
HARRISMITH
FICKSBURG
BLOEMFONTEIN
WEPENER
SMITHFIELD
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SOUTH AFRICA
N
0 50 100 150 200 Kilometres
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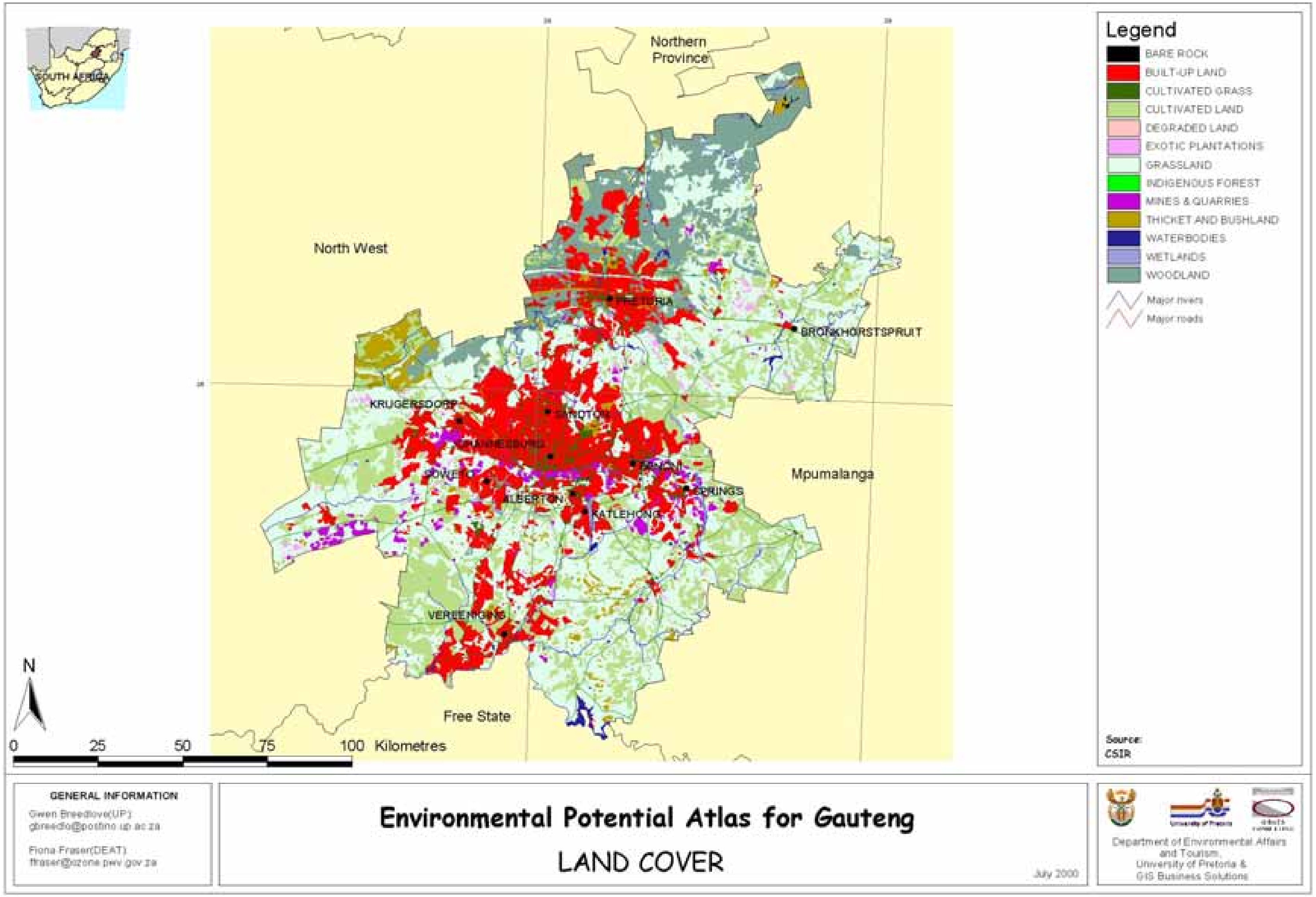
**Gauteng**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Northern Province
North West
Mpumalanga
Free State
PRETORIA
BRONKHORSTSPRUIT
KRUGERSDORP
SANDTON
JOHANNESBURG
SOWETO
BENONI
SPRINGS
ALBERTON
KATLEHONG
VEREENIGING
N
0 25 50 75 100 Kilometres
Legend
BARE ROCK
BUILT-UP LAND
CULTIVATED GRASS
CULTIVATED LAND
DEGRADED LAND
EXOTIC PLANTATIONS
GRASSLAND
INDIGENOUS FOREST
MINES & QUARRIES
THICKET AND BUSHLAND
WATERBODIES
WETLANDS
WOODLAND
Major rivers
Major roads
Source:
CSIR
GENERAL INFORMATION
Gwen Breedlove(UP)
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Environmental Potential Atlas for Gauteng
LAND COVER
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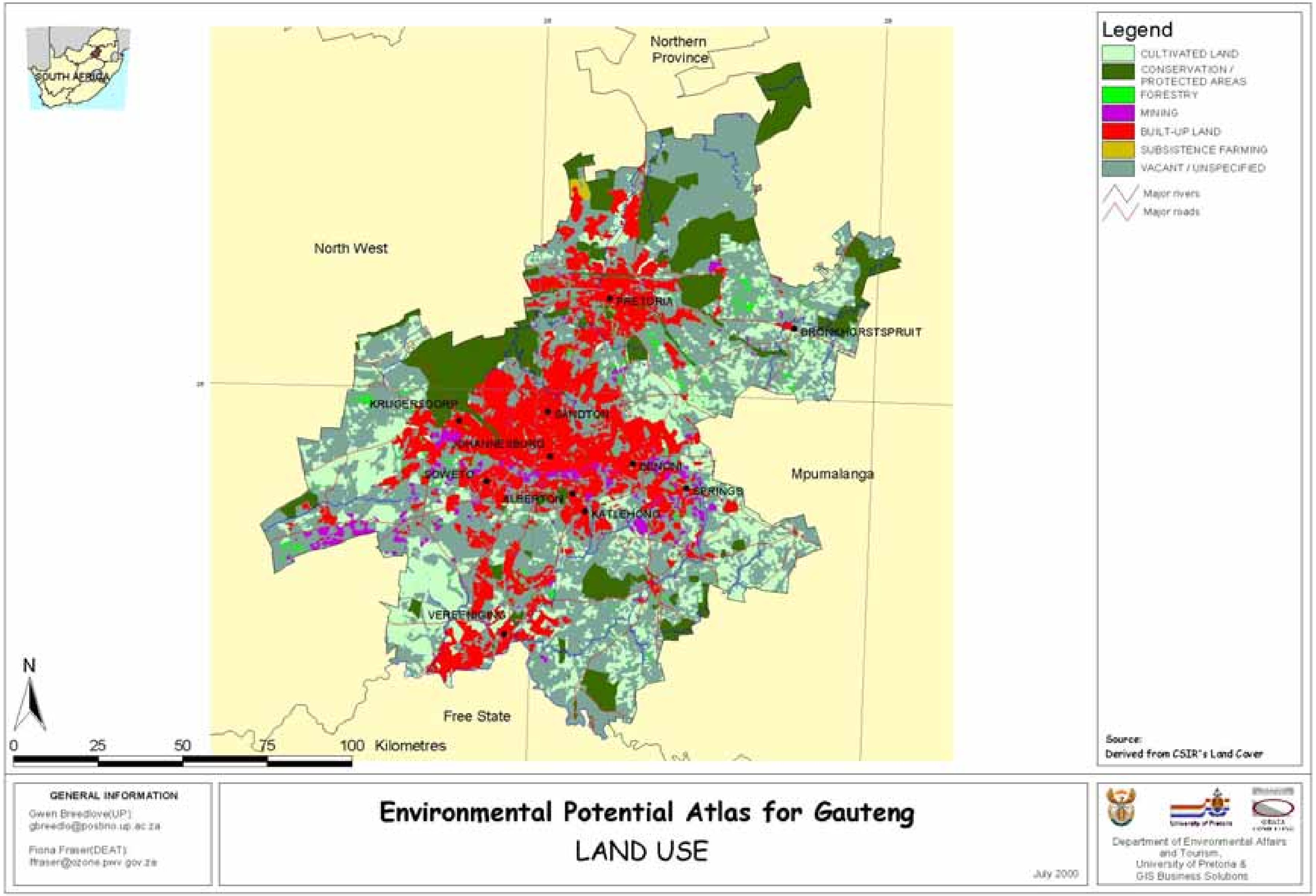
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CULTIVATED LAND
CONSERVATION / PROTECTED AREAS
FORESTRY
MINING
BUILT-UP LAND
SUBSISTENCE FARMING
VACANT / UNSPECIFIED
Major rivers
Major roads
Source:
Derived from CSIR's Land Cover
SOUTH AFRICA
Northern Province
North West
Mpumalanga
Free State
PRETORIA
BRONKHORSTSPRUIT
KRUGERSDORP
SANDTON
JOHANNESBURG
BENONI
SOWETO
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ALBERTON
KATLEHONG
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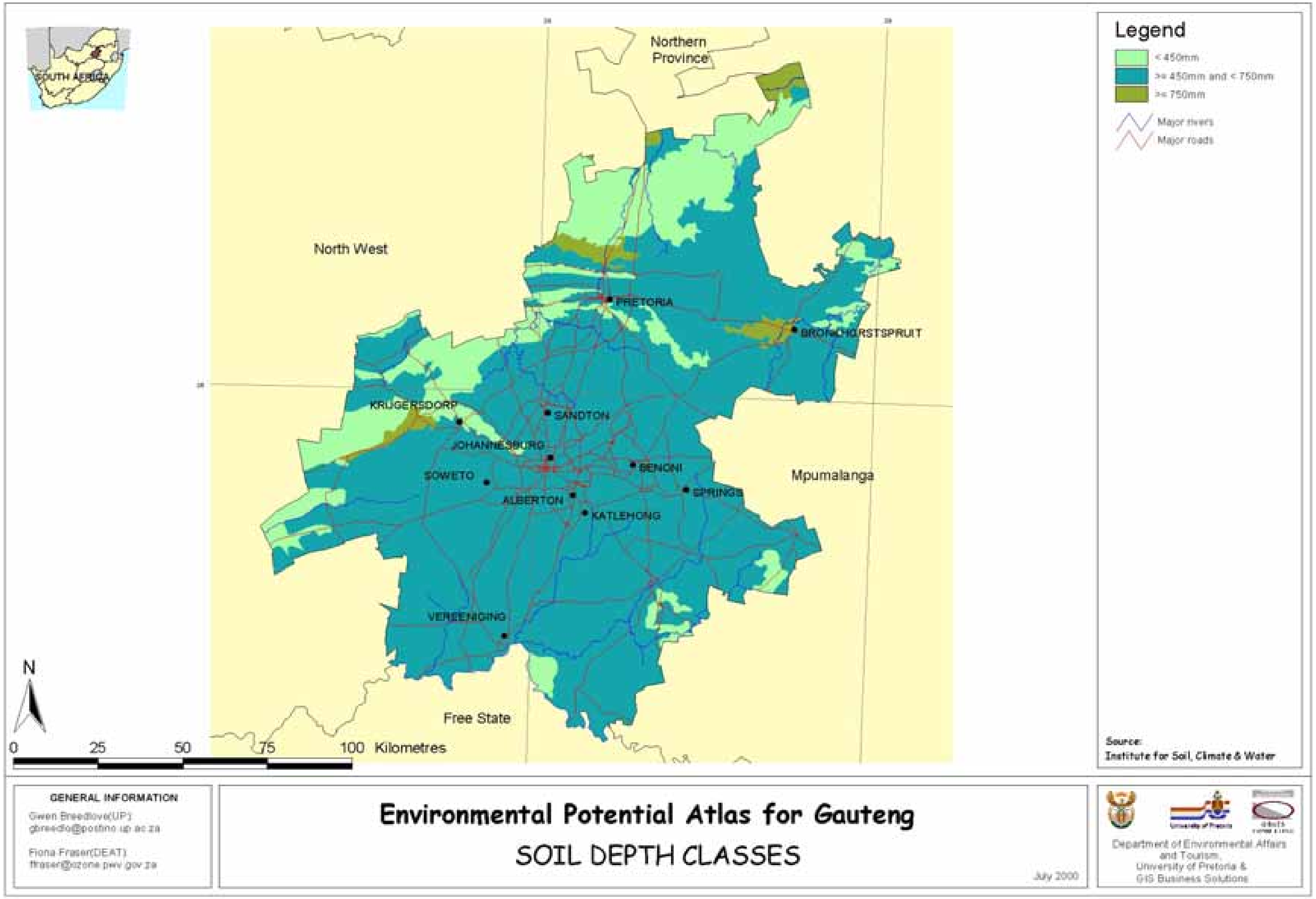
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>= 450mm and < 750mm
>= 750mm
Major rivers
Major roads
Northern Province
