

Updating National Land Cover

SANBI

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Introduction

Land cover (LC) and land use (LU) changes often indicate major impacts on biodiversity especially if those changes show the loss of natural habitat due to urban sprawl, cultivation, etc. Spatial LC/LU patterns often form a reference for applications ranging from monitoring, planning, biodiversity, climate change, etc. In the past, existing national products LC/LU changes have been widely used in different applications and projects. Most of these applications and projects used the National Land Cover project of 2000 (NLC 2000) published in 2005 and was created to update the first national land cover of 1994 (NLC 1994) published in 1996.

Due to the rather outdated information on land cover, there is high demand for improved land cover data sets on a national scale.

This document explains the processing steps involved in updating the current land cover. It also provides an overview on the data used to accomplish the task. However, the final product should not be considered or utilized as a final new version of National Land Cover. It should also not be utilized for fine scale planning, but instead be considered a current best approach of assessing land cover on a national. On this national scale the final product aims for updating Biodiversity Planning procedures and products.

A graphic overview of the processings is given in figure A1 on page 21. A map overview on the final data product is given in map A1 on page 22.

1. Updating National Land Cover Map of 2000 using the best available data

The National Land Cover of 2000 (NLC 2000), officially published in 2005, is completely outdated since it was based on original data of 2000. Since then a lot of changes that have occurred on the ground. In the meantime some provinces and municipalities have already produced finer scale land cover (LC) and/or land use (LU) data products. In addition an impressive list of national data products on LC and LU has been produced and become available through several state and parastatal institutions. Therefore this project looks into harmonizing the best available data sets to update LC/LU information given by NLC 2000. On the downside this project has to make use of NLC 2000 as a base layer still where provinces municipalities or other institutions could not provide updated information on LC or LU. Merging of spatial information sources described in this document is set to follow a standardized harmonization process ensuring spatial compatibility and thematic comparability among the different data sets.

The final data product will be used for the NSBA (National Spatial Biodiversity Assessment) 2010 and will also be used to calculate indicator statistics for SANBI's Biodiversity Monitoring Programme. In addition, it will be utilized to calibrate models helping SANBI to update LC/LU data on an ongoing basis. A graphic overview of the processings is given in figure A1 on page 21. A map overview on the final data product is given in map A1 on page 22.

2. Overview on data sources

Below, table 1 and table 2 give an overview of the different data sources utilized in addition to the base layer of NLC 2000.

Province	Coverage	Data Type & Spatial Resolution	Source	Year
KwaZulu Natal	Provincial LC	Raster 30m * 30m	KZN Wildlife	2005-2008
North West	Provincial LC	Raster 10m * 10m	North West Department of Environment (Ray Schaller)	2006-2007
Gauteng	Provincial LC	Polygon-Vector mapped at 1: 10 000 scale	Gauteng Conservation Planning project	2005-2006
Western Cape	9 Municipality fine scale LC, no complete land cover.	Raster 30m * 30m	CAPE Project (9 Municipality land cover sets)	2000-2005
Mpumalanga	Selectively updated NLC 2000 data available - no complete land cover.	Polygon-Vector	Mpumalanga Conservation Plan (Mervyn Lotter)	2000-2005
Northern Cape	The finer scale biota land cover map was used to update NLC 2000 in this province	Polygon-Vector and Raster of 30m * 30m	SANBI Biota Subproject	2000-2005
Eastern.Cape, Limpopo,Free State	For these provinces NLC 2000 will be used as a base layer	Raster 30m * 30m	National Land Cover DVD's from Department of Agriculture)	2000

Table 1: Listing of land cover products used in updating the national land cover map of 2000 (NLC 2000). Please contact the producers for further meta-information on these data products.

Data Set	Type	Year	Data Source	Reason / Function
Cultivated fields	Vector-Polygon	2006-2009	Agricultural Research Council (ARC)	Polygons will be used to update cultivation class in NLC 2000
Building Count	Vector Point	2006-2007	Electricity Supply Commission of South Africa (ESKOM)	To update all the urbanized structures in NLC 2000, this point file includes all the building structures in the country.
Informal Settlements	Vector-Polygon	2006-2007	Electricity Supply Commission of South Africa (ESKOM)	This polygon file has the informal settlements in the country and they will represent transformed areas. Also to update the "Urban: Informal settlement" class of NLC 2000.
Plantations	Vector-Polygon	2008	Department of Water Affairs and Forestry (DWAF)	This polygon file have all the plantation that the state has record of, it will be used to update the plantation class of NLC 2000.
Indigenous Forest	Vector-Polygon	2008	Department of Water Affairs and Forestry (DWAF).	This polygon file represents all the indigenous forestry in the country.
1:50.000 Dams	Vector-Polygon	2008	Department of Water Affairs and Forestry (DWAF).	Will be used to update all the artificial waterbodies in the final product.

Table 2: Listing of additional national land cover / land use data and sources utilized for updating the national land cover map of 2000 (NLC 2000). Please contact the producers for further meta-information on these data products.

3. Geometric harmonization of data sets

To ensure spatial compatibility of all raster and vector LC/LU products used in updating NLC 2000, geometrical harmonization was performed in the first step of preprocessing. The projection parameters presented in table 3 on page 5 were used to reproject all LC/LU data sets used prior to the analysis. In addition to the reprojection of all data sets, raster data sets were resampled to a spatial resolution of 30*30m where needed. Resampling was performed using a majority filtering.

As a last step all data sets were clipped using official provincial boundaries obtained from the Demarcation Board to prevent problems from cross boundary overlap and to avoid data gaps appearing outside of provincial regions of interest.

4. Harmonization of LC\LU classification schemes

Starting with provincial subsets of LC/LU data a harmonization of classification schemes was undertaken to allow for thematic comparability.

In general terminology used by NLC 2000 was used to standardize the class names across updated provincial land cover data of Gauteng, KZN, and North West. Obtained land cover data often used synonymous terminology when descriptively classifying land cover or land use. For example in KwaZulu Natal provincial land cover included a class of “Natural Fresh Water”, while in North West provincial land cover the same class was named “water-natural”. Following standardization to NLC 2000 terminology both classes were remapped to the NLC class of “Waterbodies (natural)” and NLC 2000 class ID of “1”. A full tabular listing of all class mappings is presented in the ANNEX Table A1-A3. A special case was made for some provinces where updated fine scale municipal data sets were provided for some areas. For these provinces both the fine scale municipal data and NLC 2000 was used but priority was given to the fine scale data where it existed. Although more detailed in many areas all fine scale municipal data sets already provided class mappings in relation to NLC 2000 in their meta-data. Therefore no remapping was necessary to integrate the fine-scale information. Lastly the three provinces of Limpopo, Free State, Eastern Province did not have either provincial land cover or fine scale data and NLC 2000 was used for those only. Finally all provincial LC\LU data were merged.

