

1990 to 2013/14

REPORT

# South African National Land-cover Change

SEPTEMBER 2015



**environmental affairs**

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**energy**

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Energy  
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**sonedi**  
South African National Energy  
Development Institute



## Strategic Climate Policy Fund

### Sustainability of Decentralised Renewable Energy Systems

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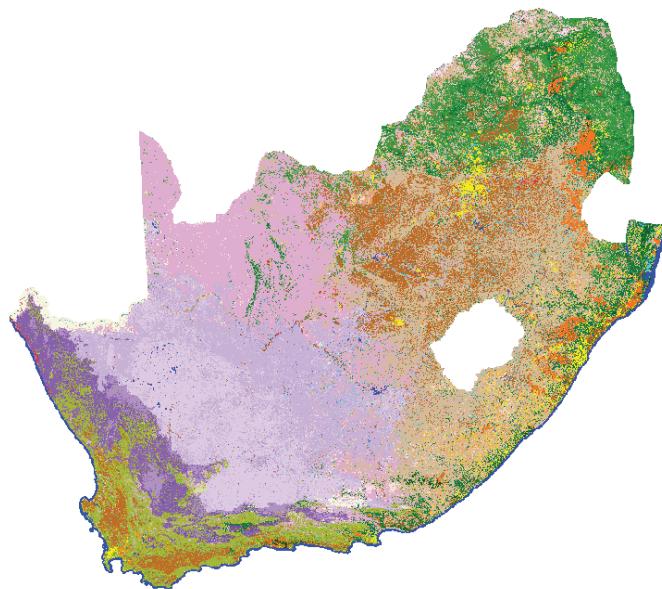


SOUTH  
SOUTH  
NORTH



# 1990 to 2013/14 South African National Land-cover Change

DEA/CARDNO SCPF002:  
Implementation of Land-use Maps for South Africa



DATA PRODUCT CREATED BY  
**GEOTERRAIMAGE (South Africa)**

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**PLEASE NOTE:**

This report provides information on the land-cover change statistics derived from a comparison of the specific versions of the 1990 and 2013/14 GTI South African National Land-cover Dataset supplied to the South African Department of Environmental Affairs under the DEA/CARDNO Project: SCPF002: Implementation of Land-use Maps for South Africa. These datasets represent information subsets of the full 1990 and 2013/14 GTI South African National Land-cover Datasets, in terms of supplied land-cover/land-use categories and associated class legend.

# 1. BACKGROUND

An assessment of land-cover change has been undertaken using the 1990 and 2013/14 South African National Land-cover Datasets. Both of these datasets have been generated from comparable historical and current Landsat satellite imagery, using the same model-based mapping techniques.

The two source datasets are therefore, as far as possible, directly comparable in terms of land-cover content, spatial detail and associated mapping accuracies. The production of both of these national land-cover datasets is fully documented in separate reports pertaining to each land-cover dataset. It is assumed that a user of the statistical land-cover change data is fully aware and appreciative of the information contained in these land-cover data generation reports.

In preparation for the land-cover change assessment, the original 35-class national land-cover datasets were reformed into the DEA-requested, simplified 17-class legend format to be used for land-cover change reporting.

Table 1 and Table 2 illustrate the class and code conversions that were used to collapse the 35-class legend into a 17-class legend.

dea_cardno_2014_sa_lcov_utm35n_vs2b.img							
Row	Color	Class_Names	Color2	Class_Names2	Area	Histogram	Opacity
0					0	0	0
1	Indigenous Forest		Indigenous Forest		395720	4396888	1
2	Thicket /Dense bush		Thicket /Dense bush		7.09698e+006	78855335	1
3	Woodlan/Open bush		Woodlan/Open bush		1.09087e+007	121207366	1
4	Low shrubland		Low shrubland		1.80007e+007	200008268	1
5	Plantations / Woodlots		Plantations / Woodlots		1.8737e+006	20818902	1
6	Cultivated commercial annual crops non-pivot		Cultivated commercial annual crops non-pivot		782049	8689435	1
7	Cultivated commercial annual crops pivot		Cultivated commercial annual crops pivot		1.06108e+007	117898196	1
8	Cultivated commercial permanent orchards		Cultivated commercial permanent orchards		346950	3855005	1
9	Cultivated commercial permanent vines		Cultivated commercial permanent vines		188711	2096791	1
10	Cultivated subsistence crops		Cultivated subsistence crops		2.04053e+006	22672521	1
11	Settlements		Settlements		2.90828e+006	32314218	1
12	Wetlands		Wetlands		1.0259e+006	11398887	1
13	Grasslands		Grasslands		2.37573e+007	263970479	1
14	Fynbos: forest		Indigenous Forest		32724	363600	1
15	Fynbos: thicket		Thicket /Dense bush		691164	7679603	1
16	Fynbos: open bush		Woodlan/Open bush		307674	3418605	1
17	Fynbos: low shrub		Low shrubland		5.32864e+006	59207100	1
18	Fynbos: grassland		Grasslands		381413	4237918	1
19	Fynbos: bare ground		Bare Ground		210113	2334586	1
20	Nama Karoo: forest		Indigenous Forest		0	0	1
21	Nama Karoo: thicket		Thicket /Dense bush		328724	3652485	1
22	Nama Karoo: open bush		Woodlan/Open bush		540805	6008941	1
23	Nama Karoo: low shrub		Low shrubland		1.40578e+007	156197442	1
24	Nama Karoo: grassland		Grasslands		1.31982e+006	14664675	1
25	Nama Karoo: bare ground		Bare Ground		9.38285e+006	104253894	1
26	Succulent Karoo: forest		Indigenous Forest		0	0	1
27	Succulent Karoo: thicket		Thicket /Dense bush		174801	1942236	1
28	Succulent Karoo: open bush		Woodlan/Open bush		677790	7530997	1
29	Succulent Karoo: low shrub		Low shrubland		4.44011e+006	49334527	1
30	Succulent Karoo: grassland		Grasslands		335397	3726633	1
31	Succulent Karoo: bare ground		Bare Ground		1.97062e+006	21895741	1
32	Mines		Mines		328973	3655254	1
33	Waterbodies		Waterbodies		2.04562e+006	22729092	1
34	Bare Ground		Bare Ground		1.49435e+006	16603927	1
35	Degraded		Degraded		944061	10489566	1

35 x Class Full DEA / CARDNO Legend	Simplified 17 x Class DEA / CARDNO legend	
Indigenous forests	Indigenous forests	1
Forest: Fynbos		
Thicket/dense bush		
Thicket: Fynbos	Thicket/dense bush	2
Thicket: Nama-Karoo		
Thicket: Succulent Karoo		
Woodland/open bush		
Open bush: Fynbos	Woodland/open bush	3
Open bush: Nama-Karoo		
Open bush: Succulent Karoo		
Low shrubland		
Low shrubland: Fynbos	Low shrubland	4
Low shrubland: Nama-Karoo		
Low shrubland: Succulent Karoo		
Plantations/woodlots	Plantations/woodlots	5
Cultivated commercial annual: non-pivot	Cultivated commercial annual: non-pivot	6
Cultivated commercial annual: pivot	Cultivated commercial annual: pivot	7
Cultivated commercial permanent orchards	Cultivated commercial permanent orchards	8
Cultivated commercial permanent vines	Cultivated commercial permanent vines	9
Cultivated subsistence crops	Cultivated subsistence crops	10
Settlements	Settlements	11
Wetlands	Wetlands	12
Grasslands		
Grasslands: Fynbos	Grasslands	13
Grasslands: Nama-Karoo		
Grasslands: Succulent Karoo		
Mines	Mines	14
Waterbodies	Waterbodies	15
Bare ground		
Bare ground: Fynbos	Bare ground	16
Bare ground: Nama-Karoo		
Bare ground: Succulent Karoo		
Degraded	Degraded	17

## 2. COMMENTS ON 1990 TO 2014 SOUTH AFRICAN LAND-COVER CHANGE ASSESSMENT

There are three basic factors that may have influenced land-cover change results and associated statistics, namely land-cover mapping accuracies, seasonal/climatic conditions under which the original source imagery was acquired, and the level of (landscape) detail that is being compared over time.

### 2.1 Influence of mapping accuracies on land-cover change

Mapping accuracies have been calculated for the 2013/14 land-cover dataset and are reported in the 2013-14 Data User's Report. The results of the 2013/14 map accuracy assessment are assumed to be representative of the 1990 accuracies, since comparable image data and modelling/mapping techniques were used for both datasets. No independent map accuracy assessment was undertaken for the 1990 dataset due to the unavailability of suitable reference data. The reliability of (land-cover) change statistics are greatly influenced by the accuracy of the input data against which change is determined. In simplistic terms, the sum of the known mapping error associated with a particular land-cover class over two time periods can indicate the level of "statistical change" that is, in fact, a result of compounded mapping errors over time, and not actual land-cover change. For this reason, all statistical (land-cover) change values must be interpreted and evaluated in the context of the reported land-cover class mapping accuracy, especially the user (as opposed to the producer) accuracy. Class-specific mapping accuracies are included in the land-cover change results reported below and in the accompanying spreadsheet.

### 2.2 Influence of seasonal/climatic differences on land-cover change

It is important to understand the influence that seasonal and possible climatic differences between 1990 and 2013/14 may have had on the generation of each land-cover dataset in terms of landscape characteristics, and the possible effect of such differences on the change assessment results and associated spatial statistics.

The seasonal representation and range of monthly acquisition dates is generally better for the 1990 land-cover dataset than for the 2013/14 dataset, despite the same average number of acquisition dates per frame for the two datasets. This is because the 2013/14 dataset was limited to what cloud-free imagery was recorded between April 2013 and the designated March 2014 cut-off date, whereas the 1990 dataset had access to a wider range of imagery from 1989 to 1993. This greater seasonal representation may have influenced the modelling results in terms of the distribution and extent of some of the natural vegetation classes (excluding indigenous forests), since a better seasonal profile was often possible in 1990 compared to 2014 in some image frame locations.

The 1990 period appears to have been generally wetter than the 2013/14 period in most regions, as observed qualitatively through the increase in observable surface water features in 1990. This is especially evident in the pans across the central regions of the Free State and Northern Cape, where many pans are water-filled in 1990 and dry in 2013-14<sup>1</sup>. These differences will reflect as changes between the two assessment periods, but do not necessarily represent a permanent loss of water bodies over the approximately 24-year period, but rather a seasonal (or climate)-induced difference. This fact needs to be noted during modelling and the interpretation of the land-cover change results and associated statistics.

The wetter conditions that were prevalent in the 1990 dataset have allowed the wetland modelling to be extended across the full national coverage, unlike the

<sup>1</sup> This difference in observable surface water extents does not infer that the 1990 or the 2013/14 period was wetter or drier than normal long-term trends, just that, in many geographic locations, there appears to have been more rainfall in 1990 than in 2013/14 during the image-acquisition periods under analysis.

drier 2013/14 image data, which restricted wetland modelling to the wetter eastern and southern regions. These differences will reflect as statistical and spatial changes between the two assessment periods. They do not necessarily represent a permanent loss of wetlands over the approximately 24-year period, but rather indicate a seasonal (or climate)-induced difference that could be temporary. This fact needs to be noted during the modelling and interpretation of land-cover change results.

The apparent wetter conditions prevalent in the 1990 dataset may also have influenced the boundary between low-shrub (i.e. Karoo type) and Highveld grassland vegetation, since the 1990 grassland/low shrub transition in the western Free State region appears to have shifted generally to the west compared to 2013/14, which may be a result of a greater grass component being present in the Karoo/grass transition zone in 1990.

The (Highveld, montane and coastal) grassland correction procedures applied to the 1990 dataset are considered to be slightly more accurate than

those applied to the 2013/14 data, as a result of both modified procedures used and better image seasonal representation in 1990. It is therefore potentially possible that some of the “grassland” to “open woody vegetation” changes in these regions may be a result of the improved grassland delineation in 1990 and not actual bush cover increases in 2013/14.

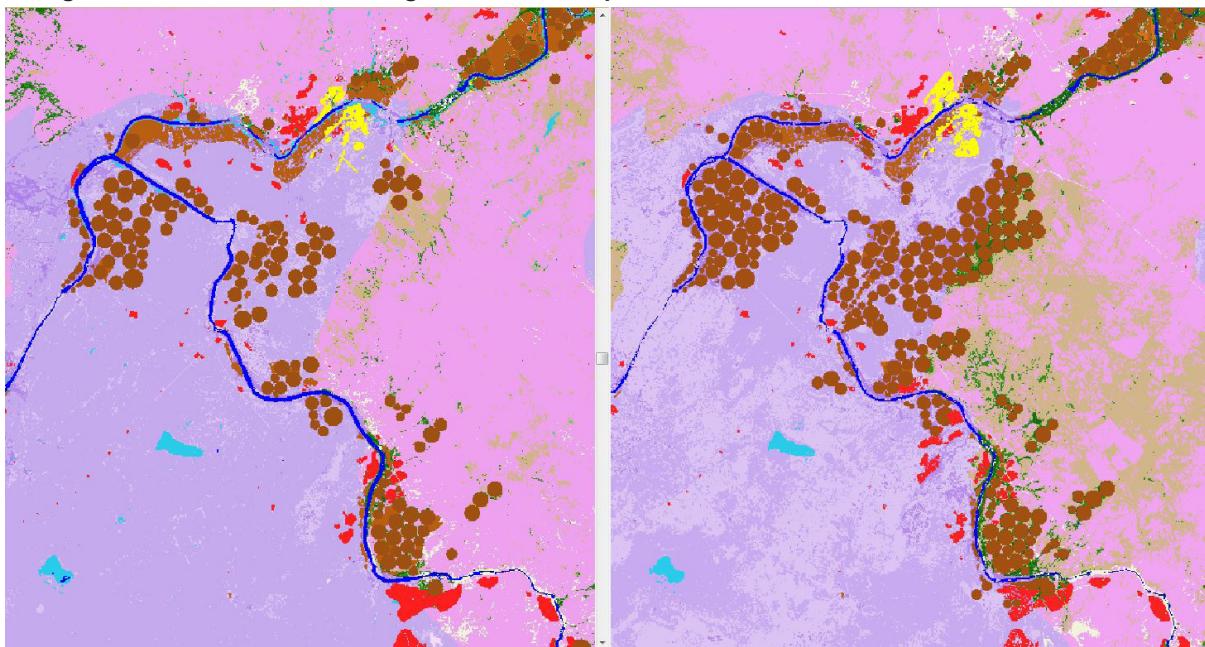
## 2.3 Influence of mapping detail on land-cover change

The ability to determine change is obviously dependent on the level of detail that is being observed and compared. For example, changes in the extent of urban areas between 1990 and 2013/14 may not be as locally significant as may be expected, since the total built-up footprint defined in the “settlements” class in both the 1990 and 2013/14 datasets includes peripheral smallholding areas around the main built-up areas, and these tend to be the first land use that is converted to formal urban areas before further expansion into natural and cultivated lands.

## 3. QUALITATIVE EXAMPLES OF LAND-COVER CHANGE 1990 TO 2013/14

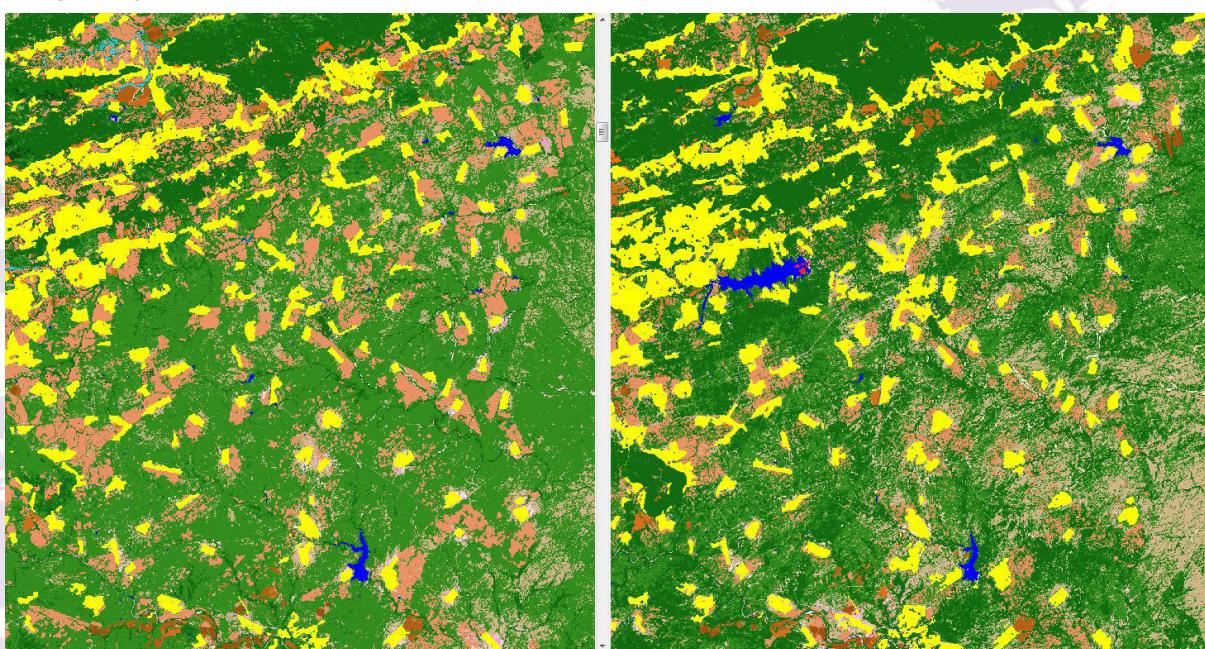
The following screen shots provide visual examples of the type of land-cover changes that have been observed and mapped over the approximately 24-year period between 1990 and 2013/14, based on the Landsat-derived land-cover datasets. The 1990 land cover is on the left and the 2013/14 land cover is on the right in all examples.