North West
Mpumalanga
Free State
PRETORIA
BRONKHORSTSPRUIT
KRUGERSDORP
SANDTON
JOHANNESBURG
SOWETO
BENONI
SPRINGS
ALBERTON
KATLEHONG
VEREENIGING
SOUTH AFRICA
N
0 25 50 75 100 Kilometres
Source:
Institute for Soil, Climate & Water
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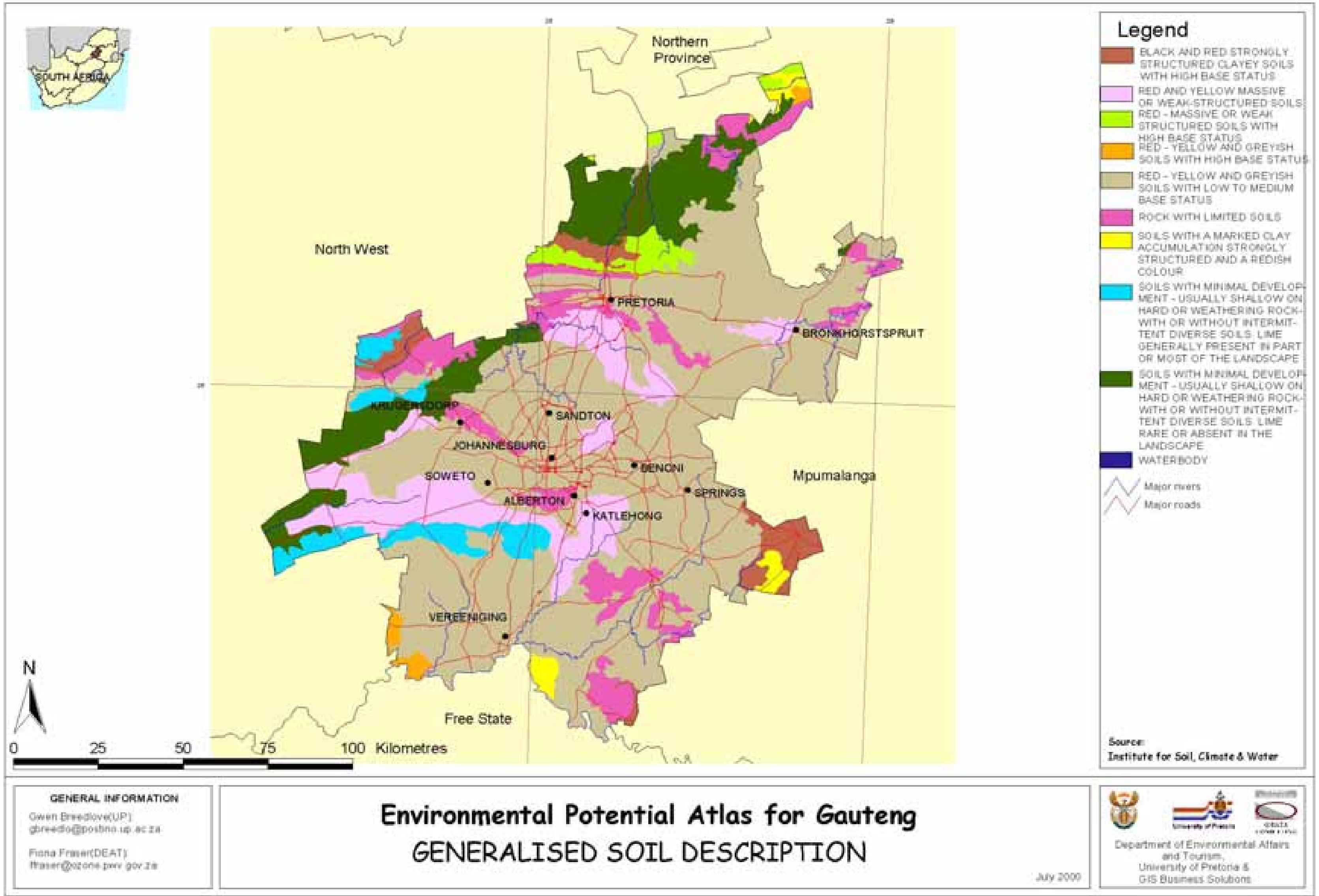
SOUTH AFRICA
Northern Province
North West
Mpumalanga
Free State
PRETORIA
BRONKHORSTSPRUIT
KRUGERSDORP
SANDTON
JOHANNESBURG
BENONI
SOWETO
SPRINGS
ALBERTON
KATLEHONG
VEREENIGING
N
0 25 50 75 100 Kilometres
Legend
BLACK AND RED STRONGLY STRUCTURED CLAYEY SOILS WITH HIGH BASE STATUS
RED AND YELLOW MASSIVE OR WEAK-STRUCTURED SOILS
RED - MASSIVE OR WEAK STRUCTURED SOILS WITH HIGH BASE STATUS
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SOILS WITH A MARKED CLAY ACCUMULATION STRONGLY STRUCTURED AND A REDISH COLOUR
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WATERBODY
Major rivers
Major roads
Source:
Institute for Soil, Climate & Water
GENERAL INFORMATION
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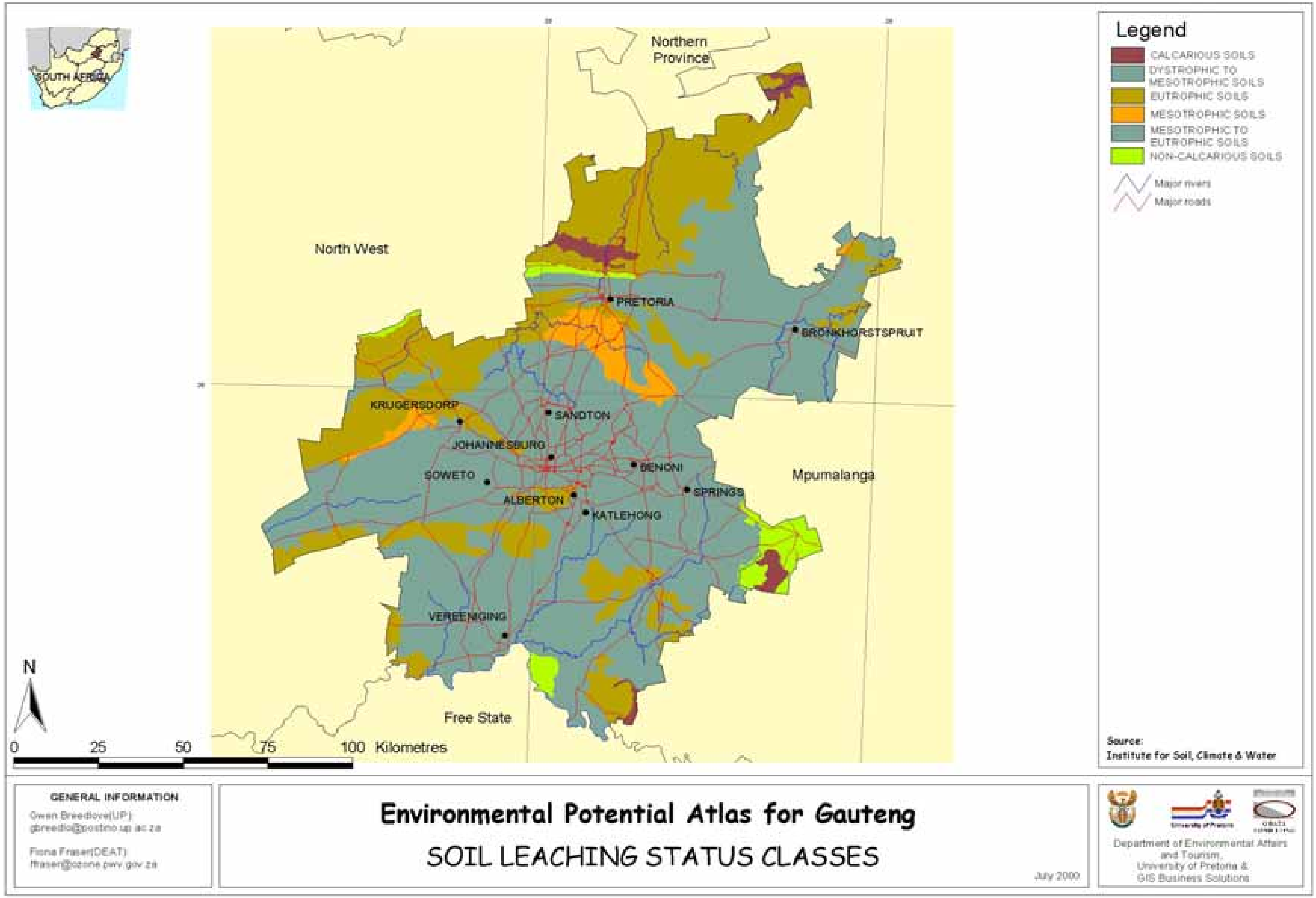
SOUTH AFRICA
Northern Province
North West
Mpumalanga
Free State
PRETORIA
BRONKHORSTSPRUIT
KRUGERSDORP
SANDTON
JOHANNESBURG
BENONI
SOWETO
SPRINGS
ALBERTON
KATLEHONG
VEREENIGING
N
0 25 50 75 100 Kilometres
Legend
CALCARIOUS SOILS
DYSTROPHIC TO MESOTROPHIC SOILS
EUTROPHIC SOILS
MESOTROPHIC SOILS
MESOTROPHIC TO EUTROPHIC SOILS
NON-CALCARIOUS SOILS
Major rivers
Major roads
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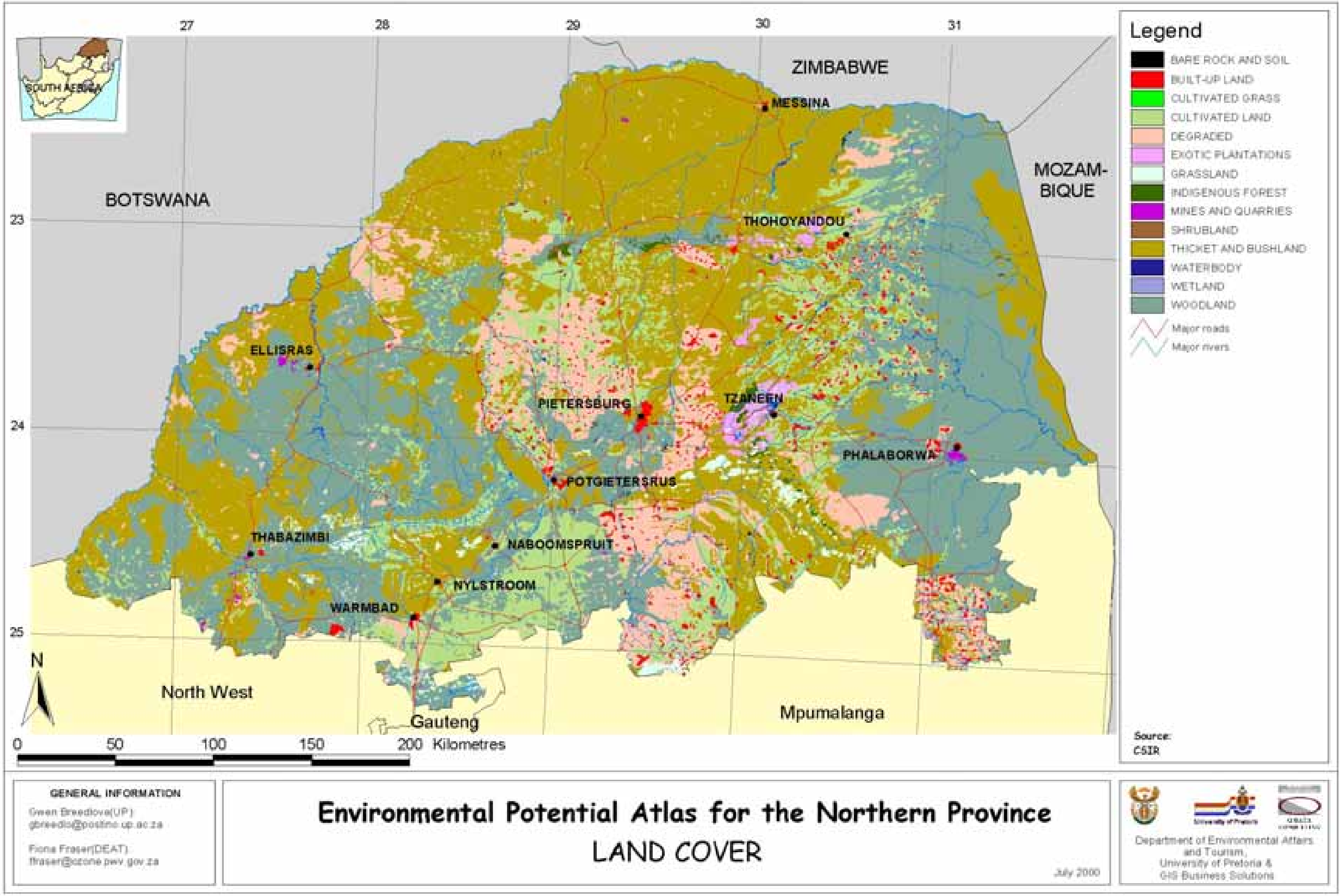
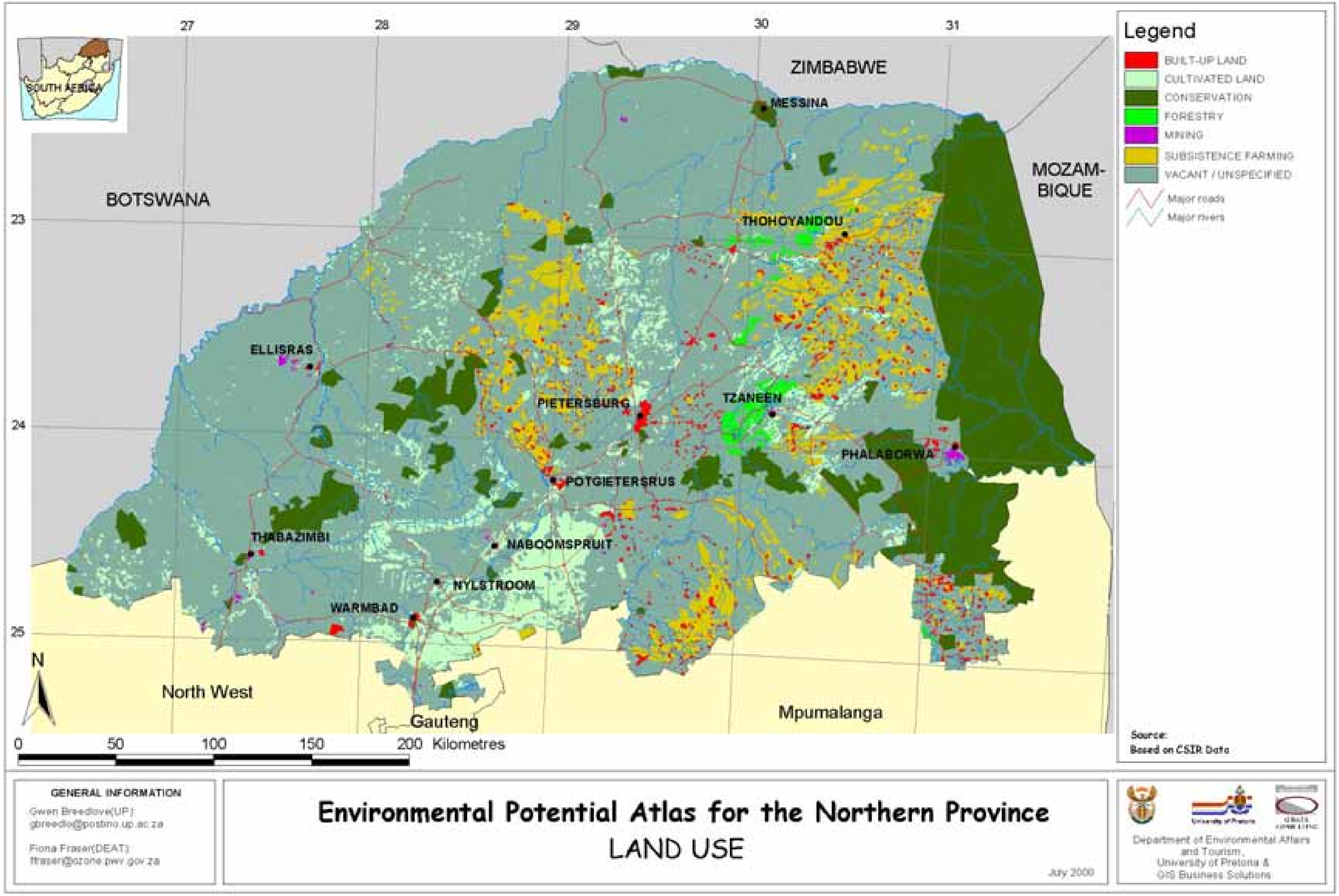
**Limpopo Province**