Due to different mapping approaches and methodologies used in the past some of the provincial land cover data sets also employed differing numbers of classes / different level of classification detail. In order to overcome the problem of differing detail classes were standardized further toward a classification level of detail common to all data sets and most applicable for the proposed utilization of the finalized LC/LU product. Therefore the final classification scheme was reduced to 8 classes in total presented in table 4. A full tabular listing of all class mappings is presented in the ANNEX Table A4.

Projections Type	Albers Conical Equal Area
Linear Unit	Meter
False Easting	0
False Northing	0
Longitude of Central Meridian	25
Latitude of 1st Standard Parallel	-33
Latitude of 2nd Standard Parallel	-24
Latitude of origin	0
Datum Name:	WGS 1984
Spheroid Name:	WGS 1984

Table 3: Projection parameters used for geometric harmonization of different data sources.

Class ID	Class Description
0	Missing Data
1	Natural
2	Cultivation
3	Degraded
4	Urban Built-Up
5	Waterbodies
6	Plantations
7	Mines

Table 4: Reduced classification scheme.

5. Introduction of additional LC/LU data sets

This chapter focuses on the description, processing, and introduction of the additional national information on land cover and land use as presented in table 2 earlier.

5.1. ESKOM SPOT Building Count and Informal settlements

2006/07 SPOT Building Count (SBC) data set maps the location of all dwelling units and building (electrifiable) structures in South Africa in point vector format. Produced by ESKOM this product is frequently updated as part of their mandate on structural planning on countrywide electrification. Thus the point vector file consists of over 3 million GPS points representing electrifiable structures obtained from pansharpned SPOT5 satellite imagery 2.5m images acquired between 2006 and 2007 in GIS environment, for cross validation. The vector points are used to map location of dwelling units and building structures while the densely populated areas of informal settlements are presented by polygons. Overall the different structures are classified into 4 classes:

- Dwellings (+/- 90% of all points)
- School
- Complex/Hostel
- Mine/Quarry
- Resort
- Informal settlements polygons

Mapping by ESKOM has been performed by regions according to electricity networks, not per province or municipality. Therefore all original data sets are split into 6 different ESKOM-specific regions on a national level.

5.1.1. Preprocessing of SPOT Building Count (SBC) and Informal settlements

Reprojection:

All individual vector point data obtained from ESKOM were reprojected into Albers Conical Equal Area projection (compare table 3). Reprojected individual point shapefiles were then mosaiced to produce a coherent national information layer. The same procedure was followed for the vector polygons on informal settlements.

Rasterization:

Rasterization was performed using “Polygon to Raster” function in ArcGIS for the polygon vector file representing informal settlements. Below the processing parameters are listed:

Value field: Unique code or FID

Cell assignment type: Maximum area

*Cellsize: 30m * 30m*

Rasterization of SCB point vector data was performed using the “Point to Raster” in ArcGIS. For converting the points into raster, the following parameters were set:

Value field: Unique code or FID

Cell assignment: Count (this will count the number of points that fall within each pixel; this can show density as well)

Cellsize: 250

5.1.2. Classification of SPOT Building Count (SBC) and Informal settlements

Converting the SCB point vector file into raster format of 250*250m pixel resolution did not only convert the format of the file from vector to raster but also assigned the total point count to each newly created raster cell comprising an area equivalent of 62500 m². Range of total pixel counts within raster cells varied between 0 in areas known to consist of hermland, veld, cattle camps, etc and 254 for known urban complexes. Subsequently pixel counts were classified according to different levels of building densities, representing different stages of urbanization.

Recorded counts of building structures per defined area have been widely used for classifying different levels of housing density. For example a study performed in Haiti looked at building density based on a 0.3*0.3km grid (Myrtho, 2000). A different study was undertaken in the UK where the recorded number of dwellings per hectare (Supplementary Planning Guidance, 2000). In the following both studies served as a starting point for classifying different levels of building densities obtained from the SBC data.

Firstly and based on the urban areas extracted from NLC 2000 a lower threshold for the total pixel count still referring to truly urban areas was determined empirically. Comparing the extracted urban areas with the counts on building densities derived from the SBC data, it became obvious that areas showing of less than 12 building structures per 62500 m² showed no reference to urban areas as classified by NLC 2000 and should thus be excluded from the analysis. Furthermore this empirically derived threshold was also based on the relationship of 12 single building structures including individual a plot sizes of ~5208 m². Although being an assumption based on the equal distribution of building structures these plot sizes clearly point towards peri-urban and rural areas where people own acres surrounding their properties. The authors are aware that those areas should be classified as transformed areas from an ecological perspective, however they should not be associated with truly urban structures.

Following the first stratification process, remaining areas derived from the SCB were then classified into 3 classes of Medium Density (13-45), High Density (46-100), and Very High Density (> 100) based on the number of points counts (dwellings) within the area of 250*250 m or 62500 m². This stratification was partly based on the thresholds used by Myrtho (2000) and Supplementary Planning Guidance (2000) and partly plot sizes commonly found in urbanized South African areas. An overview of the relationships is given in table 5 below.

Density Class	Building Count	Plot Sizes	Mean SA Plot Size	Urban Class
Low Density	≤ 12	~5208 m ²	-	Rural/Peri-Urban
Medium Density	13-45	~4807 - ~1388 m ²	2500 m ²	Suburbs
High Density	46-100	~1359 – 625 m ²	650 m ²	Formal Townships
Very High Density	> 100	< 625 m ²	-	Metro Areas

Table 5: Overview on classifying housing densities

5.1.3 Integrating urban areas from NLC 2000, Provincial Land Cover, and SBC

Following the classification of the SCB data, all classified urban areas derived from NLC 2000, Provincial Land Cover data sets were merged with the SCB classification. Urban areas derived from SCB classification were given different classes from the ones used in NLC 2000 to distinguish between them and to identify urban growth at a later stage. Although being derived on a 250m resolution the SCB density data was merged with 30m spatial resolution of the Provincial and NLC data sets maintaining the minimum cell size overall. The resulting file representing updated urban areas on a national level was called **urbanareas** in the following.