**Orange/Vaal River confluence, Douglas, Northern Cape**

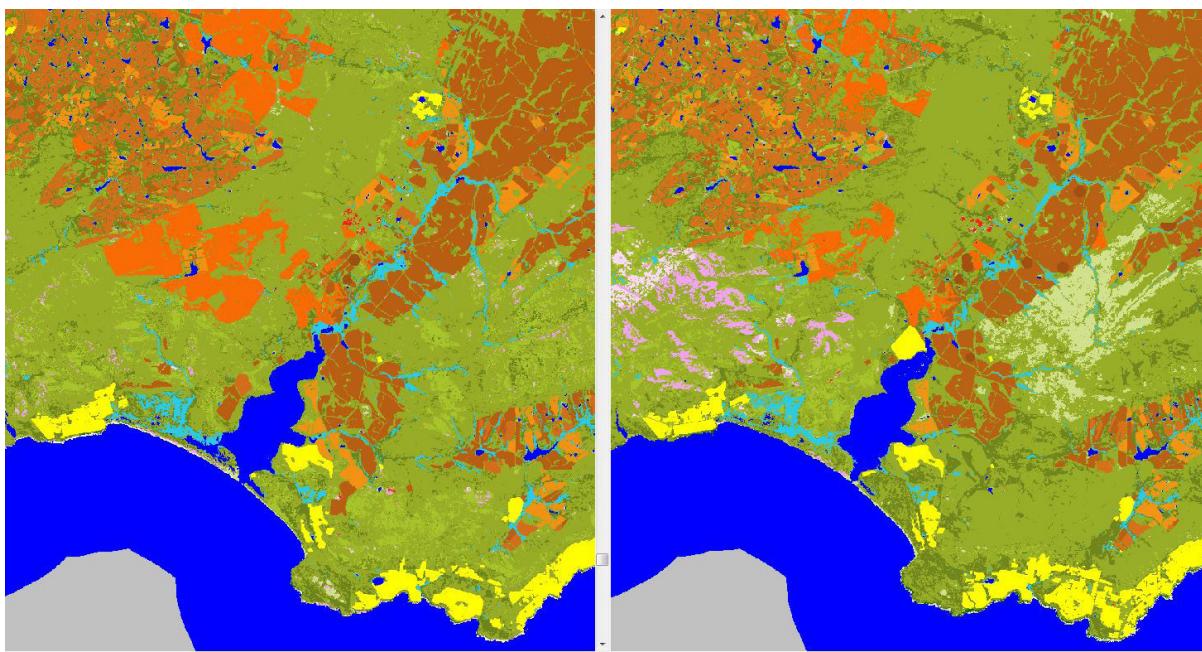


Note the significant increase in centre pivot-irrigation fields in 2013/14 compared to 1990.

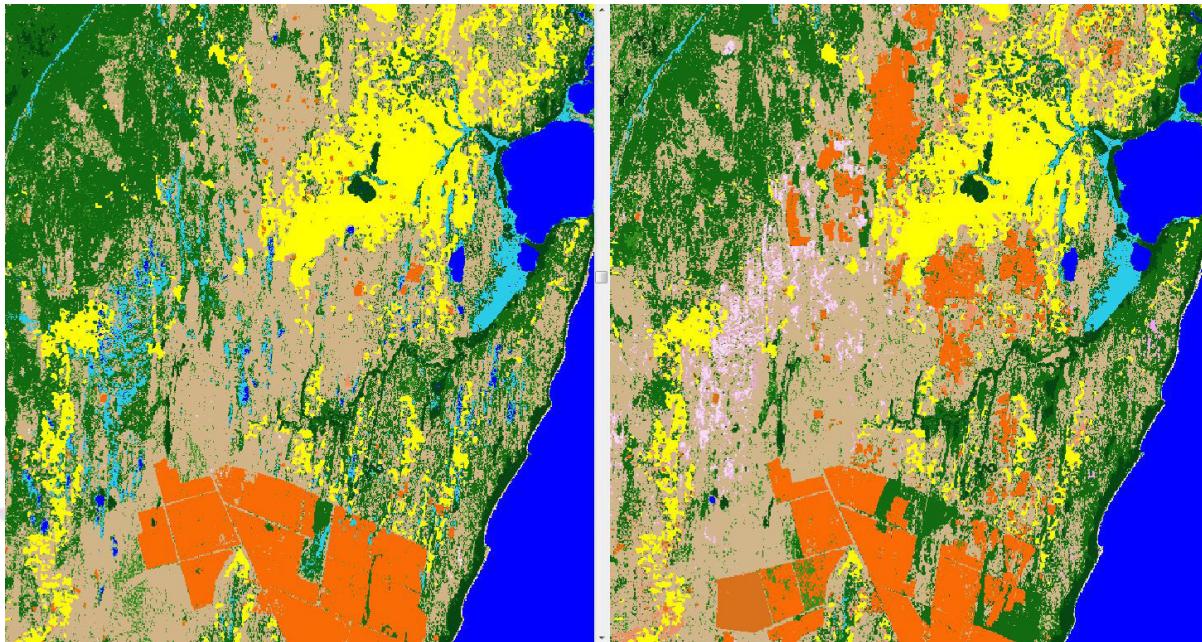
**Villages, Giyani, Limpopo**



Note the bush-clearing effects around the villages in 2013/14 compared to 1990, and a new dam in 2013/14.

**Kleinmond, Western Cape**

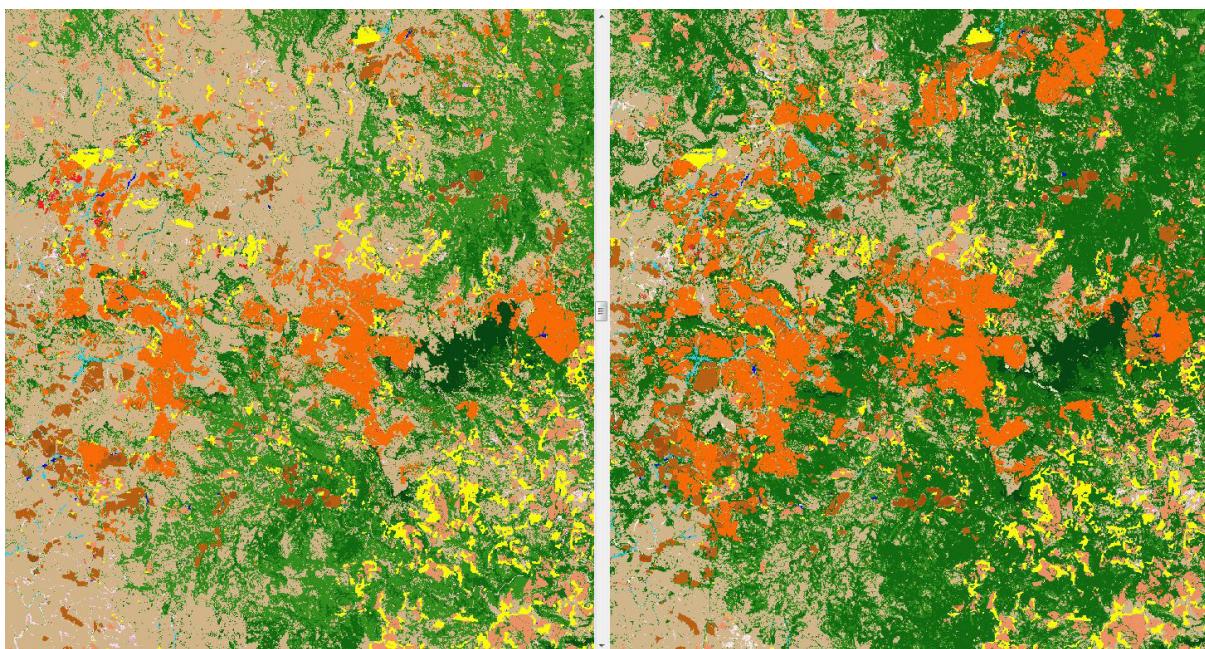
Note the new settlements and reduction in plantations (orange) in 2013/14 compared to 1990. The light green and pink areas in 2013/14 are low-vegetation areas, likely the result of mountain fire scars that were not evident in 1990.

**Kosi Bay, KwaZulu-Natal**

Note the increase in plantation forestry (orange) in 2013/14 and the greater extent of wetlands (light blue) in 1990 as a result of the (generally) wetter conditions.

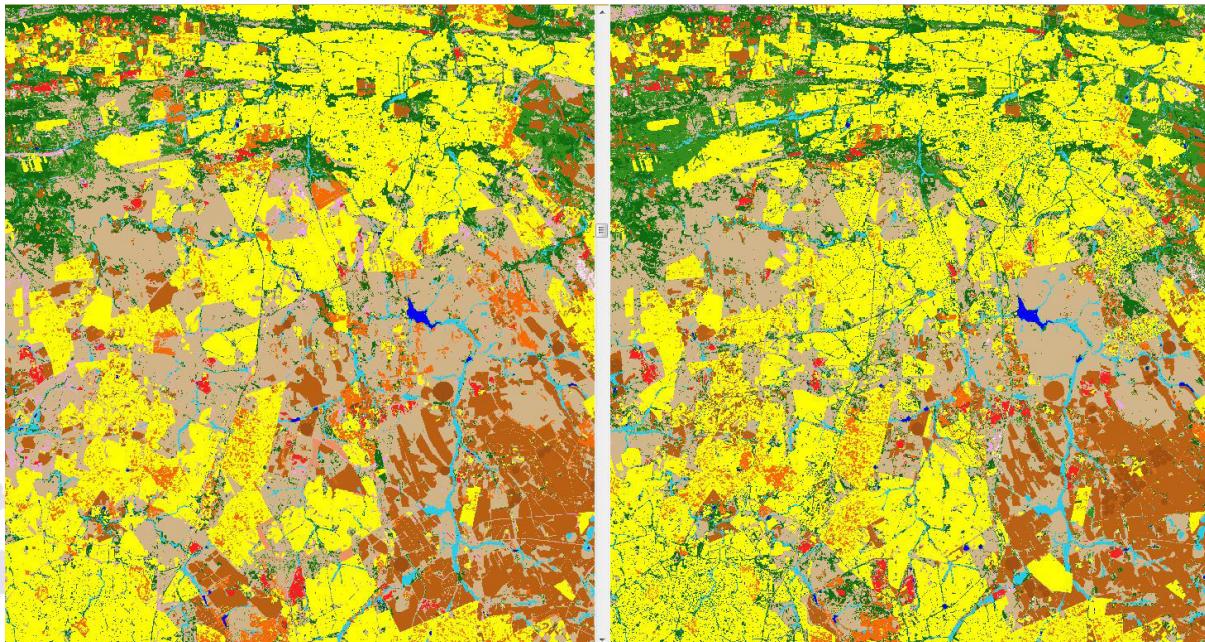
# South African National Land-cover Dataset 1990 to 2013/14

KwaZulu-Natal Midlands, KwaZulu-Natal

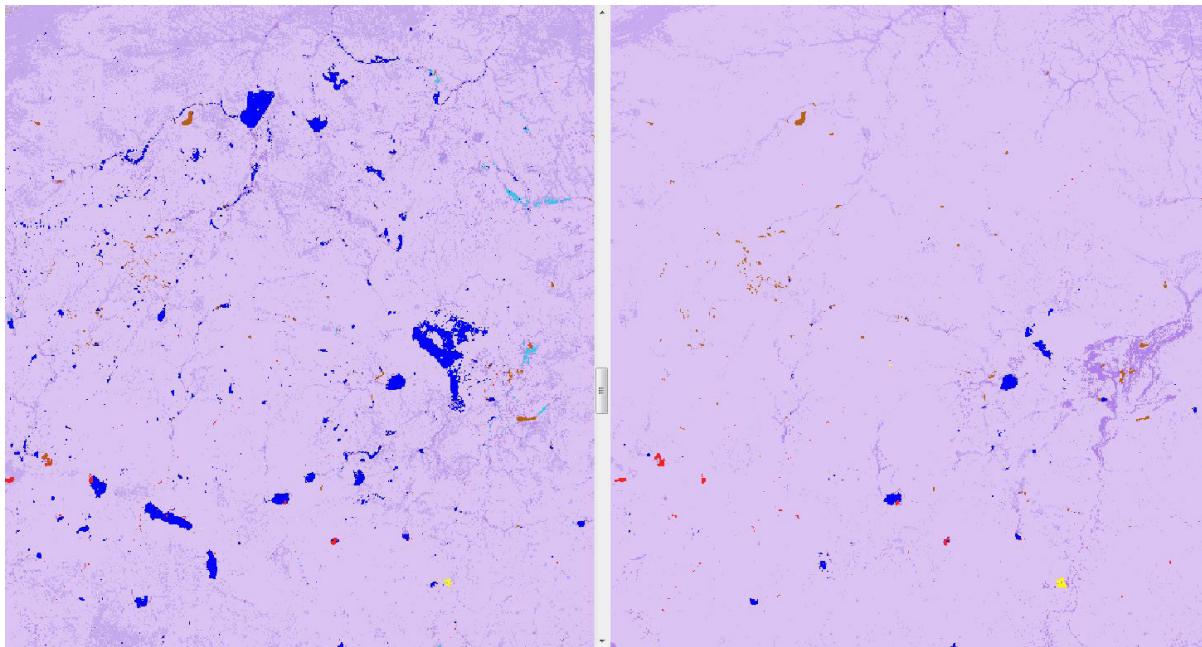


Note the increase in plantation forestry (orange) in 2013/14.

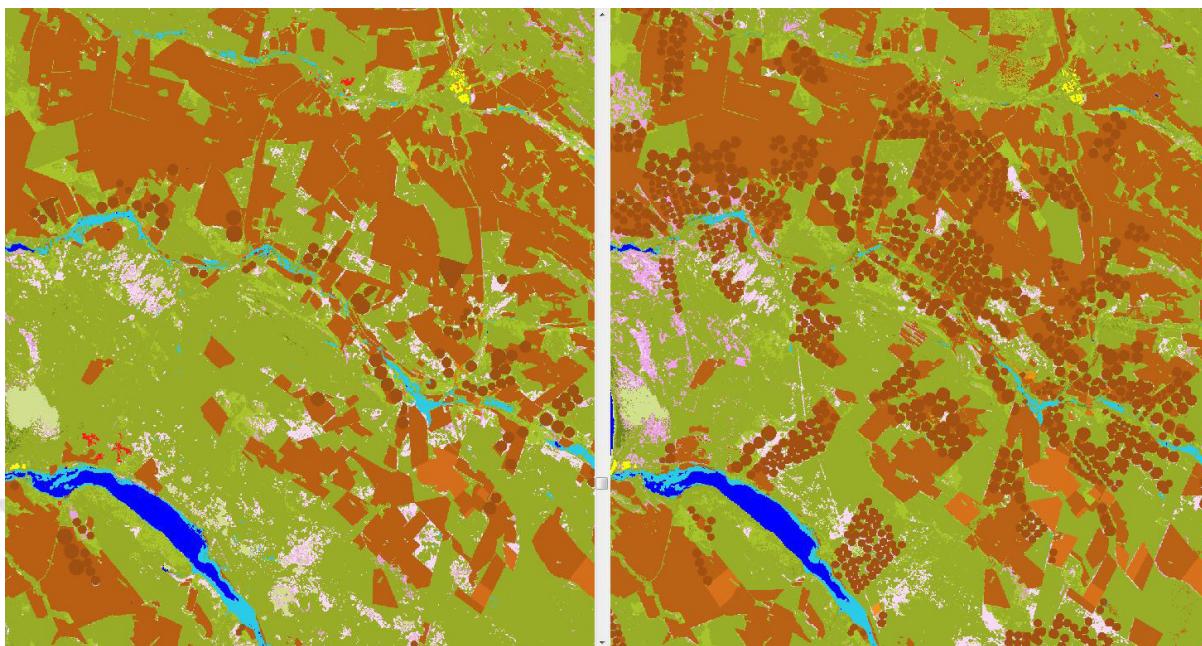
Midrand, Gauteng



Note the significant expansion of settlements (yellow) in 2013/14 compared to 1990. Note that the settlement class includes smallholdings, so in this area, the expansion of settlements has gone into other land-cover classes as well, such as natural grasslands.