Legend
BUILT-UP LAND
CULTIVATED LAND
CONSERVATION
FORESTRY
MINING
SUBSISTENCE FARMING
VACANT / UNSPECIFIED
Major roads
Major rivers
ZIMBABWE
BOTSWANA
MOZAM-BIQUE
SOUTH AFRICA
MESSINA
THOHOYANDOU
ELLISRAS
PIETERSBURG
TZANEEN
PHALABORWA
POTGIETERSRUS
THABAZIMBI
NABOOMSPRUIT
NYLSTROOM
WARMBAD
North West
Gauteng
Mpumalanga
N
0 50 100 150 200 Kilometres
Source:
Based on CSIR Data
GENERAL INFORMATION
Gwen Breedlove(UP):
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Fiona Fraser(DEAT):
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LAND USE
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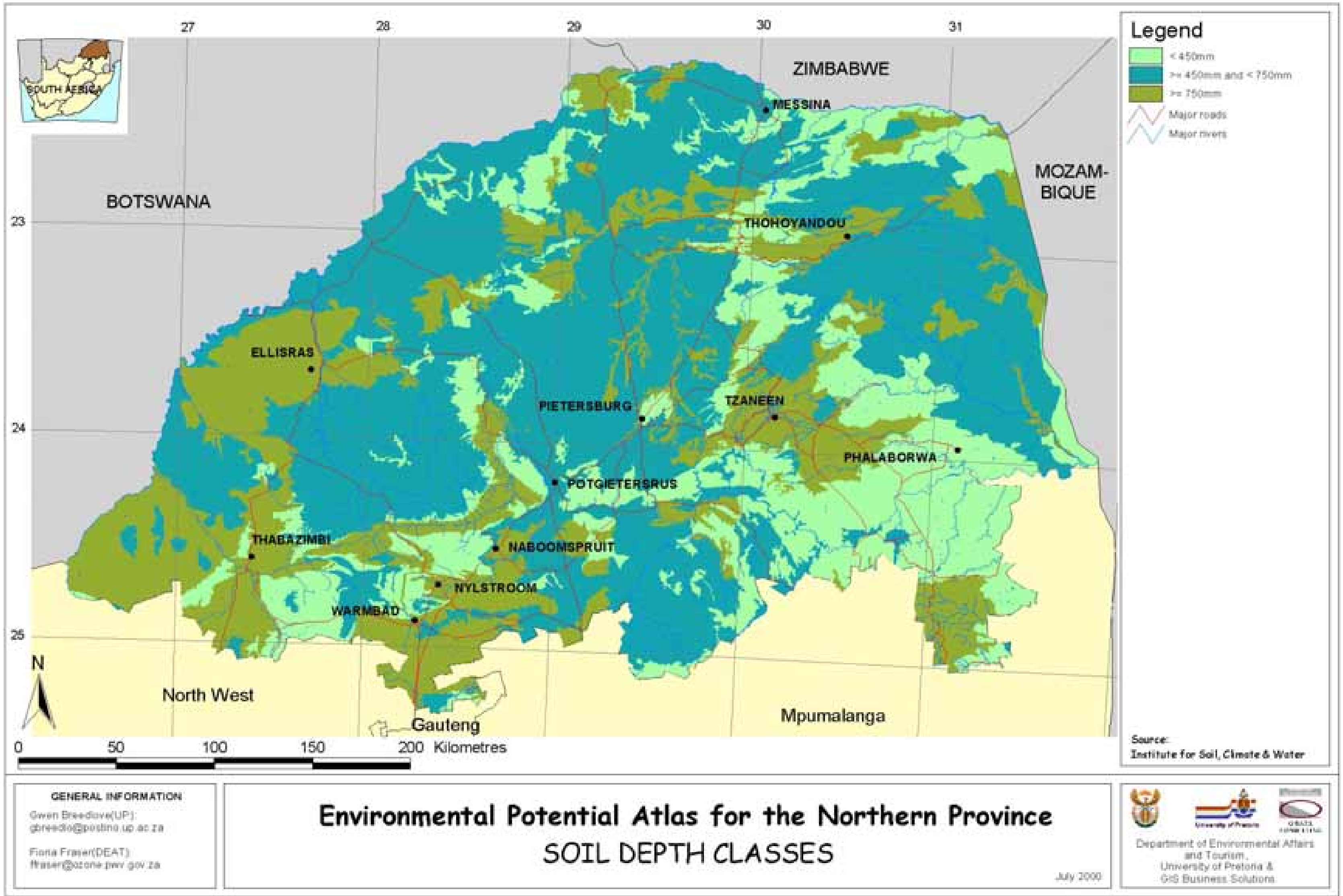
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>= 750mm
Major roads
Major rivers
ZIMBABWE
BOTSWANA
MOZAM-
BIQUE
SOUTH AFRICA
MESSINA
THOHOYANDOU
ELLISRAS
PIETERSBURG
TZANEEN
PHALABORWA
POTGIETERSRUS
THABAZIMBI
NABOOMSPRUIT
NYLSTROOM
WARMBAD
North West
Gauteng
Mpumalanga
N
27
28
29
30
31
23
24
25
0 50 100 150 200 Kilometres
Source:
Institute for Soil, Climate & Water
GENERAL INFORMATION
Gwen Breedlove(UP):
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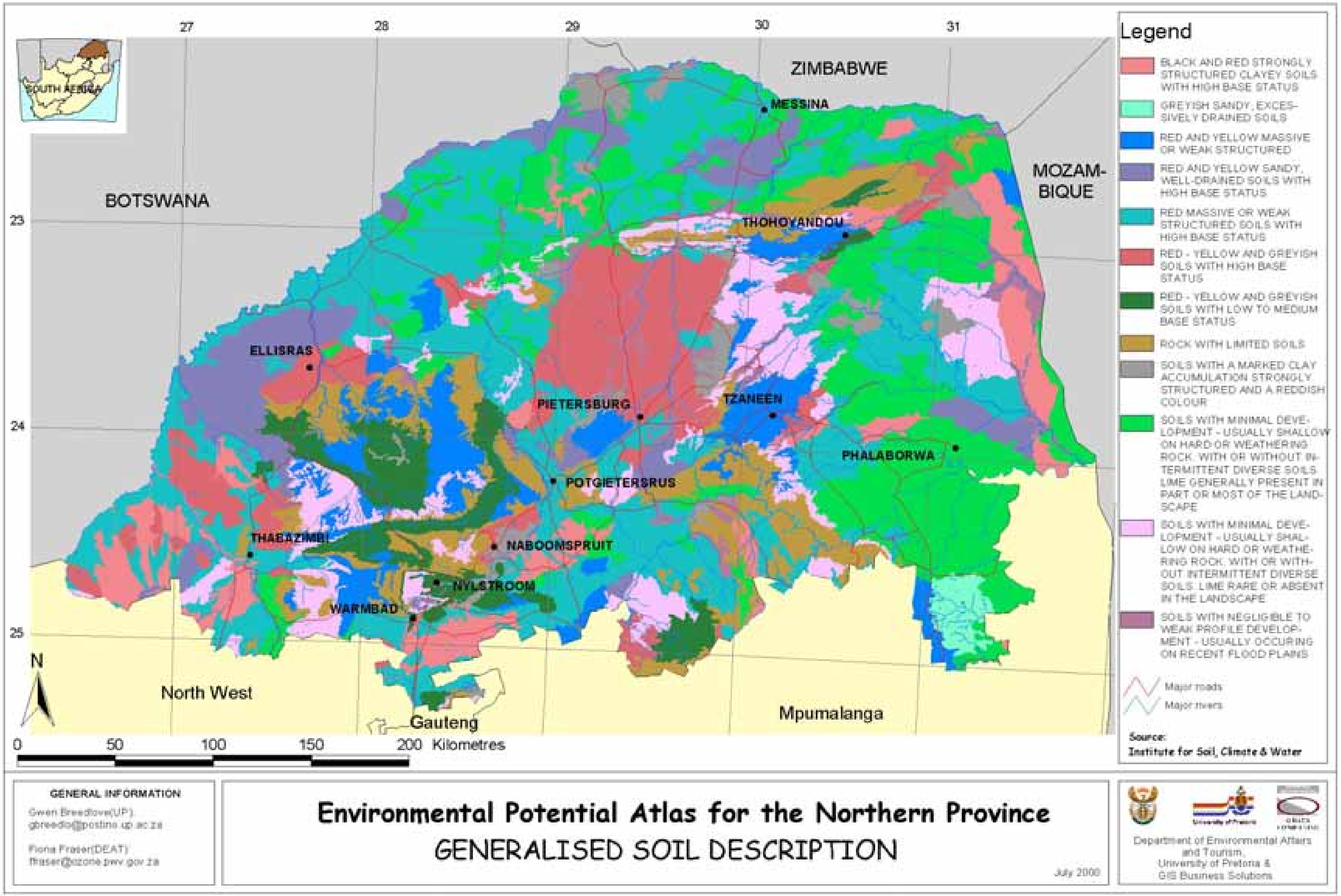
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SOUTH AFRICA
ZIMBABWE
BOTSWANA
MOZAM-
BIQUE
MESSINA
THOHOYANDOU
ELLISRAS
PIETERSBURG
TZANEEN
PHALABORWA
POTGIETERSRUS
THABAZIMBI
NABOOMSPRUIT
NYLSTROOM
WARMBAD
N
North West
Gauteng
Mpumalanga
0 50 100 150 200 Kilometres
Legend
BLACK AND RED STRONGLY STRUCTURED CLAYEY SOILS WITH HIGH BASE STATUS
GREYISH SANDY, EXCESSIVELY DRAINED SOILS
RED AND YELLOW MASSIVE OR WEAK STRUCTURED
RED AND YELLOW SANDY, WELL-DRAINED SOILS WITH HIGH BASE STATUS
RED MASSIVE OR WEAK STRUCTURED SOILS WITH HIGH BASE STATUS
RED - YELLOW AND GREYISH SOILS WITH HIGH BASE STATUS
RED - YELLOW AND GREYISH SOILS WITH LOW TO MEDIUM BASE STATUS
ROCK WITH LIMITED SOILS
SOILS WITH A MARKED CLAY ACCUMULATION STRONGLY STRUCTURED AND A REDDISH COLOUR
SOILS WITH MINIMAL DEVELOPMENT - USUALLY SHALLOW ON HARD OR WEATHERING ROCK, WITH OR WITHOUT INTERMITTENT DIVERSE SOILS. LIME GENERALLY PRESENT IN PART OR MOST OF THE LANDSCAPE
SOILS WITH MINIMAL DEVELOPMENT - USUALLY SHALLOW ON HARD OR WEATHERING ROCK, WITH OR WITHOUT INTERMITTENT DIVERSE SOILS. LIME RARE OR ABSENT IN THE LANDSCAPE
SOILS WITH NEGLIGIBLE TO WEAK PROFILE DEVELOPMENT - USUALLY OCCURING ON RECENT FLOOD PLAINS
Major roads
Major rivers
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Institute for Soil, Climate & Water
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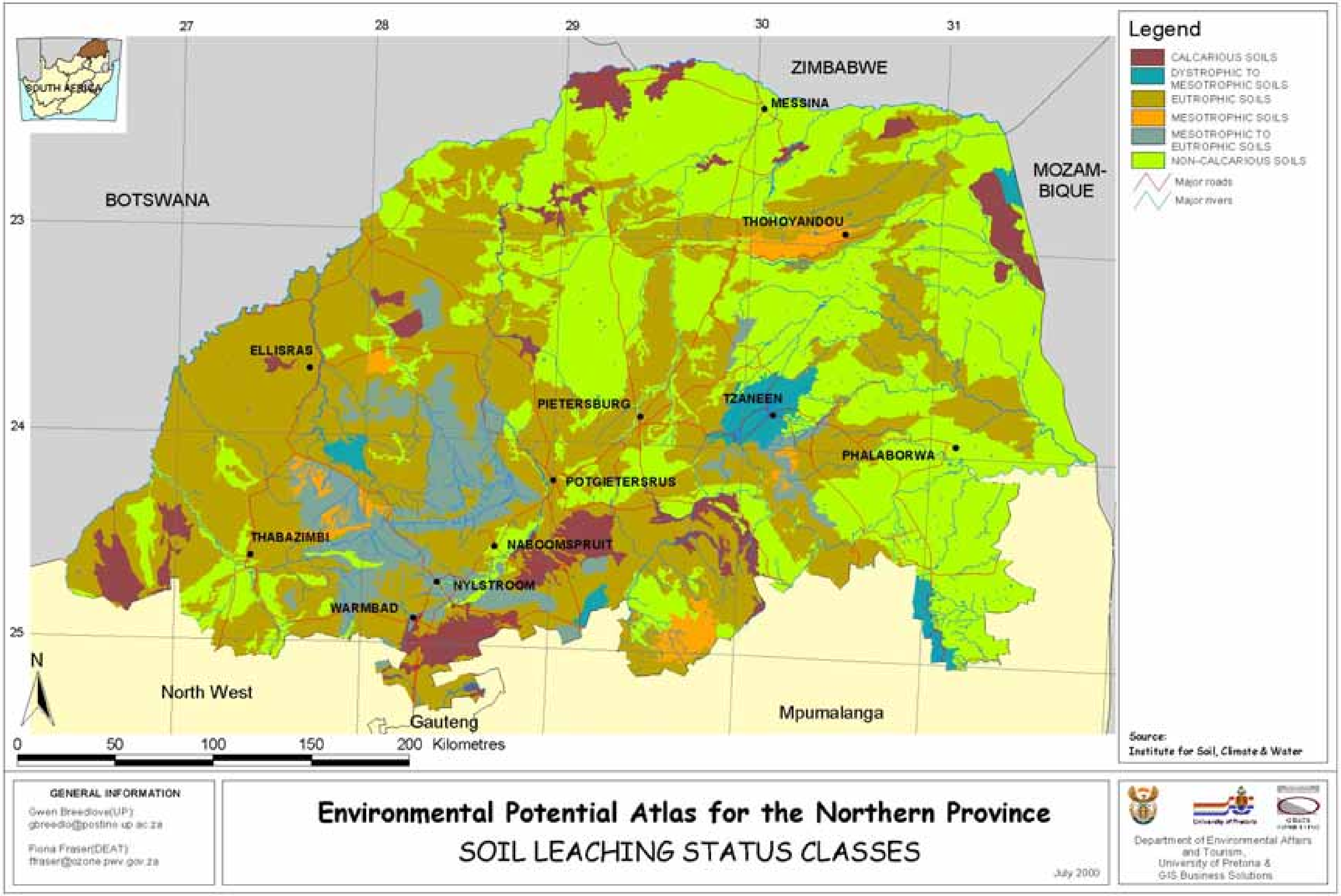
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SOUTH AFRICA
ZIMBABWE
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MOZAM-
BIQUE
MESSINA
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ELLISRAS
PIETERSBURG
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NABOOMSPRUIT
NYLSTROOM
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North West
Gauteng
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Legend
CALCARIOUS SOILS
DYSTROPHIC TO MESOTROPHIC SOILS
EUTROPHIC SOILS
MESOTROPHIC SOILS
MESOTROPHIC TO EUTROPHIC SOILS
NON-CALCARIOUS SOILS
Major roads
Major rivers
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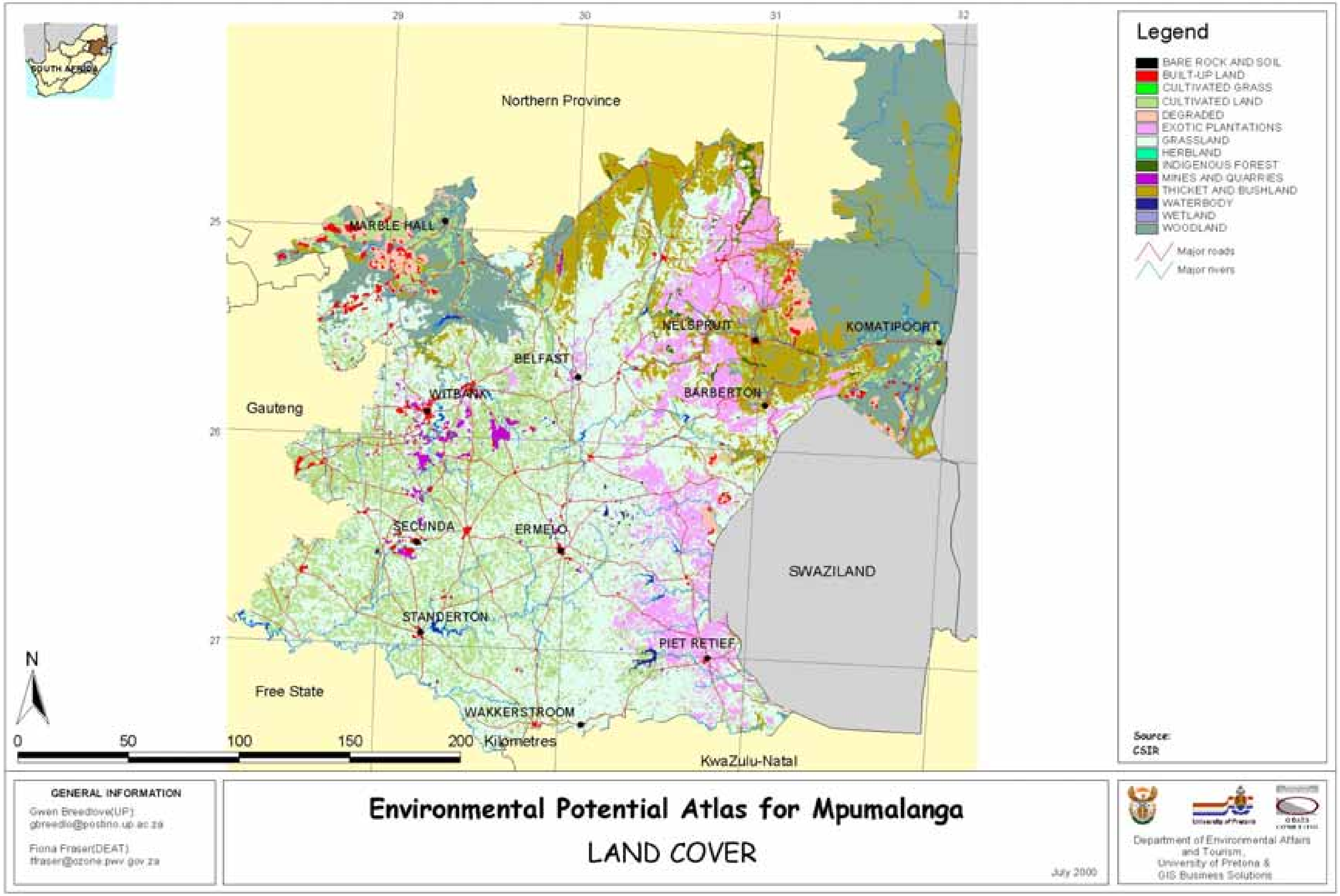
**Mpumalanga**


