Land and Ecosystem Accounting in KwaZulu-Natal, South Africa

Discussion Document

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Preface

South Africa is one of seven pilot countries involved in a global initiative called Advancing SEEA Experimental Ecosystem Accounting,[1] led by the United Nations Statistics Division (UNSD) in partnership with the United Nations Environment Programme (UNEP) and the Convention on Biodiversity (CBD), with funding from the Government of Norway. Within South Africa, the South African National Biodiversity Institute (SANBI) and Statistics South Africa (Stats SA) have worked in partnership with the Council for Scientific and Industrial Research (CSIR), Ezemvelo KZN Wildlife, the Department of Water and Sanitation (DWS) and the Department of Environmental Affairs (DEA) to take this project forward.

This discussion document forms part of a set of deliverables resulting from South Africa's participation in Phase 1 of Advancing SEEA Experimental Ecosystem Accounting, which took place from mid-2014 to May 2016.

Related reports

The document forms part of a set of deliverables from South Africa for the Advancing SEEA Experimental Ecosystem Accounting (AEEA) project. Related project reports include:

- National River Ecosystem Accounts in South Africa: Discussion Document
- Advancing Experimental Ecosystem Accounting in South Africa: Stakeholder Engagement Report
- National Plan for Advancing Environmental-Economic Accounting: South Africa

Note

The land cover datasets that formed the basis for the accounts presented in this discussion document have been analysed in detail in a separate paper on land cover change in KwaZulu-Natal (Jewitt et al 2015). Jewitt et al's analysis was not linked to this ecosystem accounting project, and used a different approach and different methods to those discussed here (e.g. land cover classes were aggregated differently). Consequently, the results are not directly comparable with those presented in this discussion document.

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[1] Also referred to in some of the global project documents as Advancing Natural Capital Accounting or ANCA.

Acknowledgements

We gratefully acknowledge the support of the UNSD, UNEP and the CBD Secretariat through the Advancing SEEA Experimental Ecosystem Accounting project, as well as funding from the Government of Norway. In particular we thank the UNSD for their enthusiastic support for South Africa's emerging programme of work on ecosystem accounting. We thank Mark Eigenraam, a consultant to the UNSD on the project, for encouraging us to include land accounts as part of the work and for his support throughout the project, including comments on a draft of this document. We thank Michael Bordt and Emil Ivanov, consultants to the UNSD, for their helpful comments on the approach and on a draft of this document.

Stats SA has been a key partner in this work and a champion of ecosystem accounting, building on their existing work on environmental accounting. In particular we thank Joe de Beer, Gerhardt Bouwer, Riaan Grobler, Ester Koch, Robert Parry, Thembalihle Ndlovu and Brenda Mphakane for their active advice and involvement.

We thank Ezemvelo KwaZulu-Natal Wildlife for their collaboration, including for sharing their excellent land cover data for the province of KwaZulu-Natal (KZN), which has made the analysis presented here possible.

On 21 April 2015 we held a stakeholder workshop in Durban at which initial draft results were presented and discussed with over 20 people from a range of government, civil society, academic and private organisations including Ezemvelo KZN Wildlife, KZN Department of Agriculture and Rural Development, Ethekwini Metropolitan Municipality, Msunduzi Municipality, Stats SA, Department of Environmental Affairs, University of KZN, Institute for Natural Resources, Wildlands Conservation Trust, GroundTruth, and Prime Africa Consultants. We thank the participants for their active engagement and insights.

The work benefited from the input of a Technical Reference Group and South Africa's Strategic Advisory Committee on Ecosystem Accounting. For lists of members and further information about stakeholder engagement linked to the project please see the Stakeholder Engagement Report for the project as a whole.

We thank Lindie Smith-Adao for her careful attention to detail in formatting the many tables in this document.

Acronyms

AEEA	Advancing SEEA Experimental Ecosystem Accounting
CBA	Critical Biodiversity Area
CBD	Convention on Biological Diversity
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DWS	Department of Water and Sanitation
ESA	Ecological Support Area
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
KZN	KwaZulu-Natal (a province of South Africa)
IOCB	Indian Ocean Coastal Belt
LCCS	Land Cover Classification System
LCEU	Land Cover Ecosystem Unit
NLC	National Land Cover
SANBI	South African National Biodiversity Institute
SEEA	System of Environmental-Economic Accounting
SNA	System of National Accounts
Stats SA	Statistics South Africa
UN	United Nations
UNEP	United Nations Environment Programme
UNSD	United Nations Statistics Division

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Executive summary

This discussion document presents the results of South Africa's first pilot set of land and ecosystem accounts, undertaken as part of a global project on Advancing SEEA Experimental Ecosystem Accounting. The purpose of the document includes informing further ecosystem accounting work in South Africa, as well as contributing to the global research agenda on ecosystem accounting.

KwaZulu-Natal (KZN) was selected as a provincial pilot owing to the excellent land cover data in time series that has been developed by the provincial conservation authority, Ezemvelo KZN Wildlife. **The accounts are set out in three parts**:

- Land cover accounts for KZN, based on the System of Environmental-Economic Accounting (SEEA) Central Framework,
- Ecosystem extent accounts for KZN, based on SEEA Experimental Ecosystem Accounting,
- Land accounts for ecosystems in KZN, which integrate the land cover accounts and ecosystem extent accounts to provide information about land cover change in different ecosystem types.

In the first part, **land cover accounts for the periods 2005-2008 and 2008-2011 are presented for KZN**, first using the set of interim land cover classes proposed in the SEEA Central Framework, and then using an alternative set of KZN summary land cover classes that are more ecologically meaningful and that link to socio-economic drivers of change in the KZN landscape (see Table A below or Table 8 in main report). The land cover class with the largest increases over the period 2005-2011, in both absolute and percentage terms, was subsistence agriculture (370 000 ha and 175% respectively). The percentage turnover in land cover for the province as a whole was 23% in the period 2005-2008, dropping to 5% in 2008-2011, with substantially less change across almost all land cover classes in the second period.

In the second part, **ecosystem extent accounts are presented for KZN**, with ecosystem units defined on the basis of 101 vegetation types that have been delineated in KZN, nested within five biomes. Vegetation types have been mapped based on their potential or historical extent prior to major human modification, independently of current land cover. In many cases the current land cover class in an area (for example, irrigated cultivation) bears no relation to the underlying ecosystem unit / vegetation type (which might be, for example, Midlands Mistbelt Grassland). Changes in ecosystem extent are measured by calculating how much of each ecosystem unit / vegetation type falls within the land cover class "Natural" (which includes natural and near-natural areas), in relation to its historical extent.

Ecosystem extent accounts summarised by biome in KZN (see Table B below or Table 13 in main report) show that the largest absolute decline in extent has taken place in the Grassland biome (with a current extent of 2.6 million ha relative to historical extent of 4.6 million ha – a decline of 43%), while the largest percentage decline has taken place in the Indian Ocean Coastal Belt (with a current extent of 0.3 million ha relative to historical extent of 0.9 million ha – a decline of 67%). The decline in extent per biome can be viewed in relation to ecological thresholds that indicate, for example, when loss of ecological functioning may be expected and when loss of species associated with the biome may occur – shown by the ecological function threshold and extinction threshold respectively

in Figure A below (or Figure 17 in the main report). Ecosystem extent accounts reported at the level of the 101 vegetation types in KZN highlight those that have experienced the largest declines in extent, in absolute or percentage terms, many of which form part of the Grassland, Indian Ocean Coastal Belt or Wetland biomes.

In the third part, the **land cover accounts and ecosystem extent accounts are integrated**, in order to provide information about which land cover changes are occurring in which biomes or vegetation types. The results show that subsistence agriculture is the dominant cause of decline in extent in every biome except Forest. In the Indian Ocean Coastal Belt, built-up areas also played a significant role, reflecting the expansion of coastal development. Wetlands are being converted to both subsistence agriculture and dryland cultivation, which is of concern for wetland functioning and the provision of ecosystem services from wetlands (such as water purification and flood regulation).

Land and ecosystem accounts at the level of individual vegetation types can highlight changes in those ecosystem units that are of particular concern from an ecosystem service or biodiversity point of view. Table C (or Table 17 in the main report) shows some examples: Freshwater Wetlands and Alluvial Wetlands are known for their capacity to regulate water quality and quantity; the Southern and Northern Highland Grassland vegetation types fall within a water source area that generates over 90% of the water supply for the greater eThekwini region (the second largest economic centre of South Africa, including the city of Durban); the Subtropical Dune Thicket and KZN Dune Forests offer an important buffering capacity in the event of coastal storms; and the KZN Coastal Belt Grassland and Sandstone Sourveld are examples of important biodiversity that is critically endangered. The account in Table C (or Table 17) offers valuable information that can be used as a starting point for identifying drivers of land cover change that can point towards the most appropriate management or regulatory interventions, and ensure the continued provision of the ecosystem services generated by these ecosystem assets.

Because the accounts are based on spatially detailed information, they can be reported at a range of spatial scales, not just for the province as a whole. For example, for all three sets of accounts, the information can be summarised by local or district municipality, often providing useful additional insights into patterns and trends. See Tables 10 and 11 and Figure 10 in the main report, and Table 24 in the Appendix, for examples of using local municipalities as reporting units for the accounts. It would also be possible to summarise the results for reporting units such as catchments (although these present the challenge that some of them straddle neighbouring provinces), or according to land tenure, for example communally owned land vs privately owned land.

Table A: Physical account for land cover in KZN, using KZN summary land cover classes, 2005-2008 and 2008-2011

Hectares	Natural	Degraded	Fallow lands	Timber plantations	Subsistence agriculture	Dryland agriculture	Irrigated agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dams	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network	No data	Total
Land cover 2005	6 187 163	641 270	43 114	694 126	240 492	251 003	119 380	503 760		66 185	52 467	258 714	3 108	191 937	4 524	76 475	1 420	9 335 137
Total additions to stock	83 733	176 067	26 289	66 319	398 724	67 898	23 290	52 252	3 036	27 494	9 088	54 646	1 509	27 557	1 862	43 569	1 164	
Total reductions in stock	658 180	110 937	3 743	23 070	26 965	10 026	4 163	169 945		8 622	1 208	21 230	375	19 209	350	6 347	126	
Net additions (additions - reductions)	-574 448	65 130	22 546	43 249	371 759	57 872	19 128	-117 692	3 036	18 872	7 880	33 416	1 134	8 348	1 512	37 223	1 037	
Net additions as % of opening land cover	-9	10	52	6	155	23	16	-23		29	15	13	36	4	33	49	73	
Total turnover (reductions + additions)	741 913	287 004	30 032	89 390	425 689	77 924	27 453	222 197	3 036	36 116	10 295	75 875	1 884	46 766	2 212	49 916	1 290	2 128 992
Total turnover as a % of opening land cover	12	45	70	13	177	31	23	44		55	20	29	61	24	49	65	91	23
No land cover change	5 528 983	530 333	39 371	671 055	213 526	240 977	115 217	333 815		57 562	51 259	237 484	2 733	172 728	4 173	70 129	1 293	8 270 641
No land cover change as a % of opening land cover	89	83	91	97	89	96	97	66		87	98	92	88	90	92	92	91	89
Land cover 2008	5 612 716	706 400	65 660	737 375	612 250	308 874	138 507	386 067	3 036	85 056	60 347	292 130	4 243	200 285	6 035	113 698	2 457	9 335 137
Total additions to stock	105	8 003	2 382	5 449	65 963	51 846	4 290	3 634	288	11 234	5 354	47 301	138	8 075	1 146	9 084	17	
Total reductions in stock	126 981	41 474	3 387	4 596	8 051	15 302	9 900	3 759	1 584	1 149	343	6 493	486	450	332	21		
Net additions (additions - reductions)	-126 876	-33 471	-1 005	853	57 912	36 544	-5 610	-125	-1 296	10 084	5 011	40 808	-348	7 625	814	9 063	17	
Net additions as % of opening land cover	-2	-5	-2		9	12	-4		-43	12	8	14	-8	4	13	8	1	
Total turnover (reductions + additions)	127 086	49 477	5 768	10 045	74 014	67 148	14 190	7 392	1 873	12 383	5 697	53 794	623	8 525	1 478	9 106	17	5
Total turnover as a % of opening land cover	2	7	9	1	12	22	10	2	62	15	9	18	15	4	24	8	1	448 616
No land cover change	5 485 734	664 926	62 274	732 779	604 199	293 572	128 608	382 309	1 452	83 907	60 004	285 637	3 757	199 835	5 703	113 677	2 457	98
No land cover change as a % of opening land cover	98	94	95	99	99	95	93	99	48	99	99	98	89	100	95	100	100	9 110 829
Land cover 2011	5 485 839	672 929	64 655	738 228	670 162	345 418	132 898	385 943	1 740	95 140	65 358	332 937	3 894	207 910	6 849	122 761	2 474	9 335 137

Table notes:

- Rehabilitated mines were not identified as a class in their own right in the KZN 2005 land cover dataset, hence the zero value in 2005. The increase in rehabilitated mines from 2005 to 2008 is thus partly a mapping artefact.
- In 2008 and 2011, a distinction was made between plantations (either active or newly clearfelled) and old plantations (which were categorised as fallow land). The increase in fallow land from 2005 to 2008 is thus partly a mapping artefact.