5.1.4 Utilizing ESKOM SCB data for updating Urban Areas

In addition to updating the urban areas of NLC2000, the ESKOM SPOT Building Count was used also used to identify urban sprawl in a different analysis.

On page 10, figure 1 gives an impression as SBC point vector data is overlaid on the original NLC2000 data. Here vector points indicate where natural areas represented by NLC 2000 in green color have been lost to housing developments. One can also identify the rough compliance of NLC 2000 housing areas and actually recorded SCB point densities.

In contrast to the rough compliance of NLC 2000 urban areas and recorded SCB point densities, figure 2 on page 10 represents a much better impression of urban areas, despite the obvious the loss of natural habitats through the housing developments.

5.1.5 Identification of Coastal Developments using ESKOM SCB data

Being a developing country, South Africa is largely characterized with development especially along its coastline. Some of the pressure experienced in these sensitive environments during the last years could also be spotted from the introduction of the updated urbanized areas. Figure 3 and Figure 4 on page 11 give an impression on urban development for parts of the Ethekwini municipality.

5.1.6 A new detailed definition of urban areas using ESKOM SCB data

In addition to the updated information on urbanization in general the level of detail introduced by the introduction of the updated information has also meant quite an advance. Figure 5 and Figure 6 on page 11 give quite a compelling impression comparing two parts of the Ethekwini municipality.



Figure 1: NLC 2000 Urban Areas (red), Natural Areas (green) and ESKOM SCB.



Figure 2: Showing The New Updated Land Cover, Urban Areas (Red) and Natural Areas (Green).



Figure 3: Coastal Development areas are still marked as natural areas on NLC 2000 Urban Areas (Red), Natural Areas (Green), Waterbodies (blue), ESKOM SBC (dots).

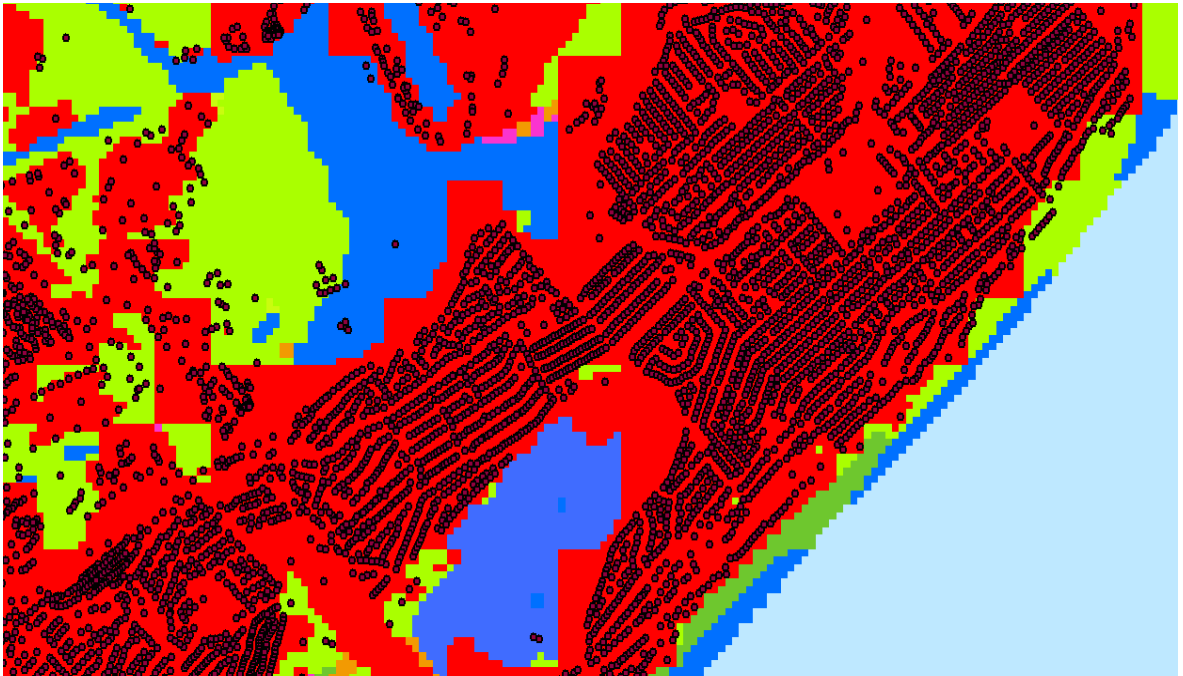


Figure 4: Same area as shown in figure 3, after being updated using SBC data. Urban Areas (Red), Natural Areas (Green), Waterbodies (Blue), ESKOM SBC (dots).

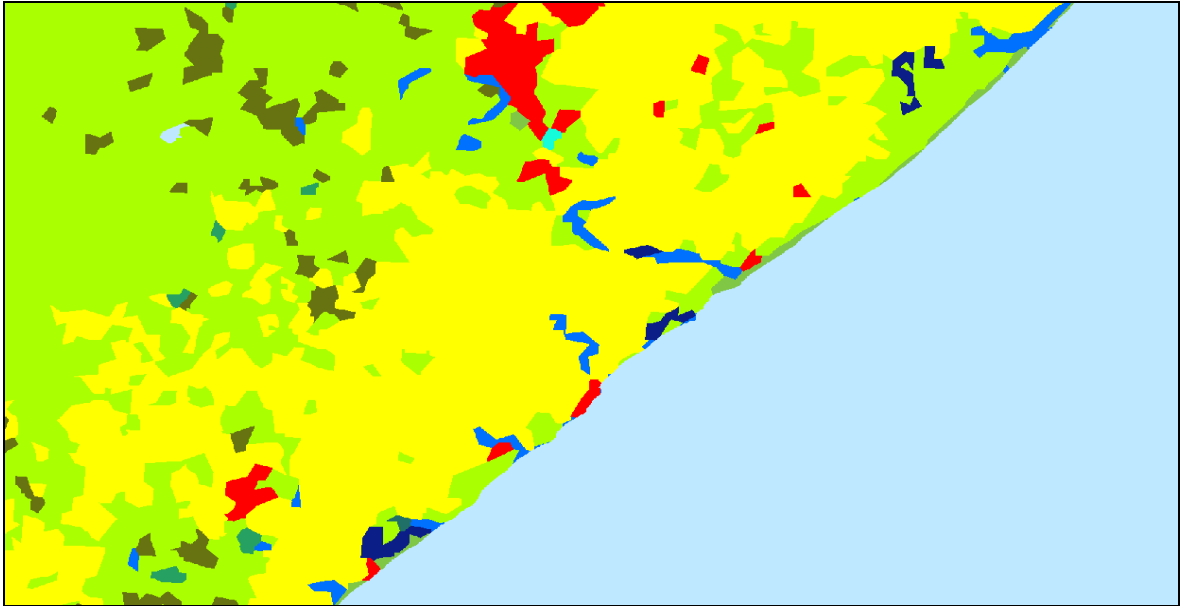


Figure 5: NLC 2000 data subset showing urbanized areas around an estuary mouth. However many features are not clearly outlined and features like roads cannot be identified at all.