SOUTH AFRICA
Northern Province
MARBLE HALL
NELSPRUIT
KOMATIPOORT
BELFAST
WITBANK
BARBERTON
Gauteng
SECUNDA
ERMELO
SWAZILAND
STANDERTON
PIET RETIEF
Free State
WAKKERSTROOM
KwaZulu-Natal
N
0 50 100 150 200 Kilometres
Legend
BARE ROCK AND SOIL
BUILT-UP LAND
CULTIVATED GRASS
CULTIVATED LAND
DEGRADED
EXOTIC PLANTATIONS
GRASSLAND
HERBLAND
INDIGENOUS FOREST
MINES AND QUARRIES
THICKET AND BUSHLAND
WATERBODY
WETLAND
WOODLAND
Major roads
Major rivers
Source:
CSIR
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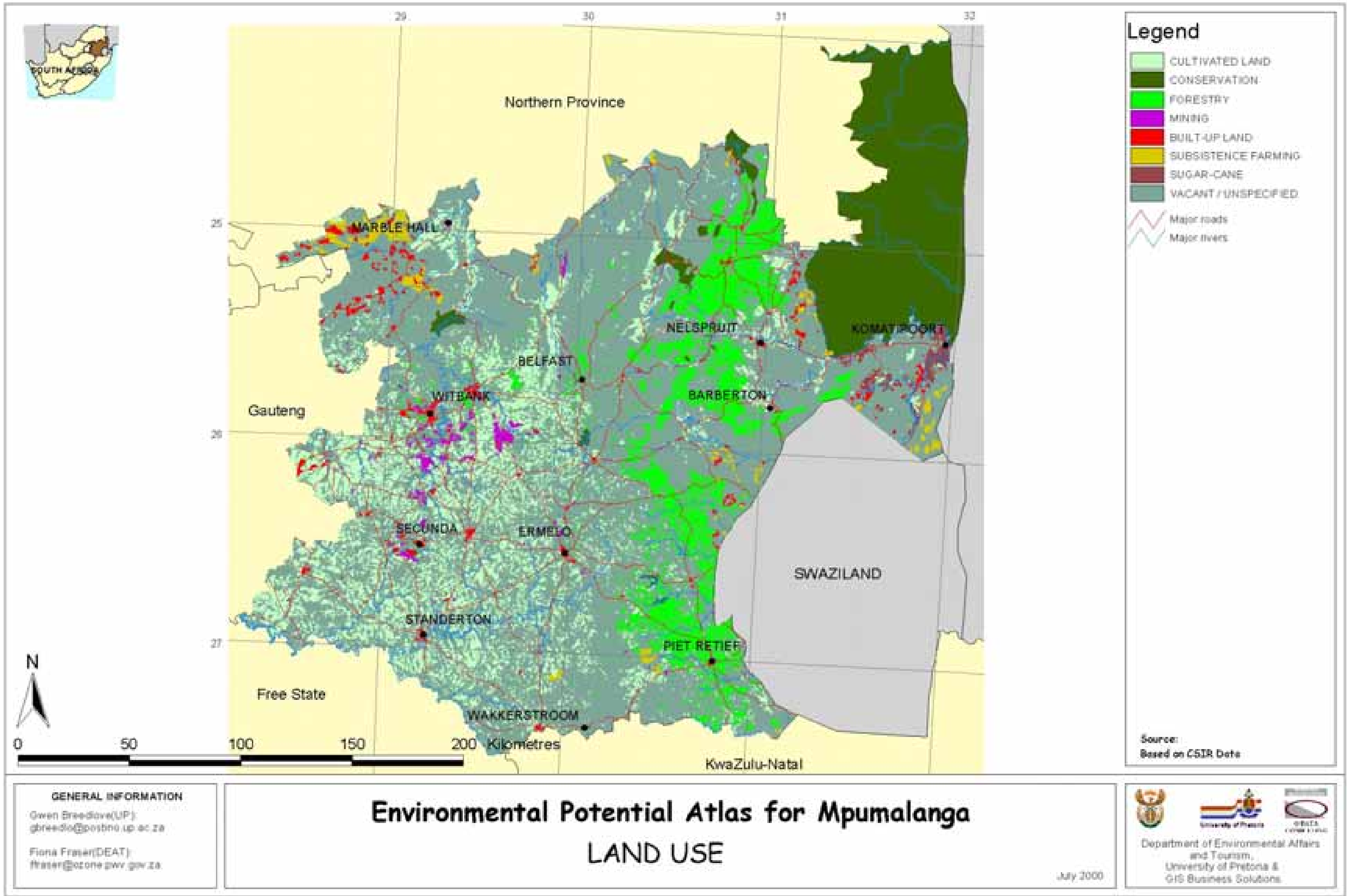
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CULTIVATED LAND
CONSERVATION
FORESTRY
MINING
BUILT-UP LAND
SUBSISTENCE FARMING
SUGAR-CANE
VACANT / UNSPECIFIED
Major roads
Major rivers
Northern Province
Gauteng
Free State
KwaZulu-Natal
SWAZILAND
MARBLE HALL
NELSPRUIT
KOMATIPOORT
BELFAST
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SECUNDA
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STANDERTON
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0 50 100 150 200 Kilometres
Source:
Based on CSIR Data
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LAND USE
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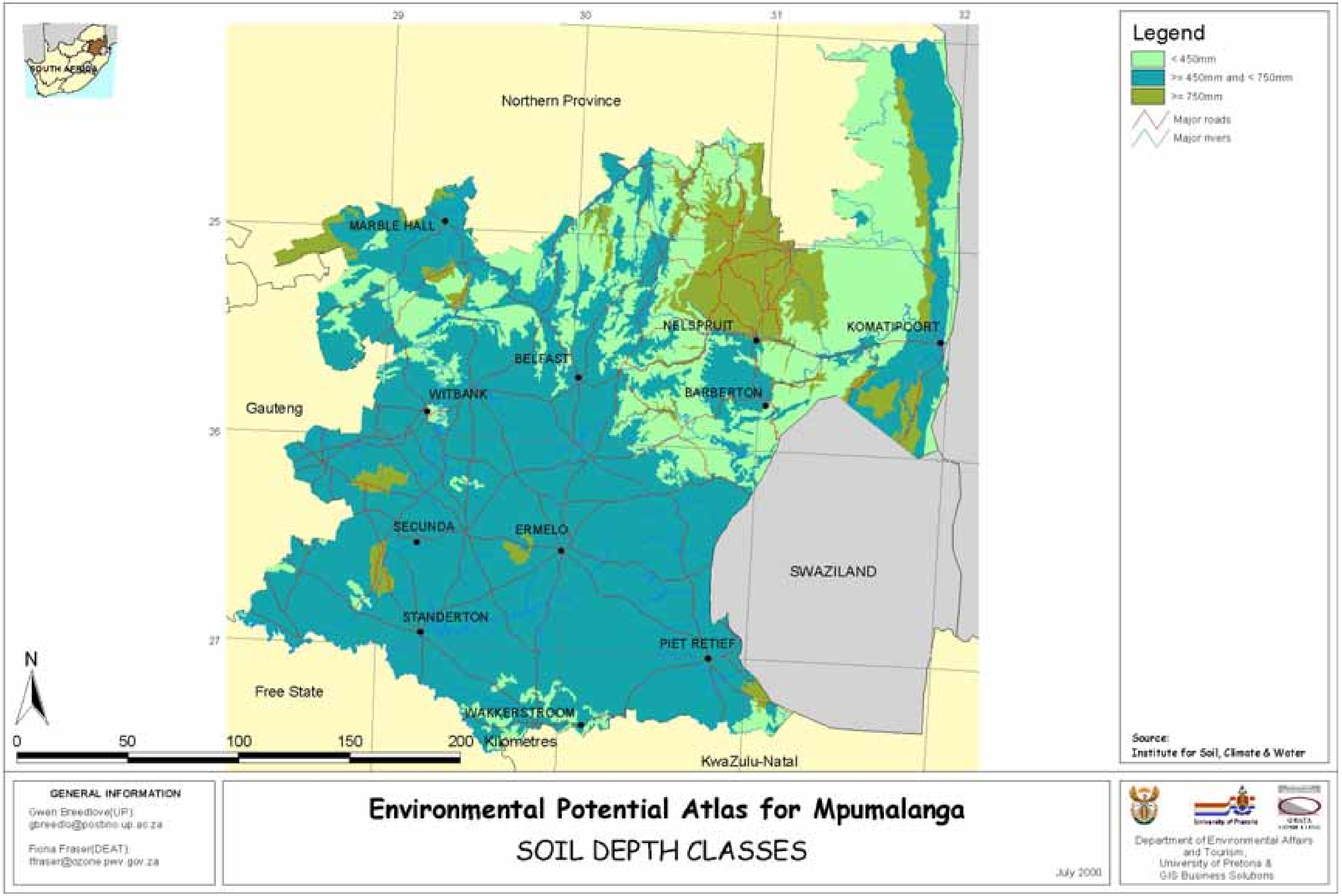
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>= 750mm
Major roads
Major rivers
Northern Province
MARBLE HALL
NELSPRUIT
KOMATIPOORT
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Free State
WAKKERSTROOM
KwaZulu-Natal
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Source:
Institute for Soil, Climate & Water
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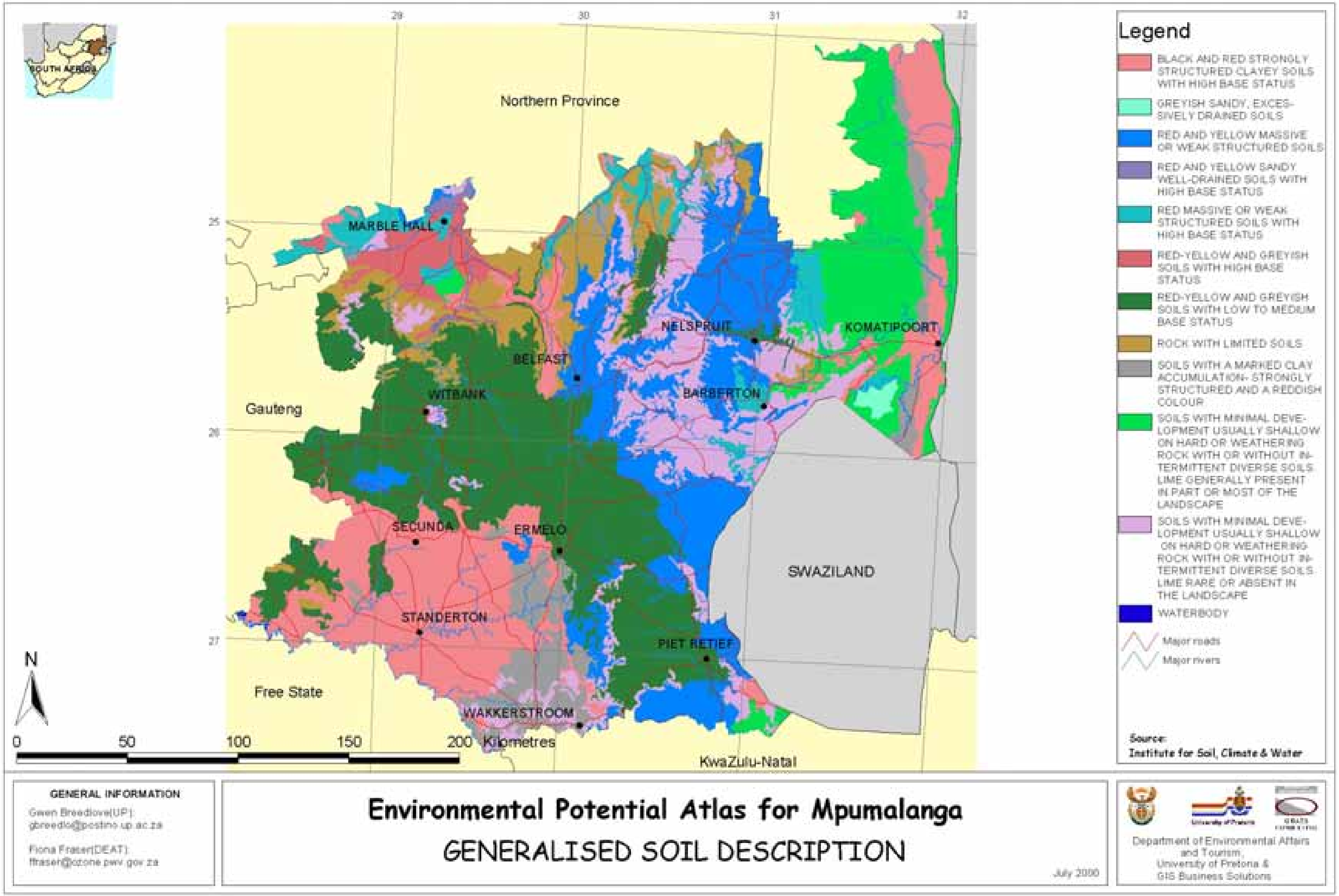
Northern Province
Gauteng
Free State
KwaZulu-Natal
SWAZILAND
MARBLE HALL
NELSPRUIT
KOMATIPOORT
BELFAST
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PIET RETIEF
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SOUTH AFRICA
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Legend
BLACK AND RED STRONGLY STRUCTURED CLAYEY SOILS WITH HIGH BASE STATUS
GREYISH SANDY, EXCESSIVELY DRAINED SOILS
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Major roads
Major rivers
Source:
Institute for Soil, Climate & Water
GENERAL INFORMATION
Gwen Breedlove(UP):
gbreedlo@postino.up.ac.za
Fiona Fraser(DEAT):
ffraser@ozone.pwv.gov.za
Environmental Potential Atlas for Mpumalanga
GENERALISED SOIL DESCRIPTION
July 2000
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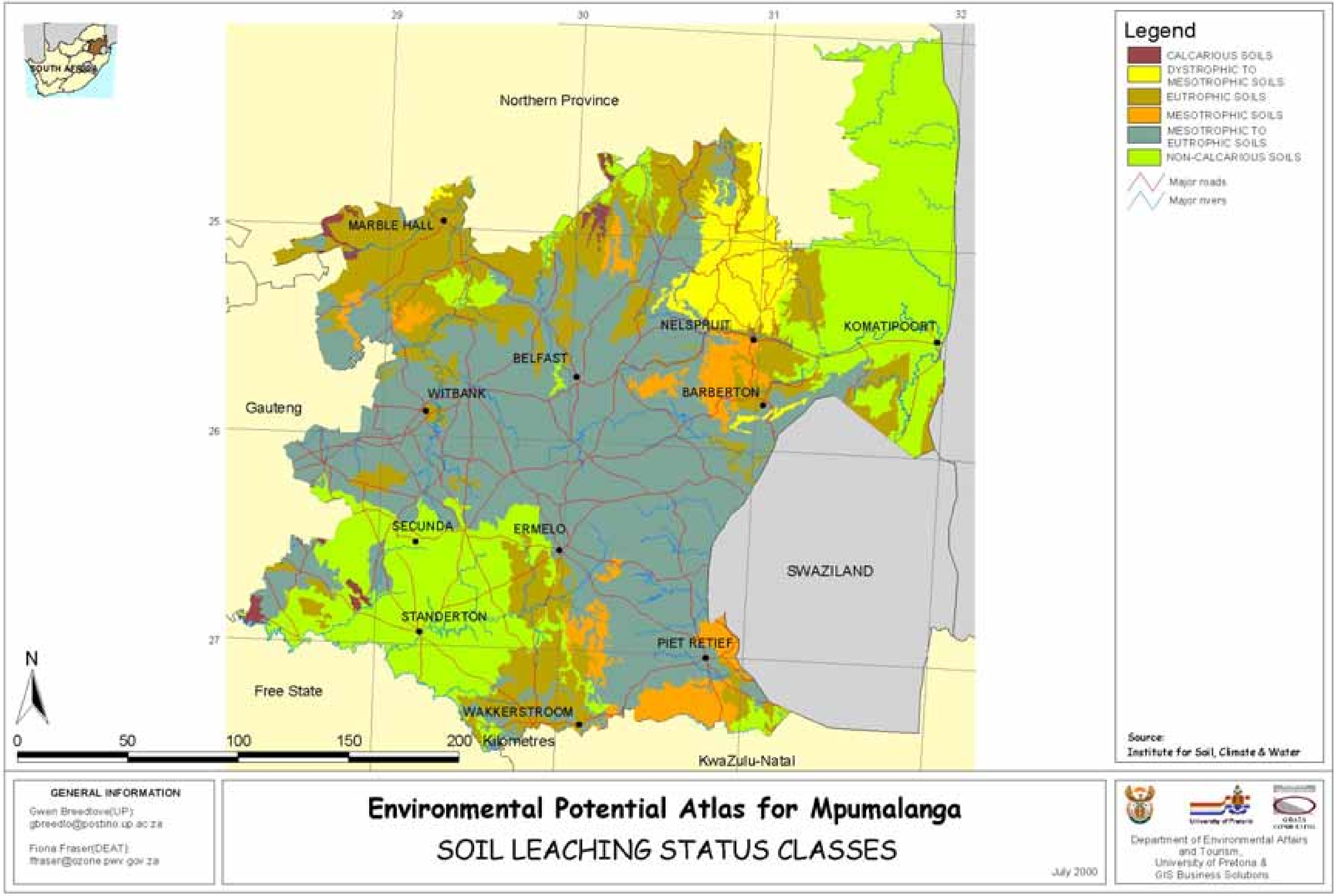
Legend
CALCARIOUS SOILS
DYSTROPHIC TO MESOTROPHIC SOILS
EUTROPHIC SOILS
MESOTROPHIC SOILS
MESOTROPHIC TO EUTROPHIC SOILS
NON-CALCARIOUS SOILS
Major roads
Major rivers
SOUTH AFRICA
Northern Province
MARBLE HALL
NELSPRUIT
KOMATIPOORT
BELFAST
WITBANK
BARBERTON
Gauteng
SECUNDA
ERMELO
SWAZILAND
STANDERTON
PIET RETIEF
Free State
WAKKERSTROOM
KwaZulu-Natal
N
0
50
100
150
200 Kilometres
29
30
31
32
25
26
27
Source:
Institute for Soil, Climate & Water
GENERAL INFORMATION
Gwen Breedlove(UP):
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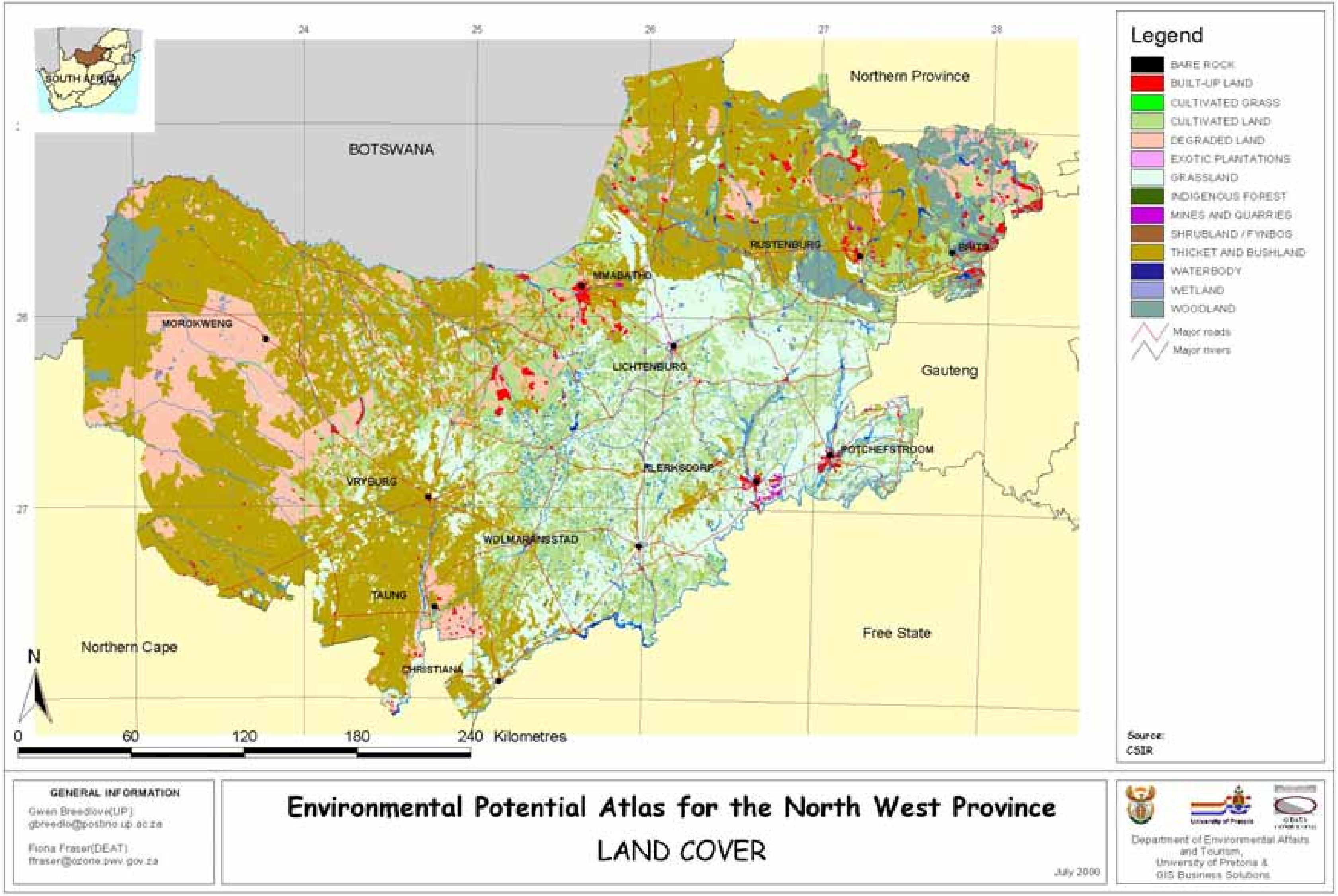
**North West**