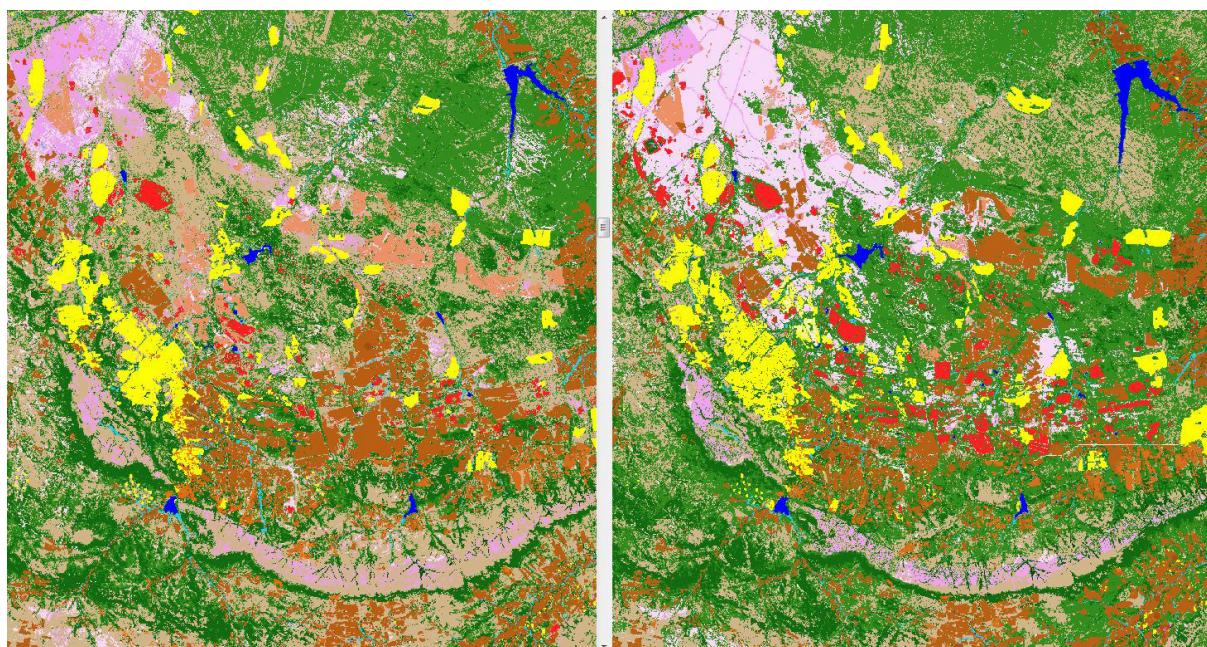
**Pan (wetlands), Northern Cape**

Note the significantly greater extent and number of water features evident in the pans in 1990 as result of the apparent wetter conditions compared to 2013/14.

**Olfants River, Western Cape**

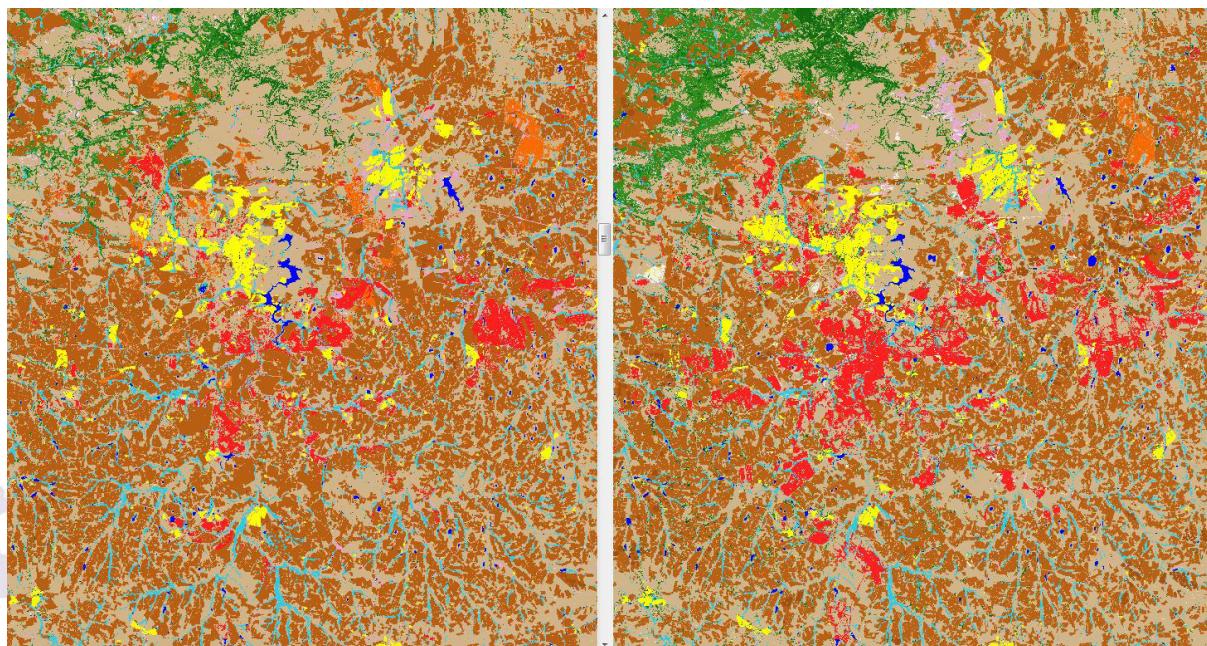
Note the significant increase in centre pivot-irrigation fields in 2013/14 compared to 1990.

## Rustenburg, North West



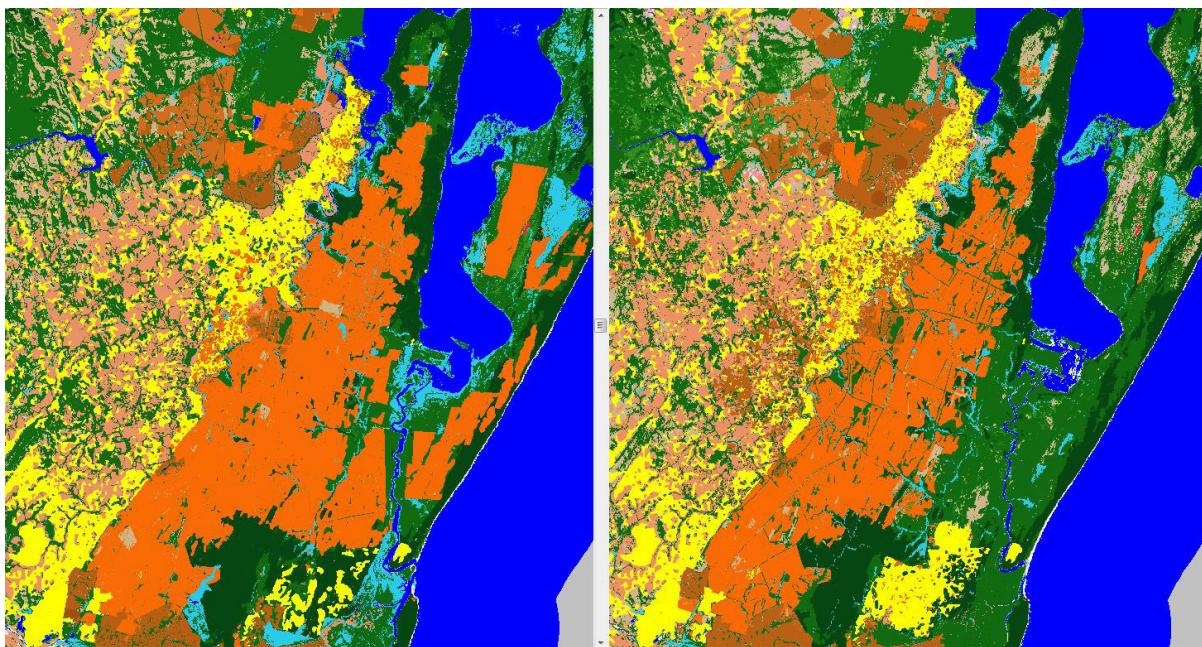
Note the significant increase in mining activity (red) in 2013/14 compared to 1990.

## Witbank/eMalahleni, Mpumalanga



Note the significant increase in mining activity (red) in 2013/14 compared to 1990, and the urban expansion.

### St. Lucia, KwaZulu-Natal



Note the reduction of plantations (orange) on the eastern shores of St Lucia in 2013/14 and the significant settlement expansion (yellow) and loss of indigenous forest (dark green) in Dukuduku Forest in 2013/14, in the southern central section. The apparent wetter conditions in 1990 have resulted in more observable wetlands (light blue) compared to 2013/14.

## 4. QUANTITATIVE ASSESSMENT OF LAND-COVER CHANGE 1990 TO 2013/14

A quantitative assessment of land-cover change between 1990 and 2013/14 has been completed, with the results presented below in respect of both change reported in terms of the original 30 m-resolution raster cell format, and also in terms of a spatially resampled 90 x 90 cell format.

The resampled 90 m cell format data was created by a spatial aggregation process that determined the majority land-cover from a window of 3 x 3 original 30 m cells and returned this to a new, single 90 m raster cell representing the equivalent spatial area. Comparison of (national) change statistics derived from both the original 30 m-resolution raster cell data and the resampled 90 m-resolution cell data would provide an indication of whether or not a significant level of variation was introduced into the change results from pixel-level mapping anomalies compared to the local majority land-cover characteristics.

### 4.1 National-level land-cover change results

The tables below show the results of comparing the 1990 land-cover data to the 2013/14 land cover on a national basis, based on both the original 30 m raster format data and the spatially resampled 90 m raster cell format data, which represents the majority land-cover class in an area of approximately 1 ha. Users are again reminded to interpret all statistical (land-cover) change values in the context of the reported land-cover class mapping accuracy (especially user accuracy), and the overall number of mapped image pixels. Class-specific mapping accuracies are included in the land-cover change results reported below and in the accompanying spreadsheet.

# South African National Land-cover Dataset 1990 to 2013/14

Table 3: National change statistics 1990 to 2013/14, based on original 30 m raster data

National	change based on the 30m pixels		(change based on standardised areas)						Class mapping accuracy (2013)	
	1990 Land Cover		2014 Land Cover		Change from 1990 to 2014					
	Pixels	Hectares	Pixels	Hectares	Pixels	Hectares				
Indigenous Forest	4185008	376650.72	4760488	428443.92	575480	51793.20	13.75	72.6 / 94.64		
Thicket /Dense bush	73844264	6645983.76	92129659	8291669.31	18285395	1645685.55	24.76	53.74 / 83.64		
Woodlan/Open bush	122308776	11007789.84	138165909	12434931.81	15857133	1427141.97	12.96	60.84 / 54.13		
Low shrubland	457109576	41139861.84	464747337	41827260.33	7637761	687398.49	1.67	70.59 / 61.82		
Plantations / Woodlots	21364651	1922818.59	20818902	1873701.18	-545749	-49117.41	-2.55	89.3 / 94.35		
Cultivated commercial annual crops non-pivot	127628703	11486583.27	117898196	10610837.64	-9730507	-875745.63	-7.62	91.91 / 99.54		
Cultivated commercial annual crops pivot	2714095	244268.55	8689435	782049.15	5975340	537780.60	220.16	95.38 / 92.42		
Cultivated commercial permanent orchards	3484129	313571.61	3855005	346950.45	370876	33378.84	10.64	92.18 / 95.29		
Cultivated commercial permanent vines	1803936	162354.24	2096791	188711.19	292855	26356.95	16.23	91.61 / 97.26		
Cultivated subsistence crops	22047815	1984303.35	22672521	2040526.89	624706	56223.54	2.83	89.00 / 94.00		
Settlements (incl smallholdings)	30476891	2742920.19	32314218	2908279.62	1837327	165359.43	6.03	93.90 / 98.68		
Wetlands	16957092	1526138.28	11398887	1025899.83	-5558205	-500238.45	-32.78	88.07 / 91.18		
Grasslands	305455194	27490967.46	286599705	25793973.45	-18855489	-1696994.01	-6.17	84.56 / 69.82		
Mines	3241741	291756.69	3655254	328972.86	413513	37216.17	12.76	92.82 / 98.10		
Waterbodies	24467125	2202041.25	22729092	2045618.28	-1738033	-156422.97	-7.10	79.64 / 93.31		
Bare Ground	154471675	13902450.75	145088148	13057933.32	-9383527	-844517.43	-6.07	98.77 / 97.58		
Degraded	16548442	1489359.78	10489566	944060.94	-6058876	-545298.84	-36.61	78.69 / 85.95		
<b>totals</b>	<b>1388109113</b>	<b>124929820</b>	<b>1388109113</b>	<b>124929820</b>				<i>User / Producer class accuracies</i>		

Table 4: National change statistics 1990 to 2013/14, based on resampled 90 m raster data

National	change based on the resampled 90m pixels (ha majority equivalent)		(change based on standardised areas)						Class mapping accuracy (2013)	
	1990 Land Cover		2014 Land Cover		Change from 1990 to 2014					
	Pixels	Hectares	Pixels	Hectares	Pixels	Hectares				
Indigenous Forest	4319408	3498720.48	4760488	385995.28	441080	357274.80	10.21	72.6 / 94.64		
Thicket /Dense bush	73624120	59635537.20	92129659	74625023.79	18505539	14989486.59	25.14	53.74 / 83.64		
Woodlan/Open bush	119332961	96659698.41	138165909	111914386.29	18832948	15254687.88	15.78	60.84 / 54.13		
Low shrubland	464138942	375952543.02	464747337	376445342.97	608395	492799.95	0.13	70.59 / 61.82		
Plantations / Woodlots	21680621	17561303.01	20818902	16863310.62	-861719	-697992.39	-3.97	89.3 / 94.35		
Cultivated commercial annual crops non-pivot	132002937	106922378.97	117898196	95497538.76	-14104741	-11424840.21	-10.69	91.91 / 99.54		
Cultivated commercial annual crops pivot	2763000	2238030.00	8689435	7038442.35	5926435	4800412.35	214.49	95.38 / 92.42		
Cultivated commercial permanent orchards	3626973	2937848.13	3855005	3122554.05	228032	184705.92	6.29	92.18 / 95.29		
Cultivated commercial permanent vines	1911159	1548038.79	2096791	1698400.71	185632	150361.92	9.71	91.61 / 97.26		
Cultivated subsistence crops	22763294	18438268.14	22672521	18364742.01	-90773	-73526.13	-0.40	89.00 / 94.00		
Settlements	31096545	25188201.45	32314218	26174516.58	1217673	986315.13	3.92	93.90 / 98.68		
Wetlands	15706154	12721984.74	11398887	9233098.47	-4307267	-348886.27	-27.42	88.07 / 91.18		
Grasslands	298885099	242096930.19	286599705	232145761.05	-12285394	-9951169.14	-4.11	84.56 / 69.82		
Mines	3193829	2587001.49	3655254	2960755.74	461425	373754.25	14.45	92.82 / 98.10		
Waterbodies	24456512	19809774.72	22729092	18410564.52	-1727420	-1399210.20	-7.06	79.64 / 93.31		
Bare Ground	154114261	124832551.41	145088148	117521399.88	-9026113	-7311151.53	-5.86	98.77 / 97.58		
Degraded	14341471	11616591.51	10489566	8496548.46	-3851905	-3120043.05	-26.86	78.69 / 85.95		
<b>totals</b>	<b>1387957286</b>	<b>1124245402</b>	<b>1388109113</b>	<b>1124368382</b>				<i>User / Producer class accuracies</i>		

The percentage change results for all classes show very similar values in both the original 30 m and resampled 90 m datasets, which indicates that the comparison of the original 30 m datasets is not introducing any significant difference as a result of single-pixel anomalies. The 2013/14 land-cover mapping accuracies have been included in the tables to allow the change results to be assessed in terms of the class-mapping accuracies achieved, and the influence that this may have had on the reported class changes.

## 4.2 Provincial-level land-cover change results

The change statistics for each province are shown below. These have been generated from the original 30 m-resolution format data, and show regional trends in land-cover/land-use change over the approximately 24-year period between 1990 and 2013/14. The 2013/14 land-cover mapping accuracies have been included in tables 5 to 13 below to allow the provincial change results to be assessed in terms of the associated class-mapping accuracies.