Table B: Ecosystem extent account for biomes in KZN, 1840-2011

Hectares	Grassland	Savanna	Indian Ocean Coastal Belt	Wetland	Forest
Opening balance 1840	4 581 933	3 259 059	893 967	393 718	202 822
Total reductions in stock	1 651 736	840 380	528 754	107 567	18 208
Total reductions as a % of 1840	36	26	59	27	9
Opening balance 2005	2 930 197	2 418 679	365 213	286 151	184 614
Total reductions in stock	277 108	208 607	59 723	18 276	9 792
Total reductions as a % of 1840	6	6	7	5	5
Opening balance 2008	2 653 090	2 210 072	305 490	267 875	174 822
Total reductions in stock	68 092	34 757	11 782	9 082	3 128
Total reductions as a % of 1840	1	1	1	2	2
Opening balance 2011	2 584 998	2 175 315	293 708	258 793	171 694

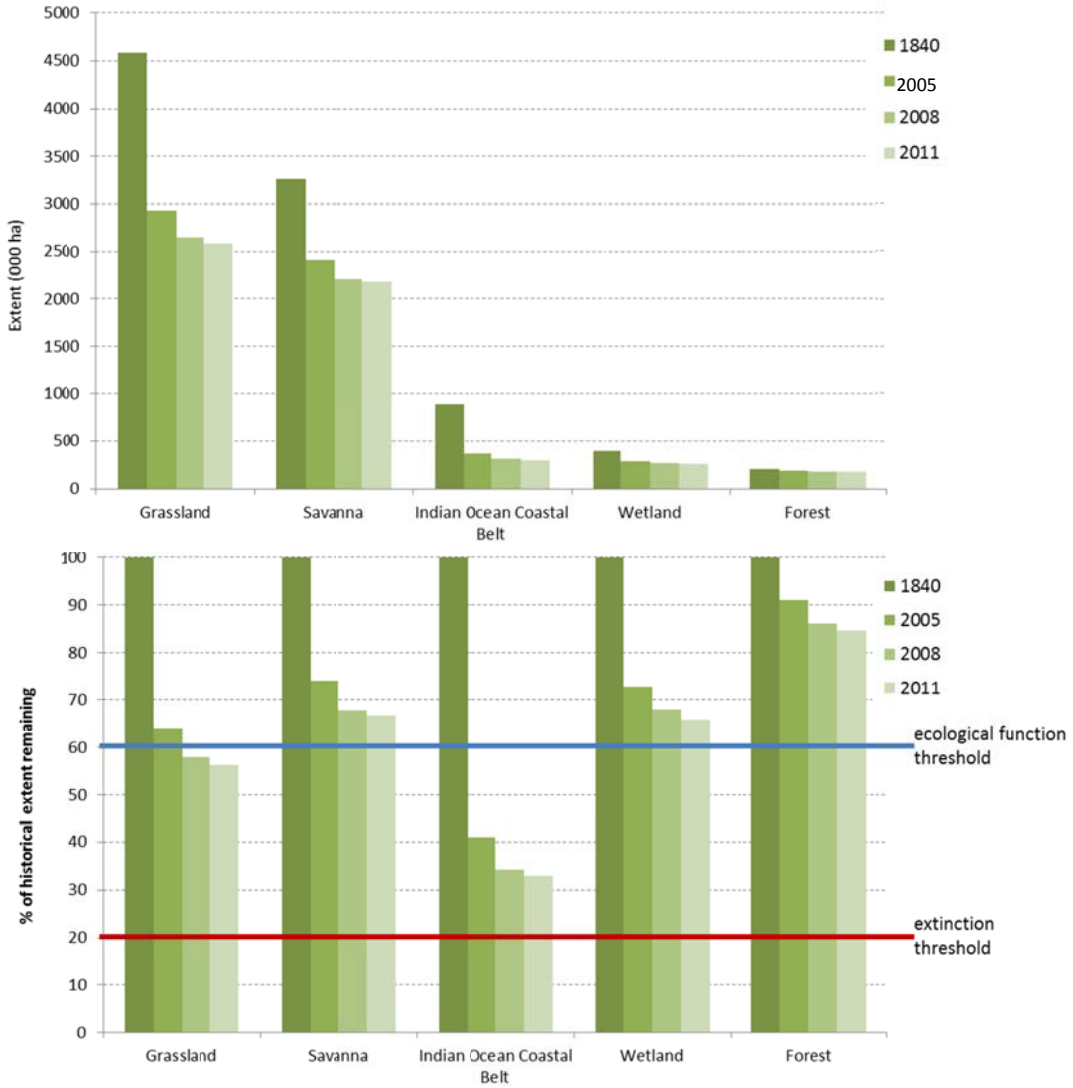

Figure A: Absolute and proportional decline in natural area in the biomes of KZN, relative to historical extent, 1840-2011

Table C: Integrated ecosystem and land cover change matrix for selected vegetation types in KZN, 2005 to 2011

Hectares		Increases (positive numbers) and decreases (negative numbers) from other land cover classes within each vegetation type or wetland type															
Vegetation type	**Biome**	Natural	Degraded	Fallow lands	Plantation	Subsistence agriculture	Dryland agriculture	Irrigated agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dams	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network
Freshwater Wetlands (all)	Wetland	-8336	1039	563	365	3104	2331	548	-1102	-193	-1873	2500	521	-596	594	-206	731
Alluvial Wetlands (all)	Wetland	-18363	-344	775	209	10066	5045	680	-2710	-1961	-7854	11512	1967	-683	864	-828	1589
Southern Drakensberg Highland Grassland	Grassland	-1053	895	0	50	1	30	0	0	0	-32	35	37	1	4	-63	92
Northern Drakensberg Highland Grassland	Grassland	-1744	1685	0	-13	-27	1	0	0	-68	64	-274	350	-28	41	-15	28
Subtropical Dune Thicket	IOCB	-285	293	0	1	1	0	0	-11	0	0	-2	3	-7	8	0	0
KwaZulu-Natal Dune Forests (all)	Forest	-2535	1806	19	438	57	0	0	-218	413	-5	-23	44	-208	-132	215	130
KwaZulu-Natal Coastal Belt Grassland	IOCB	-27056	1190	2501	-31	37574	142	2348	-33535	0	-798	-22303	29021	-57394	62998	-7869	13209
KwaZulu-Natal Sandstone Sourveld	Grassland	-10577	3256	492	873	4047	845	410	-3861	0	-252	-11888	14493	-5800	6879	-2530	3612

Table notes:

- Vegetation types in this table were selected based on the specific contribution they are known to make to biodiversity and ecosystem services.
- Freshwater Wetlands in this table combine 12 different vegetation types from the KZN vegetation map; Alluvial Wetlands combine seven; and KwaZulu-Natal Dune Forest combines two.

On the basis of the three-part approach set out above, the following **principles** for enabling integrated land and ecosystem accounting are suggested:

- **Land cover classes and ecosystem units should be distinct.** Land cover classes are not ecologically meaningful proxies for ecosystem assets, and the identification of ecosystem units should be separated from the identification of land cover classes. Ecosystem units should be delineated based on ecosystem types. Ecosystem types can be mapped and classified based on a range of data representing physical factors (such as geology, soil types, altitude, rainfall) that are important in determining the structural and functional characteristics of ecosystems. If information on species distribution and abundance is available, this is also useful for mapping and classifying ecosystem types and can be used in combination with data on physical factors, but it is not essential. Land cover data may be useful for delineating boundaries between some ecosystem types, but land cover classes and ecosystem types should not be conflated, even if they align in some cases. These ecosystem types should form the basis of ecosystem units for ecosystem accounting. Ecosystem units defined on the basis of ecosystem types (such as vegetation types) provide the ability to link ecosystem units, changes in land cover and metrics for ecosystem service supply with some precision.

- **Land cover classes should link to socio-economic drivers in the landscape.** This usually requires using enhanced land cover data that allows for inclusion of elements of land use in a detailed set of land cover classes. It is also likely to require an iterative process to identify the most suitable way to group detailed land cover classes into a set of summary or high-level classes that are meaningful for a particular socio-economic and ecological context. We recognise this may result in challenges in reaching a standard international land cover classification across all countries, especially a standard high-level classification. However, it may be possible to aim for standard land cover classification at an intermediate or detailed level, allowing countries to group a standard set of detailed land cover classes in various ways for presenting and reporting the accounts, depending on their socio-economic context.

- **As far as possible, land cover classes should link to ecological impact.** Land cover classes are not particularly useful for delineating ecosystem units, but can be a useful proxy for ecosystem condition, especially where no better data on condition exists. This requires that a consistent distinction be maintained between land cover classes that are natural, semi-natural and substantially modified. In other words, as far as possible, a single land cover class should not intentionally mix natural, semi-natural and substantially modified features or areas in the landscape. We recognise that in practice these are not three distinct categories but rather form a continuum, and also that it is sometimes difficult to distinguish between them, especially between natural and semi-natural areas. However, aiming for this distinction and even partly achieving it helps enormously in laying the basis for ecosystem extent and condition accounts and for ecosystem service accounts. Ideally the distinction between natural, semi-natural and substantially modified land cover classes should track all the way through the land cover classification, from the detailed classes to the high-level classes.

For fully integrated land, ecosystem asset and ecosystem services accounts, **several elements are required**:

- Land cover classes that link to socio-economic drivers of change and to ecological impacts,
- Stable ecosystem units based on ecosystem types that have been mapped and classified to reflect ecological characteristics related to composition, structure and function,
- An understanding of how these ecosystem units link to ecosystem services (via their functional characteristics),
- An understanding of how conversion of each ecosystem unit (or groups of similar ecosystem units) from natural to various semi-natural or substantially modified land cover classes impacts on its ability to provide ecosystem services.

Having these elements in place would allow for the construction of an integrated set of accounts for land cover, ecosystem extent, ecosystem condition and ecosystem service supply.

This initial set of land and ecosystem accounts for KZN has been undertaken with a view to informing subsequent development of national land and ecosystem accounts, as well as accounts for other classes of ecosystem assets in South Africa, such as wetlands, rivers, coastal and marine ecosystems. We hope to continue the collaboration between the range of partners involved in this work, including but not limited to SANBI, Stats SA, CSIR, DEA, DWS and Ezemvelo KZN Wildlife.

Priorities for national ecosystem accounting work include:

- *Developing national land and ecosystem accounts*, based on current mapping and classification of national ecosystem types.
- *Developing ecosystem condition accounts* and integrating them with ecosystem extent accounts, as done for river ecosystems as part of this project.
- *Working towards an integrated map of ecosystem types across terrestrial and aquatic realms*, to enable a single integrated set of ecosystem extent accounts nationally. This is a longer term undertaking, which is closely related to ongoing work on the National Ecosystem Classification System, mentioned in Section 4.2.
- *Developing land accounts for key ecological infrastructure features*, such as strategic water source areas, riparian zones, and wetlands.
- *Developing land accounts for strategic biodiversity assets,* such as protected areas and Critical Biodiversity Areas.
- *Developing metrics of ecosystem service supply* for ecosystem types in different ecological condition classes (e.g. natural, semi-natural, substantially modified), which can be used in ecosystem service accounts, especially those linked to water security or food security.
- *Piloting the development of the full set of physical ecosystem accounts,* including extent and condition accounts, as well as ecosystem service generation and use accounts.
- *Linking land, water and ecosystem accounts*, with a view to examining relationships between land use, water use, changes in ecosystems, and the supply and use of ecosystem services, at the scale of municipalities, provinces and catchments as well as nationally.
- *Using ecological indicators from ecosystem accounts together with socio-economic indicators* from national accounts, the Census and other national survey data, to monitor the implementation of Sustainable Development Goals in South Africa.

1. Introduction

This discussion document presents land accounts, ecosystem extent accounts and land accounts for ecosystems for the province of KwaZulu-Natal (KZN) in South Africa (Figure 1, Box 1). As explained in Section 2, KZN was selected as a provincial pilot because of the availability of excellent land cover data over several years for the province. This pilot has been undertaken with a view to replicating land and ecosystem accounts in other provinces and nationally as part of a broader programme of work on environmental and ecosystem accounting. It builds on initial work on national land accounts undertaken by Stats SA in 2004 based on the National Land Cover 1994/5 (Stats SA 2004). Through the work presented in this document, we have attempted to develop a set of principles for enabling the integration of land accounts and ecosystem accounts, which we hope is a useful contribution to the global research agenda on ecosystem accounting.[2]

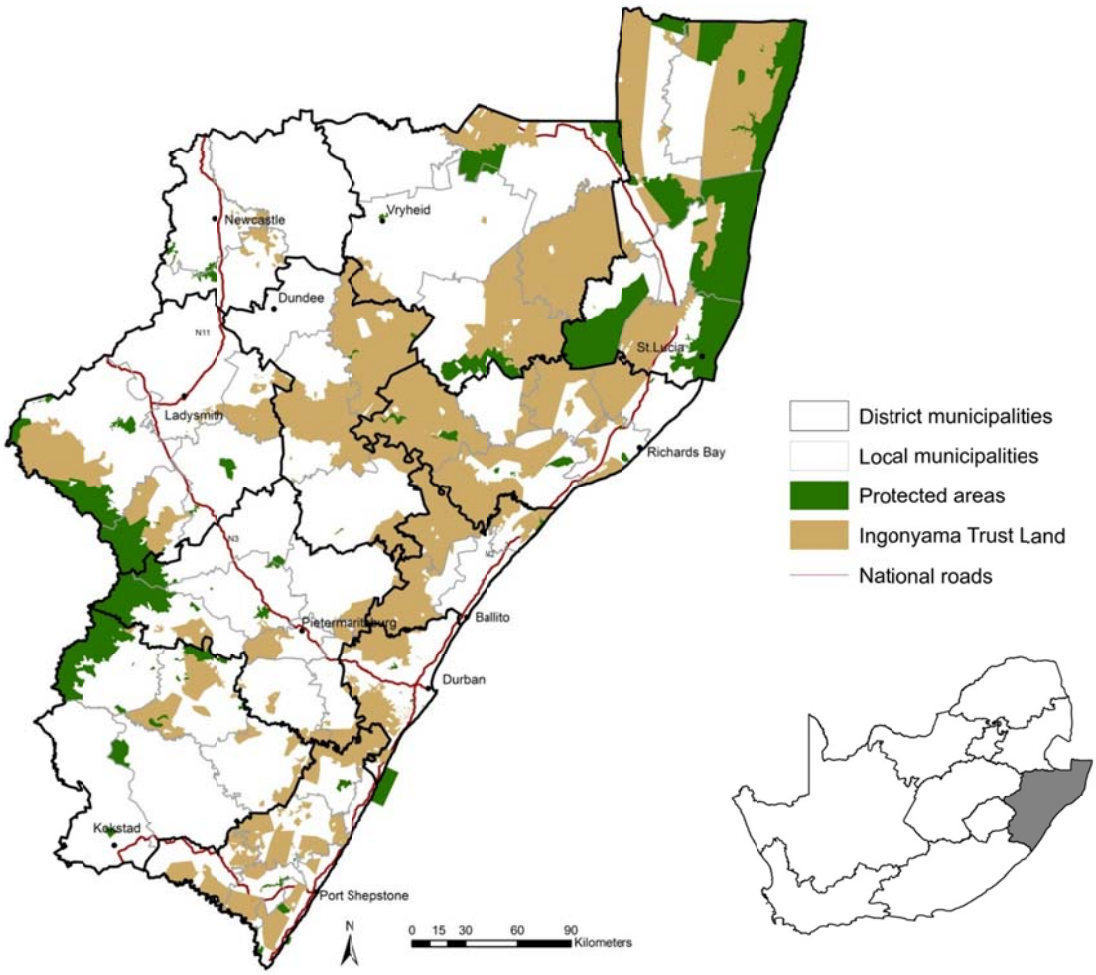

Figure 1: The province of KwaZulu-Natal

[2] The global research agenda is set out in SEEA Experimental Ecosystem Accounting (UN 2014b). This work contributes particularly to the area of research on physical ecosystem accounting (p147-148).

Box 1: KwaZulu-Natal in brief

KwaZulu-Natal (KZN) is one of the nine provinces of South Africa, and stretches from Port Edward in the south to the borders of Swaziland and Mozambique to the north. KZN is approximately 94 000 km^2 and is the country's third smallest province (8% of South Africa's area, roughly the size of Portugal), but it has the second largest population of all provinces and is home to approximately 22% of South Africa's population. A mix of Zulu, Indian, English and Afrikaans traditions give the province a rich cultural diversity. The Ingonyama Trust (a corporate entity established to administer land for the benefit of the Zulu nation) owns 30% of the land in KZN, about three million hectares, occupied by over four million people.

KZN adjoins the warm Indian Ocean in the east – providing many popular beach and coastal tourism opportunities. Along the border with Lesotho in the west is the dramatic Drakensberg mountain range, with several peaks over 3 000 m.

Pietermaritzburg is KZN's capital, but the major port city of Durban is the economic hub of the province. Durban's harbour is the busiest in South Africa and one of the ten largest in the world, handling over 30 million tons of cargo annually. In the interior, Newcastle is well-known for steel production and coal-mining, Estcourt for meat processing, and various areas for mixed agriculture such as vegetable, dairy and stock-farming. Richards Bay, on the north coast, is the centre of operations for South Africa's aluminium industry, while plantation forestry is another major source of income in several areas. The KZN coastal belt yields sugar cane, oranges, bananas, mangoes and other subtropical fruit. Tourism is a critical income generator for KZN.

KZN is a summer rainfall area, with a climate that ranges from extremely hot along the coast in summer, to heavy snow on the mountains in winter. Durban has an average annual rainfall of approximately 1 000 mm, with daytime maximum temperatures averaging 28 °C (82 °F) from January to March, and 23 °C (73 °F) from June to August. Temperatures drops towards the hinterland, and some places may drop below freezing point on winter evenings. The Drakensberg can experience heavy winter snow, with light snow occasionally on the highest peaks in summer. The north coast has the warmest climate and highest humidity.