Legend
BARE ROCK
BUILT-UP LAND
CULTIVATED GRASS
CULTIVATED LAND
DEGRADED LAND
EXOTIC PLANTATIONS
GRASSLAND
INDIGENOUS FOREST
MINES AND QUARRIES
SHRUBLAND / FYNBOS
THICKET AND BUSHLAND
WATERBODY
WETLAND
WOODLAND
Major roads
Major rivers
Source:
CSIR
SOUTH AFRICA
BOTSWANA
Northern Province
Gauteng
Free State
Northern Cape
MOROKWENG
MMABATHO
RUSTENBURG
BRITS
LICHTENBURG
POTCHEFSTROOM
KLERKSDORP
VRYBURG
WOLMARANSSTAD
TAUNG
CHRISTIANA
N
0 60 120 180 240 Kilometres
GENERAL INFORMATION
Gwen Breedlove(UP):
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Environmental Potential Atlas for the North West Province
LAND COVER
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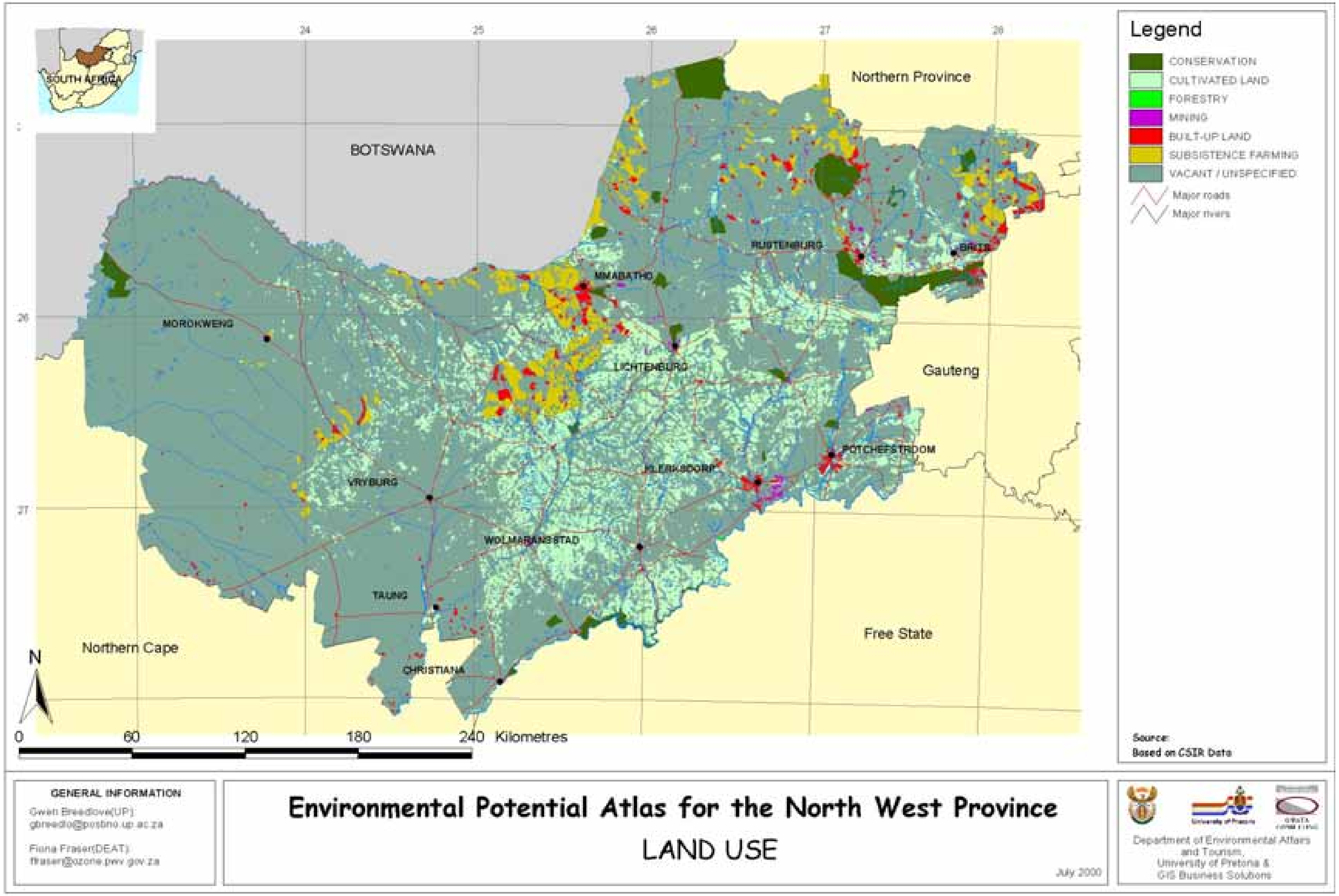
Legend
CONSERVATION
CULTIVATED LAND
FORESTRY
MINING
BUILT-UP LAND
SUBSISTENCE FARMING
VACANT / UNSPECIFIED
Major roads
Major rivers
SOUTH AFRICA
BOTSWANA
Northern Province
Gauteng
Free State
Northern Cape
MOROKWENG
MMABATHO
RUSTENBURG
BRITS
LICHTENBURG
POTCHEFSTROOM
KLERKSDORP
VRYBURG
WOLMARANSSTAD
TAUNG
CHRISTIANA
N
0 60 120 180 240 Kilometres
Source:
Based on CSIR Data
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Environmental Potential Atlas for the North West Province
LAND USE
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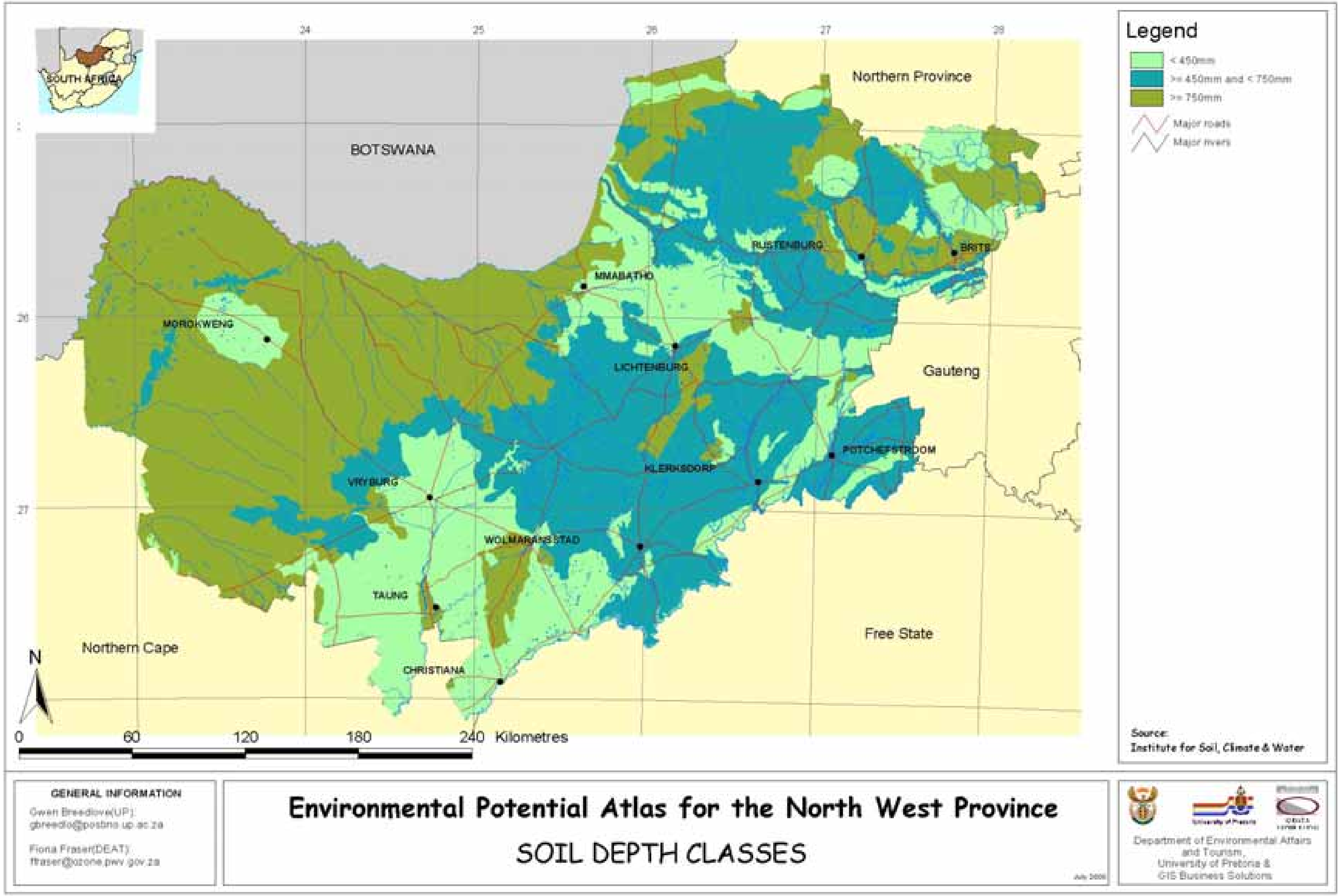
Legend
< 450mm
>= 450mm and < 750mm
>= 750mm
Major roads
Major rivers
SOUTH AFRICA
BOTSWANA
Northern Province
Gauteng
Free State
Northern Cape
MOROKWENG
MMABATHO
RUSTENBURG
BRITS
LICHTENBURG
POTCHEFSTROOM
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VRYBURG
WOLMARANSSTAD
TAUNG
CHRISTIANA
N
0
60
120
180
240 Kilometres
Source:
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SOIL DEPTH CLASSES
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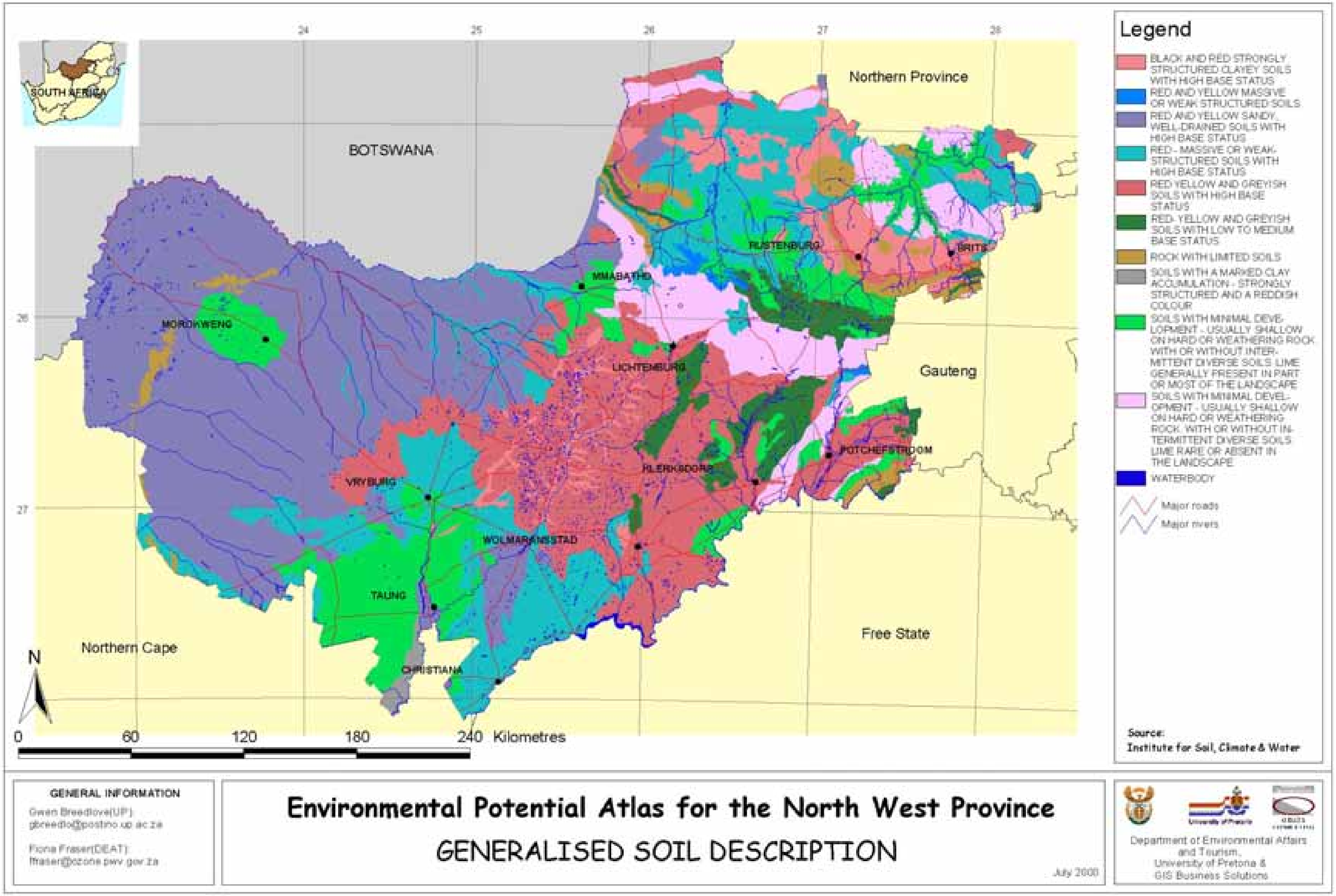