<b>Limpopo Province change based on the 30m pixels</b>		(change based on standardised areas)							
		<b>1990 Land Cover</b>		<b>2014 Land Cover</b>		<b>Change from 1990 to 2014</b>			<b>Class mapping accuracy (2013)</b>
		Pixels	Hectares	Pixels	Hectares	Pixels	Hectares	%	
Indigenous Forest		439022	39511.98	512695	46142.55	73673	6630.57	16.78	72.6 / 94.64
Thicket /Dense bush		18813387	1693204.83	19466135	1751952.15	652748	58747.32	3.47	53.74 / 83.64
Woodlan/Open bush		59679073	537116.57	69245654	6232108.86	9566581	860992.29	16.03	60.84 / 54.13
Low shrubland		3289562	296060.58	2712468	244122.12	-577094	-51938.46	-17.54	70.59 / 61.82
Plantations / Woodlots		1141021	102691.89	867962	78116.58	-273059	-24575.31	-23.93	89.3 / 94.35
Cultivated commercial annual crops non-pivot		7921472	712932.48	6317003	568530.27	-1604469	-144402.21	-20.25	91.91 / 99.54
Cultivated commercial annual crops pivot		870662	78359.58	1862126	167591.34	991464	89231.76	113.87	95.38 / 92.42
Cultivated commercial permanent orchards		865438	77889.42	1213977	109257.93	348539	31368.51	40.27	92.18 / 95.29
Cultivated commercial permanent vines		0	0.00	0	0.00	0	0.00	0.00	91.61 / 97.26
Cultivated subsistence crops		5179200	466128.00	4488068	403926.12	-691132	-62201.88	-13.34	89.00 / 94.00
Settlements (incl smallholdings)		3932762	353948.58	5066036	455943.24	1133274	101994.66	28.82	93.90 / 98.68
Wetlands		890913	80182.17	525103	47259.27	-365810	-32922.90	-41.06	88.07 / 91.18
Grasslands		30503379	2745304.11	21863009	1967670.81	-8640370	-777633.30	-28.33	84.56 / 69.82
Mines		316164	28454.76	312494	28124.46	-3670	-330.30	-1.16	92.82 / 98.10
Waterbodies		176402	15876.18	221105	19899.45	44703	4023.27	25.34	79.64 / 93.31
Bare Ground		107769	9699.21	792185	71296.65	684416	61597.44	635.08	98.77 / 97.58
Degraded		5766293	518966.37	4426499	398384.91	-1339794	-120581.46	-23.23	78.69 / 85.95
<b>totals</b>		<b>139892519</b>	<b>12590327</b>	<b>139892519</b>	<b>12590327</b>				<i>User / Producer class accuracies</i>

<b>Mpumalanga Province change based on the 30m pixels</b>		(change based on standardised areas)							
		<b>1990 Land Cover</b>		<b>2014 Land Cover</b>		<b>Change from 1990 to 2014</b>			<b>Class mapping accuracy (2013)</b>
		Pixels	Hectares	Pixels	Hectares	Pixels	Hectares	%	
Indigenous Forest		258220	23239.80	346439	31179.51	88219	7939.71	34.16	72.6 / 94.64
Thicket /Dense bush		7046448	634180.32	9615408	865386.72	2568960	231206.40	36.46	53.74 / 83.64
Woodlan/Open bush		15095444	1358589.96	14380996	1294289.64	-714448	-64300.32	-4.73	60.84 / 54.13
Low shrubland		856885	77119.65	416834	37515.06	-440051	-39604.59	-51.35	70.59 / 61.82
Plantations / Woodlots		8261786	743560.74	8358195	752237.55	96409	8676.81	1.17	89.3 / 94.35
Cultivated commercial annual crops non-pivot		14511612	1306045.08	12676152	1140853.68	-1835460	-165191.40	-12.65	91.91 / 99.54
Cultivated commercial annual crops pivot		176799	15911.91	640740	57666.60	463941	41754.69	262.41	95.38 / 92.42
Cultivated commercial permanent orchards		352775	31749.75	477595	42983.55	124820	11233.80	35.38	92.18 / 95.29
Cultivated commercial permanent vines		0	0.00	0	0.00	0	0.00	0.00	91.61 / 97.26
Cultivated subsistence crops		1020965	91886.85	742550	66829.50	-278415	-25057.35	-27.27	89.00 / 94.00
Settlements (incl smallholdings)		1987731	178895.79	2382966	214466.94	395235	35571.15	19.88	93.90 / 98.68
Wetlands		2641304	237717.36	2270547	204349.23	-370757	-33368.13	-14.04	88.07 / 91.18
Grasslands		31813622	2863225.98	31198853	2807896.77	-614769	-55329.21	-1.93	84.56 / 69.82
Mines		516604	46494.36	861892	77570.28	345288	31075.92	66.84	92.82 / 98.10
Waterbodies		456789	41111.01	508625	45776.25	51836	4665.24	11.35	79.64 / 93.31
Bare Ground		81686	7351.74	273093	24578.37	191407	17226.63	234.32	98.77 / 97.58
Degraded		136047	12244.23	63832	5744.88	-72215	-6499.35	-53.08	78.69 / 85.95
<b>totals</b>		<b>85214717</b>	<b>7669325</b>	<b>85214717</b>	<b>7669325</b>				<i>User / Producer class accuracies</i>

<b>Gauteng Province change based on the 30m pixels</b>		(change based on standardised areas)							
		<b>1990 Land Cover</b>		<b>2014 Land Cover</b>		<b>Change from 1990 to 2014</b>			<b>Class mapping accuracy (2013)</b>
		Pixels	Hectares	Pixels	Hectares	Pixels	Hectares	%	
Indigenous Forest		2	0.18	29	2.61	27	2.43	1350.00	72.6 / 94.64
Thicket /Dense bush		1064404	95796.36	1171881	105469.29	107477	9672.93	10.10	53.74 / 83.64
Woodland/Open bush		1811216	163009.44	2159919	194392.71	348703	31383.27	19.25	60.84 / 54.13
Low shrubland		232843	20955.87	88873	7998.57	-143970	-12957.30	-61.83	70.59 / 61.82
Plantations / Woodlots		472403	42516.27	296695	26702.55	-175708	-15813.72	-37.19	89.3 / 94.35
Cultivated commercial annual crops non-pivot		3897750	350797.50	3697032	332732.88	-200718	-18064.62	-5.15	91.91 / 99.54
Cultivated commercial annual crops pivot		68352	6151.68	223211	20088.99	154859	139731.31	226.56	95.38 / 92.42
Cultivated commercial permanent orchards		11483	1033.47	18527	1667.43	7044	633.96	61.34	92.18 / 95.29
Cultivated commercial permanent vines		0	0.00	0	0.00	0	0.00	0.00	91.61 / 97.26
Cultivated subsistence crops		30416	2737.44	13285	1195.65	-17131	-1541.79	-56.32	89.00 / 94.00
Settlements (incl smallholdings)		3473234	312591.06	3840546	345649.14	367312	33058.08	10.58	93.90 / 98.68
Wetlands		651038	58593.42	572043	51483.87	-78995	-7109.55	-12.13	88.07 / 91.18
Grasslands		6227097	560438.73	5946964	535226.76	-280133	-25211.97	-4.50	84.56 / 69.82
Mines		231305	20817.45	195821	17623.89	-35484	-3193.56	-15.34	92.82 / 98.10
Waterbodies		105313	9478.17	105983	9538.47	670	60.30	0.64	79.64 / 93.31
Bare Ground		12854	1156.86	22768	2049.12	9914	892.26	77.13	98.77 / 97.58
Degraded		106337	9570.33	42466	3821.94	-63871	-5748.39	-60.06	78.69 / 85.95
<b>totals</b>		<b>18396047</b>	<b>1655644</b>	<b>18396043</b>	<b>1655644</b>				<i>User / Producer class accuracies</i>

# South African National Land-cover Dataset 1990 to 2013/14

Free State Province change based on the 30m pixels			(change based on standardised areas)							
	1990 Land Cover		2014 Land Cover		Change from 1990 to 2014					Class mapping accuracy (2013)
	Pixels	Hectares	Pixels	Hectares	Pixels	Hectares	%			
Indigenous Forest	68057	6125.13	75559	6800.31	7502	675.18	11.02	72.6 / 94.64		
Thicket /Dense bush	1303575	117321.75	1665474	149892.66	361899	32570.91	27.76	53.74 / 83.64		
Woodlan/Open bush	1559397	140345.73	1255780	113020.20	-303617	-27325.53	-19.47	60.84 / 54.13		
Low shrubland	24740213	2226619.17	36760959	3308486.31	12020746	1081867.14	48.59	70.59 / 61.82		
Plantations / Woodlots	584008	52560.72	563687	50731.83	-20321	-1828.89	-3.48	89.3 / 94.35		
Cultivated commercial annual crops non-pivot	42092634	3788337.06	39985067	3598656.03	-2107567	-189681.03	-5.01	91.91 / 99.54		
Cultivated commercial annual crops pivot	306826	27614.34	1810827	162974.43	1504001	135360.09	490.18	95.38 / 92.42		
Cultivated commercial permanent orchards	26126	2351.34	38406	3456.54	12280	1105.20	47.00	92.18 / 95.29		
Cultivated commercial permanent vines	0	0.00	0	0.00	0	0.00	0.00	91.61 / 97.26		
Cultivated subsistence crops	209381	18844.29	327142	29442.78	117761	10598.49	56.24	89.00 / 94.00		
Settlements (incl smallholdings)	994363	89492.67	1147053	103234.77	152690	13742.10	15.36	93.90 / 98.68		
Wetlands	4145335	373080.15	2500935	225084.15	-1644400	-147996.00	-39.67	88.07 / 91.18		
Grasslands	65232798	5870951.82	55751383	5017624.47	-9481415	-853327.35	-14.53	84.56 / 69.82		
Mines	268735	24186.15	265584	23902.56	-3151	-283.59	-1.17	92.82 / 98.10		
Waterbodies	1780207	160218.63	1085829	97724.61	-694378	-62494.02	-39.01	79.64 / 93.31		
Bare Ground	416832	37514.88	920003	82800.27	503171	45285.39	120.71	98.77 / 97.58		
Degraded	499721	44974.89	74520	6706.80	-425201	-38268.09	-85.09	78.69 / 85.95		
<b>totals</b>	<b>144228208</b>	<b>12980539</b>	<b>144228208</b>	<b>12980539</b>					<i>User / Producer class accuracies</i>	

N.West Province change based on the 30m pixels			(change based on standardised areas)							
	1990 Land Cover		2014 Land Cover		Change from 1990 to 2014					Class mapping accuracy (2013)
	Pixels	Hectares	Pixels	Hectares	Pixels	Hectares	%			
Indigenous Forest	8124	731.16	10737	966.33	2613	235.17	32.16	72.6 / 94.64		
Thicket /Dense bush	3462931	311663.79	2577328	231959.52	-885603	-79704.27	-25.57	53.74 / 83.64		
Woodlan/Open bush	17937089	1614338.01	19385150	1744663.50	1448061	130325.49	8.07	60.84 / 54.13		
Low shrubland	30934272	2784084.48	33918389	3052655.01	2984117	268570.53	9.65	70.59 / 61.82		
Plantations / Woodlots	218282	19645.38	188391	16955.19	-29891	-2690.19	-13.69	89.3 / 94.35		
Cultivated commercial annual crops non-pivot	24511201	2206008.09	21195525	1907597.25	-3315676	-298410.84	-13.53	91.91 / 99.54		
Cultivated commercial annual crops pivot	274098	24668.82	958619	86275.71	684521	61606.89	249.74	95.38 / 92.42		
Cultivated commercial permanent orchards	58982	5308.38	59651	5368.59	669	60.21	1.13	92.18 / 95.29		
Cultivated commercial permanent vines	0	0.00	0	0.00	0	0.00	0.00	91.61 / 97.26		
Cultivated subsistence crops	2977197	267947.73	2545552	229099.68	-431645	-38848.05	-14.50	89.00 / 94.00		
Settlements (incl smallholdings)	2121938	190974.42	2407802	216702.18	285864	25277.76	13.47	93.90 / 98.68		
Wetlands	1061447	95530.23	405520	36496.80	-655927	-59033.43	-61.80	88.07 / 91.18		
Grasslands	32352041	2911683.69	28742737	2586846.33	-3609304	-324837.36	-11.16	84.56 / 69.82		
Mines	533282	47995.38	668719	60184.71	135437	12189.33	25.40	92.82 / 98.10		
Waterbodies	365068	32856.12	284141	25572.69	-80927	-7283.43	-22.17	79.64 / 93.31		
Bare Ground	21952	1975.68	487730	43895.70	465778	41920.02	2121.80	98.77 / 97.58		
Degraded	1567497	141074.73	4569410	411246.90	3001913	270172.17	191.51	78.69 / 85.95		
<b>totals</b>	<b>118405401</b>	<b>10656486</b>	<b>118405401</b>	<b>10656486</b>					<i>User / Producer class accuracies</i>	

N.Cape Province change based on the 30m pixels			(change based on standardised areas)							
	1990 Land Cover		2014 Land Cover		Change from 1990 to 2014					Class mapping accuracy (2013)
	Pixels	Hectares	Pixels	Hectares	Pixels	Hectares	%			
Indigenous Forest	0	0.00	0	0.00	0	0.00	0.00	72.6 / 94.64		
Thicket /Dense bush	3366213	302959.17	2620780	235870.20	-745433	-67088.97	-22.14	53.74 / 83.64		
Woodlan/Open bush	12906026	1161542.34	12308962	1107806.58	-597064	-53735.76	-4.63	60.84 / 54.13		
Low shrubland	273284146	24595573.14	266589150	23993023.50	-6694996	-602549.64	-2.45	70.59 / 61.82		
Plantations / Woodlots	16021	1441.89	10553	949.77	-5468	-492.12	-34.13	89.3 / 94.35		
Cultivated commercial annual crops non-pivot	1878099	169028.91	1524185	137176.65	-353914	-31852.26	-18.84	91.91 / 99.54		
Cultivated commercial annual crops pivot	487327	43859.43	1034169	93075.21	546842	49215.78	112.21	95.38 / 92.42		
Cultivated commercial permanent orchards	64495	5804.55	82917	7462.53	18422	1657.98	28.56	92.18 / 95.29		
Cultivated commercial permanent vines	325303	29277.27	358636	32277.24	33333	2999.97	10.25	91.61 / 97.26		
Cultivated subsistence crops	48383	4354.47	43488	3913.92	-4895	-440.55	-10.12	89.00 / 94.00		
Settlements (incl smallholdings)	505185	45466.65	595935	53634.15	90750	8167.50	17.96	93.90 / 98.68		
Wetlands	1383159	124484.31	508456	45761.04	-874703	-78723.27	-63.24	88.07 / 91.18		
Grasslands	16278690	1465082.10	22292088	2006287.92	6013398	541205.82	36.94	84.56 / 69.82		
Mines	1150633	103556.97	1128435	101559.15	-22198	-1997.82	-1.93	92.82 / 98.10		
Waterbodies	1484259	133583.31	597399	53765.91	-886860	-79817.40	-59.75	79.64 / 93.31		
Bare Ground	102786035	9250743.15	107782286	9700405.74	4996251	449662.59	4.86	98.77 / 97.58		
Degraded	1516457	136481.13	2992	269.28	-1513465	-136211.85	-99.80	78.69 / 85.95		
<b>totals</b>	<b>417480431</b>	<b>37573239</b>	<b>417480431</b>	<b>37573239</b>					<i>User / Producer class accuracies</i>	

W.Cape Province change based on the 30m pixels		(change based on standardised areas)									
		1990 Land Cover		2014 Land Cover		Change from 1990 to 2014			Class mapping accuracy (2013)		
		Pixels	Hectares	Pixels	Hectares	Pixels	Hectares	%			
Indigenous Forest		613558	55220.22	620891	55880.19	7333	659.97	1.20	72.6 / 94.64		
Thicket /Dense bush		6566621	59095.89	8837553	795379.77	2270932	204383.88	34.58	53.74 / 83.64		
Woodland/Open bush		4529692	407672.28	5983259	538493.31	1453567	130821.03	32.09	60.84 / 54.13		
Low shrubland		68281558	6145340.22	73218655	6589678.95	4937097	444338.73	7.23	70.59 / 61.82		
Plantations / Woodlots		1335352	120181.68	902534	81228.06	-432818	-38953.62	-32.41	89.3 / 94.35		
Cultivated commercial annual crops non-pivot		18774280	1689685.20	18150014	1633501.26	-624266	-56183.94	-3.33	91.91 / 99.54		
Cultivated commercial annual crops pivot		209325	18839.25	816599	73493.91	607274	54654.66	290.11	95.38 / 92.42		
Cultivated commercial permanent orchards		1182748	106447.32	1158901	104301.09	-23847	-2146.23	-2.02	92.18 / 95.29		
Cultivated commercial permanent vines		1478633	133076.97	1738155	156433.95	259522	23356.98	17.55	91.61 / 97.26		
Cultivated subsistence crops		11463	1031.67	8049	724.41	-3414	-307.26	-29.78	89.00 / 94.00		
Settlements (incl smallholdings)		1152346	103711.14	1296109	116649.81	143763	12938.67	12.48	93.90 / 98.68		
Wetlands		1597375	143763.75	1201787	108160.83	-395588	-35602.92	-24.76	88.07 / 91.18		
Grasslands		7856963	707126.67	5774440	519699.60	-2082523	-187427.07	-26.51	84.56 / 69.82		
Mines		68726	6185.34	103314	9298.26	34588	3112.92	50.33	92.82 / 98.10		
Waterbodies		624675	56220.75	632120	56890.80	7445	670.05	1.19	79.64 / 93.31		
Bare Ground		30290215	2726119.35	24439993	2199599.37	-5850222	-526519.98	-19.31	98.77 / 97.58		
Degraded		578680	52081.20	269837	24285.33	-308843	-27795.87	-53.37	78.69 / 85.95		
totals		145152210	13063699	145152210	13063699				User / Producer		
									class accuracies		

E.Cape Province change based on the 30m pixels		(change based on standardised areas)									
		1990 Land Cover		2014 Land Cover		Change from 1990 to 2014			Class mapping accuracy (2013)		
		Pixels	Hectares	Pixels	Hectares	Pixels	Hectares	%			
Indigenous Forest		1228483	110563.47	1447897	130310.73	219414	19747.26	17.86	72.6 / 94.64		
Thicket /Dense bush		13359572	1202361.48	23983177	2158485.93	10623605	956124.45	79.52	53.74 / 83.64		
Woodland/Open bush		2899673	260570.57	6257286	563155.74	3357613	302185.17	115.79	60.84 / 54.13		
Low shrubland		49812767	4483149.03	45612154	4105093.86	-4200613	-378055.17	-8.43	70.59 / 61.82		
Plantations / Woodlots		1700089	153008.01	1717407	154566.63	17318	1558.62	1.02	89.3 / 94.35		
Cultivated commercial annual crops non-pivot		6036456	543281.04	5414653	487318.77	-621803	-55962.27	-10.30	91.91 / 99.54		
Cultivated commercial annual crops pivot		112612	10135.08	578446	52060.14	465834	41925.06	413.66	95.38 / 92.42		
Cultivated commercial permanent orchards		646710	58203.90	529148	47623.32	-117562	-10580.58	-18.18	92.18 / 95.29		
Cultivated commercial permanent vines		0	0.00	0	0.00	0	0.00	0.00	91.61 / 97.26		
Cultivated subsistence crops		8014517	721306.53	8524339	767190.51	509822	45883.98	6.36	89.00 / 94.00		
Settlements (incl smallholdings)		7024149	632173.41	6818491	613664.19	-205658	-18509.22	-2.93	93.90 / 98.68		
Wetlands		2429514	218656.26	1696628	152696.52	-732886	-65959.74	-30.17	88.07 / 91.18		
Grasslands		71195882	6407629.38	77548852	6979396.68	6352970	571767.30	8.92	84.56 / 69.82		
Mines		83262	7493.58	44781	4030.29	-38481	-3463.29	-46.22	92.82 / 98.10		
Waterbodies		710949	63985.41	689420	62047.80	-21529	-1937.61	-3.03	79.64 / 93.31		
Bare Ground		17044376	1533993.84	6305249	567472.41	-10739127	-966521.43	-63.01	98.77 / 97.58		
Degraded		5466225	491960.25	597308	53757.72	-4868917	-438202.53	-89.07	78.69 / 85.95		
totals		187765236	16898871	187765236	16898871				User / Producer		
									class accuracies		