The province contains rich areas of biodiversity and is located in the Maputaland-Pondoland-Albany biodiversity hotspot. The iSimangaliso Wetland Park and the uKhahlamba Drakensberg Park have been declared World Heritage Sites. Several wetlands of international importance are designated as Ramsar sites, and numerous game reserves host a rich abundance of wildlife. The marine ecology of KZN's coast provides critical fish nursery areas. Ezemvelo KZN Wildlife (Ezemvelo) is the provincial agency mandated to carry out biodiversity conservation and associated activities in the province.

Sources:
https://en.wikipedia.org/wiki/KwaZulu-Natal
http://www.kznonline.gov.za/index.php?option=com_content&view=article&id=82&Itemid=174

The purpose of land accounts is to quantify and track changes in land cover, land use or land ownership, or a combination of these, over time, in order to inform a range of policy, planning and decision-making processes related to the use and management of land and other natural resources. Land provides the physical space within which social and economic activity takes place, and is also a fundamental part of many ecosystems. This means that there is a close link between land accounts and ecosystem accounts. The use of land, including the location of different types of socio-economic

activity, is also a key factor in determining whether development is socially, economically and ecologically sustainable or not. Land and ecosystem accounts can support strategic planning and decision-making about natural resource management and about trade-offs between different land uses, for example in relation to the food-water-energy nexus. They can also provide a powerful set of information and indicators for measuring and reporting on sustainable development.

Land accounts form part of the System of Environmental-Economic Accounting (SEEA), developed by the United Nations as a counterpart to the System of National Accounts (SNA). The SNA focuses on how much is produced, consumed and invested in a country's economy, providing a range of information and indicators to inform macro-economic policy, the most well-known of which is Gross Domestic Product (GDP). The SEEA focuses on interactions between the environment and the economy, providing a set of complementary accounts to the SNA. The SEEA includes a Central Framework, which was adopted by the United Nations Statistical Commission as an international standard in 2012 (UN 2014a), as well as a more recent volume on Experimental Ecosystem Accounting (UN 2014b). The SEEA Central Framework focuses on accounting for individual environmental assets, such as timber, water, minerals and fish, while SEEA Experimental Ecosystem Accounting focuses on accounting for ecosystem assets and ecosystem services. Land is included as a non-produced asset in the SNA, as an environmental asset in the SEEA Central Framework, and also as a core element of ecosystem accounting in SEEA Experimental Ecosystem Accounting. Land accounts are often seen as a bridge between the SEEA Central Framework and SEEA Experimental Ecosystem Accounting. As we will discuss in this document, the ability of land accounts to play this bridging role effectively depends on certain principles being applied in identifying land cover classes and ecosystem units.

The "national accounting approach" has several distinguishing characteristics, described in the technical guidelines for ecosystem accounting that were in draft form at the time of writing (UN 2015a). It implies that measurement efforts are guided by an accounting framework in which concepts are consistently and coherently defined, thereby allowing the pragmatic integration of multiple data sources and methods to develop metrics that provide the best possible estimates of the concept(s) being measured. There is full recognition that data and methods are seldom perfect and change over time, and that as data and methods change and improve, revisions of previously published results will be required. A national accounting approach also implies a focus beyond the local level or an individual sector – the aim is to develop a broad picture that covers the full scope and territory of the concepts concerned.

Importantly, accounting does not necessarily imply quantification or valuation in monetary terms. In both the SEEA Central Framework and SEEA Experimental Ecosystem Accounting, the starting point is to develop accounts in physical terms. As explained in SEEA Experimental Ecosystem Accounting, "A key feature of the SEEA lies in the fact that the organisation of information in physical terms facilitates comparison with economic data even without monetary valuation and thus contributes to analysis from both economic and environmental perspectives" (UN 2014b, p4). Monetary accounts that build on the physical accounts may be appropriate and useful in some instances.

The accounting approach provides a systematic way of gathering and synthesising large amounts of data that can then be used in multiple applications by a variety of users in a range of sectors. Accounts in themselves do not constitute policy advice or policy recommendations – they describe a series of stocks and flows, and how these have changed over time. Because of the consistency and coherence of the accounting approach, accounts can be used to provide indicators, aggregates and other information that may help to identify key policy issues and inform policy responses. The multi-purpose nature of accounts is key – they are not aimed at one particular use or sector but should be able to be used in a range of different contexts. Once-off accounts can be useful, but the real power lies in accounts that are produced regularly to provide consistent information over several accounting periods.

The focus of the land accounts presented here for KZN is on physical accounts of land cover and aspects of land use, not on land ownership or monetary accounts. In addition to physical land accounts, two further sets of accounts are presented: ecosystem extent accounts, and land accounts for ecosystems. The purpose of the document is two-fold:

- To present the pilot accounts for KZN, highlighting key results,
- To explore the link between land accounts and ecosystem accounts in order to draw out principles and potential implications for future environmental and ecosystem accounting.

The document is structured as follows:

- Section 2 gives background on land cover data in South Africa and KZN, as a fundamental dataset for land accounts,
- Section 3 presents physical land accounts for KZN, contrasting the use of the land cover classes suggested in the SEEA Central Framework with the use of an adapted set of land cover classes,
- Section 4 presents extent accounts for ecosystems in KZN at the biome and vegetation type level,
- Section 5 presents land accounts for ecosystems in KZN, bringing together the perspectives of both land accounts and ecosystem extent accounts to analyse land cover change in relation to biomes and vegetation types,
- Section 6 discusses recommendations and priorities for further work.

The intended users of this document include:

- Those who have an interest in development planning or natural resource management in KZN, including municipalities and provincial government departments,
- Those who have an interest in environmental accounting and ecosystem accounting, especially organisations or individuals involved in experimental ecosystem accounting work, in South Africa or elsewhere,
- Those involved in developing national accounts and other officials statistics, especially those with an interest in strengthening the integration between geospatial and statistical information,
- Those involved in producing land cover data, of which land accounts are an important application.

2. Land cover data in South Africa and KwaZulu-Natal

Land cover data is spatial data about the different types of physical and biological cover found on the Earth's surface, whether natural or modified, generally organised into land cover classes.[3] Land cover datasets are essential not only for land accounts, but also have a wide range of other applications, for example in urban planning and natural resource management. Land cover datasets are usually produced based on remotely sensed images (such as satellite images) that are processed and interpreted in various ways. Land cover data can be in vector or raster format, but for the purposes of land accounts raster data is usually most appropriate. A key characteristic of land cover data is its spatial scale. For land cover data in raster format, the spatial resolution is generally between 10m and 1km.

Land use is related to land cover but not equivalent. Land use refers to socio-economic activities, and is often less easy to observe via remote sensing than land cover. Also, while only one type of land cover can exist at a particular spatial point, it is possible to have several different land uses in the same place. This makes land use more difficult to map than land cover; however, in practice land cover datasets often include some elements of land use.

Various attempts have been made at the national, regional and global levels to standardise land cover classes, usually in the form of a hierarchical classification system. Although a single agreed land cover classification system has yet to be achieved, the Food and Agriculture Organization's (FAO's) Land Cover Classification System (LCCS) is commonly used internationally.

South Africa's first National Land Cover (NLC) dataset and classification was developed for the year 1994 (Thompson 1999), with a subsequent update for the year 2000 (Van den Berg et al 2008). However, the methods, spatial scale and land cover classes were not equivalent in 1994 and 2000, meaning that these two NLCs cannot be used as a strict time series.[4]

Subsequent to 2000, several provinces initiated their own land cover projects, given the importance of land cover data for a range of applications. In several cases land cover datasets were developed as part of provincial biodiversity planning processes, as an essential input into spatial biodiversity plans. The province that has invested most heavily in land cover data is KwaZulu-Natal, thanks to the efforts of the provincial conservation authority, Ezemvelo KZN Wildlife. Ezemvelo commissioned three provincial land cover datasets, for 2005, 2008 and 2011, with a fourth one for 2014 underway at the time of writing. At the time the AEEA project was initiated in South Africa, in mid-2014, KZN's time series land cover data was by far the best available data for piloting land accounts.

Key characteristics of the KZN land cover datasets that make them highly useful for land and ecosystem accounting include:

[3] Definition of land cover from the SEEA Central Framework: "Land cover refers to the observed physical and biological cover of the Earth's surface and includes natural vegetation and abiotic (non-living) surfaces" (UN 2014a, p316).

[4] Nevertheless, an analysis of land cover change based on these datasets, generalised to five land cover classes at a broad spatial scale, was done by Schoeman et al (2010).

- Detailed and consistent land cover classes (47) across the three datasets,[5]
- Fine spatial resolution (20m),[6]
- High accuracy levels (see Box 3 in the Appendix for detailed information on accuracy levels),
- Interpretation of remote images drawing on local expert knowledge of landscape structure and function,
- Incorporation of ancillary data such as roads and dams to aid image interpretation,
- Analysis of multiple seasonal images to identify degraded areas, rehabilitated lands and fallow lands.
- Maintenance of the integrity of the time series, e.g. through retrospectively correcting the earlier datasets as technology, data and knowledge improve,[7]

The last four points mean that these are effectively "enhanced" rather than "standard" land cover datasets, incorporating elements of land use and ecological condition.

Figure 2 shows thumbnail images of the KZN land cover for 2005, 2008 and 2011 (Ezemvelo KZN Wildlife 2011, 2013a, 2013b). For the results of detailed spatial analysis of land cover change in KZN enabled by this time series, see Jewitt et al (2015). For technical information about Ezemvelo's land cover data see Ezemvelo KZN Wildlife & GTI (2013).

[5] There are some minor differences. The 2008 and 2011 datasets include five additional classes that were not included in the 2005 dataset. One of these, rehabilitated mines, resulted in some accounting challenges that are mentioned in later sections.

[6] We suggest further work to test whether using land cover data at a coarser resolution (between 30m and 100m) would make a substantial difference from a land accounting point of view.

[7] The 2008 land cover has been fully updated to be consistent with the newer 2011 land cover, resulting in the generation of the 2008 v2 product (Ezemvelo KZN Wildlife 2013a). However, due to funding constraints, the 2005 v3 product (Ezemvelo KZN Wildlife 2011) has not yet been fully updated based on improvements made in the 2011 product. One effect of this is reflected in the wetland categories. In the 2008 v2 and 2011 v1 products, modelled wetland extents were incorporated for the first time; this has still to be done in the 2005 v3 product.

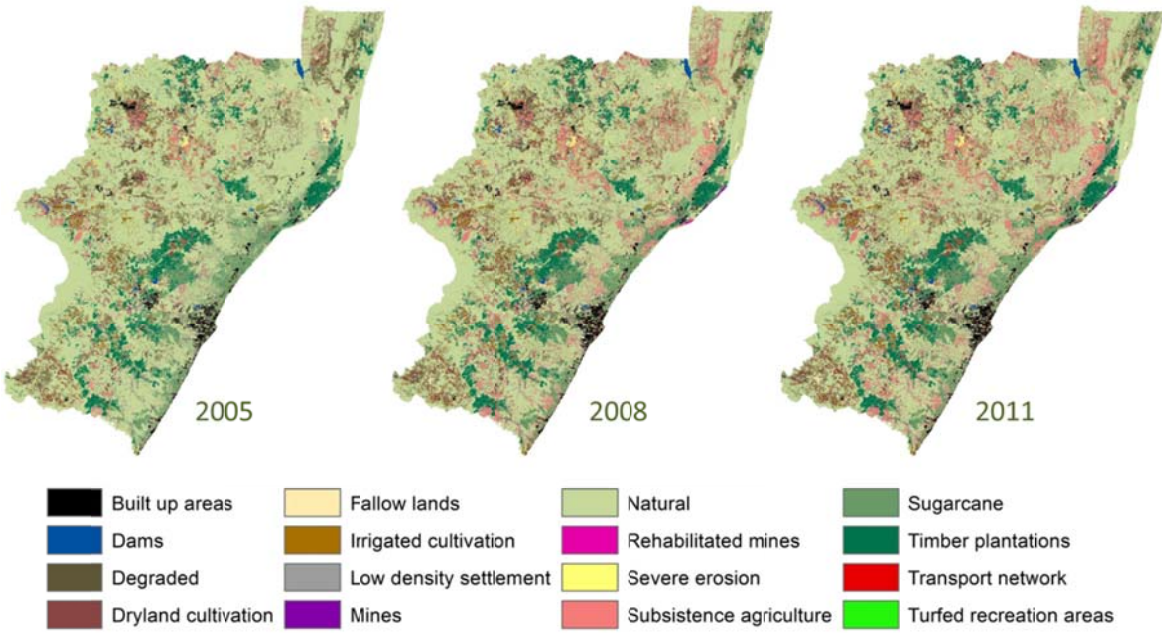

Figure 2: KZN land cover maps for 2005, 2008 and 2011, showing the 16 KZN summary land cover classes used in the accounts

In 2014, GeoTerraImage (GTI), a private company that has produced many of the land cover datasets in South Africa (including KZN's), produced a National Land Cover dataset for 2013-14 (GTI 2015) – the first since the NLC 2000. In 2015, the Department of Environmental Affairs purchased this national dataset with an open licence, enabling unrestricted distribution of the data.

Figure 3 shows an image of the NLC 2013-14. The spatial resolution of the data is 30m and 72 land cover classes have been identified. At the time of writing, GTI was in the process of finalising a National Land Cover for the year 1990, using the same methods, consistent classes[8] and the same resolution as the NLC 2014. When the NLC 1990 becomes available, it will be possible to undertake national land accounts for South Africa for the period 1990 to 2014, drawing on lessons from the pilot work presented here for KZN. As with the KZN land cover data, the NLC 2014 is enhanced land cover that incorporates ancillary data and interpretation of multiple seasonal images. This adds enormous value for land and ecosystem accounts.

[8] The number of classes will be fewer than 72 in the 1990 dataset but the 2014 classes will nest within 1990 classes.