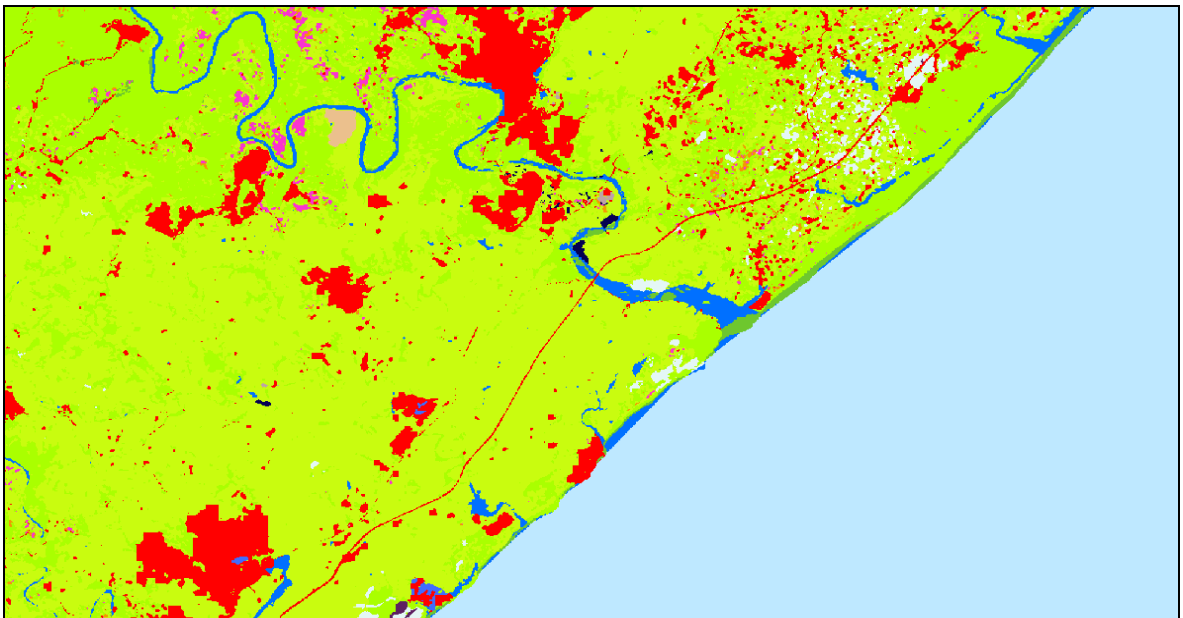


Figure 6: The same area as presented in Figure 5 showing the updated land cover product. Here the estuary mouth is clearly visible and also features like roads can be identified. In addition urbanized structures can be clearly delineated.

5.2 DWAF Forest Plantations

From the Department of Water Affairs and Forestry of South Africa (DWAF) a national data set was received delineating all forest plantations that the state has record of. In this study the information given by the vector data as of 2008 will be utilized to update the “Plantation” class originally defined by NLC 2000, with no plantation areas previously demarcated in NLC 2000 being discarded in the process.

Although very much comprehensive the vector data set might still miss out on any unregistered and therefore illegal commercial plantations. To allow for complete integration of the polygon vector data set, we rasterized the data to a pixel size of 30x30 meter and created a binary plantation mask for the whole country. The resulting raster file was named **DWAF_plan**.

Figure 7 on page 13 gives a graphic example of an image pair where original NLC 2000 data (right) is compared to the updated version on the left. Here red areas delineate plantations in areas that were listed as natural areas (green) before.

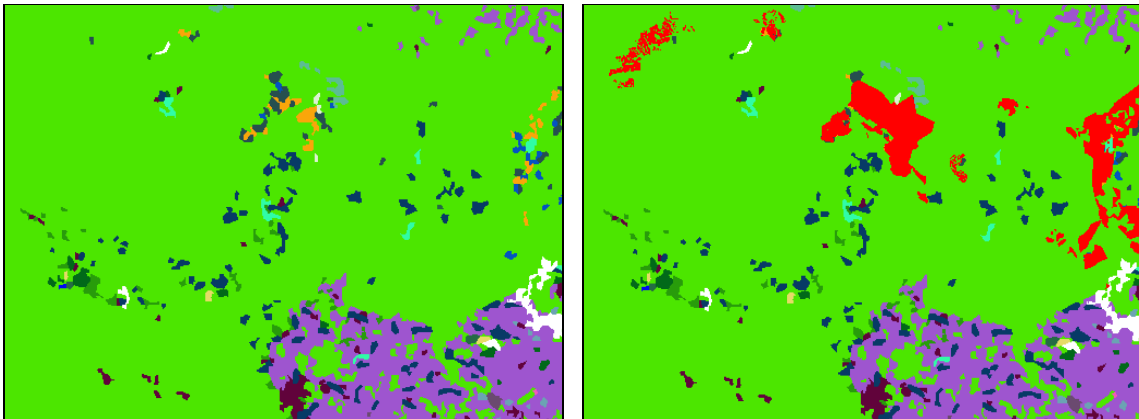


Figure 7: Original NLC 2000 data (right) is compared to the updated version on the left. Here red areas delineate plantations in areas that were listed as natural areas (green) before.

5.3 ARC cultivated fields

Updated regularly the Agriculture Research Council (ARC) provides provincial data sets on cultivated fields for South Africa. Stored in vector format, polygons file represent field boundaries across the country, classified/attributed according to seven different types of intensity of agriculture given in table 6.