KZN Province change based on the 30m pixels		(change based on standardised areas)									
		1990 Land Cover		2014 Land Cover		Change from 1990 to 2014			Class mapping accuracy (2013)		
		Pixels	Hectares	Pixels	Hectares	Pixels	Hectares	%			
Indigenous Forest		1562303	140607.27	1737698	156392.82	175395	15785.55	11.23	72.6 / 94.64		
Thicket /Dense bush		18224568	1640211.12	21644486	1948003.74	3419918	307792.62	18.77	53.74 / 83.64		
Woodland/Open bush		5539515	498556.35	6679261	601133.49	1139746	102577.14	20.57	60.84 / 54.13		
Low shrubland		793855	71446.95	421930	37973.70	-371925	-33473.25	-46.85	70.59 / 61.82		
Plantations / Woodlots		7626157	686354.13	7898486	710863.74	272329	24509.61	3.57	89.3 / 94.35		
Cultivated commercial annual crops non-pivot		8014310	721287.90	8947473	805272.57	933163	83984.67	11.64	91.91 / 99.54		
Cultivated commercial annual crops pivot		208201	18738.09	752526	67727.34	544325	48899.25	261.44	95.38 / 92.42		
Cultivated commercial permanent orchards		275452	24790.68	275947	24835.23	495	44.55	0.18	92.18 / 95.29		
Cultivated commercial permanent vines		0	0.00	0	0.00	0	0.00	0.00	91.61 / 97.26		
Cultivated subsistence crops		4556007	410040.63	5935919	534232.71	1379912	124192.08	30.29	89.00 / 94.00		
Settlements (incl smallholdings)		9285448	835690.32	8760355	788431.95	-525093	-47258.37	-5.66	93.90 / 98.68		
Wetlands		2059826	185384.34	1653356	148802.04	-406470	-36582.30	-19.73	88.07 / 91.18		
Grasslands		43293284	3896395.56	36954844	3325935.96	-6338440	-570459.60	-14.64	84.56 / 69.82		
Mines		59789	5381.01	58698	5282.82	-1091	-98.19	-1.82	92.82 / 98.10		
Waterbodies		2381049	214294.41	2233886	201049.74	-147163	-13244.67	-6.18	79.64 / 93.31		
Bare Ground		377880	34009.20	771169	69405.21	393289	35396.01	104.08	98.77 / 97.58		
Degraded		909550	81859.50	441160	39704.40	-468390	-42155.10	-51.50	78.69 / 85.95		
totals		105167194	9465047	105167194	9465047				User / Producer		
									class accuracies		

## 4.3 Inter-class land-cover change results

The tables below illustrate the inter-class changes between 1990 and 2013/14, and allow an interpretation of (a) what the 1990 extent of land-cover class X has changed to in 2013/14; or (b) what the current extent of class Y in 2013/14 was, in terms of 1990 land-cover characteristics. These statistics are based on the fact that a 17-class land-cover legend in both 1990 and 2013/14 means that there are 289 possible solutions to what a 1990 class can become in 2013/14. Interpretation of these inter-class changes should again be assessed in terms of the associated class mapping accuracies. Note that the table statistics are based on the original 30 m-resolution datasets.

Table 14 below shows the numeric codes used to represent all 289 possible inter-class changes between 1990 and 2013/14.

		1990 to 2013 Land Cover Change Matrix CHANGE MAP CODES																
		2013																
ORIGINAL VALUE	RICCODE VALUE	Indigenous forest	Thicket/dense bush	Woodland/open bush	Low shrubland	Plantations/woodlots	Cultivated/commercial annual: non-pivot	Cultivated/commercial annual: pivot	Cultivated/commercial permanent orchards	Cultivated/commercial permanent vines	Cultivated/subsistence crops	Settlements	Wetlands	Grasslands	Mines	Waterbodies	Bare ground	Degraded
		1 Indigenous Forest	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Indigenous Forest	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
2	Thicket/dense bush	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
3	Woodland/open bush	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
4	Low shrubland	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68
5	Plantations/woodlots	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
6	Cultivated/commercial annual: non-pivot	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102
7	Cultivated/commercial annual: pivot	109	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119
8	Cultivated/commercial permanent orchards	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136
9	Cultivated/commercial permanent vines	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153
10	Cultivated/subsistence crops	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170
11	Settlements	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187
12	Wetlands	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204
13	Grasslands	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221
14	Mines	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238
15	Waterbodies	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255
16	Bare ground	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272
17	Degraded	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	290

Table 15 below provides the definition of each of the 289 inter-class changes in terms of what 1990 class changed to what 2013/14 class, together with the number of 30 m-resolution pixel (not hectare) occurrences.

Change Map Codes	1990 Class	2013 Class	Class names in Change Dataset	Histogram Values in Change Dataset
2	Indigenous Forest	Indigenous Forest	Indigenous Forest-NO_CHANGE	3425197
3	Indigenous Forest	Thicket/dense bush	Indigenous Forest-CHANGE-TO-Thicket/dense bush	496041
4	Indigenous Forest	Woodland/open bush	Indigenous Forest-CHANGE-TO-Woodland/open bush	87036
5	Indigenous Forest	Low shrubland	Indigenous Forest-CHANGE-TO-Low shrubland	15980
6	Indigenous Forest	Plantations/woodlots	Indigenous Forest-CHANGE-TO-Plantations/woodlots	10211
7	Indigenous Forest	Cultivated commercial annual: non-pivot	Indigenous Forest-CHANGE-TO-Cultivated commercial annual: non-pivot	9394
8	Indigenous Forest	Cultivated commercial annual: pivot	Indigenous Forest-CHANGE-TO-Cultivated commercial annual: pivot	157
9	Indigenous Forest	Cultivated commercial permanent orchards	Indigenous Forest-CHANGE-TO-Cultivated commercial permanent orchards	7518
10	Indigenous Forest	Cultivated commercial permanent vines	Indigenous Forest-CHANGE-TO-Cultivated commercial permanent vines	4
11	Indigenous Forest	Cultivated subsistence crops	Indigenous Forest-CHANGE-TO-Cultivated subsistence crops	10813
12	Indigenous Forest	Settlements	Indigenous Forest-CHANGE-TO-Settlements	22459
13	Indigenous Forest	Wetlands	Indigenous Forest-CHANGE-TO-Wetlands	15482
14	Indigenous Forest	Grasslands	Indigenous Forest-CHANGE-TO-Grasslands	74806
15	Indigenous Forest	Mines	Indigenous Forest-CHANGE-TO-Mines	2937
16	Indigenous Forest	Waterbodies	Indigenous Forest-CHANGE-TO-Waterbodies	387
17	Indigenous Forest	Bare ground	Indigenous Forest-CHANGE-TO-Bare ground	6096
18	Indigenous Forest	Degraded	Indigenous Forest-CHANGE-TO-Degraded	490
19	Indigenous Forest	Indigenous Forest	Indigenous Forest-CHANGE-TO-Indigenous Forest	535829
20	Thicket/dense bush	Thicket/dense bush	Thicket/dense bush-NO_CHANGE	41489926
21	Thicket/dense bush	Woodland/open bush	Thicket/dense bush-CHANGE-TO-Woodland/open bush	14380109
22	Thicket/dense bush	Low shrubland	Thicket/dense bush-CHANGE-TO-Low shrubland	4262575
23	Thicket/dense bush	Plantations/woodlots	Thicket/dense bush-CHANGE-TO-Plantations/woodlots	124836
24	Thicket/dense bush	Cultivated commercial annual: non-pivot	Thicket/dense bush-CHANGE-TO-Cultivated commercial annual: non-pivot	1127386
25	Thicket/dense bush	Cultivated commercial annual: pivot	Thicket/dense bush-CHANGE-TO-Cultivated commercial annual: pivot	106823
26	Thicket/dense bush	Cultivated commercial permanent orchards	Thicket/dense bush-CHANGE-TO-Cultivated commercial permanent orchards	261667
27	Thicket/dense bush	Cultivated commercial permanent vines	Thicket/dense bush-CHANGE-TO-Cultivated commercial permanent vines	42843
28	Thicket/dense bush	Cultivated subsistence crops	Thicket/dense bush-CHANGE-TO-Cultivated subsistence crops	570577
29	Thicket/dense bush	Settlements	Thicket/dense bush-CHANGE-TO-Settlements	525574
30	Thicket/dense bush	Wetlands	Thicket/dense bush-CHANGE-TO-Wetlands	461453
31	Thicket/dense bush	Grasslands	Thicket/dense bush-CHANGE-TO-Grasslands	9379956
32	Thicket/dense bush	Mines	Thicket/dense bush-CHANGE-TO-Mines	95493
33	Thicket/dense bush	Waterbodies	Thicket/dense bush-CHANGE-TO-Waterbodies	121670
34	Thicket/dense bush	Bare ground	Thicket/dense bush-CHANGE-TO-Bare ground	243213
35	Thicket/dense bush	Degraded	Thicket/dense bush-CHANGE-TO-Degraded	114337
36	Woodland/open bush	Indigenous Forest	Woodland/open bush-CHANGE TO-Indigenous Forest	112400
37	Woodland/open bush	Thicket/dense bush	Woodland/open bush-CHANGE-TO-Thicket/dense bush	16947193
38	Woodland/open bush	Woodland/open bush	Woodland/open bush-NO_CHANGE	61875159
39	Woodland/open bush	Low shrubland	Woodland/open bush-CHANGE-TO-Low shrubland	14546501
40	Woodland/open bush	Plantations/woodlots	Woodland/open bush-CHANGE-TO-Plantations/woodlots	403028
41	Woodland/open bush	Cultivated commercial annual: non-pivot	Woodland/open bush-CHANGE-TO-Cultivated commercial annual: non-pivot	1072568
42	Woodland/open bush	Cultivated commercial annual: pivot	Woodland/open bush-CHANGE-TO-Cultivated commercial annual: pivot	380461
43	Woodland/open bush	Cultivated commercial permanent orchards	Woodland/open bush-CHANGE-TO-Cultivated commercial permanent orchards	129177
44	Woodland/open bush	Cultivated commercial permanent vines	Woodland/open bush-CHANGE-TO-Cultivated commercial permanent vines	18826
45	Woodland/open bush	Cultivated subsistence crops	Woodland/open bush-CHANGE-TO-Cultivated subsistence crops	792577
46	Woodland/open bush	Settlements	Woodland/open bush-CHANGE-TO-Settlements	902541
47	Woodland/open bush	Wetlands	Woodland/open bush-CHANGE-TO-Wetlands	256720
48	Woodland/open bush	Grasslands	Woodland/open bush-CHANGE-TO-Grasslands	20502381
49	Woodland/open bush	Mines	Woodland/open bush-CHANGE-TO-Mines	170431
50	Woodland/open bush	Waterbodies	Woodland/open bush-CHANGE-TO-Waterbodies	131075
51	Woodland/open bush	Bare ground	Woodland/open bush-CHANGE-TO-Bare ground	1795439
52	Woodland/open bush	Degraded	Woodland/open bush-CHANGE-TO-Degraded	2272812
53	Low shrubland	Indigenous Forest	Low shrubland-CHANGE-TO-Indigenous Forest	54894
54	Low shrubland	Thicket/dense bush	Low shrubland-CHANGE-TO-Thicket/dense bush	6698306
55	Low shrubland	Woodland/open bush	Low shrubland-CHANGE-TO-Woodland/open bush	15910778
56	Low shrubland	Low shrubland	Low shrubland-NO_CHANGE	353889933
57	Low shrubland	Plantations/woodlots	Low shrubland-CHANGE-TO-Plantations/woodlots	136003
58	Low shrubland	Cultivated commercial annual: non-pivot	Low shrubland-CHANGE-TO-Cultivated commercial annual: non-pivot	2551230
59	Low shrubland	Cultivated commercial annual: pivot	Low shrubland-CHANGE-TO-Cultivated commercial annual: pivot	713514
60	Low shrubland	Cultivated commercial permanent orchards	Low shrubland-CHANGE-TO-Cultivated commercial permanent orchards	153208
61	Low shrubland	Cultivated commercial permanent vines	Low shrubland-CHANGE-TO-Cultivated commercial permanent vines	154873
62	Low shrubland	Cultivated subsistence crops	Low shrubland-CHANGE-TO-Cultivated subsistence crops	107219
63	Low shrubland	Settlements	Low shrubland-CHANGE-TO-Settlements	631219
64	Low shrubland	Wetlands	Low shrubland-CHANGE-TO-Wetlands	393885
65	Low shrubland	Grasslands	Low shrubland-CHANGE-TO-Grasslands	46144882
66	Low shrubland	Mines	Low shrubland-CHANGE-TO-Mines	87795
67	Low shrubland	Waterbodies	Low shrubland-CHANGE-TO-Waterbodies	140265
68	Low shrubland	Bare ground	Low shrubland-CHANGE-TO-Bare ground	28132624
69	Low shrubland	Degraded	Low shrubland-CHANGE-TO-Degraded	1208540
70	Plantations/woodlots	Indigenous Forest	Plantations/woodlots-CHANGE-TO-Indigenous Forest	297592
71	Plantations/woodlots	Thicket/dense bush	Plantations/woodlots-CHANGE-TO-Thicket/dense bush	1511452
72	Plantations/woodlots	Woodland/open bush	Plantations/woodlots-CHANGE-TO-Woodland/open bush	512937
73	Plantations/woodlots	Low shrubland	Plantations/woodlots-CHANGE-TO-Low shrubland	270400
74	Plantations/woodlots	Plantations/woodlots	Plantations/woodlots-NO_CHANGE	16403751
75	Plantations/woodlots	Cultivated commercial annual: non-pivot	Plantations/woodlots-CHANGE-TO-Cultivated commercial annual: non-pivot	285536
76	Plantations/woodlots	Cultivated commercial annual: pivot	Plantations/woodlots-CHANGE-TO-Cultivated commercial annual: pivot	6562
77	Plantations/woodlots	Cultivated commercial permanent orchards	Plantations/woodlots-CHANGE-TO-Cultivated commercial permanent orchards	70818
78	Plantations/woodlots	Cultivated commercial permanent vines	Plantations/woodlots-CHANGE-TO-Cultivated commercial permanent vines	8215
79	Plantations/woodlots	Cultivated subsistence crops	Plantations/woodlots-CHANGE-TO-Cultivated subsistence crops	26000
80	Plantations/woodlots	Settlements	Plantations/woodlots-CHANGE-TO-Settlements	306544
81	Plantations/woodlots	Wetlands	Plantations/woodlots-CHANGE-TO-Wetlands	171567
82	Plantations/woodlots	Grasslands	Plantations/woodlots-CHANGE-TO-Grasslands	1420820
83	Plantations/woodlots	Mines	Plantations/woodlots-CHANGE-TO-Mines	39850
84	Plantations/woodlots	Waterbodies	Plantations/woodlots-CHANGE-TO-Waterbodies	15341
85	Plantations/woodlots	Bare ground	Plantations/woodlots-CHANGE-TO-Bare ground	10488
86	Plantations/woodlots	Degraded	Plantations/woodlots-CHANGE-TO-Degraded	6899
87	Cultivated commercial annual: non-pivot	Indigenous Forest	Cultivated commercial annual: non-pivot-CHANGE-TO-Indigenous Forest	8055
88	Cultivated commercial annual: non-pivot	Thicket/dense bush	Cultivated commercial annual: non-pivot-CHANGE-TO-Thicket/dense bush	1037970
89	Cultivated commercial annual: non-pivot	Woodland/open bush	Cultivated commercial annual: non-pivot-CHANGE-TO-Woodland/open bush	2470525
90	Cultivated commercial annual: non-pivot	Low shrubland	Cultivated commercial annual: non-pivot-CHANGE-TO-Low shrubland	4441322
91	Cultivated commercial annual: non-pivot	Plantations/woodlots	Cultivated commercial annual: non-pivot-CHANGE-TO-Plantations/woodlots	325617
92	Cultivated commercial annual: non-pivot	Cultivated commercial annual: non-pivot	Cultivated commercial annual: non-pivot-NO_CHANGE	103779265