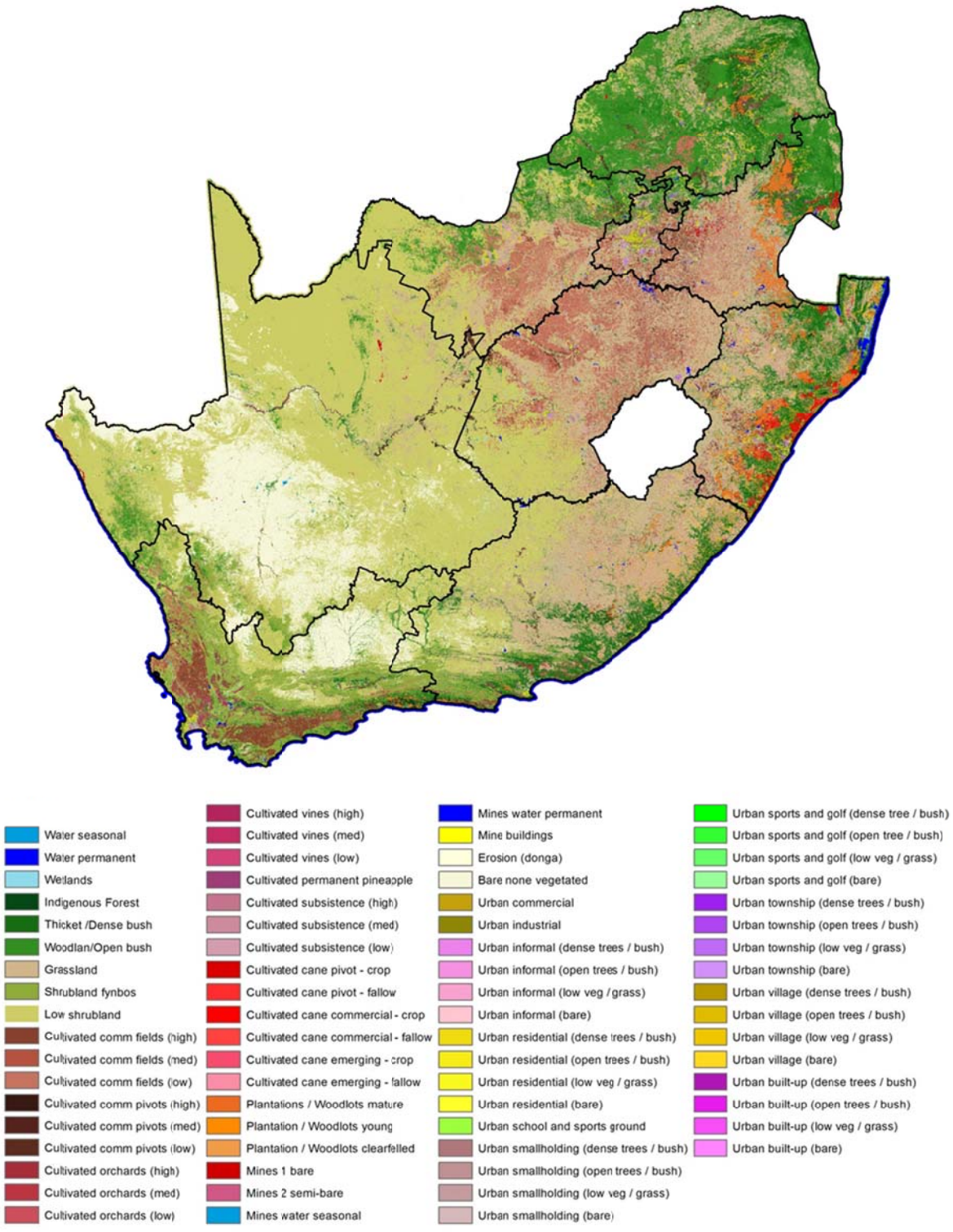

Figure 3: National Land Cover 2013-14 for South Africa

3. Land accounts for KwaZulu-Natal

This section presents land accounts for KZN using two different sets of land cover classes, with a view to informing ongoing discussion on the most suitable land cover classes for land accounts. The first presentation of the accounts uses the interim land cover classes suggested in the SEEA Central Framework. The second uses an adapted set of land cover classes designed to illuminate drivers of landscape change in KZN as well as to lay the basis for integrated land and ecosystem accounts. The accounts are presented in two different table formats: the format suggested in the SEEA Central Framework, and the format used in the European land accounts for 1990-2000 (EEA 2006).

This section consists of four parts:

- A brief summary of key requirements for land accounts from the SEEA Central Framework,
- Land accounts for KZN using land cover classes suggested in the SEEA Central Framework,
- Land accounts for KZN using adapted land cover classes,
- Analysis of land cover trends at the municipal level within KZN.

3.1 Land accounts in the SEEA Central Framework

As noted in Section 1, the SEEA Central Framework deals with accounts for individual environmental assets such as timber, water, minerals or fish. It also deals with land, which is considered "a unique environmental asset that delineates the space in which economic activities and environmental processes take place and within which environmental assets and economic assets are located" (UN 2014a, p174). Land accounts thus require the use of spatial data, unlike the accounts for other environmental assets, which may be produced with no spatial reference other than to the country's territory as a whole.

Chapter 5 of the SEEA Central Framework gives guidance on asset accounts for the various environmental assets, including a section on asset accounts for land. High-level classifications for land use and land cover are suggested, noting that land use and land cover are interrelated but not equivalent, and noting that both of the suggested classifications are interim rather than final. The SEEA's interim classification for land cover is based on the FAO LCCS, and is summarised in Table 1, with more detailed descriptions of the categories or classes[9] provided in Table 19 in the Appendix.

[9] The SEEA Central Framework seems to use the terms "category" and "class" interchangeably with respect to land cover. We have used the term "class" in this document, except in Table 1 which is reproduced exactly from the Central Framework.

Table 1: Land cover classification from the SEEA Central Framework

Category		Basic rule
01	Artificial surfaces (including urban and associated areas)	The category is composed of any type of artificial surfaces.
02	Herbaceous crops	The category is composed of a main layer of cultivated herbaceous plants.
03	Woody crops	The category is composed of a main layer of cultivated tree or shrub plants.
04	Multiple or layered crops	The category is composed of at least two layers of cultivated woody and herbaceous plants or different layers of cultivated plants combined with natural vegetation.
05	Grassland	The category is composed of a main layer of natural herbaceous vegetation with a cover from 10 to 100 per cent.
06	Tree-covered areas	The category is composed of a main layer of natural trees with a cover from 10 to 100 per cent.
07	Mangroves	The category is composed of natural trees with a cover from 10 to 100 per cent in aquatic or regularly flooded areas in salt and brackish water.
08	Shrub-covered areas	The category is composed of a main layer of natural shrubs with a cover from 10 to 100 per cent.
09	Shrubs and/or herbaceous vegetation, aquatic or regularly flooded	The category is composed of natural shrubs or herbs with a cover from 10 to 100 per cent in aquatic or regularly flooded areas with water persistence from 2 to 12 months per year.
10	Sparsely natural vegetated areas	The category is composed of any type of natural vegetation (all growth forms) with a cover from 2 to 10 per cent.
11	Terrestrial barren land	The category is composed of abiotic natural surfaces.
12	Permanent snow and glaciers	The category is composed of any type of glacier and perennial snow with persistence of 12 months per year.
13	Inland water bodies	The category is composed of any type of inland water body with a water persistence of 12 months per year.
14	Coastal water bodies and intertidal areas	The category is composed on the basis of geographical features in relation to the sea (lagoons and estuaries) and abiotic surfaces subject to water persistence (intertidal variations).

(Source: UN 2014a, Annex 1, p299)

Asset accounts are accounts of changes in the stock of an asset over a certain period of time (the accounting period). They are generally structured as **balance sheets**, with an opening balance, additions to and reductions in stock, and a closing balance. The SEEA Central Framework provides an example of a physical account for land cover, reproduced here in Table 2. *Managed expansions or regressions* are increases or decreases in the area of a land cover class that result from human activity, while *natural expansions or regressions* are the result of natural processes. *Reappraisals* are changes that result from improved information.

Another way of viewing the data is in the form of a **matrix** that summarises changes between land cover categories in the accounting period concerned, thereby giving more information about which land cover classes were converted to or from which other classes. The SEEA Central Framework provides an example of a land cover change matrix, reproduced here in Table 3. Only *net changes*

are shown in such a matrix, which may hide important information about changes that are taking place in the landscape. For example, "…when high-quality agricultural land is converted into built-up land, but, at the same time, less productive agricultural land is added through deforestation, total agricultural land cover will not change" (UN 2014a, p180).

Table 2 and Table 3 together make up the core land cover accounts envisaged in the SEEA Central Framework. These tables can be disaggregated or extended to show more detail, depending on which categories or issues are of most relevance for the country or region concerned. They should be seen as a starting point rather than an endpoint.

The SEEA Central Framework notes that the structure of land use accounts would be similar to those for land cover accounts. Land ownership accounts would be structured according to the institutional units in the SNA (for example, government, households, corporations, non-profit institutions).

Table 2: Example of a physical account for land cover from the SEEA Central Framework

(hectares)	Artificial surfaces	Crops	Grassland	Tree-covered area	Mangroves	Shrub-covered areas	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	Coastal water and inter-tidal areas
Opening stock of resources	12 292.5	445 431.0	106 180.5	338 514	214.5	66 475.5	73.5	1 966.5		12 949.5	19 351.5
Additions to stock											
Managed expansion	183.0	9 357.0									
Natural expansion			64.5								1.5
Upward reappraisals			4.5								
Total additions to stock	183.0	9 357.0	69.0								
Reductions in stock											1.5
Managed regression		147.0	4 704.0	3 118.5	9.0	1 560.0	1.5				
Natural regression					1.5	64.5					
Downward reappraisals						4.5					
Total reductions to stock		147.0	4 704.0	3 118.5	10.5	1 629.0	1.5				
Closing stock	12 475.5	454 641.0	101 545.5	335 395.5	204.0	64 846.5	72.0	1 966.5		12 949.5	19 353.0

Note: Crops include herbaceous crops, woody crops, and multiple or layered crops.

(Source: UN 2014a, p179)

Table 3: Example of a land cover change matrix from the SEEA Central Framework

Land cover (hectares)	Opening area	Increases (positive numbers) and decreases (negative numbers) from other land covers											Net change (increase-decrease)	Closing area
		Artificial surfaces	Crops	Grassland	Tree- covered area	Mangroves	Shrub-covered areas	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	Coastal water and inter-tidal areas		
Artificial surfaces	12 292.5		147.0	27.0		9.0							183.0	12 475.5
Crops	445 431.0	-147.0		4 677.0			1 560.0	1.5					9 210.0	454 641.0
Grassland	106 180.5	-27.0	-4 677.0				69.0						-4 635.0	101 545.5
Tree- covered area	338 514.0		-3 118.5										-3 118.5	335 395.5
Mangroves	214.5	-9										-1.5	-10.5	204.0
Shrub- covered areas	66 475.5		-1 560.0	-69.0									-1 629.0	64 846.5
Regularly flooded areas	73.5		-1.5										-1.5	72.0
Sparse natural vegetated areas	1 966.5													1 966.5
Terrestrial barren land														
Permanent snow, glaciers and inland water bodies	12 949.5													12 949.5
Coastal water and inter-tidal areas	19 351.5					1.5							1.5	19 353.0

Note: Crops include herbaceous crops, woody crops and multiple or layered crops.

(Source: UN 2014a, p181)

3.2 Land cover accounts for KZN using land cover classes from SEEA Central Framework

In order to produce land cover accounts according to the template suggested in the SEEA Central Framework, we assigned each of the 47 land cover classes in the KZN Land Cover to one of the 14 SEEA land cover classes, as shown in Table 20 in the Appendix. The land cover account was then constructed for the period 2005 to 2011, and is shown in Table 4. This was done using ArcGIS Spatial Analyst and Excel rather than with specialised ecosystem accounting software, using the KZN land cover data grid at a resolution of 20m.

The account in Table 4 reflects two accounting periods for which data are available: 2005 to 2008, and 2008 to 2011, and is structured according to the example given in the SEEA Central Framework, showing managed expansions and regressions, natural expansions and regressions, and total additions to and reductions in stock. In Table 5, we have presented the account in a different format, borrowing the structure used for Europe's land accounts (EEA 2006). The European format does not distinguish between managed and natural changes in stock, but provides useful additional information in the form of total turnover (additions plus reductions) and the total area for which land cover remained unchanged, in percentage as well as absolute terms.

Table 4: Physical account for land cover in KZN, using land cover classes and table format from the SEEA Central Framework, 2005-2008 and 2008-2011

Hectares	Artificial surfaces	Crops	Grassland	Tree-covered area	Mangroves	Shrub-covered areas	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	Coastal water and inter-tidal areas	No data
Opening stock 2005	**276 045**	**1 808 760**	**3 975 937**	**1 319 391**	**1 198**	**1 352 795**	**126 222**	**258 714**	**116 801**	**52 467**	**45 389**	**1 420**
Additions to stock												
Managed expansion	68 644	521 077	9 630	404 823	204	142 486	28 906	51 401	30 129	9 383	1 759	
Natural expansion												
Upward reappraisal												1 852
Total additions to stock	68 644	521 077	9 630	404 823	204	142 486	28 906	51 401	30 129	9 383	1 759	1 852
Reductions in stock												
Managed regression	20 428	139 686	498 937	183 607	129	377 897	12 894	17 984	14 847	1 501	753	815
Natural regression												
Downward reappraisal		9	53	13		27	16		693	2	1	
Total reductions in stock	20 428	139 694	498 990	183 621	129	377 924	12 911	17 984	15 539	1 503	754	815
Opening stock 2008	**324 261**	**2 190 142**	**3 486 577**	**1 540 593**	**1 273**	**1 117 357**	**142 218**	**292 130**	**131 390**	**60 347**	**46 393**	**2 457**
Additions to stock												
Managed expansion	17 177	101 111	3 234	26 296	1 224	72 167	32 228	46 950	8 217	5 552	805	17
Natural expansion												
Upward reappraisal	6		1								9	
Total additions to stock	17 184	101 111	3 235	26 296	1 224	72 167	32 228	46 950	8 217	5 552	814	17
Reductions in stock												
Managed regression	29	11 591	206 897	28 637		52 207	6 708	6 142	2 042	541	200	
Natural regression												
Downward reappraisal												
Total reductions in stock	29	11 591	206 897	28 637		52 207	6 708	6 142	2 042	541	200	
Opening stock 2011	**341 415**	**2 279 662**	**3 282 916**	**1 538 251**	**2 496**	**1 137 317**	**167 738**	**332 937**	**137 565**	**65 358**	**47 008**	**2 474**

Table notes:

- In the SEEA Central Framework, "forest plantations" are included in tree covered areas, while other forms of plantations (such as coffee, rubber) are included in woody crops. In the account shown here, we have included timber plantations in crops rather than in tree-covered areas. In the South African context, timber plantations consist of exotic species and are ecologically much more similar to woody crops than to indigenous tree-covered areas.
- In the period 2008-2011 we know that no changes in land cover were due to large-scale natural disturbances (such as a storm that expands a floodplain), so all changes are recorded in the account as natural rather than managed. We considered changes such as cultivated land that is left to become fallow as managed changes, because they are the result of human decisions, usually based on economic factors rather than natural factors.