Class ID	Class Description
1	Low Cultivation
2	Medium Cultivation
3	Pivot Irrigation
4	High Cultivation
5	Old Fields
6	Small Holdings
7	Small Scale Farming

Table 6: Classification of different types of agriculture according to intensity.

In contrast to the other provinces, the Western Cape does follow the scheme given in table 6 but uses slightly different classes. However, since all information on cultivation was rasterized in the process and summarized to a binary raster layer national layer on cultivation, these differences were of no importance to this study. Integrating the information on cultivated fields it was given a priority over all other data sources utilized in this study due to the mapping precision and the high update frequency.

Especially important to provinces that could not provide updated land cover information to this study this national data layer can be regarded as one of the key layers for updating national land cover information. Figure 8 and figure 9 on page 15 give graphic examples on how natural areas outlined by NLC 2000 have been lost to cultivation in recent years according to the ARC data set.

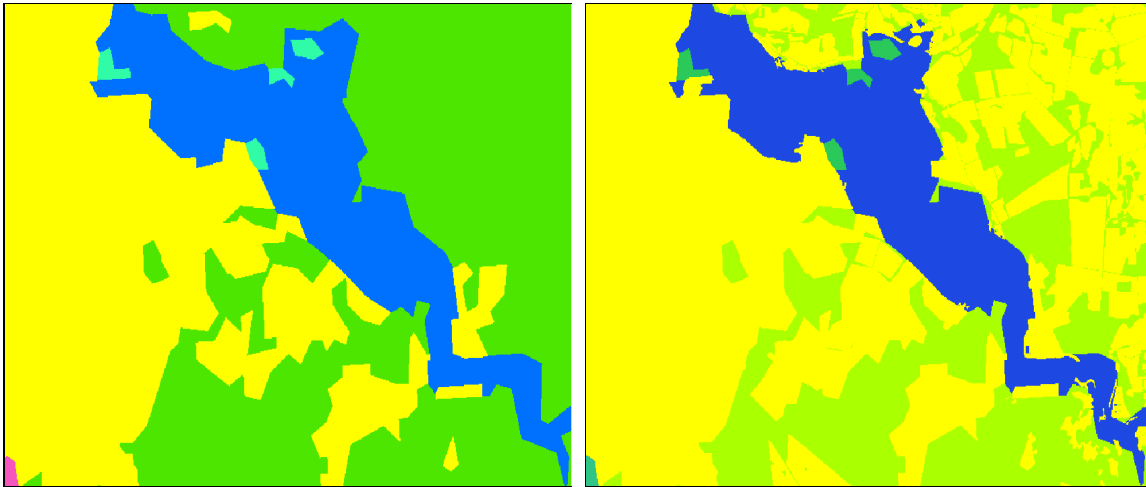


Figure 8: Following the color code of Cultivation (yellow), Waterbodies (blue) and Natural Areas (green) above figures graphically show the increase of cultivation since 2000 on the left and 2008 on the right using ARC cultivated fields data.

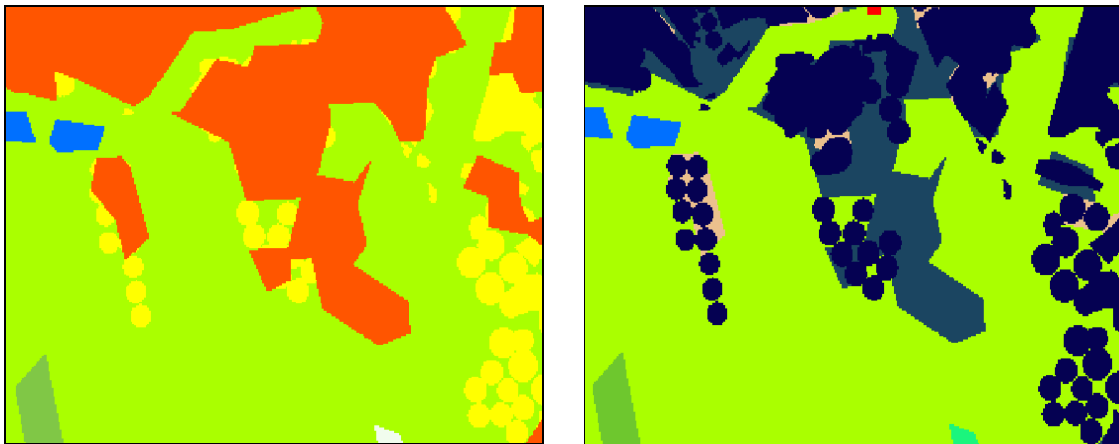


Figure 9: This figure gives to examples on how the updated information on cultivated fields has been added to improve existing land cover information. On the left cultivated areas from NLC 2000 are shown (red) overlaying the updated ARC cultivation fields (yellow). In the second figure on the right ARC cultivation fields (navy) overlays cultivated areas from NLC 2000 (grey) outlining the extra precision gained. Other colors show Natural areas (green) and Waterbodies (blue).

6. References:

Myrtho Joseph (2009): A GIS-based modeling of environmental health risks in populated area of Port-au-prince, Haiti. University of Arizona.

Supplementary Planning Guidance (2000): Housing Density. Planning Policy Guidance Note 1 on General Policy and Principles, London, UK.