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*continued ...*

93	Cultivated commercial annual: non-pivot	Cultivated commercial annual: pivot	Cultivated commercial annual: non-pivot-CHANGE-TO-Cultivated commercial annual: pivot	432620
94	Cultivated commercial annual: non-pivot	Cultivated commercial permanent orchards	Cultivated commercial annual: non-pivot-CHANGE-TO-Cultivated commercial permanent orchards	352492
95	Cultivated commercial annual: non-pivot	Cultivated commercial permanent vines	Cultivated commercial annual: non-pivot-CHANGE-TO-Cultivated commercial permanent vines	96170
96	Cultivated commercial annual: non-pivot	Cultivated subsistence crops	Cultivated commercial annual: non-pivot-CHANGE-TO-Cultivated subsistence crops	191151
97	Cultivated commercial annual: non-pivot	Settlements	Cultivated commercial annual: non-pivot-CHANGE-TO-Settlements	308848
98	Cultivated commercial annual: non-pivot	Wetlands	Cultivated commercial annual: non-pivot-CHANGE-TO-Wetlands	398645
99	Cultivated commercial annual: non-pivot	Grasslands	Cultivated commercial annual: non-pivot-CHANGE-TO-Grasslands	8998529
100	Cultivated commercial annual: non-pivot	Mines	Cultivated commercial annual: non-pivot-CHANGE-TO-Mines	415666
101	Cultivated commercial annual: non-pivot	Waterbodies	Cultivated commercial annual: non-pivot-CHANGE-TO-Waterbodies	24353
102	Cultivated commercial annual: non-pivot	Bare ground	Cultivated commercial annual: non-pivot-CHANGE-TO-Bare ground	113120
103	Cultivated commercial annual: non-pivot	Degraded	Cultivated commercial annual: non-pivot-CHANGE-TO-Degraded	340494
104	Cultivated commercial annual: pivot	Indigenous Forest	Cultivated commercial annual: pivot-CHANGE-TO-Indigenous Forest	39
105	Cultivated commercial annual: pivot	Thicket/dense bush	Cultivated commercial annual: pivot-CHANGE-TO-Thicket/dense bush	31372
106	Cultivated commercial annual: pivot	Woodland/open bush	Cultivated commercial annual: pivot-CHANGE-TO-Woodland/open bush	64179
107	Cultivated commercial annual: pivot	Low shrubland	Cultivated commercial annual: pivot-CHANGE-TO-Low shrubland	31680
108	Cultivated commercial annual: pivot	Plantations/woodlots	Cultivated commercial annual: pivot-CHANGE-TO-Plantations/woodlots	1474
109	Cultivated commercial annual: pivot	Cultivated commercial annual: non-pivot	Cultivated commercial annual: pivot-CHANGE-TO-Cultivated commercial annual: non-pivot	276629
110	Cultivated commercial annual: pivot	Cultivated commercial annual: pivot	Cultivated commercial annual: pivot-NO_CHANGE	2165075
111	Cultivated commercial annual: pivot	Cultivated commercial permanent orchards	Cultivated commercial annual: pivot-CHANGE-TO-Cultivated commercial permanent orchards	38822
112	Cultivated commercial annual: pivot	Cultivated commercial permanent vines	Cultivated commercial annual: pivot-CHANGE-TO-Cultivated commercial permanent vines	10317
113	Cultivated commercial annual: pivot	Cultivated subsistence crops	Cultivated commercial annual: pivot-CHANGE-TO-Cultivated subsistence crops	3895
114	Cultivated commercial annual: pivot	Settlements	Cultivated commercial annual: pivot-CHANGE-TO-Settlements	10501
115	Cultivated commercial annual: pivot	Wetlands	Cultivated commercial annual: pivot-CHANGE-TO-Wetlands	5044
116	Cultivated commercial annual: pivot	Grasslands	Cultivated commercial annual: pivot-CHANGE-TO-Grasslands	59212
117	Cultivated commercial annual: pivot	Mines	Cultivated commercial annual: pivot-CHANGE-TO-Mines	7278
118	Cultivated commercial annual: pivot	Waterbodies	Cultivated commercial annual: pivot-CHANGE-TO-Waterbodies	485
119	Cultivated commercial annual: pivot	Bare ground	Cultivated commercial annual: pivot-CHANGE-TO-Bare ground	1835
120	Cultivated commercial annual: pivot	Degraded	Cultivated commercial annual: pivot-CHANGE-TO-Degraded	6258
121	Cultivated commercial permanent orchards	Indigenous Forest	Cultivated commercial permanent orchards-CHANGE-TO-Indigenous Forest	1629
122	Cultivated commercial permanent orchards	Thicket/dense bush	Cultivated commercial permanent orchards-CHANGE-TO-Thicket/dense bush	164211
123	Cultivated commercial permanent orchards	Woodland/open bush	Cultivated commercial permanent orchards-CHANGE-TO-Woodland/open bush	94690
124	Cultivated commercial permanent orchards	Low shrubland	Cultivated commercial permanent orchards-CHANGE-TO-Low shrubland	66696
125	Cultivated commercial permanent orchards	Plantations/woodlots	Cultivated commercial permanent orchards-CHANGE-TO-Plantations/woodlots	17875
126	Cultivated commercial permanent orchards	Cultivated commercial annual: non-pivot	Cultivated commercial permanent orchards-CHANGE-TO-Cultivated commercial annual: non-pivot	200708
127	Cultivated commercial permanent orchards	Cultivated commercial annual: pivot	Cultivated commercial permanent orchards-CHANGE-TO-Cultivated commercial annual: pivot	40679
128	Cultivated commercial permanent orchards	Cultivated commercial permanent orchards	Cultivated commercial permanent orchards-NO_CHANGE	2601967
129	Cultivated commercial permanent orchards	Cultivated commercial permanent vines	Cultivated commercial permanent orchards-CHANGE-TO-Cultivated commercial permanent vines	112248
130	Cultivated commercial permanent orchards	Cultivated subsistence crops	Cultivated commercial permanent orchards-CHANGE-TO-Cultivated subsistence crops	44868
131	Cultivated commercial permanent orchards	Settlements	Cultivated commercial permanent orchards-CHANGE-TO-Settlements	11874
132	Cultivated commercial permanent orchards	Wetlands	Cultivated commercial permanent orchards-CHANGE-TO-Wetlands	10464
133	Cultivated commercial permanent orchards	Grasslands	Cultivated commercial permanent orchards-CHANGE-TO-Grasslands	109016
134	Cultivated commercial permanent orchards	Mines	Cultivated commercial permanent orchards-CHANGE-TO-Mines	644
135	Cultivated commercial permanent orchards	Waterbodies	Cultivated commercial permanent orchards-CHANGE-TO-Waterbodies	1293
136	Cultivated commercial permanent orchards	Bare ground	Cultivated commercial permanent orchards-CHANGE-TO-Bare ground	1976
137	Cultivated commercial permanent orchards	Degraded	Cultivated commercial permanent orchards-CHANGE-TO-Degraded	3291
138	Cultivated commercial permanent vines	Indigenous Forest	Cultivated commercial permanent vines-CHANGE-TO-Indigenous Forest	2
139	Cultivated commercial permanent vines	Thicket/dense bush	Cultivated commercial permanent vines-CHANGE-TO-Thicket/dense bush	56336
140	Cultivated commercial permanent vines	Woodland/open bush	Cultivated commercial permanent vines-CHANGE-TO-Woodland/open bush	6175
141	Cultivated commercial permanent vines	Low shrubland	Cultivated commercial permanent vines-CHANGE-TO-Low shrubland	59039
142	Cultivated commercial permanent vines	Plantations/woodlots	Cultivated commercial permanent vines-CHANGE-TO-Plantations/woodlots	2146
143	Cultivated commercial permanent vines	Cultivated commercial annual: non-pivot	Cultivated commercial permanent vines-CHANGE-TO-Cultivated commercial annual: non-pivot	32272
144	Cultivated commercial permanent vines	Cultivated commercial annual: pivot	Cultivated commercial permanent vines-CHANGE-TO-Cultivated commercial annual: pivot	6516
145	Cultivated commercial permanent vines	Cultivated commercial permanent orchards	Cultivated commercial permanent vines-CHANGE-TO-Cultivated commercial permanent orchards	38015
146	Cultivated commercial permanent vines	Cultivated commercial permanent vines	Cultivated commercial permanent vines-NO_CHANGE	1569751
147	Cultivated commercial permanent vines	Cultivated subsistence crops	Cultivated commercial permanent vines-CHANGE-TO-Cultivated subsistence crops	0
148	Cultivated commercial permanent vines	Settlements	Cultivated commercial permanent vines-CHANGE-TO-Settlements	6140
149	Cultivated commercial permanent vines	Wetlands	Cultivated commercial permanent vines-CHANGE-TO-Wetlands	7576
150	Cultivated commercial permanent vines	Grasslands	Cultivated commercial permanent vines-CHANGE-TO-Grasslands	16097
151	Cultivated commercial permanent vines	Mines	Cultivated commercial permanent vines-CHANGE-TO-Mines	33
152	Cultivated commercial permanent vines	Waterbodies	Cultivated commercial permanent vines-CHANGE-TO-Waterbodies	1787
153	Cultivated commercial permanent vines	Bare ground	Cultivated commercial permanent vines-CHANGE-TO-Bare ground	1924
154	Cultivated commercial permanent vines	Degraded	Cultivated commercial permanent vines-CHANGE-TO-Degraded	127
155	Cultivated subsistence crops	Indigenous Forest	Cultivated subsistence crops-CHANGE-TO-Indigenous Forest	3000
156	Cultivated subsistence crops	Thicket/dense bush	Cultivated subsistence crops-CHANGE-TO-Thicket/dense bush	926626
157	Cultivated subsistence crops	Woodland/open bush	Cultivated subsistence crops-CHANGE-TO-Woodland/open bush	2005372
158	Cultivated subsistence crops	Low shrubland	Cultivated subsistence crops-CHANGE-TO-Low shrubland	150274
159	Cultivated subsistence crops	Plantations/woodlots	Cultivated subsistence crops-CHANGE-TO-Plantations/woodlots	21873
160	Cultivated subsistence crops	Cultivated commercial annual: non-pivot	Cultivated subsistence crops-CHANGE-TO-Cultivated commercial annual: non-pivot	501104
161	Cultivated subsistence crops	Cultivated commercial annual: pivot	Cultivated subsistence crops-CHANGE-TO-Cultivated commercial annual: pivot	20097
162	Cultivated subsistence crops	Cultivated commercial permanent orchards	Cultivated subsistence crops-CHANGE-TO-Cultivated commercial permanent orchards	30839
163	Cultivated subsistence crops	Cultivated commercial permanent vines	Cultivated subsistence crops-CHANGE-TO-Cultivated commercial permanent vines	3013
164	Cultivated subsistence crops	Cultivated subsistence crops	Cultivated subsistence crops-NO_CHANGE	17119412
165	Cultivated subsistence crops	Settlements	Cultivated subsistence crops-CHANGE-TO-Settlements	96593
166	Cultivated subsistence crops	Wetlands	Cultivated subsistence crops-CHANGE-TO-Wetlands	15456
167	Cultivated subsistence crops	Grasslands	Cultivated subsistence crops-CHANGE-TO-Grasslands	865519
168	Cultivated subsistence crops	Mines	Cultivated subsistence crops-CHANGE-TO-Mines	15791
169	Cultivated subsistence crops	Waterbodies	Cultivated subsistence crops-CHANGE-TO-Waterbodies	10686
170	Cultivated subsistence crops	Bare ground	Cultivated subsistence crops-CHANGE-TO-Bare ground	63648
171	Cultivated subsistence crops	Degraded	Cultivated subsistence crops-CHANGE-TO-Degraded	201516
172	Settlements	Indigenous Forest	Settlements-CHANGE-TO-Indigenous Forest	11562
173	Settlements	Thicket/dense bush	Settlements-CHANGE-TO-Thicket/dense bush	791009
174	Settlements	Woodland/open bush	Settlements-CHANGE-TO-Woodland/open bush	371976
175	Settlements	Low shrubland	Settlements-CHANGE-TO-Low shrubland	211660
176	Settlements	Plantations/woodlots	Settlements-CHANGE-TO-Plantations/woodlots	154235
177	Settlements	Cultivated commercial annual: non-pivot	Settlements-CHANGE-TO-Cultivated commercial annual: non-pivot	199312
178	Settlements	Cultivated commercial annual: pivot	Settlements-CHANGE-TO-Cultivated commercial annual: pivot	1465
179	Settlements	Cultivated commercial permanent orchards	Settlements-CHANGE-TO-Cultivated commercial permanent orchards	8007
180	Settlements	Cultivated commercial permanent vines	Settlements-CHANGE-TO-Cultivated commercial permanent vines	2453
181	Settlements	Cultivated subsistence crops	Settlements-CHANGE-TO-Cultivated subsistence crops	348146
182	Settlements	Settlements	Settlements-NO_CHANGE	27135957
183	Settlements	Wetlands	Settlements-CHANGE-TO-Wetlands	43837
184	Settlements	Grasslands	Settlements-CHANGE-TO-Grasslands	1104986
185	Settlements	Mines	Settlements-CHANGE-TO-Mines	15905
186	Settlements	Waterbodies	Settlements-CHANGE-TO-Waterbodies	7021
187	Settlements	Bare ground	Settlements-CHANGE-TO-Bare ground	36828
188	Settlements	Degraded	Settlements-CHANGE-TO-Degraded	32532
189	Wetlands	Indigenous Forest	Wetlands-CHANGE-TO-Indigenous Forest	40226
190	Wetlands	Thicket/dense bush	Wetlands-CHANGE-TO-Thicket/dense bush	1729337
191	Wetlands	Woodland/open bush	Wetlands-CHANGE-TO-Woodland/open bush	895070
192	Wetlands	Low shrubland	Wetlands-CHANGE-TO-Low shrubland	1479148
193	Wetlands	Plantations/woodlots	Wetlands-CHANGE-TO-Plantations/woodlots	98639
194	Wetlands	Cultivated commercial annual: non-pivot	Wetlands-CHANGE-TO-Cultivated commercial annual: non-pivot	530799
195	Wetlands	Cultivated commercial annual: pivot	Wetlands-CHANGE-TO-Cultivated commercial annual: pivot	67641
196	Wetlands	Cultivated commercial permanent orchards	Wetlands-CHANGE-TO-Cultivated commercial permanent orchards	26126
197	Wetlands	Cultivated commercial permanent vines	Wetlands-CHANGE-TO-Cultivated commercial permanent vines	25811
198	Wetlands	Cultivated subsistence crops	Wetlands-CHANGE-TO-Cultivated subsistence crops	173086
199	Wetlands	Settlements	Wetlands-CHANGE-TO-Settlements	41391
200	Wetlands	Wetlands	Wetlands-NO_CHANGE	7043659