Table 5: Physical account for land cover in KZN, using land cover classes from the SEEA Central Framework and table format from the European land accounts, 2005-2008 and 2008-2011

Hectares	Artificial surfaces	Crops	Grassland	Tree-covered area	Mangroves	Shrub-covered areas	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	Coastal water and inter-tidal areas	No data
Land cover 2005	276 045	1 808 760	3 975 937	1 319 391	1 198	1 352 795	126 222	258 714	116 801	52 467	45 389	1 420
Total additions to stock	68 644	521 077	9 630	404 823	204	142 486	28 906	51 401	30 129	9 383	1 759	1 852
Total reductions in stock	20 428	139 694	498 990	183 621	129	377 924	12 911	17 984	15 539	1 503	754	815
Net additions (additions - reductions)	48 216	381 382	-489 360	221 202	75	-235 439	15 995	33 416	14 590	7 880	1 005	1 037
Net additions as % of opening land cover	17	21	-12	17	6	-17	13	13	13	15	2	73
Total turnover (reductions + additions)	89 073	660 771	508 620	588 443	333	520 410	41 817	69 385	45 668	10 885	2 513	2 667
Total turnover as a % of opening land cover	32	37	13	45	28	38	33	27	39	21	6	187
No land cover change	255 616	1 669 065	3 476 947	1 135 770	1 069	974 871	113 312	240 729	101 262	50 964	44 635	606
No land cover change as a % of opening land cover	93	92	87	86	89	72	90	93	87	97	98	43
Land cover 2008	324 261	2 190 142	3 486 577	1 540 593	1 273	1 117 357	142 218	292 130	131 390	60 347	46 393	2 457
Total additions to stock	17 184	101 111	3 235	26 296	1 224	72 167	32 228	46 950	8 217	5 552	814	17
Total reductions in stock	29	11 591	206 897	28 637	0	52 207	6 708	6 142	2 042	541	200	0
Net additions (additions - reductions)	17 154	89 520	-203 662	-2 341	1 224	19 960	25 520	40 808	6 175	5 011	615	17
Net additions as % of opening land cover	5	4	-6	0	96	2	18	14	5	8	1	0
Total turnover (reductions + additions)	17 213	112 701	210 132	54 933	1 224	124 373	38 937	53 092	10 259	6 093	1 014	17
Total turnover as a % of opening land cover	5	5	6	4	96	11	27	18	8	10	2	0
No land cover change	324 231	2 178 551	3 279 680	1 511 955	1 272	1 065 150	135 509	285 987	129 348	59 806	46 194	2 457
No land cover change as a % of opening land cover	100	99	94	98	100	95	95	98	98	99	100	100
Land cover 2011	341 415	2 279 662	3 282 916	1 538 251	2 496	1 137 317	167 738	332 937	137 565	65 358	47 008	2 474

The account shown in Table 4 highlights that:

- The biggest additions to stock in absolute terms were to crops. Other big additions were to tree covered areas and shrub covered areas.
- The biggest reductions in stock in absolute terms were to grassland and shrub covered areas.
- The changes in stock, both additions and reductions, were in general larger in the first period (2005-2008) than in the second period (2008-2011).
- Natural expansion or regression in land cover classes was negligible – almost all expansion and regression was managed i.e. the result of human intervention. Where land has been left to become fallow (e.g. old fields or old timber plantations), we have considered these managed changes in the sense that a human decision was made no longer to cultivate the land.

The account shown in Table 5 again highlights that the area of land under crops increased substantially, with net additions of over 470 000 ha over the two periods combined. Tree covered areas increased in extent by 220 000 ha, while grassland and shrub covered areas had large net decreases in extent (490 000 ha and 230 000 ha respectively).

The biggest net percentage changes in 2005-2008 were in the classes crops (21% increase), tree covered areas (17% increase), artificial surfaces (17% increase) and shrub covered areas (17% decrease). In the 2008-2011 period, sparse natural vegetated areas increased substantially (14%).[10]

The inclusion in Table 5 of rows showing total turnover (i.e. additions plus reductions) is useful, as looking only at net change can mask large changes. A small net change in a particular land cover class might hide the fact that there were nevertheless large additions and reductions in that class that cancelled each other out. High turnover helps to indicate land cover classes in which there was substantial conversion to and from other classes, irrespective of whether the net change was large or small. High turnover combined with a small net change indicates that although the total area of that land cover class remained quite stable, there were probably locational shifts – the spatial distribution of the land cover class may have changed.

As discussed in Section 3.1, a balance sheet showing additions to and reductions in stock can be complemented by a matrix showing changes between different land cover classes. Such a matrix for KZN is shown in Table 6.[11] Reading along a particular row gives information about increases (positive numbers) or decreases (negative numbers) from other land cover classes. For example, the row for crops shows that 9 923 ha of cropland was converted to artificial surfaces, and 2 602 ha of cropland was converted from regularly flooded areas.

[10] The large increases in the area of mangroves and regularly flooded areas are the result of changes in the way these features were mapped, which have not yet been fully reflected in the earlier datasets.

[11] Our experience in presenting these accounts to potential users is that there is often confusion about how to read the matrix, and some of them have suggested that calling it something other than a matrix might help. In the European land accounts, information about changes between land cover classes is structured slightly differently and is called a flow account. For this discussion document we have decided to keep the matrix format from the SEEA Central Framework and refer to it as a matrix, but in future work we would like to explore alternative ways to present this information.

Table 6: Land cover change matrix for KZN, using land cover classes from the SEEA Central Framework, 2005-2011

		Increases (positive numbers) and decreases (negative numbers) from other land cover classes													
Hectares	Land cover 2005	Artificial surfaces	Crops	Grassland	Tree covered area	Mangroves	Shrub covered areas	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	Coastal water and inter-tidal areas	No data	Net change	Land cover 2011
Artificial surfaces	276 045	68 617	-2 856	1 465	-1 992	-9	-387	43	445	5	5	38	-3	65 371	341 415
Crops	1 808 760	-9 923	518 831	9 748	-31 393	-2	-11 245	2 602	-6 377	-721	-539	-72	-6	470 902	2 279 662
Grassland	3 975 937	-31 467	-341 977	-14 101	-125 399	-7	-106 271	-19 677	-28 175	-22 468	-3 333	-63	-85	-693 022	3 282 916
Tree covered area	1 319 391	-6 163	-94 049	-37 212	403 896	-38	-31 227	-3 426	-7 785	-4 115	-854	-143	-24	218 861	1 538 251
Mangroves	1 198	2		2	880	175	3	150		-2		90		1 299	2 496
Shrub covered areas	1 352 795	-5 158	-84 862	-9 421	-244 018	-10	142 125	-4 192	-6 518	-2 601	-713	-56	-55	-215 478	1 137 317
Regularly flooded areas	126 222	-288	-2 229	25 879	-4 046	-105	630	25 023	-12	240	-3 200	-286	-90	41 515	167 738
Sparse natural vegetated areas	258 714	-15 026	11 147	21 015	1 721		5 281	140	48 875	887	151	34	-1	74 224	332 937
Terrestrial barren land	116 801	-616	-4 436	-121	50		808	-1 448	-469	29 196	-77	-1 019	-1 105	20 764	137 565
Permanent snow, glaciers and inland water bodies	52 467	34	465	2 786	456		309	213	19	49	8 563	-2		12 891	65 358
Coastal water and inter-tidal areas	45 389	-17	-24	11	-142	-3	1	588	-2	221	-2	1 471	-482	1 619	47 008
No Data	1 420	6	-9	-52	-13		-27	-16		-693	-2	8	1 852	1 054	2 474

Table note:

- Reading along a particular row gives information about increases (positive numbers) or decreases (negative numbers) from other land cover classes.

The matrix in Table 6 confirms that crops are a big driver of landscape change in KZN. However, Table 4, Table 5 and Table 6 provide relatively limited insight into the full suite of drivers of landscape change in the province, from either a socio-economic or an ecological point of view, as many of these drivers are obscured within and across the land cover classes. This is discussed in more detail below and a set of adapted land cover classes is proposed.

3.3 Land cover accounts for KZN using adapted land cover classes

The land cover classes suggested in the SEEA Central Framework provide limited insight into the nature and causes of landscape change in KZN, for two main reasons:

- With the exception of cultivation, *it is difficult to link the land cover classes to socio-economic drivers of change*, because there might be several drivers of landscape change within a land cover class, and a single driver of landscape change might straddle two classes in combination with other drivers. For example, there is rapid expansion of low density settlement in many rural areas in KZN. Based on the rules and descriptions for the LCCS classes used in the SEEA Central Framework, low density settlement falls within "sparse natural vegetated areas", which makes it difficult to distinguish low density settlement from areas that have become sparsely vegetated (degraded) as a result of other drivers of change or from areas that are naturally sparsely vegetated.
- *Some of the land cover classes include types of land cover with widely differing ecological impacts. Natural, semi-natural and substantially modified areas are often mixed in one class*. For example, "tree-covered areas" could include natural forests, areas invaded by invasive alien trees (semi-natural) and exotic timber plantations (substantially modified).[12] The class "inland water bodies" includes natural water bodies as well as human-made dams, which have vastly different ecological impacts.

By using land cover classes that link more explicitly to socio-economic drivers of landscape change and that distinguish consistently between degrees of ecological impact, it is possible for land cover accounts to provide more useful information. To achieve this, we reallocated the 47 detailed classes identified in the KZN land cover to an adapted set of 16 KZN summary land cover classes. The adapted set of classes was devised through an iterative process based on a combination of prior knowledge about key changes taking place in the landscape and testing different groupings of land cover classes to see which best illuminated trends and issues.

The KZN summary land cover classes, which reflect a combination of land cover and land use, are listed in Table 7, also showing which detailed classes from the KZN land cover fall within each summary class. Descriptions of the detailed land cover classes are provided in Table 21 in the Appendix. The ability to distinguish some of these classes relies on the fact that the KZN land cover datasets are enhanced, for example by the incorporation of ancillary data, as explained in Section 2.

[12] For the accounts shown in Section 3.2 we chose to allocate timber plantations to the land cover class "woody crops" but according to the rules and descriptions for the LCCS classes they fall within "tree-covered areas" (see table note below Table 4).

Table 7: KZN summary land cover classes, showing relationship with KZN detailed land cover classes

KZN summary land cover class		KZN detailed land cover classes	
01	Natural*	1	Water (natural)
		4	Wetlands
		5	Wetlands – mangrove
		18	Forest (indigenous)
		19	Dense thicket & bush (70 – 100 % cc)
		20	Medium bush (< 70% cc)
		21	Woodland & Wooded Grassland
		22	Bush Clumps / Grassland
		23	Grassland
		24	Bare sand
		32	Bare rock
		33	Alpine grass-heath
		37	Water (estuarine)
		38	Water (sea)
		39	Bare sand (coastal)
		40	Forest glade
02	Degraded	25	Degraded forest
		26	Degraded bushland (all types)
		27	Degraded grassland
03	Fallow lands	28	Old Fields (previously grassland)
		29	Old Fields (previously bushland)
		44	Old plantation- high vegetation
		45	Old plantation - low vegetation
04	Timber plantations	2	Plantation
		3	Plantation - clear-felled
05	Subsistence agriculture	15	Cultivation, subsistence, dryland
06	Dryland cultivation	7	Orchards - permanent, dryland, cashew nuts
		8	Orchards - permanent, dryland, pineapples
		16	Cultivation, commercial, annual crops, dryland
07	Irrigated cultivation	6	Orchards - permanent, irrigated, bananas and citrus
		17	Cultivation, commercial, annual crops, irrigated
08	Sugarcane	9	Sugarcane, commercial, irrigated & dryland
		10	Sugarcane, semi-commercial, emerging farmer, irrigated & dryland
09	Rehabilitated mines	46	Rehabilitated mines - high vegetation
		47	Rehabilitated mines - low vegetation
10	Severe erosion	31	Erosion
11	Dams	36	Water (dams)
12	Low density settlement	14	Low density settlements
		30	Smallholdings
13	Turfed recreation areas	13	Golf courses (also includes golf estates, sports fields, racetracks)
14	Built-up areas	12	Built-up / dense settlement
15	Mines	11	Mines and quarries
16	Transport network	34	KZN national roads
		35	KZN main & district roads
		42	KZN railways
		43	Airfields

* Class 01 Natural is likely to include some areas that are no longer natural or near-natural from an ecological point of view, and that should ideally be allocated to class 02 Degraded. For example, areas with woody invasive alien plants can be difficult to distinguish from natural vegetation in the interpretation of satellite images, and may be mistakenly identified as natural (especially in detailed classes 19 and 20). Other forms of mild to moderate degradation, for example as a result of over-grazing, can also be difficult to identify based on satellite images and such areas may mistakenly be classed as natural rather than degraded.

The main differences between the land cover classes in the SEEA Central Framework and the adapted KZN summary land cover classes are:

- There is a consistent distinction in the KZN summary land cover classes between natural, semi-natural and substantially modified areas, which are never mixed within a single class. In other words, land cover classes are defined in such a way that they can be linked to ecological condition. The advantages of taking this approach are discussed further in Sections 4 and 5.
- Degraded areas are identified as a class in their own right rather than subsumed under various other categories.
- Within the Natural and Degraded classes there is no attempt to distinguish between different ecosystem types (such as grassland or shrubland) – this is left for mapping of ecosystem types. As discussed in Section 4, there are more ecologically sound ways to map ecosystem types than using land cover data as a starting point.
- Severe erosion is identified as a class in its own right as it associated with complete loss of most regulating ecosystem services.
- Commercial agriculture is distinguished from subsistence agriculture as the social and economic dynamics and ecological impacts of the two are very different.
- Dryland cultivation is distinguished from irrigated cultivation as the impacts on ecosystem services differ vastly, especially in terms of water quality and quantity.
- Sugarcane is identified as a class in its own right, rather than subsumed under other cultivation categories, as is subject to different economic dynamics from many other crops and has particular ecological impacts. It includes both irrigated and dryland sugarcane. Sugarcane is also historically one of the province's major commodities.
- Fallow lands are identified as a class in their own right, rather than subsumed under grasslands (which they usually resemble on a satellite image), because they are ecologically very different from grasslands that have never been cultivated or planted (especially in terms of species composition), and will also most likely return to crops or plantations should farmers have additional money and/or water available.
- Mines are identified as a class in their own right rather than subsumed under artificial surfaces, because although they have a small spatial footprint they have a large ecological impact, and are subject to different dynamics from other artificial surfaces such as urban areas.
- Rehabilitated mines are identified as a class in their own right rather than subsumed under natural or degraded. Even if the rehabilitation is successful these areas seldom regain the structural and functional characteristics of natural vegetation. A case might be made for subsuming rehabilitated mines under degraded areas, but it is useful to be able to monitor the extent of mine rehabilitation, which is subject to different dynamics from the rehabilitation of other degraded areas (such as catchments that are overgrazed or infested by invasive alien plants).
- Inland water bodies are not identified as a class in their own right. Natural inland water bodies such as rivers and wetlands are subsumed under the class Natural, and dams are identified as a class in their own right. This is because land cover datasets are generally poor at identifying natural inland water bodies – rivers are linear features that are not picked up well in raster data and the majority of South Africa's wetlands are seasonal and thus difficult to identify based on

remote images. We prefer to map rivers and wetlands separately using other methods to identify them (see Section 4).[13]

- Dams are identified as a class in their own right rather than grouped with inland water bodies as they have large ecological impacts, especially on natural inland water bodies, and the number and extent of dams is changing rapidly.
- Low density settlement (Figure 4) is identified as a class in its own right as it is subject to different social and economic dynamics and has different ecological impacts from urban areas. In KZN, low density settlement tends to be closely spatially related to subsistence agriculture (Figure 5), so there could be an argument for subsuming it under subsistence agriculture, but we decided to keep the two separate in case this relationship diverges in future.
- Turfed recreation areas (such as golf courses, golf estates, sports fields and racetracks) are identified as a class in their own right rather than subsumed under built-up areas, because although they are usually associated with built-up areas, their ecological impact is substantially different from the hard surfaces that characterise the bulk of built-up areas. We recognise that this might be seen as unnecessary splitting given their small spatial footprint; however, this split is likely to become important when it comes to assessing the impact of different land cover classes on the generation of ecosystem services for ecosystem service accounts.
- The transport network is identified as a class in its own right rather than subsumed under artificial surfaces because although its footprint is small it is increasing rapidly and is a major driver of a range of associated changes in the landscape – the expanding transport network opens up new areas of the province to land uses that would previously not have been possible or viable.

Table 8 presents physical land cover accounts using the KZN summary land cover classes. We have chosen to use the table format from the European land accounts, as it provides useful information about turnover and percentage changes. Physical land cover accounts using the KZN summary land cover classes in the format suggested in the SEEA Central Framework are provided in Table 23 in the Appendix. The results in terms of percentage change per land cover class are summarised graphically in Figure 6.

[13] Ultimately we should aim to include river channels and all wetlands in an integrated map of ecosystem units for the country, but this ideal has not yet been achieved, as discussed in 4.2.