Legend
BLACK AND RED STRONGLY STRUCTURED CLAYEY SOILS WITH HIGH BASE STATUS
RED AND YELLOW MASSIVE OR WEAK STRUCTURED SOILS
RED AND YELLOW SANDY, WELL-DRAINED SOILS WITH HIGH BASE STATUS
RED - MASSIVE OR WEAK-STRUCTURED SOILS WITH HIGH BASE STATUS
RED YELLOW AND GREYISH SOILS WITH HIGH BASE STATUS
RED- YELLOW AND GREYISH SOILS WITH LOW TO MEDIUM BASE STATUS
ROCK WITH LIMITED SOILS
SOILS WITH A MARKED CLAY ACCUMULATION - STRONGLY STRUCTURED AND A REDDISH COLOUR
SOILS WITH MINIMAL DEVELOPMENT - USUALLY SHALLOW ON HARD OR WEATHERING ROCK WITH OR WITHOUT INTERMITTENT DIVERSE SOILS LIME GENERALLY PRESENT IN PART OR MOST OF THE LANDSCAPE
SOILS WITH MINIMAL DEVELOPMENT - USUALLY SHALLOW ON HARD OR WEATHERING ROCK. WITH OR WITHOUT INTERMITTENT DIVERSE SOILS LIME RARE OR ABSENT IN THE LANDSCAPE
WATERBODY
Major roads
Major rivers
SOUTH AFRICA
BOTSWANA
Northern Province
Gauteng
Free State
Northern Cape
MMABATHO
RUSTENBURG
BRITS
MORORWENG
LICHTENBURG
POTCHEFSTROOM
KLERKSDORP
VRYBURG
WOLMARANSSTAD
TAUNG
CHRISTIANA
N
0 60 120 180 240 Kilometres
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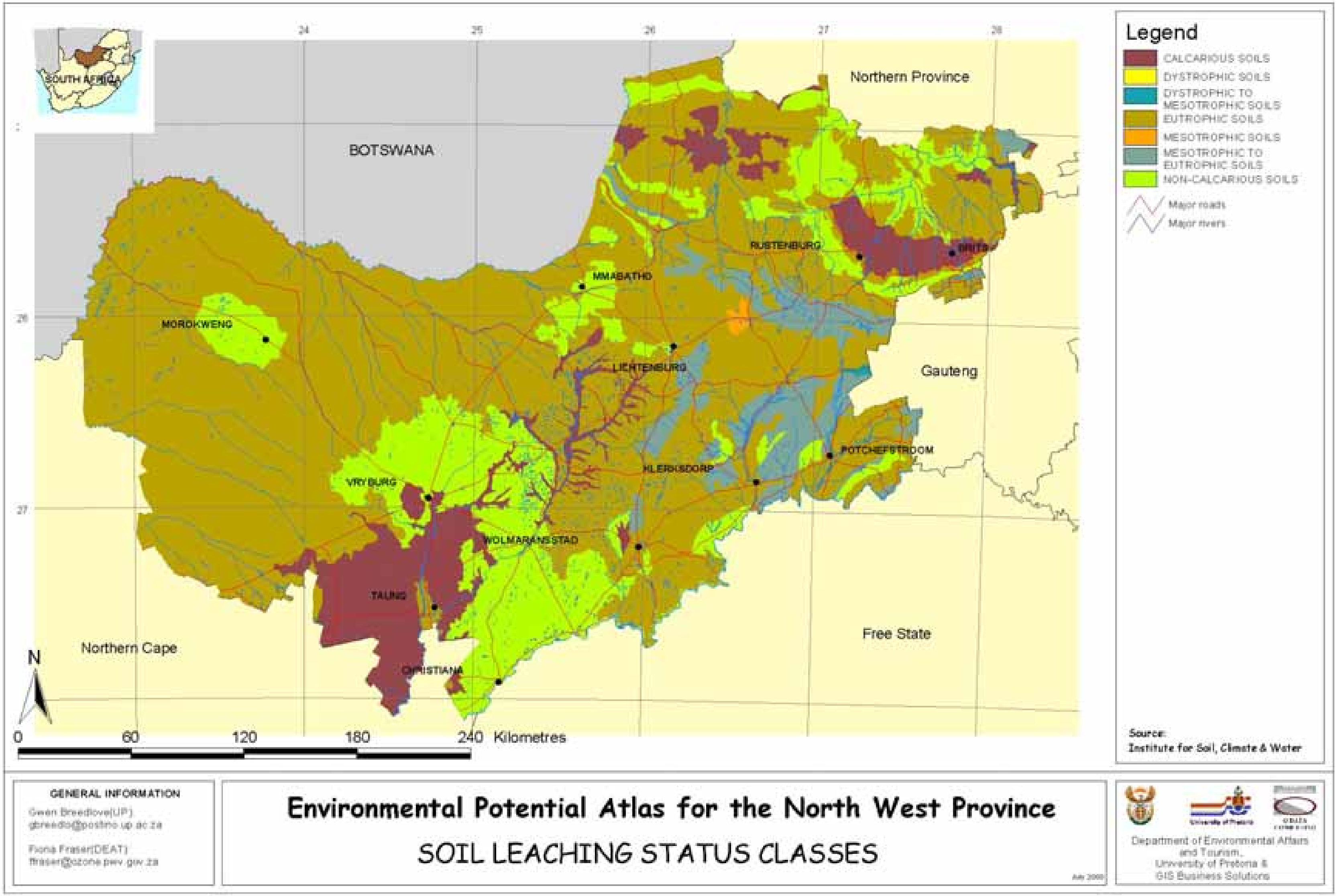
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CALCAREOUS SOILS
DYSTROPHIC SOILS
DYSTROPHIC TO MESOTROPHIC SOILS
EUTROPHIC SOILS
MESOTROPHIC SOILS
MESOTROPHIC TO EUTROPHIC SOILS
NON-CALCAREOUS SOILS
Major roads
Major rivers
SOUTH AFRICA
BOTSWANA
Northern Province
Gauteng
Free State
Northern Cape
MOROKWENG
MMABATHO
RUSTENBURG
BRITS
LICHTENBURG
POTCHEFSTROOM
KLERKSDORP
VRYBURG
WOLMARANSSTAD
TAUNG
CHRISTIANA
N
0 60 120 180 240 Kilometres
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Gwen Breedlove(UP)
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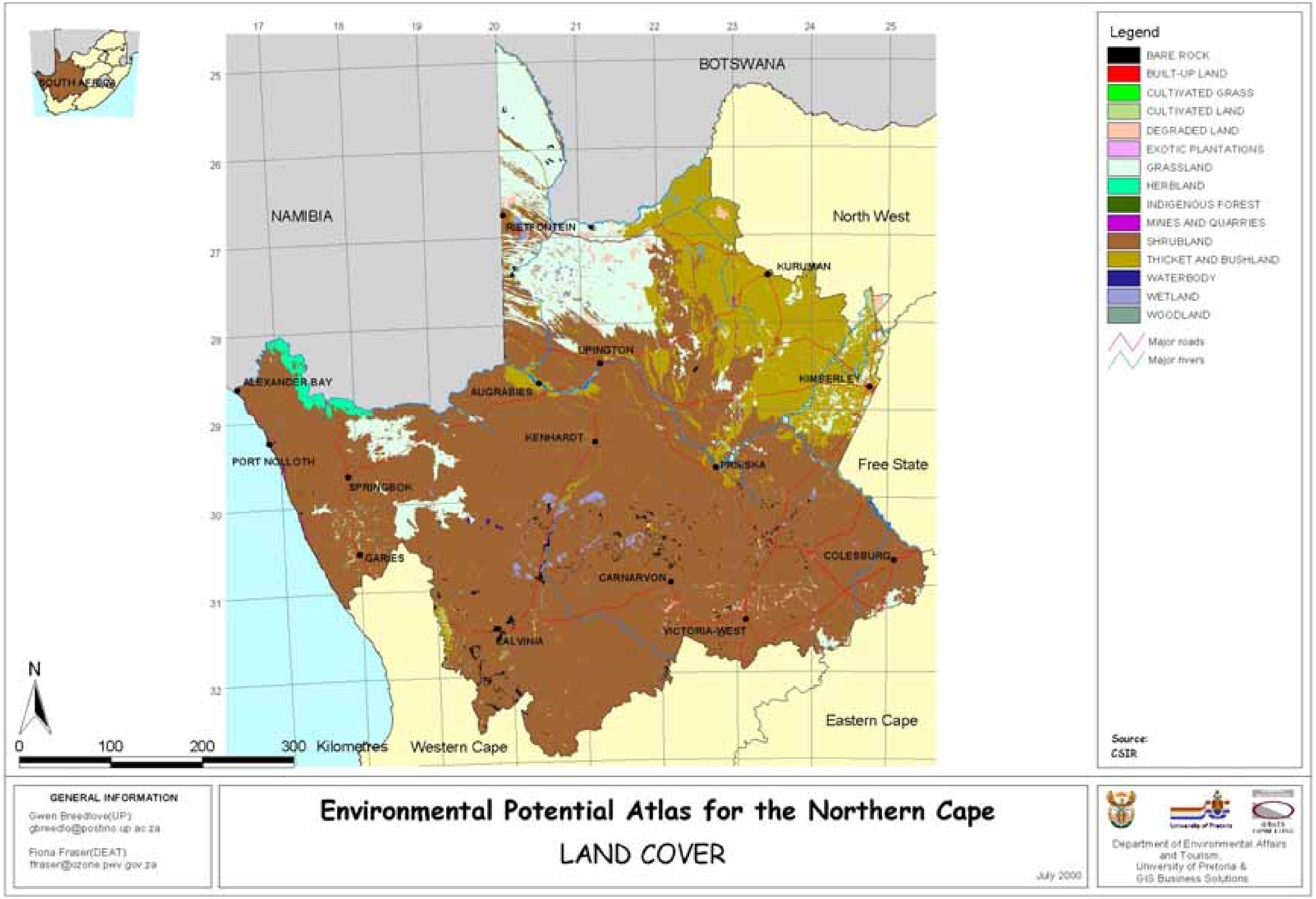
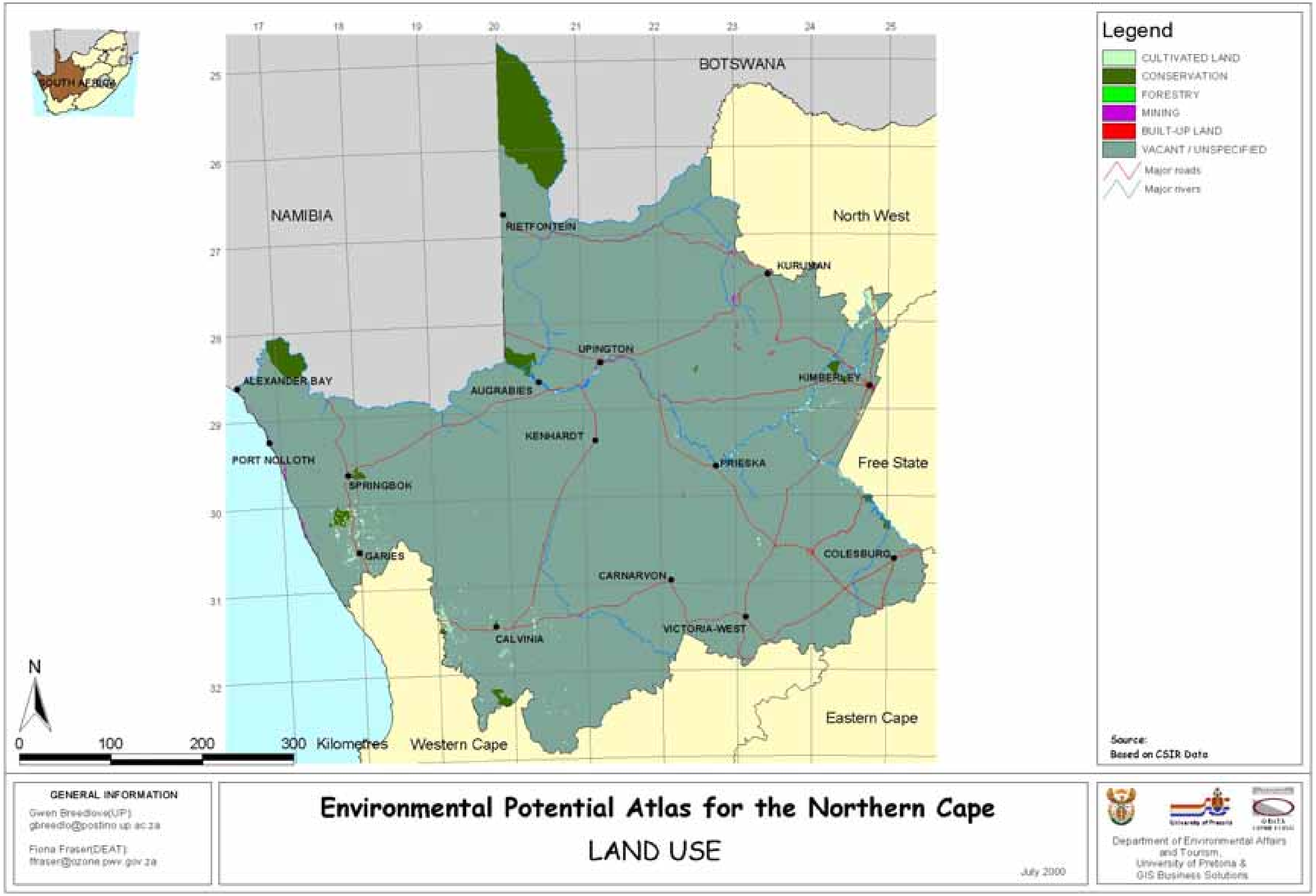
**Northern Cape**