7. ANNEX:

NLC ID	NLC 2000 Description	KZN Description
0	Missing Data	Missing Data
1	Waterbodies	Natural Fresh Water
2	Forest Plantations (Other / mixed spp)	Plantation
3	Forest Plantations (clearfelled)	Plantation clearfelled
4	Wetlands	Wetlands
5	Wetlands	Wetlands - mangrove
6	Cultivated, permanent, commercial, irrigated	Permanent orchards (banana, citrus) irrigated
7	Cultivated, permanent, commercial, dryland	Permanent orchards (cashew) dryland
8	Cultivated, permanent, commercial, dryland	Permanent pineapples dryland
9	Cultivated, permanent, commercial, sugarcane	Sugarcane - commercial
10	Cultivated, permanent, subsistence, dryland	Sugarcane - emerging farmer
11	Mines and Quarries	Mines and quarries
12	Urban / Built-up	Urban
13	Improved Grassland	Golf courses
14	Urban / Built-up (rural cluster)	Rural dwellings
15	Cultivated, permanent, subsistence, dryland	Subsistence (rural)
16	Cultivated, temporary, commercial, dryland	Annual commercial crops dryland
17	Cultivated, temporary, commercial, irrigated	Annual commercial crops irrigated
18	Forest (indigenous)	Forest
19	Thicket & Bushland	Dense bush (70 -100 cc)
20	Thicket & Bushland	Bushland (< 70cc)
21	Woodland	Woodland
22	Thicket & Bushland	Grassland / Bush Clumps mix
23	Grassland	Grassland
24	Bare rock & sand	Bare sand
25	Degraded Forest & Woodland	Degraded forest
26	Degraded Thicket, Bushland, etc	Degraded bushland (all types)
27	Degraded Unimproved (natural) Grassland	Degraded grassland
28	Cultivated, permanent, Grassland	Old cultivated fields - grassland
29	Cultivated, permanent, Bushland	Old cultivated fields - bushland
30	Urban / Built-up (smallholding, grassland)	Smallholdings - grassland
31	Bare Rock and Soil (erosion: dongas / gullies)	Erosion
32	Bare Rock & Soil	Bare rock
33	Shrubland & Low Fynbos	Alpine grass - heath
34	Urban / Built-up (industrial / transport: heavy)	KZN national roads
35	Urban / Built-up (industrial / transport: light)	KZN main & district roads
36	Waterbodies	Dams
37	Waterbodies	Estuarine Water
38	Waterbodies	Marine Water
39	Coastal Sand & Rock	Coastal Sand and Rock

Table A1: Remapping of LC/LU classes of KZN Province.

Gauteng ID	NLC 2000 Description	Gauteng Description
1	Thicket, Bushland, Bush Clumps, High Fynbos	Natural Thicket
2	Thicket, Bushland, Bush Clumps, High Fynbos	Bushland, Bush Clumps
3	Natural Grassland	Natural Grassland
9	Woodland	Woodland
22	Bare Rock & Soil (erosion: dongas / gullies)	Bare Rock & Soil (soil erosion surfaces : dongas / gullies)
23	Bare Rock & Soil (natural surfaces)	Bare Rock & Soil (natural surfaces)
27	Bare Rock & Soil (erosion: sheet)	Bare Rock & Soil (soil erosion surfaces : sheet)
29	Shrubland and Low Fynbos	Shrubland & Low Fynbos
30	Woodland	Wooded Grassland
43	Forest (indigenous)	Scrub Forest
51	Herbland	Herbland
4	Urban / Built-up (smallholdings, thicket, bushland)	Urban / Built-up : smallholdings - thicket, bushland, bush
5	Urban / Built-up (industrial / transport: light)	Road Infrastructure
13	Urban / Built-up (smallholdings, grassland)	Urban / Built-up : smallholdings - natural grassland
15	Urban / Built-up	Urban / Built-up
19	Urban / Built-up (industrial / transport: light)	Urban / Built-up : industrial / transport - light
20	Urban / Built-up (smallholdings, forest & woodland)	Urban / Built-up : smallholdings - woodland
21	Urban / Built-up (industrial / transport: heavy)	Urban / Built-up : industrial / transport - heavy
32	Urban / Built-up (commercial, education, health, IT)	Urban / Built-up : commercial - educational, health, IT
33	Urban / Built-up (residential, formal suburbs)	Urban / Built-up : residential, formal suburbs
34	Urban / Built-up (residential, rural cluster)	Urban / Built-up : rural cluster
35	Urban / Built-up (residential, mixed)	Urban / Built-up : residential, residential mixed
36	Urban / Built-up	Cemeteries
37	Urban / Built-up (residential, informal squatters)	Urban / Built-up : residential, informal squatter camp
38	Urban / Built-up (residential, formal township)	Urban / Built-up : residential, formal township
39	Urban / Built-up (commercial, mercantile)	Urban / Built-up : commercial - mercantile
40	Urban / Built-up (residential, hostels)	Urban / Built-up : residential, hostels
41	Urban / Built-up (residential, informal township)	Urban / Built-up : residential, informal township
42	Urban / Built-up (industrial / transport: heavy)	Railway lines
44	Urban / Built-up (smallholdings, shrubland)	Urban / Built-up : smallholdings - shrubland & low fynbos
46	Urban / Built-up (residential, flatland)	Urban / Built-up : residential, flatlands
49	Mines & Quarries (underground / sub-surface mining)	Mines & Quarries (underground / sub-surface mining)
50	Mines & Quarries (mine tailings, waste dumps)	Mines & Quarries (mine tailings, waste dumps)
6	Planted Grassland	Planted Grassland
7	Cultivated, permanent, commercial, dryland	Cultivated, permanent, commercial, dryland / rainfed
12	Cultivated, permanent, commercial, irrigated	Cultivated, permanent, commercial, irrigated
16	Cultivated, temporary, commercial, dryland	Cultivated, temporary, commercial, dryland / rainfed
18	Forest Plantations (Other / mixed spp)	Forest Plantations
25	Cultivated, temporary, subsistence, dryland	Cultivated, temporary, semi-commercial / subsistence, dryland
26	Cultivated, temporary, commercial, irrigated	Cultivated, temporary, commercial, irrigated
28	Cultivated, temporary, subsistence, irrigated	Cultivated, temporary, semi-commercial / subsistence, irrigated
31	Cultivated, permanent, commercial, sugarcane	Cultivated, permanent, commercial, sugarcane
47	Forest Plantations (clear felled)	Clear Felled (Forest Plantations)
10	Degraded Thicket, Bushland, etc	Degraded Thicket, Bushland, Bush Clumps & High Fynbos
11	Degraded Unimproved (natural) Grassland	Degraded Natural Grassland
24	Degraded Forest and Woodland	Degraded Forest and Woodland
8	Waterbodies	Dams
14	Waterbodies	Rivers
17	Waterbodies	Cannals
45	Wetlands	Wetlands
48	Waterbodies	Pans

Table A2: Remapping of LC/LU classes of Gauteng Province.