Figure 4: An example of low density settlement in KZN
(Photo: John Craigie, Ezemvelo KZN Wildlife)

Figure 5: An example of subsistence agriculture, with associated low density settlement, in KZN
(Photo: John Craigie, Ezemvelo KZN Wildlife)

Table 8: Physical account for land cover in KZN, using KZN summary land cover classes, 2005-2008 and 2008-2011

Hectares	Natural	Degraded	Fallow lands	Timber plantations	Subsistence agriculture	Dryland agriculture	Irrigated agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dams	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network	No data	Total
Land cover 2005	6 187 163	641 270	43 114	694 126	240 492	251 003	119 380	503 760		66 185	52 467	258 714	3 108	191 937	4 524	76 475	1 420	9 335 137
Total additions to stock	83 733	176 067	26 289	66 319	398 724	67 898	23 290	52 252	3 036	27 494	9 088	54 646	1 509	27 557	1 862	43 569	1 164	
Total reductions in stock	658 180	110 937	3 743	23 070	26 965	10 026	4 163	169 945		8 622	1 208	21 230	375	19 209	350	6 347	126	
Net additions (additions - reductions)	-574 448	65 130	22 546	43 249	371 759	57 872	19 128	-117 692	3 036	18 872	7 880	33 416	1 134	8 348	1 512	37 223	1 037	
Net additions as % of opening land cover	-9	10	52	6	155	23	16	-23		29	15	13	36	4	33	49	73	
Total turnover (reductions + additions)	741 913	287 004	30 032	89 390	425 689	77 924	27 453	222 197	3 036	36 116	10 295	75 875	1 884	46 766	2 212	49 916	1 290	2 128 992
Total turnover as a % of opening land cover	12	45	70	13	177	31	23	44		55	20	29	61	24	49	65	91	23
No land cover change	5 528 983	530 333	39 371	671 055	213 526	240 977	115 217	333 815		57 562	51 259	237 484	2 733	172 728	4 173	70 129	1 293	8 270 641
No land cover change as a % of opening land cover	89	83	91	97	89	96	97	66		87	98	92	88	90	92	92	91	89
Land cover 2008	5 612 716	706 400	65 660	737 375	612 250	308 874	138 507	386 067	3 036	85 056	60 347	292 130	4 243	200 285	6 035	113 698	2 457	9 335 137
Total additions to stock	105	8 003	2 382	5 449	65 963	51 846	4 290	3 634	288	11 234	5 354	47 301	138	8 075	1 146	9 084	17	
Total reductions in stock	126 981	41 474	3 387	4 596	8 051	15 302	9 900	3 759	1 584	1 149	343	6 493	486	450	332	21		
Net additions (additions - reductions)	-126 876	-33 471	-1 005	853	57 912	36 544	-5 610	-125	-1 296	10 084	5 011	40 808	-348	7 625	814	9 063	17	
Net additions as % of opening land cover	-2	-5	-2		9	12	-4		-43	12	8	14	-8	4	13	8	1	
Total turnover (reductions + additions)	127 086	49 477	5 768	10 045	74 014	67 148	14 190	7 392	1 873	12 383	5 697	53 794	623	8 525	1 478	9 106	17	5
Total turnover as a % of opening land cover	2	7	9	1	12	22	10	2	62	15	9	18	15	4	24	8	1	448 616
No land cover change	5 485 734	664 926	62 274	732 779	604 199	293 572	128 608	382 309	1 452	83 907	60 004	285 637	3 757	199 835	5 703	113 677	2 457	98
No land cover change as a % of opening land cover	98	94	95	99	99	95	93	99	48	99	99	98	89	100	95	100	100	9 110 829
Land cover 2011	5 485 839	672 929	64 655	738 228	670 162	345 418	132 898	385 943	1 740	95 140	65 358	332 937	3 894	207 910	6 849	122 761	2 474	9 335 137

Table notes:

- Rehabilitated mines were not identified as a class in their own right in the KZN 2005 land cover dataset, hence the zero value in 2005. The increase in rehabilitated mines from 2005 to 2008 is thus partly a mapping artefact.
- In 2008 and 2011, a distinction was made between plantations (either active or newly clear-felled) and old plantations (which were categorised as fallow land). The increase in fallow land from 2005 to 2008 is thus partly a mapping artefact.

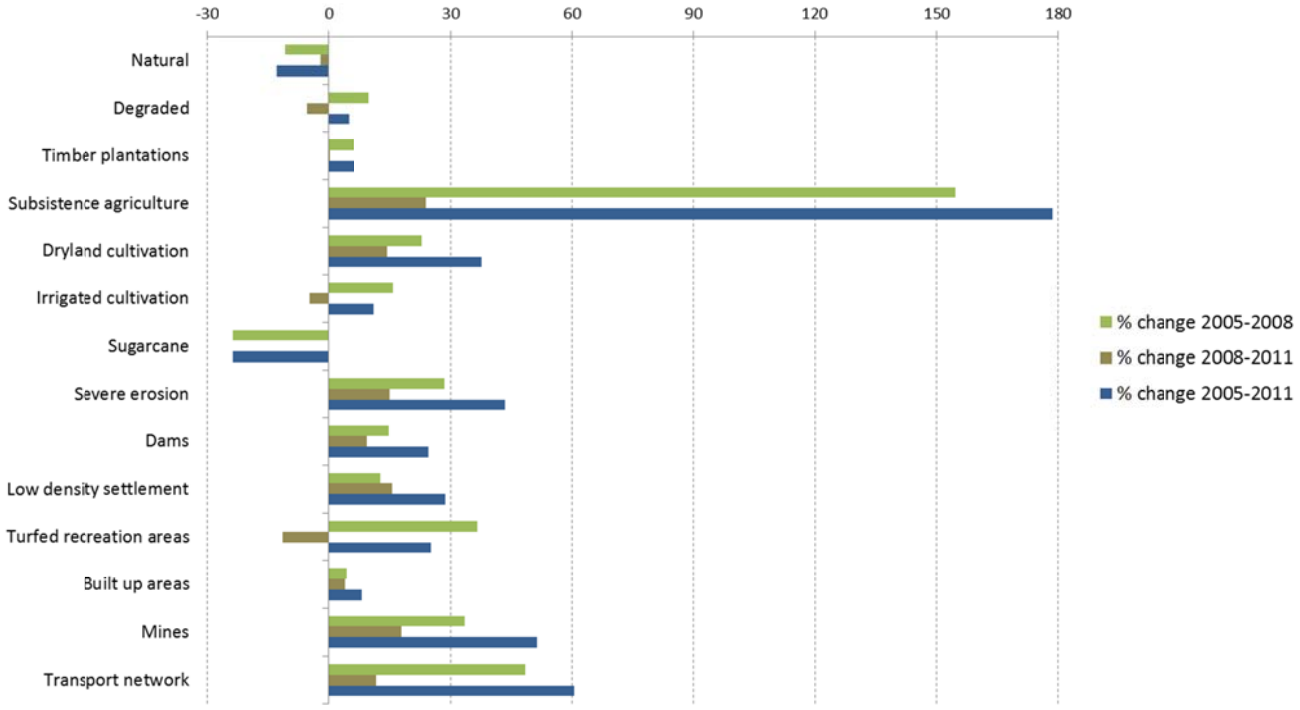

Figure 6: Percentage change per summary land cover class in KZN, 2005-2011

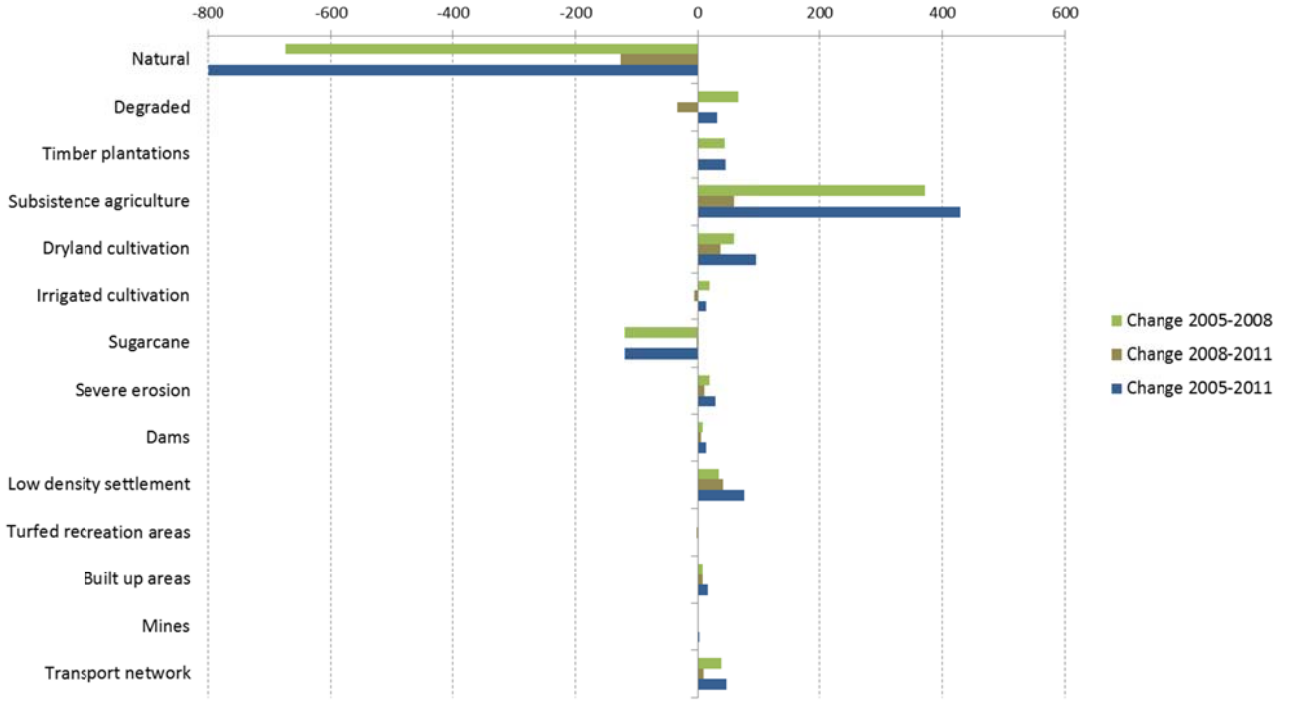

Figure 7: Absolute change per summary land cover class in KZN, 2005-2011

Table 8, Figure 6 and Figure 7 show clearly that the land cover class that expanded most between 2005 and 2011, in absolute and percentage terms, was subsistence agriculture. The area of land under subsistence agriculture increased by over 175% or 370 000 ha in this period. Subsistence agriculture tends to be undertaken by rural or peri-urban low-income households, and is often socio-economically and spatially linked to low density settlement, often in areas that are poorly serviced with formal infrastructure, for example for water and sanitation. It plays a vital role in supporting rural livelihoods, in the context of persistent, massively high unemployment.[14] Unplanned expansion of subsistence agriculture and associated low density settlement can lead to degradation, erosion and water quality impacts, with a resulting decrease in agricultural potential.

The next biggest expansions in absolute terms between 2005 and 2011 were in dryland (rain-fed) cultivation (approximately 57 000 ha) and degraded areas (approximately 65 000 ha). As shown in the land cover matrix below (Table 9), increases in dryland cultivation came both from the conversion of natural vegetation to cultivation, and from irrigated cultivation changing to dryland cultivation. It may be that farmers will revert to irrigation should their economic circumstances and/or water availability improve. The ecosystem impacts of dryland cultivation are substantial, for example on sediment retention, but less than those of irrigated cultivation, which has a bigger impact on water quantity and quality.

The expansion of degraded areas is of concern, along with the increase of more than 40% in severely eroded areas. The capacity of degraded areas to provide ecosystem services is reduced, while for severely eroded areas it has been almost completely lost, as the ecological functioning of these areas has been severely compromised.

The biggest regression in absolute terms was in natural areas, which decreased by approximately 670 000 ha (11%), a large portion of which was converted to subsistence agriculture or dryland cultivation. The biggest regression in percentage terms was in sugarcane, which decreased by nearly 25% (approximately 117 000 ha), mostly in the period 2005 to 2008.

The analysis of percentage changes summarised in Figure 6 is useful because it allows for the identification of classes that may have a small spatial footprint in and of themselves but that either have large ecological impacts (such as mines) or help to drive other changes in the landscape (such as the transport network and dams).

The area under mines increased by just over 50%, to nearly 9 000 ha. Although the direct spatial footprint of mines remains quite small, the footprint of their social-ecological impact is often much larger, especially related to water, for example through downstream impacts on water quality.

The transport network increased by over 60% (approximately 46 000 ha) and the area under dams by nearly 25%. The rapid expansion of the transport network, mainly in the form of roads in South Africa, is likely to open up new areas for a range of forms of development, while new dams may

[14] Narrow unemployment (counting only those actively seeking work) is around 25% in South Africa; broad unemployment (including discouraged work seekers) is around 40%. Unemployment rates tend to be even higher in rural areas.

enable expansion of agriculture and settlements. Close attention to the location of new roads and dams can help to ensure that they are appropriately placed to maximise development opportunities and to avoid degradation or other changes in the landscape that will impact negatively on human well-being.

Another big increase in percentage terms was in fallow land (52%). Increases in fallow land may be reversed if farmers decide to re-cultivate or forestry companies decide to re-plant.

The rate of change slowed for all land cover classes in the second time period (2008-2011) relative to the first time period (2005-2008), except for low density settlement, for which the rate of change increased slightly, and built-up areas, which stabilised.

Perhaps of most interest in this account are the shaded rows in Table 8, which give turnover as a percentage of opening land cover and percentage of opening stock for which land cover remained unchanged, especially the percentages for the province as a whole in the last column. *These two indicators, percentage turnover in land cover and percentage land cover unchanged, together provide a good sense of the degree or stability or change in land cover for the province as a whole,* and are shown graphically in Figure 8. In the period 2005-2008 there was much more change in land cover, with 23% turnover and 89% of land cover remaining unchanged, compared with the period 2008-2011, in which turnover dropped to 5% and the proportion of land that had the same cover at the start and end of the period was much higher at 98%. This suggests substantial changes in socio-economic dynamics between the two periods – for more on this see Jewitt et al (2015).

We suggest that percentage turnover and percentage land cover unchanged provide useful indicators of overall levels of land cover change and that these would be useful headline indicators to extract from land accounts, to compare across provinces as well as over time for each province and the country as a whole. As discussed below, these indicators could also be analysed at the sub-provincial level, for example for district or local municipalities.