Legend
CULTIVATED LAND
CONSERVATION
FORESTRY
MINING
BUILT-UP LAND
VACANT / UNSPECIFIED
Major roads
Major rivers
SOUTH AFRICA
BOTSWANA
NAMIBIA
North West
Free State
Eastern Cape
Western Cape
RIETFONTEIN
KURUMAN
UPINGTON
ALEXANDER BAY
AUGRABIES
KIMBERLEY
KENHARDT
PORT NOLLOTH
PRIESKA
SPRINGBOK
GARIES
COLESBURG
CARNARVON
VICTORIA-WEST
CALVINIA
N
0 100 200 300 Kilometres
Source:
Based on CSIR Data
GENERAL INFORMATION
Gwen Breedlove(UP)
gbreedlo@postino.up.ac.za
Fiona Fraser(DEAT)
ffraser@ozone.pwv.gov.za
Environmental Potential Atlas for the Northern Cape
LAND USE
July 2000
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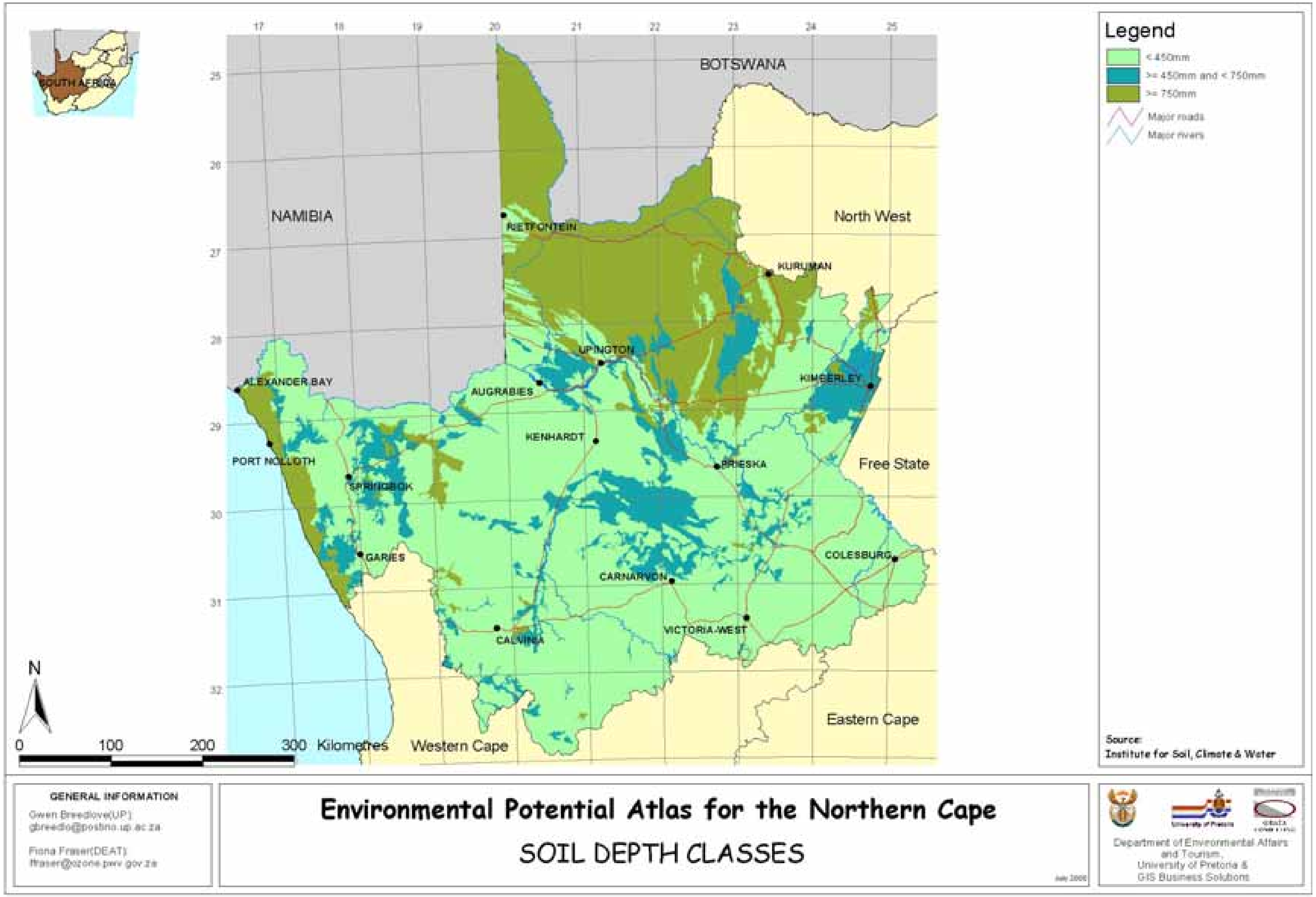
Legend
< 450mm
>= 450mm and < 750mm
>= 750mm
Major roads
Major rivers
SOUTH AFRICA
NAMIBIA
BOTSWANA
North West
Free State
Eastern Cape
Western Cape
RIETFONTEIN
KURUMAN
UPINGTON
AUGRABIES
ALEXANDER BAY
KIMBERLEY
KENHARDT
PORT NOLLOTH
SPRINGBOK
PRIESKA
GARIES
COLESBURG
CARNARVON
CALVINIA
VICTORIA-WEST
N
0 100 200 300 Kilometres
Source:
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GENERAL INFORMATION
Gwen Breedlove(UP)
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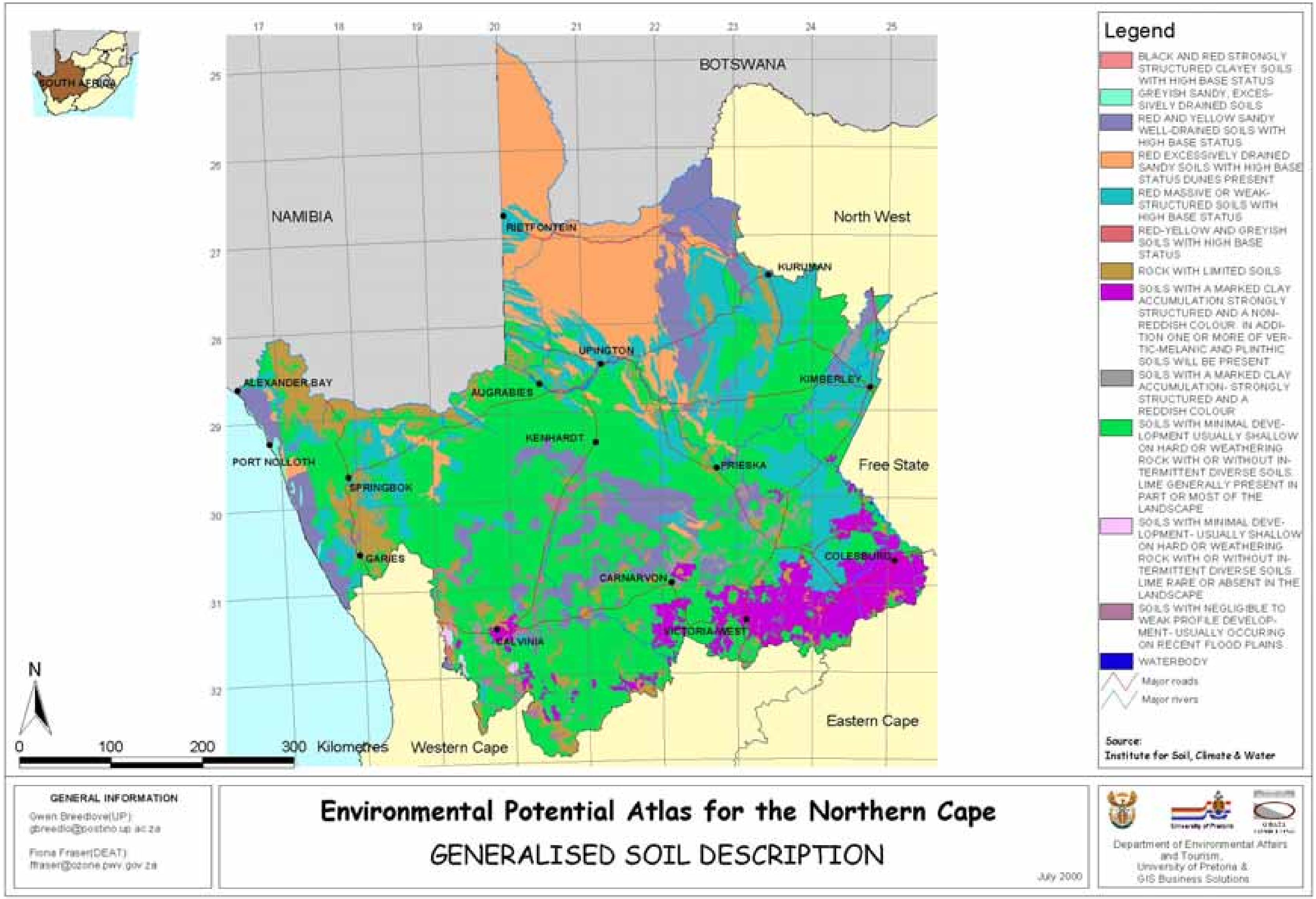
Legend
BLACK AND RED STRONGLY STRUCTURED CLAYEY SOILS WITH HIGH BASE STATUS
GREYISH SANDY, EXCESSIVELY DRAINED SOILS
RED AND YELLOW SANDY WELL-DRAINED SOILS WITH HIGH BASE STATUS
RED EXCESSIVELY DRAINED SANDY SOILS WITH HIGH BASE STATUS DUNES PRESENT
RED MASSIVE OR WEAK-STRUCTURED SOILS WITH HIGH BASE STATUS
RED-YELLOW AND GREYISH SOILS WITH HIGH BASE STATUS
ROCK WITH LIMITED SOILS
SOILS WITH A MARKED CLAY ACCUMULATION STRONGLY STRUCTURED AND A NON-REDDISH COLOUR. IN ADDITION ONE OR MORE OF VERTIC-MELANIC AND PLINTHIC SOILS WILL BE PRESENT
SOILS WITH A MARKED CLAY ACCUMULATION- STRONGLY STRUCTURED AND A REDDISH COLOUR
SOILS WITH MINIMAL DEVELOPMENT USUALLY SHALLOW ON HARD OR WEATHERING ROCK WITH OR WITHOUT INTERMITTENT DIVERSE SOILS. LIME GENERALLY PRESENT IN PART OR MOST OF THE LANDSCAPE
SOILS WITH MINIMAL DEVELOPMENT- USUALLY SHALLOW ON HARD OR WEATHERING ROCK WITH OR WITHOUT INTERMITTENT DIVERSE SOILS. LIME RARE OR ABSENT IN THE LANDSCAPE
SOILS WITH NEGLIGIBLE TO WEAK PROFILE DEVELOPMENT- USUALLY OCCURING ON RECENT FLOOD PLAINS
WATERBODY
Major roads
Major rivers
Source:
Institute for Soil, Climate & Water
SOUTH AFRICA
BOTSWANA
NAMIBIA
North West
Free State
Eastern Cape
Western Cape
RIETFONTEIN
KURUMAN
UPINGTON
AUGRABIES
ALEXANDER BAY
KIMBERLEY
KENHARDT
PORT NOLLOTH
PRIESKA
SPRINGBOK
GARIES
COLESBURG
CARNARVON
CALVINIA
VICTORIA WEST
N
0 100 200 300 Kilometres
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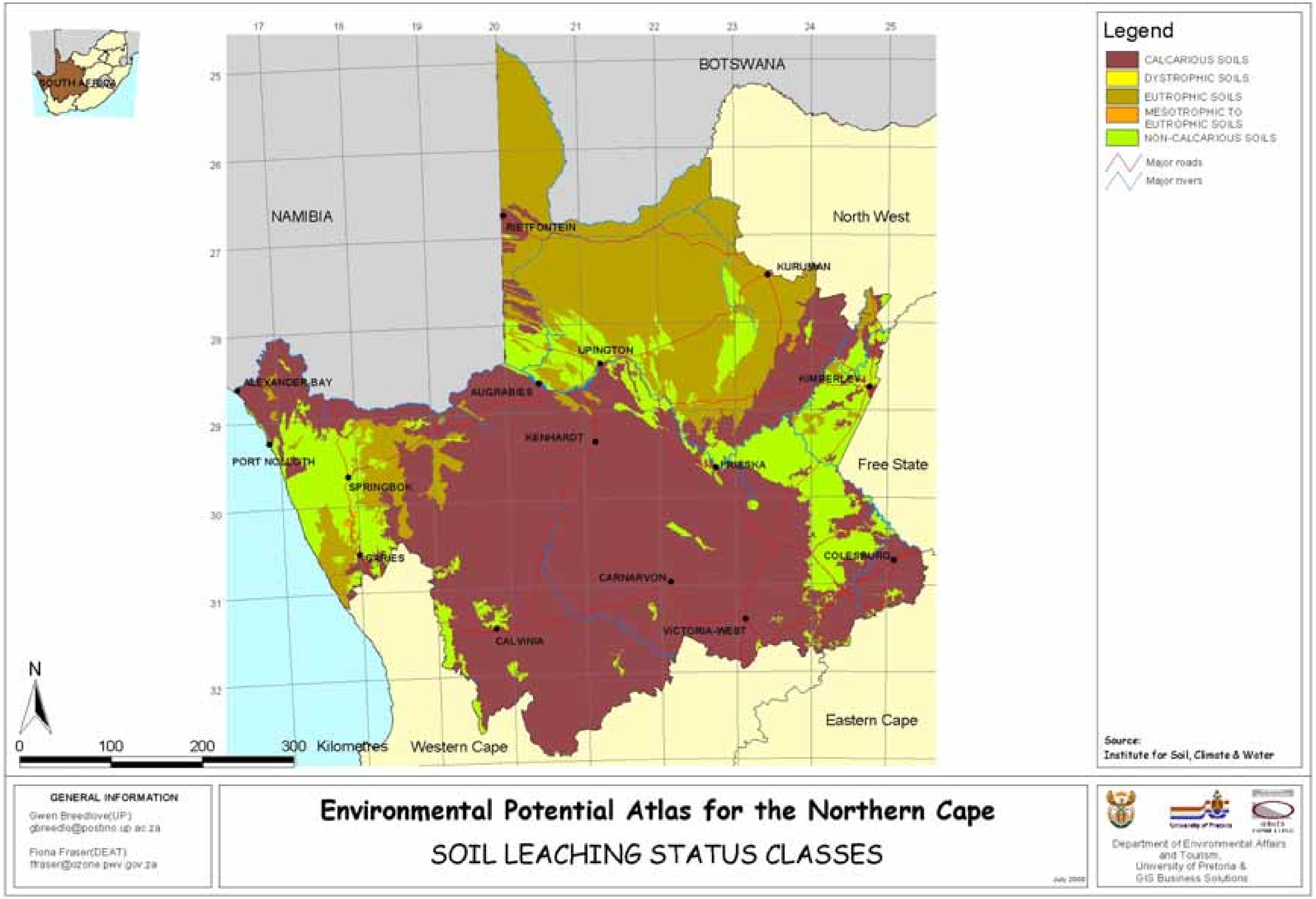
Legend
CALCARIOUS SOILS
DYSTROPHIC SOILS
EUTROPHIC SOILS
MESOTROPHIC TO EUTROPHIC SOILS
NON-CALCARIOUS SOILS
Major roads
Major rivers
NAMIBIA
BOTSWANA
North West
Free State
Eastern Cape
Western Cape
RIETFONTEIN
KURUMAN
UPINGTON
AUGRABIES
ALEXANDER BAY
KIMBERLEY
KENHARDT
PORT NOLLOTH
PRIESKA
SPRINGBOK
GARIES
COLESBURG
CARNARVON
CALVINIA
VICTORIA-WEST
SOUTH AFRICA
N
0 100 200 300 Kilometres
Source:
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GENERAL INFORMATION
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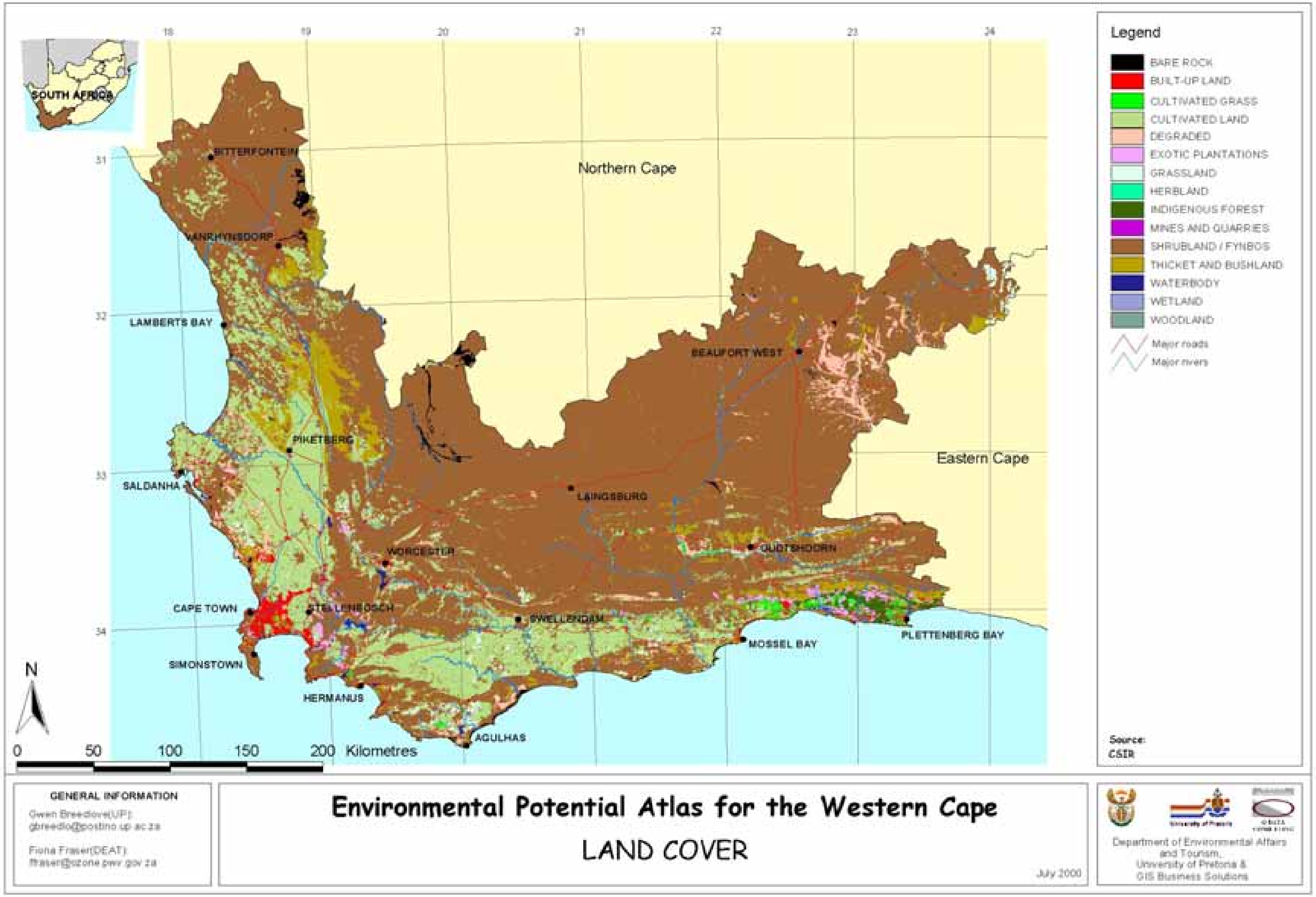
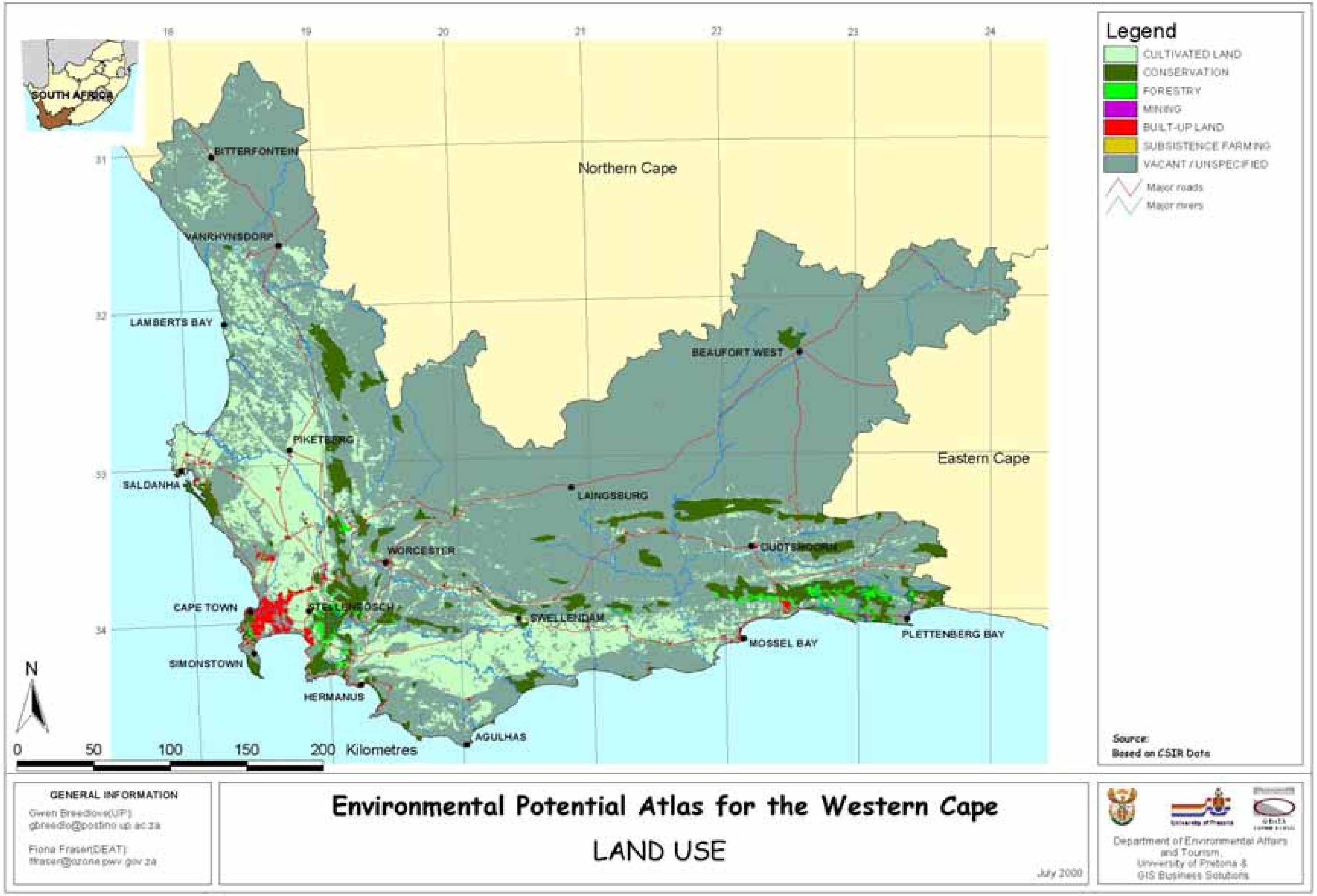
Environmental Potential Atlas for the Northern Cape
SOIL LEACHING STATUS CLASSES
Department of Environmental Affairs and Tourism, University of Pretoria & GIS Business Solutions