*continued ...*

201	Wetlands	Grasslands	Wetlands-CHANGE-TO-Grasslands	4525139
202	Wetlands	Mines	Wetlands-CHANGE-TO-Mines	21442
203	Wetlands	Waterbodies	Wetlands-CHANGE-TO-Waterbodies	130659
204	Wetlands	Bare ground	Wetlands-CHANGE-TO-Bare ground	112062
205	Wetlands	Degraded	Wetlands-CHANGE-TO-Degraded	16857
206	Grasslands	Indigenous Forest	Grasslands-CHANGE-TO-Indigenous Forest	263981
207	Grasslands	Thicket/dense bush	Grasslands-CHANGE-TO-Thicket/dense bush	18699512
208	Grasslands	Woodland/open bush	Grasslands-CHANGE-TO-Woodland/open bush	34080118
209	Grasslands	Low shrubland	Grasslands-CHANGE-TO-Low shrubland	43194219
210	Grasslands	Plantations/woodlots	Grasslands-CHANGE-TO-Plantations/woodlots	3059156
211	Grasslands	Cultivated commercial annual: non-pivot	Grasslands-CHANGE-TO-Cultivated commercial annual: non-pivot	7065338
212	Grasslands	Cultivated commercial annual: pivot	Grasslands-CHANGE-TO-Cultivated commercial annual: pivot	757172
213	Grasslands	Cultivated commercial permanent orchards	Grasslands-CHANGE-TO-Cultivated commercial permanent orchards	120470
214	Grasslands	Cultivated commercial vines	Grasslands-CHANGE-TO-Cultivated commercial permanent vines	20166
215	Grasslands	Cultivated subsistence crops	Grasslands-CHANGE-TO-Cultivated subsistence crops	2553768
216	Grasslands	Settlements	Grasslands-CHANGE-TO-Settlements	2141715
217	Grasslands	Wetlands	Grasslands-CHANGE-TO-Wetlands	1796988
218	Grasslands	Grasslands	Grasslands-NO_CHANGE	18483601
219	Grasslands	Mines	Grasslands-CHANGE-TO-Mines	579306
220	Grasslands	Waterbodies	Grasslands-CHANGE-TO-Waterbodies	251139
221	Grasslands	Bare ground	Grasslands-CHANGE-TO-Bare ground	2436517
222	Grasslands	Degraded	Grasslands-CHANGE-TO-Degraded	4052016
223	Mines	Indigenous Forest	Mines-CHANGE-TO-Indigenous Forest	31
224	Mines	Thicket/dense bush	Mines-CHANGE-TO-Thicket/dense bush	82675
225	Mines	Woodland/open bush	Mines-CHANGE-TO-Woodland/open bush	209152
226	Mines	Low shrubland	Mines-CHANGE-TO-Low shrubland	97741
227	Mines	Plantations/woodlots	Mines-CHANGE-TO-Plantations/woodlots	9537
228	Mines	Cultivated commercial annual: non-pivot	Mines-CHANGE-TO-Cultivated commercial annual: non-pivot	12300
229	Mines	Cultivated commercial annual: pivot	Mines-CHANGE-TO-Cultivated commercial annual: pivot	1264
230	Mines	Cultivated commercial permanent orchards	Mines-CHANGE-TO-Cultivated commercial permanent orchards	100
231	Mines	Cultivated commercial permanent vines	Mines-CHANGE-TO-Cultivated commercial permanent vines	12
232	Mines	Cultivated subsistence crops	Mines-CHANGE-TO-Cultivated subsistence crops	4560
233	Mines	Settlements	Mines-CHANGE-TO-Settlements	14026
234	Mines	Wetlands	Mines-CHANGE-TO-Wetlands	20498
235	Mines	Grasslands	Mines-CHANGE-TO-Grasslands	557721
236	Mines	Mines	Mines-NO_CHANGE	2183569
237	Mines	Waterbodies	Mines-CHANGE-TO-Waterbodies	2211
238	Mines	Bare ground	Mines-CHANGE-TO-Bare ground	28696
239	Mines	Degraded	Mines-CHANGE-TO-Degraded	17648
240	Waterbodies	Indigenous Forest	Waterbodies-CHANGE-TO-Indigenous Forest	2786
241	Waterbodies	Thicket/dense bush	Waterbodies-CHANGE-TO-Thicket/dense bush	298299
242	Waterbodies	Woodland/open bush	Waterbodies-CHANGE-TO-Woodland/open bush	169719
243	Waterbodies	Low shrubland	Waterbodies-CHANGE-TO-Low shrubland	310052
244	Waterbodies	Plantations/woodlots	Waterbodies-CHANGE-TO-Plantations/woodlots	9158
245	Waterbodies	Cultivated commercial annual: non-pivot	Waterbodies-CHANGE-TO-Cultivated commercial annual: non-pivot	41978
246	Waterbodies	Cultivated commercial annual: pivot	Waterbodies-CHANGE-TO-Cultivated commercial annual: pivot	1915
247	Waterbodies	Cultivated commercial permanent orchards	Waterbodies-CHANGE-TO-Cultivated commercial permanent orchards	3120
248	Waterbodies	Cultivated commercial permanent vines	Waterbodies-CHANGE-TO-Cultivated commercial permanent vines	1536
249	Waterbodies	Cultivated subsistence crops	Waterbodies-CHANGE-TO-Cultivated subsistence crops	9028
250	Waterbodies	Settlements	Waterbodies-CHANGE-TO-Settlements	12064
251	Waterbodies	Wetlands	Waterbodies-CHANGE-TO-Wetlands	609557
252	Waterbodies	Grasslands	Waterbodies-CHANGE-TO-Grasslands	392102
253	Waterbodies	Mines	Waterbodies-CHANGE-TO-Mines	2811
254	Waterbodies	Waterbodies	Waterbodies-NO_CHANGE	21575609
255	Waterbodies	Bare ground	Waterbodies-CHANGE-TO-Bare ground	1022673
256	Waterbodies	Degraded	Waterbodies-CHANGE-TO-Degraded	4718
257	Bare ground	Indigenous Forest	Bare ground-CHANGE-TO-Indigenous Forest	3067
258	Bare ground	Thicket/dense bush	Bare ground-CHANGE-TO-Thicket/dense bush	912848
259	Bare ground	Woodland/open bush	Bare ground-CHANGE-TO-Woodland/open bush	2365435
260	Bare ground	Low shrubland	Bare ground-CHANGE-TO-Low shrubland	39284146
261	Bare ground	Plantations/woodlots	Bare ground-CHANGE-TO-Plantations/woodlots	8072
262	Bare ground	Cultivated commercial annual: non-pivot	Bare ground-CHANGE-TO-Cultivated commercial annual: non-pivot	32666
263	Bare ground	Cultivated commercial annual: pivot	Bare ground-CHANGE-TO-Cultivated commercial annual: pivot	21028
264	Bare ground	Cultivated commercial permanent orchards	Bare ground-CHANGE-TO-Cultivated commercial permanent orchards	2513
265	Bare ground	Cultivated commercial permanent vines	Bare ground-CHANGE-TO-Cultivated commercial permanent vines	29770
266	Bare ground	Cultivated subsistence crops	Bare ground-CHANGE-TO-Cultivated subsistence crops	3812
267	Bare ground	Settlements	Bare ground-CHANGE-TO-Settlements	51055
268	Bare ground	Wetlands	Bare ground-CHANGE-TO-Wetlands	88152
269	Bare ground	Grasslands	Bare ground-CHANGE-TO-Grasslands	2144355
270	Bare ground	Mines	Bare ground-CHANGE-TO-Mines	9491
271	Bare ground	Waterbodies	Bare ground-CHANGE-TO-Waterbodies	309464
272	Bare ground	Bare ground	Bare ground-NO_CHANGE	103176933
273	Bare ground	Degraded	Bare ground-CHANGE-TO-Degraded	28668
274	Degraded	Indigenous Forest	Degraded-CHANGE-TO-Indigenous Forest	198
275	Degraded	Thicket/dense bush	Degraded-CHANGE-TO-Thicket/dense bush	256546
276	Degraded	Woodland/open bush	Degraded-CHANGE-TO-Woodland/open bush	2667479
277	Degraded	Low shrubland	Degraded-CHANGE-TO-Low shrubland	2435971
278	Degraded	Plantations/woodlots	Degraded-CHANGE-TO-Plantations/woodlots	33291
279	Degraded	Cultivated commercial annual: non-pivot	Degraded-CHANGE-TO-Cultivated commercial annual: non-pivot	179711
280	Degraded	Cultivated commercial annual: pivot	Degraded-CHANGE-TO-Cultivated commercial annual: pivot	72806
281	Degraded	Cultivated commercial permanent orchards	Degraded-CHANGE-TO-Cultivated commercial permanent orchards	10146
282	Degraded	Cultivated commercial permanent vines	Degraded-CHANGE-TO-Cultivated commercial permanent vines	783
283	Degraded	Cultivated subsistence crops	Degraded-CHANGE-TO-Cultivated subsistence crops	716609
284	Degraded	Settlements	Degraded-CHANGE-TO-Settlements	95717
285	Degraded	Wetlands	Degraded-CHANGE-TO-Wetlands	59904
286	Degraded	Grasslands	Degraded-CHANGE-TO-Grasslands	5920583
287	Degraded	Mines	Degraded-CHANGE-TO-Mines	6812
288	Degraded	Waterbodies	Degraded-CHANGE-TO-Waterbodies	5647
289	Degraded	Bare ground	Degraded-CHANGE-TO-Bare ground	1904076
290	Degraded	Degraded	Degraded-NO_CHANGE	2182163

# South African National Land-cover Dataset 1990 to 2013/14

Table 16 below describes the actual 1990 to 2013/14 inter-class land-cover changes for the whole of South Africa in hectares.

		Quantitative units: Hectares (1990 vs 2013)																		
		ORIGINAL VALUE	RECODE VALUE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	308287.73	44645.69	7833.24	1438.20	918.99	845.46	14.13	676.62	0.36	973.17	2021.31	1393.38	6732.54	264.33	34.83	548.64	44.10	376650.72		
2	48224.61	1273493.34	1294500.81	388631.75	11225.24	101464.74	23550.03	3855.87	51531.93	47301.66	41530.77	844196.04	8594.37	10950.30	21889.17	10299.33	6645984.03			
3	10116.00	152547.37	556876.31	13095155.09	36272.52	9631.12	34241.49	11625.93	1694.34	71311.93	81238.69	154514.29	15338.79	11796.75	161589.51	102553.08	1100786.01			
4	4940.46	602847.54	441397.02	3185095.97	224336.00	147633.79	25988.24	590.58	6737.62	13788.72	13938.57	9649.71	56869.71	2531936.16	108788.60	41139825.12				
5	69	26783.28	136803.68	44616.33	222347.25	399718.98	29305.53	9340113.95	389365.40	739.58	2340.00	27588.96	15441.03	3880.69	549.52	620.91	1922829.48			
6	86	92417.30	724.95	222347.25	399718.98	29305.53	9340113.95	389365.40	739.58	2340.00	27588.96	15441.03	3880.69	549.52	620.91	1922829.48				
7	3.51	2323.48	5757.11	2551.20	132.66	24995.61	194556.75	3493.98	923.53	390.55	945.99	452.96	522.98	655.02	42.65	165.15	532.22	244468.53		
8	120	146.61	14778.99	8527.10	6002.64	1608.75	18065.72	3661.11	34177.03	1020.32	4038.12	1068.66	941.76	981.14	57.56	116.37	177.84	296.19	313871.61	
9	13.7	0.18	555.75	5315.51	193.14	2504.48	586.44	3421.35	142277.59	0.00	552.30	681.84	1448.73	2.97	160.83	16254.54				
10	270.00	83396.34	180483.48	13524.66	1968.57	45995.36	1808.73	2775.51	271.17	1540477.68	8693.37	1391.04	77896.71	14221.19	961.74	5728.32	18136.44	188430.71		
11	1040.58	71190.81	33477.84	19049.40	19881.15	17393.08	111.35	720.63	220.77	3133.14	2443236.13	3945.33	9448.74	1431.45	631.89	3314.52	2927.88	2342920.19		
12	155640.33	80565.30	133123.32	3887479.71	132.66	24995.61	194556.75	3493.98	923.53	390.55	945.99	452.96	522.98	655.02	42.65	165.15	532.22	244468.53		
13	205	23758.29	1628256.08	3067210.62	275224.04	633880.42	68145.48	10842.90	1814.94	2322.99	15377.74	3725.19	163392.31	40762.51	17275.35	1929.73	11759.31	10085.58	364681.44	2798966.38
14	2.79	7440.56	18823.68	8795.69	885.33	1107.00	113.76	9.00	1.08	410.40	1262.34	1844.82	50194.89	196512.21	198.99	2582.64	1588.52	29175.69		
15	267.04	28646.91	15274.71	27904.68	823.42	172.35	260.80	138.24	812.52	1085.76	54860.13	3782.18	2299.18	222.99	194186.81	9260.57	424.62	278041.25		
16	256	82136.32	212889.15	3535373.14	762.48	2393.94	1892.71	226.17	267.30	343.08	4594.95	7933.68	12995.95	854.19	52852.47	173.08	566.23	17366.84	198394.67	1488359.78
17	17.82	23089.14	240073.11	2192273.39	2996.19	1617.99	6552.54	913.14	70.47	64494.81	8614.53	591.36	172.52	10610331.64	18737071.19	2045626.89	29062729.62	1025599.83	2579393.35	2045618.38
	423403.32	823169.31	12454931.81	41327260.33	10610331.64	18737071.19	2045626.89	29062729.62	1025599.83	2579393.35	2045618.38	1305793.32	944060.94							

Table 17 below describes the actual 1990 to 2013/14 inter-class land-cover changes for the whole of South Africa, expressed in terms of the percentage of the original 1990 class extent and what it has become in 2013/14. For example, 81.84% of what was mapped as indigenous forest in 1990 is still indigenous forest in 2013/14, and 11.85% of what was indigenous forest in 1990 is mapped as thicket/dense bush in 2013/14.

		Quantitative units: Percentage of original 1990 extent in 2013 (only read table across rows)																		
		ORIGINAL VALUE	RECODE VALUE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	81.84	11.85	56.19	19.47	0.28	0.38	0.24	0.22	0.00	0.18	0.00	0.26	0.54	0.37	1.79	0.07	0.01	0.15	0.01	
2	0.73	13.86	50.59	11.89	0.26	0.38	0.17	0.15	0.14	0.35	0.06	0.77	0.71	0.62	12.70	0.13	0.16	0.33	0.15	
3	0.69	1.47	3.48	77.42	0.03	0.33	0.88	0.56	0.16	0.31	0.02	0.65	0.74	0.21	16.76	0.14	0.09	0.02	0.03	
4	0.01	0.81	1.94	3.48	0.26	0.31	0.33	0.30	0.04	0.12	0.02	0.14	0.09	0.09	0.09	0.07	0.05	0.03	0.01	
5	66	1.39	0.01	0.81	1.94	3.48	0.26	0.31	0.33	0.30	0.04	0.12	0.02	0.14	0.09	0.07	0.05	0.03	0.01	
6	0.01	0.81	1.94	3.48	0.26	0.31	0.33	0.30	0.04	0.12	0.02	0.14	0.09	0.07	0.05	0.03	0.01	0.01	0.01	
7	0.00	1.16	2.26	1.17	0.05	0.10	0.19	0.14	0.28	0.08	0.12	0.24	0.31	0.03	7.05	0.33	0.02	0.27	0.01	
8	0.00	4.71	2.72	1.93	0.51	0.12	0.17	0.17	0.14	0.34	0.03	0.29	0.38	0.19	2.18	0.27	0.02	0.23	0.01	
9	0.00	3.12	0.34	3.27	0.12	0.17	0.19	0.36	0.21	0.11	0.09	0.34	0.42	0.39	0.00	0.00	0.11	0.01	0.00	
10	0.01	4.20	9.10	0.10	0.10	0.10	0.10	0.10	0.14	0.01	0.01	0.01	0.01	0.01	0.01	0.07	0.05	0.05	0.03	
11	0.04	2.60	1.22	0.69	0.51	0.65	0.00	0.03	0.01	0.14	0.01	0.01	0.01	0.01	0.01	3.93	0.07	0.05	0.12	0.11
12	0.24	10.20	5.28	0.77	0.51	0.40	0.33	0.17	0.25	0.04	0.01	0.02	0.24	0.14	26.69	0.13	0.06	0.10	0.01	
13	0.09	6.12	11.16	14.14	1.00	2.31	0.25	0.04	0.01	0.84	0.70	0.59	60.36	0.19	0.08	0.80	0.13	0.01	0.00	
14	0.00	2.55	3.02	0.29	0.38	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	67.36	0.07	0.09	0.54	0.01	
15	0.01	2.22	0.12	0.69	0.27	0.04	0.17	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	
16	0.00	2.59	0.01	0.59	0.13	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	
17	0.00	1.55	16.12	14.72	0.20	1.09	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	

Table 18 below describes the actual 1990 to 2013/14 inter-class land-cover changes for the whole of South Africa, expressed in terms of the percentage of the current 2013/14 class extent and what it was originally in 1990. For example, 71.95% of what was mapped as indigenous forest in 2013/14 was also indigenous forest in 1990, and 11.26% of what is indigenous forest in 2013/14 was mapped as thicket/dense bush in 1990.

		Quantitative units: Percentage of final 2013 extent in 1990 (only read table down columns)																	
		RECODE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ORIGINAL VALUE	1	Indigenous Forest	71.95	0.54	0.06	0.00	0.05	0.01	0.00	0.20	0.00	0.05	0.07	0.14	0.03	0.08	0.00	0.00	0.00
2	Thicket/dense bush	11.26	45.03	0.35	10.41	0.32	0.02	0.96	1.23	6.79	2.04	2.52	1.63	4.05	2.35	3.17	2.61	0.54	1.09
3	Woodland/open bush	2.36	18.39	44.78	3.13	1.94	0.91	4.38	3.35	9.00	3.50	2.79	2.79	4.66	5.48	1.24	0.17	21.67	
4	Low shrubland	52	1.15	7.27	11.52	76.15	0.65	2.16	8.21	3.97	7.29	0.47	1.95	3.46	16.10	2.40	0.62	19.39	11.52
5	Plantations/woools	69	6.25	1.04	0.37	0.06	78.79	0.24	0.08	1.84	0.39	0.11	0.95	1.51	0.50	1.09	0.07	0.01	0.07
6	Cultivated commercial annual: non-pivot	86	0.17	1.33	1.79	0.36	1.56	88.02	49.79	9.14	4.59	0.84	0.96	3.50	3.14	11.37	0.11	0.08	3.25
7	Cultivated commercial annual: pivot	103	0.00	0.03	0.05	0.01	0.01	0.23	24.92	1.01	0.49	0.02	0.03	0.04	0.02	0.00	0.00	0.06	0.06
8	Cultivated permanent orchards	120	0.03	0.18	0.07	0.01	0.09	0.17	0.47	67.50	3.35	0.20	0.04	0.09	0.04	0.02	0.01	0.00	0.03
9	Cultivated commercial permanent orchards	137	0.00	0.06	0.01	0.01	0.03	0.01	0.07	0.99	74.46	0.00	0.02	0.02	0.07	0.01	0.00	0.01	0.00
10	Cultivated subsistence crops	154	0.06	1.01	1.45	0.03	0.11	0.43	0.23	0.80	0.14	0.30	0.14	0.30	0.43	0.30	0.43	0.05	0.04
11	Settlements	171	0.24	0.36	0.27	0.05	0.24	0.17	0.02	0.21	0.12	1.54	0.38	0.38	0.39	0.44	0.03	0.03	1.92
12	Wetlands	188	0.84	1.88	0.65	0.32	0.47	0.52	0.45	0.58	0.23	0.76	1.33	1.38	0.59	0.57	0.08	0.16	
13	Grasslands	205	5.55	20.09	24.67	9.29	14.69	5.99	0.96	11.26	6.63	6.63	15.76	64.33	15.85	1.10	1.68	38.63	
14	Mines	222	0.00	0.09	0.15	0.02	0.05	0.01	0.01	0.00	0.00	0.02	0.04	0.18	0.19	59.74	0.01	0.02	0.17
15	Waterbodies	239	0.06	0.32	0.12	0.07	0.04	0.04	0.04	0.02	0.08	0.07	0.04	0.35	0.14	0.08	94.93	0.04	0.04
16	Bare ground	256	0.06	0.39	1.71	0.85	0.04	0.03	0.24	0.07	0.02	0.16	0.77	0.75	0.26	1.36	0.27	0.19	0.02
17	Degraded	273	0.00	0.28	1.93	0.52	0.16	0.15	0.84	0.26	0.04	3.16	0.30	0.53	2.07	0.19	0.02	1.31	20.80
		TOTAL Change (%)																	
		1990																	

## 5. THE 1990 TO 2013/14 CHANGE RESULTS ANALYSIS

### 5.1 Indigenous forest

According to the land-cover data, there was a 13.75% increase nationally in the indigenous forest class extent between 1990 and 2013/14. However, the 2013/14 map accuracy results indicate a 72.6% user accuracy, which may mean that, in many cases, the reported change is a result of mapping error between true forest and the spectrally similar woody vegetation classes, such as “thicket/dense bush”, as indicated in the 2013/14 accuracy report. In Gauteng, there is a highly unlikely 1 350% statistical increase in the extent of indigenous forest in 2013/14, but this is simply due to the fact that in 1990, two pixels were mapped as forest, whereas in 2013/14, 29 pixels were mapped as forest. This difference is likely to be a result of the reported mapping inaccuracies, with 29 pixels representing only 0.0006% of the total mapped area of indigenous forest in 2013/14. National and provincial statistics should not, however, detract from the very relevant and real changes in indigenous forest cover change that are contained within the land-cover datasets on a local basis, such as around Dukuduku, St Lucia (see example above).