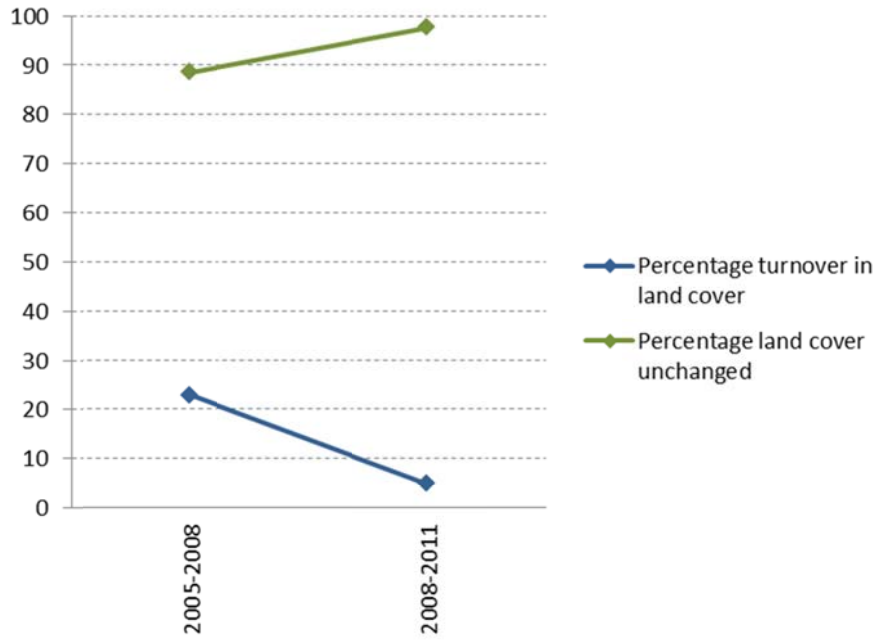

Figure 8: Trends in percentage turnover in land cover and percentage land cover unchanged in KZN, 2005-2008 and 2008-2011

Complementing Table 8, Table 9 presents a land cover change matrix for KZN for the period 2005 to 2011, using the KZN summary land cover classes. The land cover change matrix is useful for analysing changes between land cover categories. As explained in Section 3.2, reading along a particular row gives information about increases (positive numbers) or decreases (negative numbers) from other land cover classes.

Table 9: Land cover change matrix for KZN, using KZN summary land cover classes, 2005-2011

		Increases (positive numbers) and decreases (negative numbers) from other land cover classes																	
Hectares	Opening balance (2005)	Natural	Degraded	Fallow lands	Timber plantations	Subsistence agriculture	Dryland agriculture	Irrigated agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dams	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network	No data	Closing balance (2011)
Natural	6 187 163	83 733	-169627	-22 168	-61 752	-234 419	-54 833	-10 154	-35 682	-2 179	-17 214	-7 653	-32 702	-363	-14 343	-1 409	-21 682	-98 875	5 485 839
Degraded	641 270	4 207	172 942	-3 604	-1 213	-102 496	-9 956	-870	-3 361	1 446	-9 775	-406	-9 666	-41	-752	-129	-4 666	-3	672 929
Fallow lands	43 114	-774	-76	26 156	-13	-1 831	852	-59	-2 184		33	-29	-184	-4	-24	1	-323		64 655
Plantation	694 126	-6 885	826	-28	66 136	-840	-1 935	-1 387	-5 074	-129	2	-268	-3 442	-25	-275	-314	-2 256	-3	738 228
Subsistence agriculture	240 492	28 059	-2 584	2 060	301	389 862	12 003	357	172		-902	158	1 494	11	-15	10	-1 313	-2	670 162
Dryland cultivation	251 003	26 860	5 676	435	877	1 046	49 432	10 508	468		19	7	306	-39	-10	2	-1 170	-1	345 418
Irrigated cultivation	119 380	2 244	699	129	-705	28	6 669	6 858	-1 636		5	-59	-316	-29	-20		-348		132 898
Sugarcane	503 760	-64808	-19 636	-3 188	-4 976	-61 418	-1 488	-4 853	51 520	-45	-1	-377	-4 419	-268	-788	-162	-2 913		385 943
Rehabilitated mines		29	13		7		1			1 180						509			1 740
Severe erosion	66 185	5 478	105	-8	-23	-2 204	-441	-34			27 066	-91	-409	-1	-45	-50	-387		95 141
Dam	52 467	3 382	355	-10	327	14	193	94	-165	42	43	8 563	19	7	-3	44	-14		65 358
Low density settlement	258 714	17 881	10 309	200	976	12 474	-171	-289	-1 848		692	151	48 875	290	-11 917	-38	-3 361	-1	332 937
Turfed recreation areas	3 108	-247	32	-1	-21		24	5	-8			-9	-23	1 129	-75		-21		3 894
Built-up areas	191 937	-3 241	-587	-1	-272	-474	-240	-107	-841	-13	-23	-25	-25	-674	27 557	-213	-4 845	-3	207 910
Mines	4 524	514	176	12	105	23	46	-2	57	-302	-37	43	-66	-1	52	1 724	-16		6 849
Transport network	76 475	1 389	1 385	17	251	238	-156	-67	-1 418		91	-3	559	6	659	26	43 310	-1	122 761
No data	1 420	-96	-8		-4	-4	-1	-1				-2					6	1 164	2 475

Table notes:

- Reading along a particular row gives information about increases (positive numbers) or decreases (negative numbers) from other land cover classes.
- For each land cover class, the dominant class or classes from which or to which it was converted are highlighted in red.

The land cover matrix shows that expansion of subsistence agriculture over the period 2005-2011 has mainly replaced natural areas. It also seems that a substantial area of degraded land was converted to subsistence agriculture – it may be the case that the low-income households who tend to engage in subsistence agriculture do not have access to land in better condition.

Dryland cultivation has mainly replaced natural areas and irrigated cultivation. Irrigated cultivation has also replaced dryland cultivation, suggesting that swapping between dryland and irrigated cultivation is a feature of this landscape.

For more detailed analysis and discussion of land cover patterns and trends in KZN see Jewitt et al (2015).

3.4 Analysis of land cover trends at municipal level within KZN

Because the information used to compile land accounts can be spatially disaggregated, land accounts can be summarised at a range of spatial scales for a range of reporting units, not just at the aggregate provincial level. In this section we present a brief analysis of land cover change by local municipality in KZN. The municipal level is relevant and useful for summarising land accounting information because this is an important level for development planning though Integrated Development Plans, and for land-use planning through Spatial Development Frameworks.[15] In addition, the implementation of the Spatial Planning and Land Use Management Act (Act 16 of 2013), underway at the time of writing, is strengthening the devolution of land-use decisions to the municipal level.

KZN has 50 local municipalities, grouped into 10 districts, and one metropolitan municipality (Figure 9).[16] We are interested especially in local municipalities that are experiencing high rates of change in land cover. In these municipalities it is particularly important to ensure that land-use planning is strategic and that land-use authorisations are sound and support sustainable development. These municipalities may require additional support and resources to strengthen their land-use planning and decision-making functions.

It would be ideal to use percentage turnover in land cover per municipality as an indicator of which municipalities are experiencing the highest rates of change in land cover. However, this would have required substantial additional analysis, so we have used rate of decline in natural area per municipality as a proxy for rate of change in land cover. We suggest calculating percentage turnover in land cover and percentage land cover unchanged per local municipality as a priority for future work.

[15] In terms of South Africa's Municipal Systems Act (Act 32 of 2000), all municipalities must develop Integrated Development Plans and Spatial Development Frameworks, which are revised every five years.
[16] South Africa has three types of municipalities: district municipalities (47), local municipalities (283), and metropolitan municipalities (6). Local municipalities are nested within district municipalities in a two-tier system of local government, with on average six local municipalities per district.

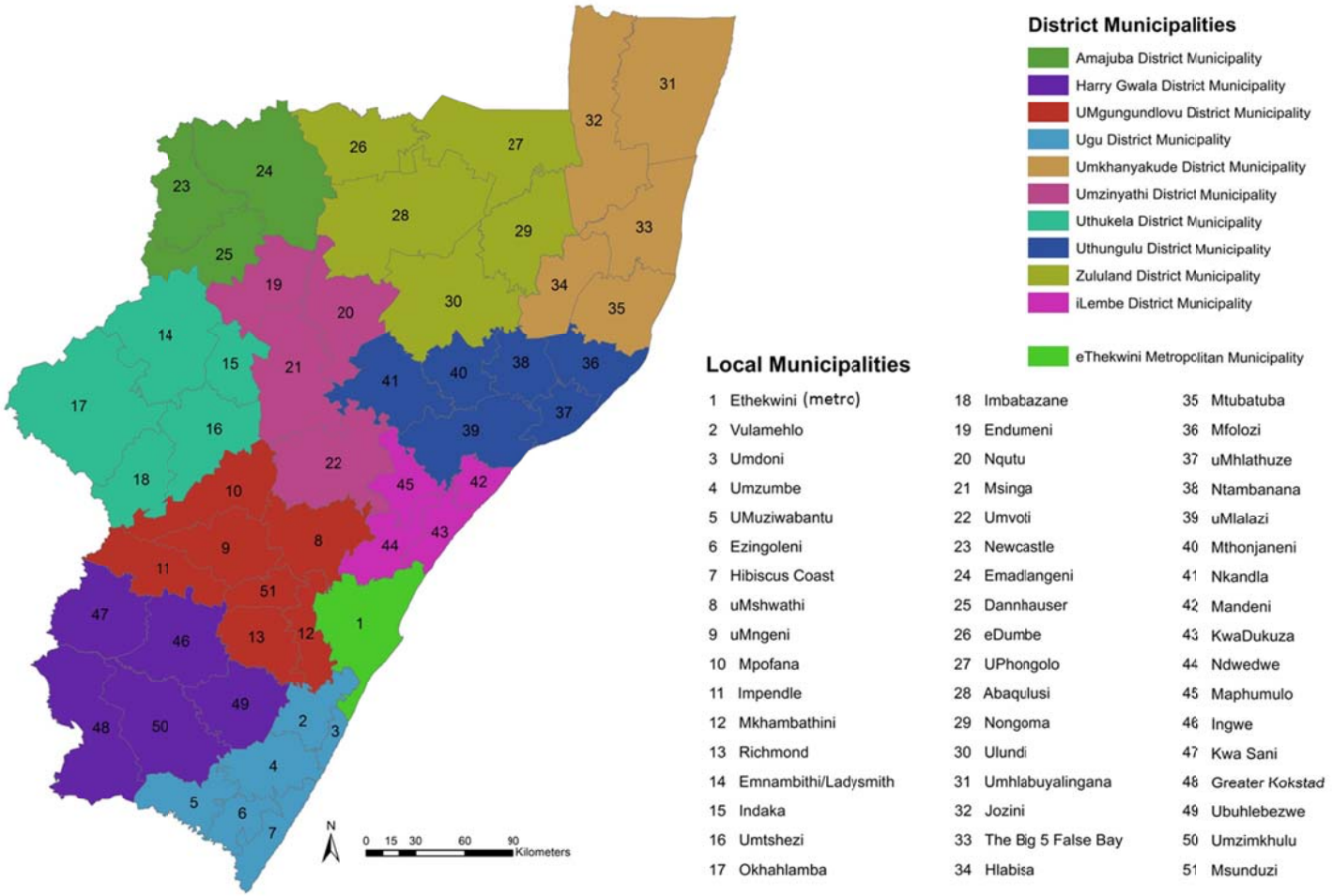

Figure 9: Municipalities in KwaZulu-Natal

Table 10 shows the local municipalities with the highest percentage decline in natural area in the period 2005 to 2011, highlighting the land cover classes with the biggest changes within each of those municipalities. Table 24 in the Appendix shows results in hectares for all local municipalities.

Mirroring patterns in the province as a whole, in nine out of these 15 municipalities the biggest percentage increases were in subsistence agriculture, often along with relatively high percentage increases in low density settlement. Built-up areas showed the largest proportional increases in the Ethekwini Metro (Durban), as well as Msunduzi (Pietermaritzburg) and uMhlathuze (Richards Bay), reflecting that these municipalities have major urban (Durban, Pietermaritzburg) or industrial (Richards Bay) centres.

Table 11 shows those local municipalities in KZN with increases of more than 5 000 ha in built-up areas between 2005 and 2011. Rapid increase in built-up areas suggests urban and/or industrial expansion, often accompanied by in-migration of people from rural areas. These municipalities are likely to face particular urban planning and service delivery challenges, and may need support in this regard.

It is possible to map information about the spatial distribution of land cover change by local municipality, as shown in Figure 10 for six of the KZN summary land cover classes. Darker colours represent larger changes, measured in hectares, with legend categories divided according to natural breaks. Some striking spatial patterns are evident from these maps:

- The spatial association between low density settlement and subsistence agriculture is evident, with similar patterns on those two maps.
- The different spatial patterns between dryland cultivation and sugarcane are evident, supporting the rationale for separating sugarcane from other crops.
- Expansion of built-up areas is concentrated especially in the Ethekwini Metro and along the coast.
- The spatial pattern for expansion of the transport network is consistent with the spatial pattern for built-up areas and low density settlement combined.

Table 10: Municipalities in KZN with the largest percentage decrease in natural area, 2005-2011

% **Municipality**	Municipal area (ha)	Natural	Degraded	Fallow lands	Timber plantations	Subsistence	Dryland agriculture	Irrigated agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dams	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network
29. Nongoma	218 241	-19	-1			17				-1	2	-4	5	-1	1	-1	2
5. UMuziwabantu	109 006	-16	2		1	9	1		2			-5	6	-2	2	-1	2
20. Nqutu	196 217	-13				9				-4	6	-4	6	-1	1	-1	1
38. Ntambanana	108 308	-13	1			10						-2	3	-2	2	-1	1
35. Mtubatuba	196 996	-13		4	1	15			-8			-3	4	-2	2	-1	1
4. Umzumbe	125 890	-12	1			12			-4			-8	9	-2	2	-1	2
9. uMngeni	156 689	-12	3		2		4	1			-2	1	2	-2	2	-1	2
34. Hlabisa	155 552	-12	1			11			-1			-2	3				1
36. Mfolozi	120 965	-12	1			12			-4	1		-3	5	-3	1		1
37. uMhlathuze	79 256	-11	4			8			-5			-3	5	-10	10		2
50. Umzimkhulu	243 632	-11			2	7					1	-5	5	-2	2		1
51. Msunduzi	63 402	-11	1		1	2	1					-11	12	-21	25	-1	3
1. Ethekwini	228 957	-10		1		2			-2		-1	-6	10	-27	31	-2	4
6. Ezingoleni	64 829	-10	1			5	1	1	-1			-5	7			-1	2
46. Ingwe	197 705	-10	-1		1	5	2	1		-1	1	-4	5		1	-1	2

Table notes:

- The percentage changes are given as a proportion of each municipality's area.
- For each municipality, the land cover class with the largest percentage increase is highlighted in red.