NLC ID	NLC2000 Description	North West Description
0	Missing Data	Missing Data
1	Forest (indigenous)	closed tree & bush
2	Woodland	open-closed bush & tree
3	Thicket, Bushland, Bush Clumps, High Fynbos	open bush
4	Thicket, Bushland, Bush Clumps, High Fynbos	sparse bush
5	Shrubland and Low Fynbos	open-closed low shrub
6	Shrubland and Low Fynbos	sparse low shrub
7	Natural Grassland	grassland
8	Natural Grassland	sparse grassland
9	Waterbodies (natural)	water - natural
10	Wetlands	wetlands - vegetated
11	Wetlands	wetlands - dry pans
12	Bare Rock and Soil (natural)	nat bare sand dunes
13	Bare Rock and Soil (natural)	nat bare non rock
14	Bare Rock and Soil (natural)	nat bare rock
15	Planted Grassland	planted grass (sport)
16	Planted Grassland	planted grass (golf)
17	Forest Plantations (Other / mixed spp)	plantation & woodlots
18	Waterbodies	water - artificial
19	Waterbodies	water - sewage
20	Bare Rock and Soil (erosion : dongas, sheet, gullies)	erosion (all types)
21	Degraded Thicket, Bushland, etc	disturbed / degraded
22	Mines & Quarries (mine tailings, waste dumps)	landfill sites
23	Improved Grassland	cattle camps
24	Cultivated, permanent, commercial, irrigated	cultiv permn irrig orchard
25	Cultivated, temporary, commercial, dryland	cultiv annual dryland comm
26	Cultivated, permanent, subsistence, dryland	cultiv annual dryland subs
27	Cultivated, temporary, subsistence, irrigated	cultiv irrig annual grain
28	Cultivated, temporary, subsistence, irrigated	cultiv irrig pivot
29	Cultivated, temporary, subsistence, dryland	cultiv old fields
30	Urban / Built-up (smallholdings, grassland, etc)	smallholdings (plots)
31	Cultivated, permanent, commercial, irrigated	smallholding (cultiv)
32	Urban / Built-up	urban (all)
33	Urban / Built-up (commercial, mercantile)	industry & commerce (all)
34	Urban / Built-up (rural cluster)	scattered rural (all)
35	Urban / Built-up (industrial / transport: light)	roads & tracks
36	Urban / Built-up	animal batteries
37	Urban / Built-up	greenhouses
38	Mines and Quarries (surface-based mining)	mines extraction & tailings
39	Mines and Quarries (underground / subsurface mining)	mines sub-surface & infrstr
40	Obscured dates	cloud obscured all dates

Table A3: Remapping of LC/LU classes of North-West Province.

ID	Updated NLC Description	NLC ID	NLC Description
0	Missing Data	0	Missing data
1	Natural	1	Forest (indigenous)
1	Natural	2	Woodland
1	Natural	3	Thicket, Bushland, Bush Clumps, High Fynbos
1	Natural	4	Shrubland and Low Fynbos
1	Natural	5	Herbland
1	Natural	6	Natural Grassland
2	Cultivation	7	Planted Grassland
6	Plantations	8	Forest Plantations (Eucalyptus spp)
6	Plantations	9	Forest Plantations (Pine spp)
6	Plantations	10	Forest Plantations (Acacia spp)
6	Plantations	11	Forest Plantations (Other / mixed spp)
6	Plantations	12	Forest Plantations (clearfelled)
5	Waterbodies	13	Waterbodies
5	Waterbodies	14	Wetlands
1	Natural	15	Bare Rock and Soil (natural)
1	Natural	16	Bare Rock and Soil (erosion: dongas / gullies)
1	Natural	17	Bare Rock and Soil (erosion: sheet)
3	Degraded	18	Degraded Forest & Woodland
3	Degraded	19	Degraded Thicket, Bushland, etc
3	Degraded	20	Degraded Shrubland and Low Fynbos
3	Degraded	22	Degraded Unimproved (natural) Grassland
2	Cultivation	23	Cultivated, permanent, commercial, irrigated
2	Cultivation	24	Cultivated, permanent, commercial, dryland
2	Cultivation	25	Cultivated, permanent, commercial, sugarcane
2	Cultivation	26	Cultivated, temporary, commercial, irrigated
2	Cultivation	27	Cultivated, temporary, commercial, dryland
2	Cultivation	28	Cultivated, temporary, subsistence, dryland
2	Cultivation	29	Cultivated, temporary, subsistence, irrigated
4	Urban Built-up	30	Urban / Built-up
4	Urban Built-up	31	Urban / Built-up (rural cluster)
4	Urban Built-up	32	Urban / Built-up (residential, formal suburbs)
4	Urban Built-up	33	Urban / Built-up (residential, flatland)
4	Urban Built-up	34	Urban / Built-up (residential, mixed)
4	Urban Built-up	35	Urban / Built-up (residential, hostels)
4	Urban Built-up	36	Urban / Built-up (residential, formal township)
4	Urban Built-up	37	Urban / Built-up (residential, informal township)
4	Urban Built-up	38	Urban / Built-up (residential, informal squatter camp)
4	Urban Built-up	39	Urban / Built-up (smallholdings, forest & woodlands)
4	Urban Built-up	40	Urban / Built-up (smallholdings, thicket, bushland, etc)
4	Urban Built-up	41	Urban / Built-up (smallholdings, shrubland, etc)
4	Urban Built-up	42	Urban / Built-up (smallholdings, grassland, etc)
4	Urban Built-up	43	Urban / Built-up (commercial, mercantile)
4	Urban Built-up	44	Urban / Built-up (commercial, education, health, IT)
4	Urban Built-up	45	Urban / Built-up (industrial / transport: heavy)
4	Urban Built-up	46	Urban / Built-up (industrial / transport: light)
7	Mines	47	Mines and Quarries (underground / subsurface mining)
7	Mines	48	Mines and Quarries (surface-based mining)
7	Mines	49	Mines and Quarries (mine tailings, waste dumps)

Table A4: Final remapping of NLC 2000 LC/LU classes.