### 5.2 Thicket/dense bush

According to the land-cover data, there was a national increase of 24.76% in the thicket/dense bush class extent between 1990 and 2013/14. However, the 2013/14 map accuracy results indicate only a 53.74% user accuracy, which may mean that, in many cases, the reported change will be due to mapping error between this class and other spectrally similar woody vegetation classes, as indicated in the 2013/14 accuracy report. Provincial changes in the woody-dominated areas vary from +16.03% in Limpopo, +18.77% in KwaZulu-Natal, +36.46% in Mpumalanga, +79.52% in the Eastern Cape and -25.57% in North West. It is recommended that such statistical changes are treated with caution unless validated by corroborating evidence of plausible local change within the actual land-cover map datasets.

## 5.3 Woodland/open bush

According to the land-cover data, there was a national increase of 12.96% in the woodland/open bush class extent between 1990 and 2013/14. However, the 2013/14 map accuracy results indicate only a 60.84% user accuracy, which may mean that, in many cases, the reported change will be due to mapping error between this class and other spectrally similar woody vegetation classes, as indicated in the 2013/14 accuracy report. Provincial changes in the woody-dominated areas vary from +3.47% in Limpopo, +20.57% in KwaZulu-Natal, -4.73% in Mpumalanga, +115.79% in the Eastern Cape and +8.07% in North West. It is recommended that such statistical changes are treated with caution unless validated by corroborating evidence of plausible local change within the actual land-cover map datasets.

## 5.4 Low shrubland

According to the land-cover data, there was a national increase of 1.67% in the low shrub class extent between 1990 and 2013/14. The 2013/14 map accuracy results indicate a 70.59% user accuracy, which may mean that the limited amount of change is a function of both increasing map accuracy and the extremely large national class footprint within which any local change is insignificant in terms of the total area affected. Provincial changes in low shrub/Karoo/fynbos-dominated areas vary from +48.59% in the Free State, -2.45% in the Northern Cape and +7.23% in the Western Cape. In most cases, the changes in low shrub extent seem to be along a transitional gradient with grasslands, and may be reflecting local annual changes in grass component cover in response to different annual rainfall conditions, as is evident in the difference in open water/wetland areas between 1990 and 2013/14. It is recommended that such statistical changes are treated with caution unless validated by corroborating evidence of plausible local change within the actual land-cover map datasets.

## 5.5 Plantations/woodlots

According to the land-cover data, there was a national decrease of 2.55% in the plantation/woodlot class extent between 1990 and 2013/14. The 2013/14 map accuracy results indicate a 89.3% user accuracy, which should mean that both the mapped and statistical representations of change are plausible and likely to be accurate. The national statistic does not, however, reflect provincial or local area changes over the same

approximately 24-year period, with some areas definitely showing losses and others expansion. Provincial changes in traditional forestry areas vary from -23.93% in Limpopo, +1.1% in Mpumalanga, +1.02% in the Eastern Cape and +3.57% in KwaZulu-Natal.

## 5.6 Cultivated commercial annual crop non-pivot

According to the land-cover data, there was a national decrease of 7.62% in the cultivated commercial annual crop non-pivot class extent between 1990 and 2013/14. The 2013/14 map accuracy results indicate a 91.91% user accuracy, which should mean that both the mapped and statistical representations of change are plausible and likely to be accurate. The national statistic does not, however, reflect provincial or local area changes over the same approximately 24-year period, with some areas definitely showing losses and others expansion. Provincial changes in traditional forestry areas vary from -20.25% in Limpopo, -12.65% in Mpumalanga, +11.64% in KwaZulu-Natal, -10.30% in the Eastern Cape and -3.33% in the Western Cape, for example. On a local scale, many of these losses and expansions also appear to relate to associated increases in other cultivation land uses, such as orchards, vines and pivots, and losses due to new mining and urban areas.

## 5.7 Cultivated commercial annual crop pivots

According to the land-cover data, there was a national 220.16% increase in the cultivated commercial annual crop pivot class extent between 1990 and 2013/14. This is by far the biggest increase in any land-cover class extent over the approximately 24-year period and represents a huge increase in irrigation activities and associated water consumption. The 2013/14 map accuracy results indicate a 95.381% user accuracy, which should mean that both the mapped and statistical representations of change are plausible and very likely to be accurate. The national statistic does not, however, reflect provincial or local area changes over the same approximately 24-year period, with provincial changes in pivot class extent varying from +113.87% in Limpopo, +262.41% in Mpumalanga, +261.41% in KwaZulu-Natal, +413.66% in the Eastern Cape and +290.11% in the Western Cape, for example. All provinces showed increases in pivot class extent since 1990. On a local scale, this expansion appears to have resulted in losses

to both other cultivated land uses and natural vegetation types, depending on location.

## 5.8 Cultivated commercial permanent orchards

According to the land-cover data, there was a national increase of 10.64% in the cultivated commercial permanent orchard class extent between 1990 and 2013/14. The 2013/14 map accuracy results indicate a 92.18% user accuracy, which should mean that both the mapped and statistical representations of change are plausible and likely to be accurate. The national statistic does not, however, reflect provincial or local area changes over the same approximately 24-year period, with some areas definitely showing losses and others expansion. Provincial changes in traditional orchard areas vary from +40.27% in Limpopo, +35.38% in Mpumalanga, +28.56% in the Northern Cape and -18.18% in the Eastern Cape, for example. On a local scale, many of these losses and expansions appear to relate to associated increases in other cultivated land uses, such as orchards, vines and pivots, and losses due to new mining and urban areas.

## 5.9 Cultivated commercial permanent vines

According to the land-cover data, there was a national increase of 16.23% in the cultivated commercial permanent vines class extent between 1990 and 2013/14. The 2013/14 map accuracy results indicate a 91.61% user accuracy, which should mean that both the mapped and statistical representations of change are plausible and likely to be accurate. The national statistic reflects provincial-level changes over the same approximately 24-year period, with similar percentage increases being reported in both the Western Cape and the Northern Cape. All provinces with vines in 1990 show an increase in 2013/14.

## 5.10 Cultivated subsistence crops

According to the land-cover data, there was only a national increase of 2.83% in the cultivated subsistence crop class extent between 1990 and 2013/14. The 2013/14 map accuracy results indicate a 89.00% user accuracy, which should mean that both the mapped and statistical representations of change

are plausible and likely to be accurate. It is important to note, however, that, unlike commercial fields that were (originally) mapped on an individual field unit basis, subsistence fields were mapped according to the outer extent of clusters of subsistence fields, as necessitated by their characteristically small areas compared to image resolution. This resulted in varied levels and patterns of inter-field non-crop land being included in the subsistence cluster boundaries. During the land-cover mapping, these inter-field non-crop areas have been reclassified, where possible, into their basic vegetation cover types, i.e. grass, dense bush, etc. Since this was based on a generic modelling procedure as opposed to image-specific classification routines, it is possible that the extent and coverage of such inter-field non-crop areas has been influenced by (a) the accuracies associated with these vegetation classes, and (b) any modifying effect resulting from 1990 conditions appearing to be generally wetter than those in 2013/14. Furthermore, the actual intensity of land use (i.e. subsistence crop yield) cannot be gauged from the single "subsistence class" defined in the 17-class legend format, since all subsistence fields have been included within one amalgamated class on the basis of (image) observable field boundaries, regardless of whether such fields were cultivated, temporary or long-term fallow (i.e. abandoned) in the assessment year. A subdivision of land-use activity intensity (also known as cropping), based on annual Normalised Difference Vegetation Index (NDVI) profiles, is available as part of the associated 72-class DEA/GTI national land-cover dataset for 2013/14, but not presently for 1990. This may be a consideration for future work and analysis, since it will allow the historical and current extents of high-intensity subsistence cropping units to be compared, as opposed to just the overall extent of image-observable field cluster boundaries.

The national statistic does not, however, reflect provincial or local area changes over the same approximately 24-year period, with some areas showing losses and others expansion. Provincial changes in subsistence cropping vary from -13.34% in Limpopo, -27.27% in Mpumalanga and +30.29% in KwaZulu-Natal. It is recommended that, until such time as subsistence changes can be validated in terms of land-use intensity changes (i.e. productive to productive, productive to fallow, fallow to productive, etc.), such statistical changes are treated with caution unless

validated by corroborating evidence of plausible local change within the actual land-cover map datasets.

## 5.11 Settlements (including smallholdings)

According to the land-cover data, there was only a national increase of 6.03% in the settlement class extent between 1990 and 2013/14. The 2013/14 map accuracy results indicate a 93.90% user accuracy, which should mean that both the mapped and statistical representations of change are plausible and likely to be accurate. The national statistic does not, however, reflect provincial or local area changes over the same approximately 24-year period, with some areas definitely showing losses and others expansion, ranging from +28.82% in Limpopo to (surprisingly) -2.93% in KwaZulu-Natal. Gauteng only shows a +10.58% increase, which – from an anecdotal perspective – may be lower than expected. This is potentially explained by the fact that the settlement footprint defined in the two land-cover datasets includes a variety of urban subclasses, including commercial, residential, villages, schools and smallholdings. Peripheral smallholdings around urban centres are typically the first land-use class to be converted to formal urban areas under urban expansion. Thus, the total settlement footprint, as defined in terms of the DEA/CARDNO national land-cover datasets, will not change over time when smallholdings are converted to formal residential or industrial areas. Settlement subclasses defining separate commercial, industrial, residential, informal, village and smallholding categories are available within the full 72-class DEA/GTI national land-cover dataset for 2013/14, but not presently for 1990. This may be a consideration for future work and analysis since it will allow a more representative interpretation of urban expansion to be evaluated.

## 5.12 Wetlands

According to the land-cover data, there was a national decrease of 32.78% in the wetland class extent between 1990 and 2013/14. The 2013/14 map accuracy results indicate a 88.07% user accuracy, which should mean that both the mapped and statistical representations of change are plausible and likely to be accurate. However, wetlands is a specific land-cover class that has been significantly affected by the general wetter landscape conditions in 1990 compared to 2013/14, especially in

the conventionally drier western areas. The generally wetter landscape conditions in 1990 allowed wetland modelling to be undertaken across the entire country, whereas in 2013/14, because of drier conditions, wetland modelling was restricted to the southern and eastern regions. Thus, any wetlands in the normally drier western regions that were mapped in 1990 have not been remapped in 2013/14, simply because they were not visible as such on the imagery under these drier conditions. This does not mean that such wetlands have been “lost”, but rather that they are temporarily absent in terms of surface representation in 2013/14. This must be noted when interpreting the statistics. A possible solution may be to take the combined area of wetlands from 1990 and 2013/14, and to subtract appropriate non-wetland land-use class extents from this for both 1990 and 2013/14 landscapes in order to derive a more accurate picture of wetland loss.

The national statistic does not, however, reflect provincial or local area changes over the same approximately 24-year period, with losses ranging from -63.24% in the Northern Cape to -12.13% in Gauteng, where the Northern Cape difference is likely to be due to the landscape wetness differences already discussed, and the Gauteng difference probably being more representative of actual loss. All provinces showed a loss in wetland extent between 1990 and 2013/14. It is therefore recommended that such statistical changes are treated with caution unless validated by corroborating evidence of plausible local change within the actual land-cover map datasets.

## 5.13 Grasslands

According to the land-cover data, there was a national decrease of 6.17% in the grassland class extent between 1990 and 2013/14. The 2013/14 map accuracy results indicate a 84.56% user accuracy, which should mean that both the mapped and statistical representations of change are plausible and likely to be accurate. As indicated in the 1990 DEA/CARDNO South African Land-cover Data Report, the post-modelling grassland correction edits are potentially more accurate than those applied to the 2013/14 land-cover dataset, as a result of better image dates and modified correction procedures. This may mean that the actual grassland extent, as represented in the 1990 dataset, is slightly more accurate than that represented in the 2013/14 dataset, and that there could be a corresponding

increase in the level of grassland/woody vegetation cover confusion in 2013/14. It is recommended that such statistical changes are treated with caution unless validated by corroborating evidence of plausible local change within the actual land-cover map datasets.

The generally wetter landscape conditions in 1990, especially in the typically arid Karoo regions, may also have experienced a regional annual increase in the grass component in the low shrub/grassland transition zone, also increasing the extent of the grassland class mapped in 1990.

The national statistic does not, however, reflect provincial or local area changes over the same approximately 24-year period, with some areas showing losses and others expansion. Provincial changes vary from -28.33% in Limpopo, +1.93% in Mpumalanga, and +36.94% in the Northern Cape.

## 5.14 Mines

According to the land-cover data, there was a national increase of 12.76% in the mining class extent between 1990 and 2013/14. The 2013/14 map accuracy results indicate a 92.82% user accuracy, which should mean that both the mapped and statistical representations of change are plausible and very likely to be accurate. The national statistic does not, however, reflect provincial or local area changes over the same approximately 24-year period, with both losses and increases being recorded, ranging from -46.22% in the Eastern Cape to +66.84% in Mpumalanga (as would be expected due to the expansion of open-cast coal mining in this area). Since mapping accuracies are high for this class, interpretation of the statistical changes must be made in the context of the original and current spatial extents.

## 5.15 Water bodies

According to the land-cover data, there was a national decrease of -7.10% in the water class extent between 1990 and 2013/14, which includes both natural, man-made, seasonal and permanent water features. The 2013/14 map accuracy results indicate a 79.64% user accuracy, which should mean that both the mapped and statistical representations of change are plausible and likely to be accurate. The national statistic does not, however, reflect provincial or local area changes over the same approximately 24-year period, with both losses

and increases being recorded, ranging from +25.34% in Limpopo, 11.35% in Mpumalanga, and -59.75% in the Northern Cape. These regional differences are likely to have been influenced by a combination of both the generally wetter landscape conditions in 1990, especially in the typically drier western regions, and by the construction of several new major dams after 1990 that are observable in 2013/14. Since mapping accuracies are high for this class, interpretation of the statistical changes must be made in the context of the original and current spatial extents, so that small spatial features do not become over-represented statistically if they have shown significant statistical, but not necessarily spatial growth.

## 5.16 Bare ground

According to the land-cover data, there was a national decrease of -6.07% in the bare ground class extent between 1990 and 2013/14. The 2013/14 map accuracy results indicate a 98.77% user accuracy, which should mean that both the mapped and statistical representations of change are plausible and very likely to be accurate. The national statistic does not, however, reflect provincial or local area changes over the same approximately 24-year period, with both losses and increases being recorded, ranging from +635.08% in Limpopo, 2 121.80% in North West and -63.01% in the Eastern Cape. Since mapping accuracies are high for this class, interpretation of the statistical changes must be made in the context of the original and current spatial extents in any given area, so that small spatial features do not become over-represented statistically if they have shown significant statistical, but not necessarily spatial growth. The 2013/14 dataset may have been influenced by the generally drier conditions in some areas, perhaps resulting in lower vegetative cover, although in some regions human activity will have increased the bare ground extent.

## 5.17 Degraded areas

According to the land-cover data, there was a national decrease of -36.61% in the degraded class extent between 1990 and 2013/14. The 2013/14 map accuracy results indicate a 78.69% user accuracy, which should mean that both the mapped and statistical representations of change are plausible and likely to be accurate. However, the degraded class is defined as areas showing significantly lower total vegetation

cover to surrounding non-impacted areas, in terms of the viewed landscape. It is feasible, therefore, that a significant portion of the difference in degraded areas between 1990 and 2013/14 could be attributed to the generally wetter conditions in 1990 compared to the drier 2013/14 conditions. The provincial results show a significantly higher area of bare ground in 1990 than in 2013/14, apart from North West. This would appear to be the opposite of what would be expected, given that 1990 was the apparently wetter period, and thus the vegetation cover would be assumed to be more extensive. However, an alternative suggestion may be that, in terms of the generic modelling procedures used to define this class, when all the vegetation is generally lower (as in a drier period), the difference between impacted (i.e. degraded) land and non-impacted land is harder to determine, compared to when non-impacted land is much greener in wetter conditions. It is recommended that such statistical changes are treated with caution unless validated by corroborating evidence of plausible local change within the actual land-cover map datasets.

## ADDITIONAL INFORMATION

### (1) EXCEL SPREADSHEET OF LAND-COVER CHANGE RESULTS

- A digital Excel spreadsheet is supplied with this report. It contains digital copies of all the tables presented in this report so that data users have access to the actual numeric information.

### (2) DIGITAL RASTER MAP OF LAND-COVER CHANGE RESULTS

- A digital raster copy of the 289-class 1990 to 2013/14 change matrix map is supplied, based on 30 m-resolution cells, equivalent to the source 1990 and 2013/14 South African national land-cover 17-class legend datasets. This dataset is the source of the land-cover class change values represented in Table 15, based on the class change codes listed in Table 15. The raster change dataset is supplied in its original UTM35 north map projection in ERDAS Imagine® format. No TIFF format is supplied since the dataset is 11Gb in size due to the 16-bit format needed to accommodate the 289 classes, which exceeds the 4Gb limit for TIFF formats.

**PLEASE NOTE THAT THIS IS NOT A LAND-COVER MAP DATASET, BUT A SPATIAL REPRESENTATION OF 1990 TO 2013/14 LAND-COVER CHANGE ON A PER-PIXEL BASIS.**



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