**Western Cape**

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CULTIVATED LAND
CONSERVATION
FORESTRY
MINING
BUILT-UP LAND
SUBSISTENCE FARMING
VACANT / UNSPECIFIED
Major roads
Major rivers
SOUTH AFRICA
Northern Cape
Eastern Cape
BITTERFONTEIN
VANRHYNSDORP
LAMBERTS BAY
BEAUFORT WEST
PIKETBERG
SALDANHA
LAINGSBURG
WORCESTER
OUDTSHOORN
CAPE TOWN
STELLENBOSCH
SWELLENDAM
MOSSEL BAY
PLETTENBERG BAY
SIMONSTOWN
HERMANUS
AGULHAS
N
0 50 100 150 200 Kilometres
Source:
Based on CSIR Data
GENERAL INFORMATION
Gwen Breedlove(UP)
gbreedlo@postino.up.ac.za
Fiona Fraser(DEAT)
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Environmental Potential Atlas for the Western Cape
LAND USE
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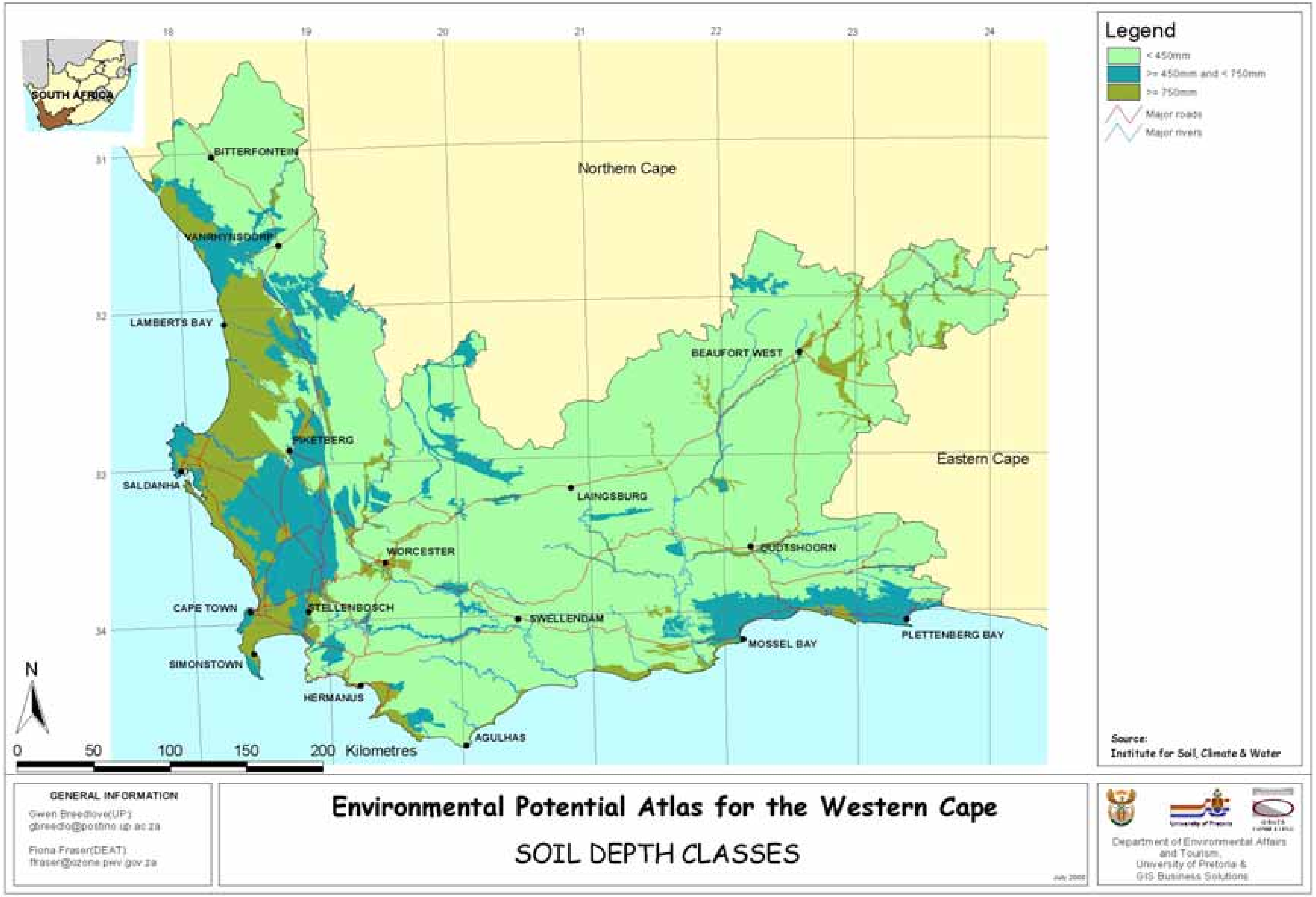
Legend
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>= 450mm and < 750mm
>= 750mm
Major roads
Major rivers
SOUTH AFRICA
Northern Cape
Eastern Cape
BITTERFONTEIN
VANRHYNSDORP
LAMBERTS BAY
PIKETBERG
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PLETTENBERG BAY
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AGULHAS
N
0 50 100 150 200 Kilometres
Source:
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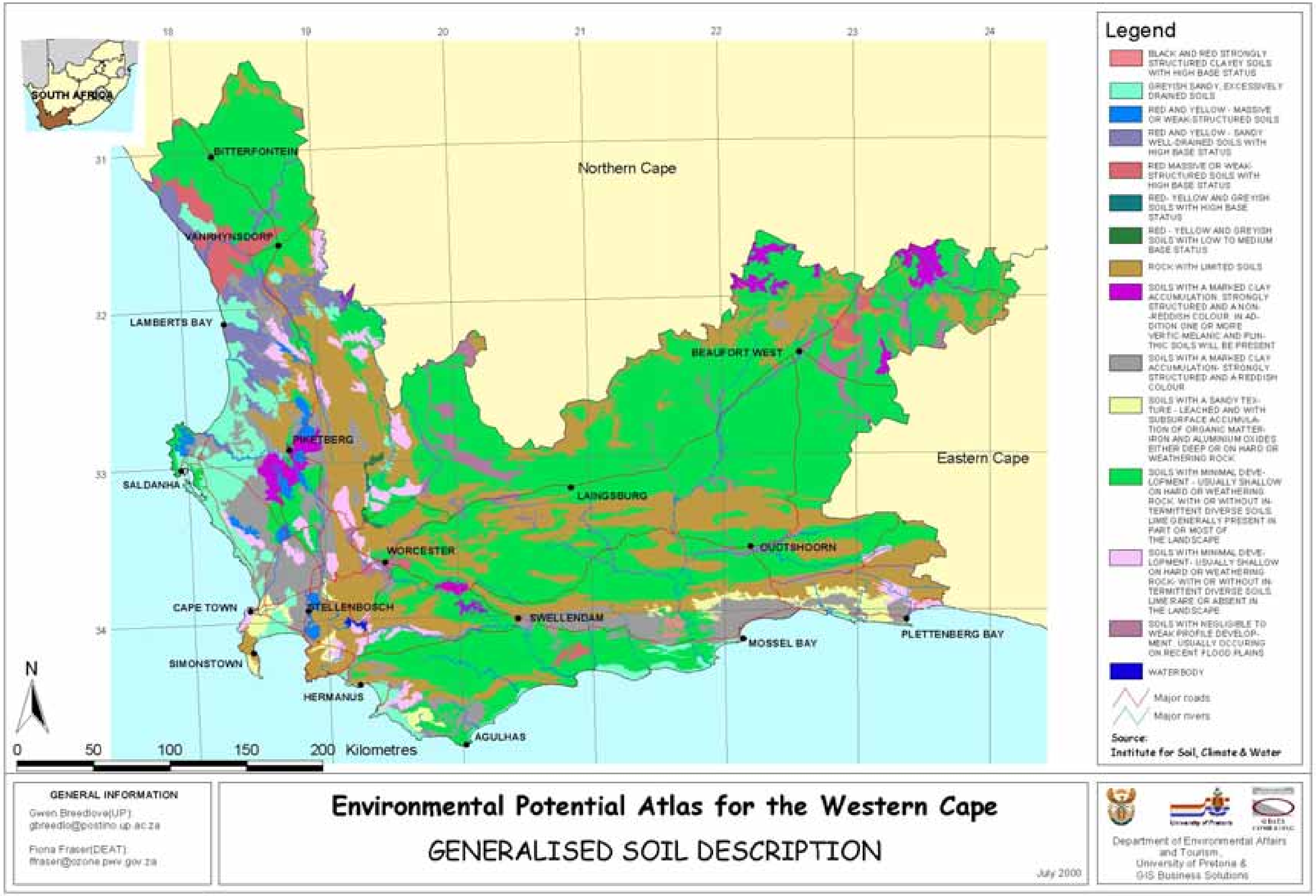
Legend
BLACK AND RED STRONGLY STRUCTURED CLAYEY SOILS WITH HIGH BASE STATUS
GREYISH SANDY, EXCESSIVELY DRAINED SOILS
RED AND YELLOW - MASSIVE OR WEAK STRUCTURED SOILS
RED AND YELLOW - SANDY WELL-DRAINED SOILS WITH HIGH BASE STATUS
RED MASSIVE OR WEAK STRUCTURED SOILS WITH HIGH BASE STATUS
RED- YELLOW AND GREYISH SOILS WITH HIGH BASE STATUS
RED - YELLOW AND GREYISH SOILS WITH LOW TO MEDIUM BASE STATUS
ROCK WITH LIMITED SOILS
SOILS WITH A MARKED CLAY ACCUMULATION, STRONGLY STRUCTURED AND A NON-REDDISH COLOUR. IN ADDITION ONE OR MORE VERTIC MELANIC AND PLINTHIC SOILS WILL BE PRESENT
SOILS WITH A MARKED CLAY ACCUMULATION- STRONGLY STRUCTURED AND A REDDISH COLOUR
SOILS WITH A SANDY TEXTURE - LEACHED AND WITH SUBSURFACE ACCUMULATION OF ORGANIC MATTER, IRON AND ALUMINIUM OXIDES EITHER DEEP OR ON HARD OR WEATHERING ROCK
SOILS WITH MINIMAL DEVELOPMENT - USUALLY SHALLOW ON HARD OR WEATHERING ROCK, WITH OR WITHOUT INTERMITTENT DIVERSE SOILS. LIME GENERALLY PRESENT IN PART OR MOST OF THE LANDSCAPE
SOILS WITH MINIMAL DEVELOPMENT- USUALLY SHALLOW ON HARD OR WEATHERING ROCK- WITH OR WITHOUT INTERMITTENT DIVERSE SOILS. LIME RARE OR ABSENT IN THE LANDSCAPE
SOILS WITH NEGLIGIBLE TO WEAK PROFILE DEVELOPMENT, USUALLY OCCURING ON RECENT FLOOD PLAINS
WATERBODY
Major roads
Major rivers
Source:
Institute for Soil, Climate & Water
Northern Cape
Eastern Cape
BITTERFONTEIN
VANRHYNSDORP
LAMBERTS BAY
PIKETBERG
SALDANHA
WORCESTER
CAPE TOWN
STELLENBOSCH
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LAINGSBURG
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MOSSEL BAY
PLETTENBERG BAY
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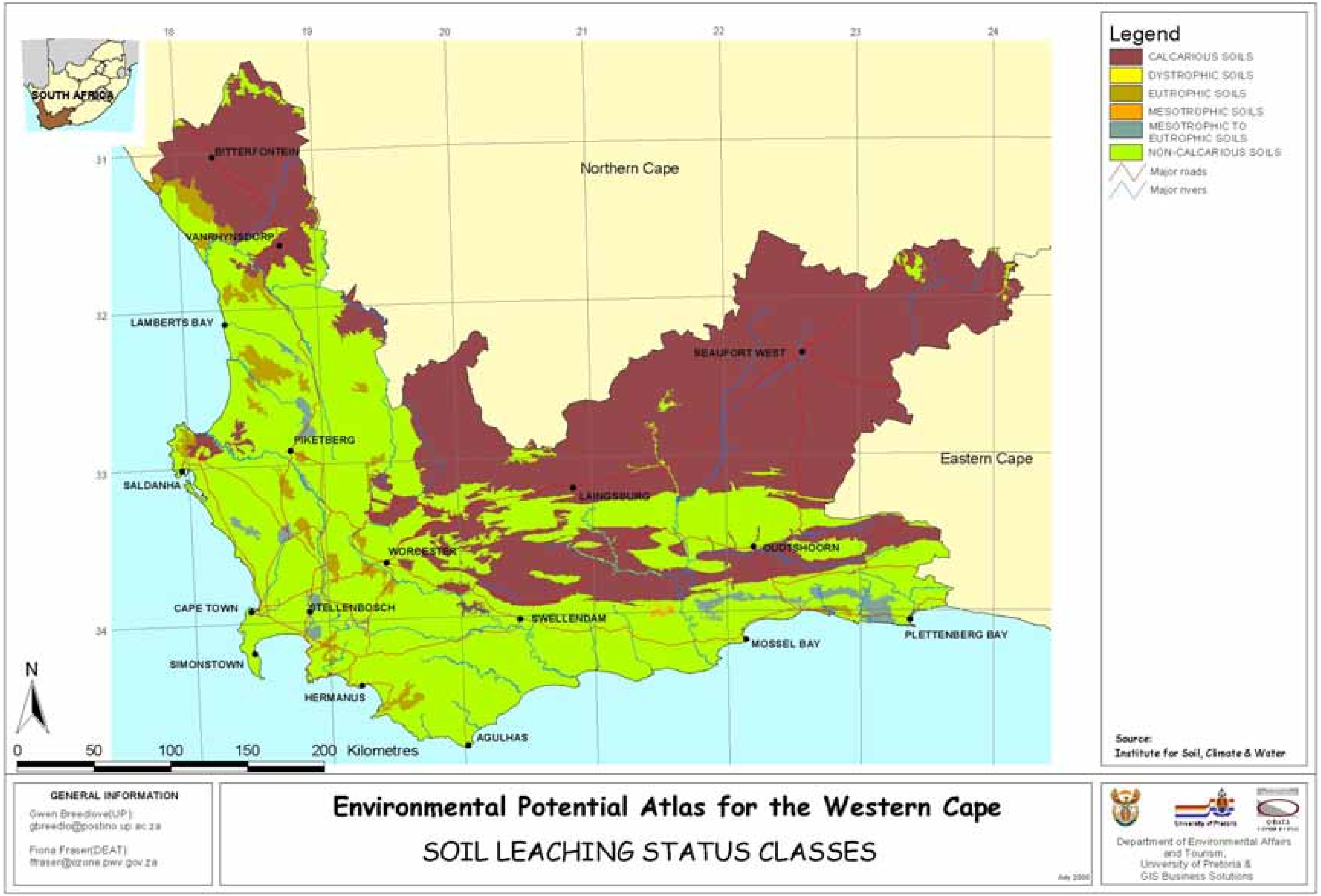
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DYSTROPHIC SOILS
EUTROPHIC SOILS
MESOTROPHIC SOILS
MESOTROPHIC TO EUTROPHIC SOILS
NON-CALCARIOUS SOILS
Major roads
Major rivers
SOUTH AFRICA
Northern Cape
Eastern Cape
BITTERFONTEIN
VANRHYNSDORP
LAMBERTS BAY
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PIKETBERG
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MOSSEL BAY
PLETTENBERG BAY
SIMONSTOWN
HERMANUS
AGULHAS
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Source:
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GENERAL INFORMATION
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**COMPETE Project Coordination**
**WP7 Coordination - Dissemination**

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**Dominik Rutz**
Phone: +49 89 720 12743
Fax: +49 89 720 12791
**E-mail:** rainer.janssen@wip-munich.de
dominik.rutz@wip-munich.de
**Web:** www.wip-munich.de

**WP1 Coordination – Current Land Use**

University of KwaZulu-Natal
School of Environmental Sciences
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**WP2 Coordination – Improved Land Use**

Utrecht University
Dept. Science, Technology and Society
The Netherlands
Contact: **Dr. Andre Faaij**
**Dr. Veronika Dornburg**
**E-mail:** A.P.C.Faaij@uu.nl
V.Dornburg@uu.nl
**Web:** www.chem.uu.nl/nws

**WP5 Coordination – Financing**

Energy for Sustainable Development
United Kingdom
Contact: **Jessica Abbott**
**Stephen Mutimba**
**E-mail:** jessica.abbott@esd.co.uk
smutimba@esda.co.ke
**Web:** www.esd.co.uk

**COMPETE Project Coordination**
**WP3 Coordination - Sustainability**

Imperial College London
Centre for Energy Policy and Technology
South Kensington Campus, London, SW7 2AZ
United Kingdom
Contact: **Dr. Jeremy Woods**
**Dr. Rocio Diaz-Chavez**
Phone: +44 20 7594 7315
Fax: +44 20 7594 9334
**E-mail:** jeremy.woods@imperial.ac.uk
r.diaz-chavez@imperial.ac.uk
**Web:** www.imperial.ac.uk

**WP4 Coordination – International Cooperation**

Winrock International India
Contact: **Sobhanbabu Patragadda**
**E-mail:** sobhan@winrockindia.org
**Web:** www.winrockindia.org

Stockholm Environment Institute
Contact: **Francis Johnson**
**E-mail:** francis.johnson@sei.se
**Web:** www.sei.se

European Biomass Industry Association
Contact: **Stephane Senechal**
**E-mail:** eubia@eubia.org
**Web:** www.eubia.org

**WP6 Coordination – Policies**

Food, Agriculture and Natural Resources Policy Analysis Network of Southern Africa
South Africa
Contact: **Douglas Merrey**
**Dr. Charles Jumbe**
**E-mail:** d.merrey@cgiar.org
charlesjumbe@bunda.unima.mw
**Web:** www.fanrpan.org

COMPETE is co-funded by the European Commission in the 6th Framework Programme – Specific Measures in Support of International Cooperation (INCO-CT-2006-032448).