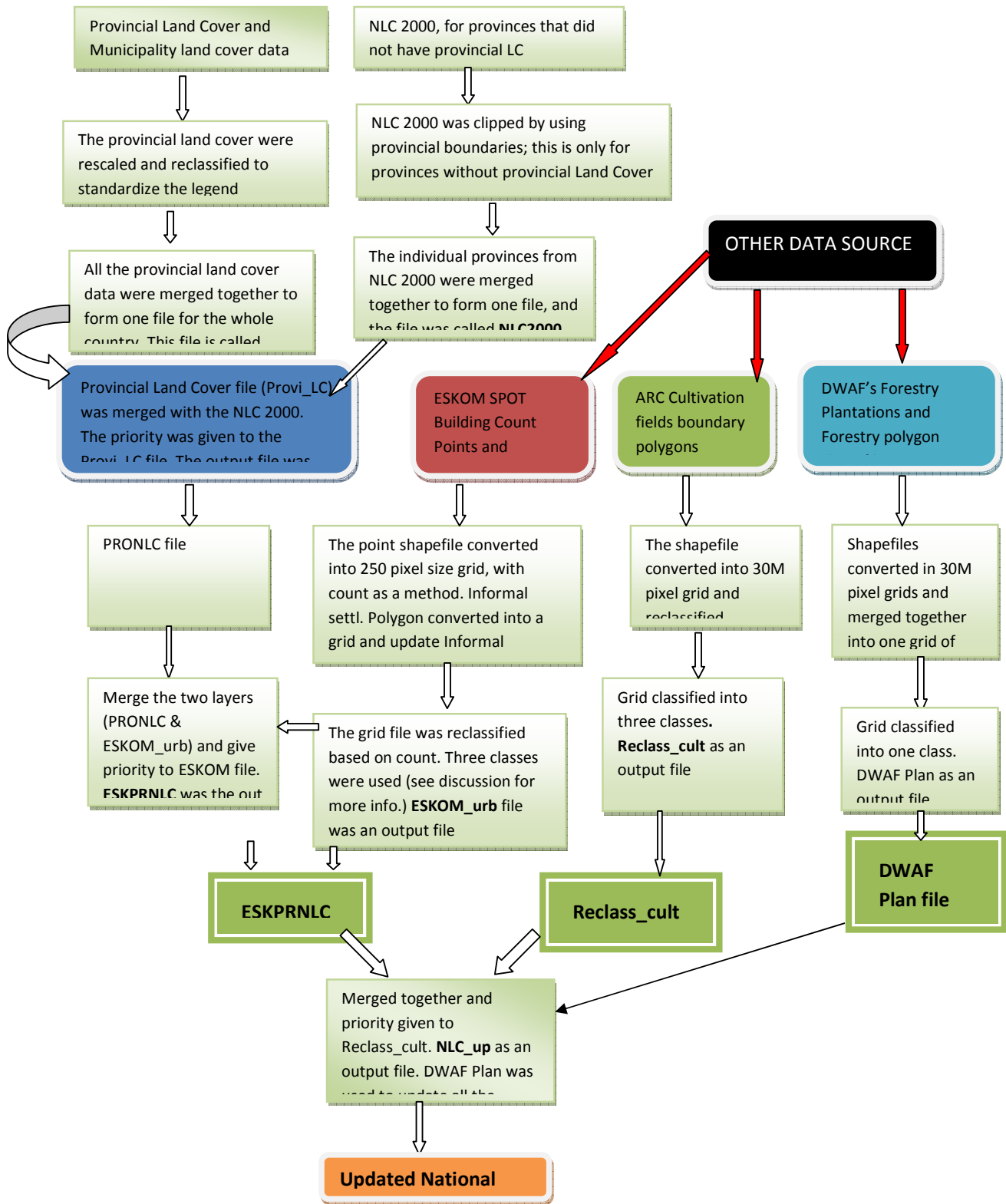
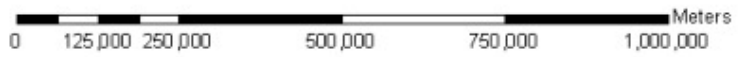
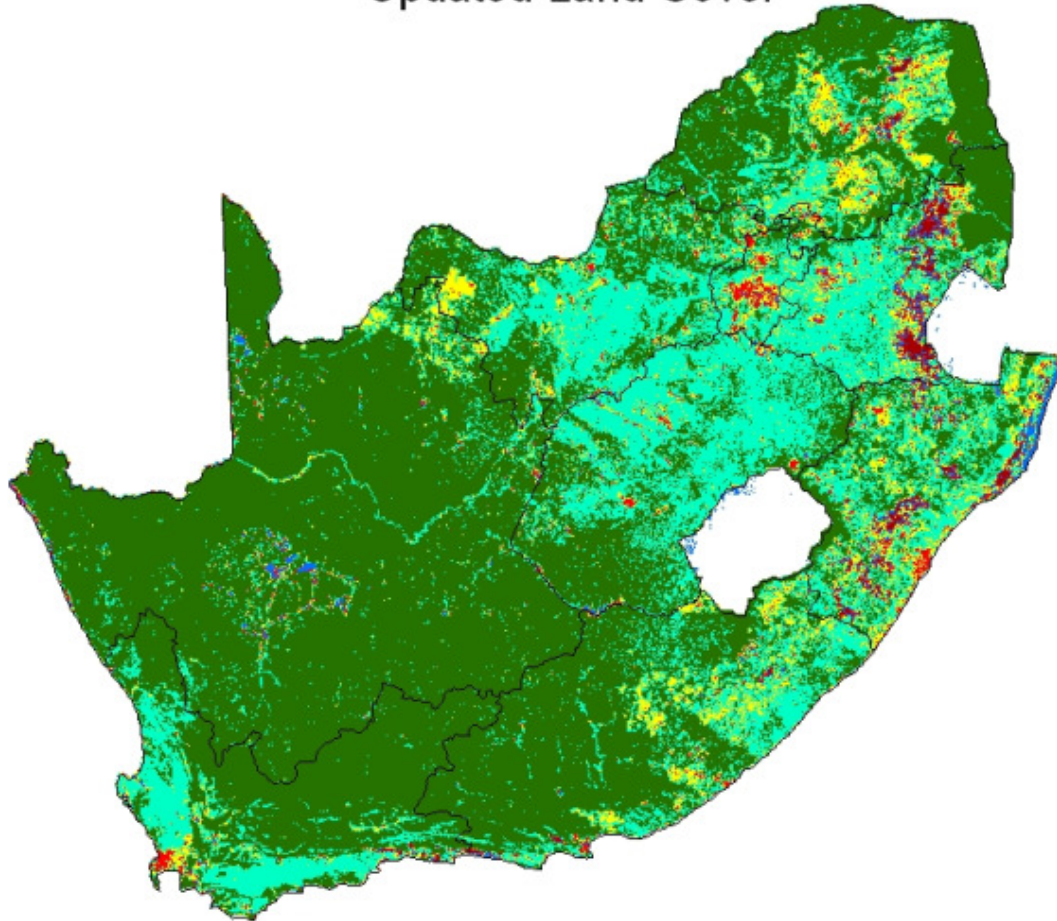


Figure A1: Graphical overview of updating the national land cover information

Updated Land Cover



Map A1: Updated national land cover map.