Table 11: Municipalities in KZN with the largest increases in built-up areas, 2005-2011 (000 ha)

000 hectares **Municipality**	Municipal area (ha)	Natural	Degraded	Fallow lands	Timber plantations	Subsistence agriculture	Dryland agriculture	Irrigated agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dams	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network
1. Ethekwini	228 957	-23 371	237	1 488	293	5 538	286	217	-4 796	-3	-2 230	-13 425	22 029	-61 640	70 596	-4 065	8 697
51. Msunduzi	63 402	-6 966	764	-49	348	1 537	412	-163	71	0	-172	-6 863	7 665	-13 467	15 588	-856	2 151
23. Newcastle	185 615	-9 900	-108	141	1 852	1 018	4 394	-237	0	-1 483	494	-1 247	3 089	-11 182	11 391	-787	2 544
7. Hibiscus Coast	83 765	-7 379	1 189	194	-567	6 730	62	2 241	-4 807	0	-191	-6 709	8 155	-8 851	9 009	-1 888	2 694
37. uMhlathuze	79 256	-8 821	3 245	-222	115	6 337	27	221	-4 121	0	-312	-2 753	4 283	-7 584	7 962	-339	1 887
43. KwaDukuza	73 425	2 689	1 305	765	114	1 010	23	211	-6 978	0	-124	-1 154	1 494	-6 063	6 251	-1 044	1 477
50. Umzimkhulu	243 632	-25 692	435	224	4 614	15 962	-951	-101	-34	-579	1 921	-11 374	13 048	-4 923	5 908	-707	2 249
14. Emnambithi/Ladysmith	296 581	-16 318	-110	1 563	284	3 098	3 799	25	0	-8 709	9 562	-3 635	7 983	-4 365	5 224	-2 136	3 732
39. uMlalazi	221 382	-7 983	-3 071	-200	878	27 092	28	353	-19 545	0	-835	-5 829	8 192	-5 233	5 041	-2 188	3 287

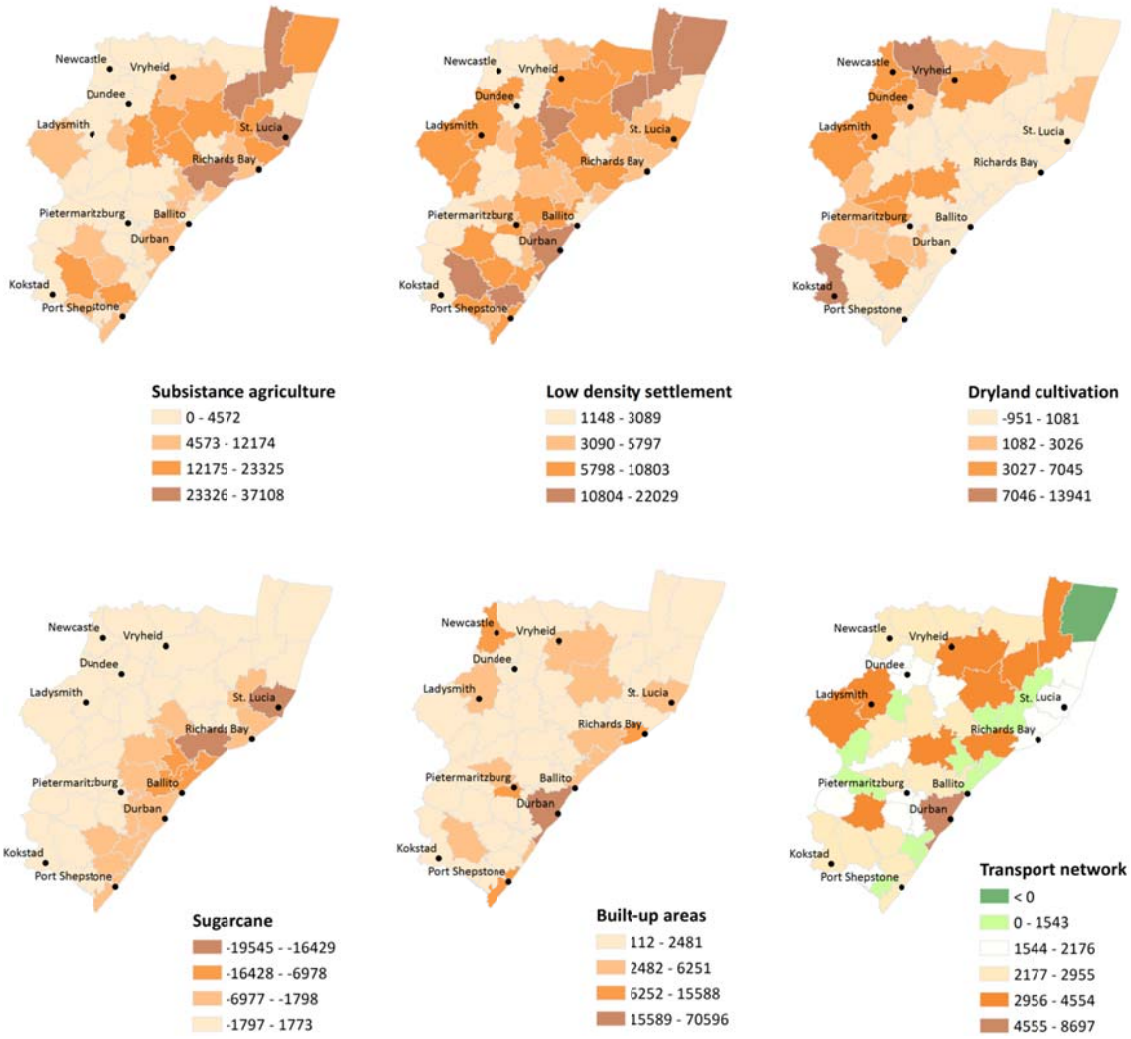

Figure 10: Summary maps of land cover change per municipality in KZN, 2005-2011, for subsistence agriculture, low density settlement, dryland cultivation, sugarcane, built-up areas and transport network

We have chosen in this section to summarise results per local municipality as a useful reporting unit for land accounts that gives insight into spatial variation in land use patterns and trends within the province. It would be possible to summarise results for a range of other reporting units, for example district municipalities or catchments (although catchments present the challenge that some of them straddle neighbouring provinces). It would also be possible to summarise the results according to land tenure, for example communally owned land vs privately owned land (communal areas correspond largely with the Ingonyama Trust lands shown in Figure 1 in Section 1). This could reveal useful additional insight into patterns and trends.

4. Ecosystem extent accounts for KwaZulu-Natal

In this section we present ecosystem extent accounts for KZN, taking us directly into the realm of SEEA Experimental Ecosystem Accounting. The section includes:

- A brief overview of what SEEA Experimental Ecosystem Accounting says about ecosystem extent accounts, including the issue of how ecosystem assets should be mapped,
- A discussion of how ecosystem types are mapped in South Africa, and an explanation of why these ecosystem types provide useful proxies for ecosystem assets in ecosystem accounting,
- Results for ecosystem extent accounts for in KZN, at the level of biomes and vegetation types.

Key issues highlighted in this section include:

- The need to separate the mapping of land cover classes from the delineation of ecosystem units,
- The need for a stable set of ecosystem units representing the potential or historical extent of different ecosystem types, against which changes in extent can be measured,
- The use of the adapted KZN land cover classes to determine where the current extent of ecosystem units differs from their historical extent (which would not be possible to do with the SEEA Central Framework land cover classes).

4.1 Ecosystem extent accounts in SEEA Experimental Ecosystem Accounting

SEEA Experimental Ecosystem Accounting sets out a framework for ecosystem accounting that includes ecosystem asset accounts and ecosystem services accounts. Ecosystem asset accounts have three main elements: ecosystem extent accounts, ecosystem condition accounts, and the expected future flow of ecosystem services (which relates to the capacity of ecosystems to provide services).

A technical guideline document that complements SEEA Experimental Ecosystem Accounting was in draft form at the time of writing and provides more detail, including a diagram showing the suggested full set of ecosystem accounts, reproduced here in Figure 11 (UN 2015a). The intention is that ecosystem accounts could be approached in a modular way, with different possible entry points, represented by the different blocks in the diagram. For example, a country might start with ecosystem service generation accounts rather than necessarily having to start with ecosystem extent accounts. However, ultimately the aim would be to have the full set of accounts. In South Africa, we have decided to start with ecosystem extent and condition accounts, as our available data is best suited to this entry point.

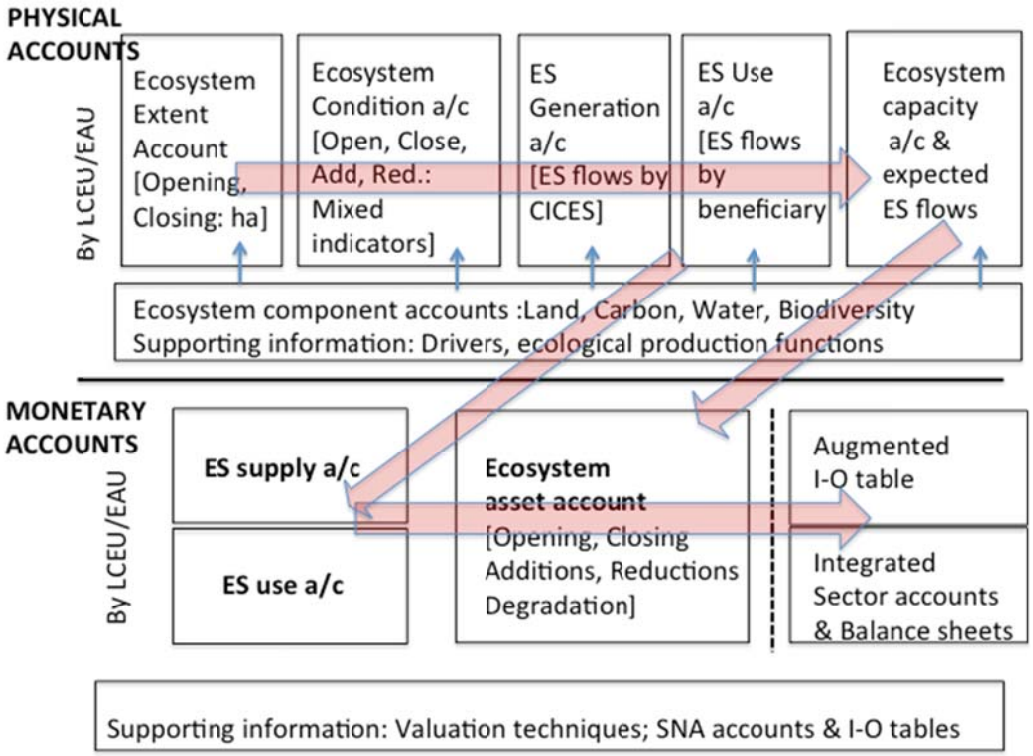

Figure 11: Steps in the compilation of ecosystem accounts (draft)

(Source: UN 2015a, p33)

Like land accounts, ecosystem accounts are inherently spatial. SEEA Experimental Ecosystem Accounting sets out three types of spatial units for ecosystem accounting:

- Basic spatial units (BSUs) – usually a grid of pixels (e.g. 100m by 100m),
- Land cover ecosystem functional units (LCEUs) – these are intended to represent ecosystem assets,
- Ecosystem accounting units (EAUs) – these are essentially reporting units to which results are aggregated, and may be administrative units (such as municipalities) or biophysical units (such as catchments or biomes).

Subsequent to the publication of SEEA Experimental Ecosystem Accounting there has been ongoing discussion about how to delineate spatial units for ecosystem accounting and what to call them. At the Forum of Experts on Ecosystem Accounting convened by the UNSD in April 2015, a proposal was made to rename LCEUs “ecosystem units”. For reasons explained in Section 4.2 below, we support this proposal and thus use the term “ecosystem units” rather than LCEUs in the rest of this document.

SEEA Experimental Ecosystem Accounting notes that land accounts are often an input into or starting point for ecosystem extent accounts, and provides as an example the same table of physical land cover accounts that is given for illustrative purposes in the SEEA Central Framework (reproduced above as Table 2). SEEA Experimental Ecosystem Accounting notes that the categories

of land cover for ecosystem accounting should align with the types of LCEU, which may take into account factors other than just land cover. Land accounts are also often referred to as a "component account" for ecosystem accounts (as in Figure 11). Although land accounts and ecosystem accounts are clearly linked within the SEEA, there is still some discussion about precisely what the relationship is (for a recent summary of the issues see UN 2015b). We hope that this document will contribute towards taking that discussion forward.

4.2 Mapping ecosystem units for ecosystem accounting

SEEA Experimental Ecosystem Accounting suggests that land cover can be used as a starting point for delineating the LCEUs which are intended to represent ecosystem assets, although LCEUs may take into account other factors than just land cover. Our view is that *ecosystem types*, mapped and classified on the basis of physical factors that are often independent of current land cover (such as geology, soil type, altitude, rainfall), are a better starting point or proxy for ecosystem units, and that ecosystem units should *not* be based in the first instance on land cover classes. Land cover *data* may sometimes be useful in delineating ecosystem units, and ecosystem units and land cover classes may align in some instances, but they should not be conflated. Our view of the relationship between ecosystem units, land cover classes and basic spatial units in shown schematically in Figure 12.

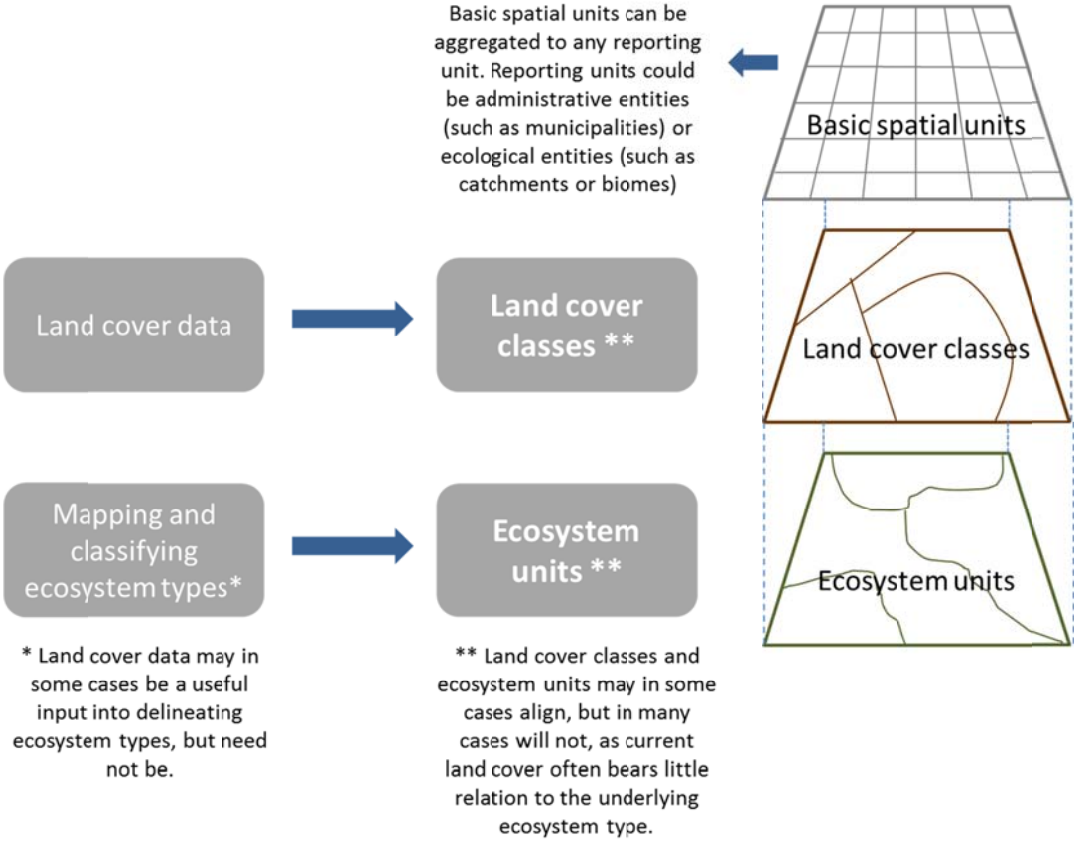

Figure 12: Relationship between ecosystem units, land cover classes and basic spatial units

In South Africa, ecosystem types are mapped and classified as part of the National Ecosystem Classification System (SANBI 2013). National ecosystem types are mapped across terrestrial and aquatic realms, and include vegetation, river, wetland, coastal, inshore and offshore types. Principals for mapping and classifying ecosystem types include:

- Wherever possible, ecosystem types are mapped based on their potential or historical (e.g. pre-colonial) extent, rather than their current remaining extent,[17]
- Ecosystem types are relatively homogenous units in terms of their composition, structure and function (Noss 1990, Box 2), and are best delineated based on a range of physical data layers (such as geology, soil type, altitude, rainfall) ideally combined with information about patterns of species distribution and community composition. Ecosystems of the same type share similar ecological characteristics. Land cover data might be one input in this process, but in many instances current land cover bears little or no relation to the underlying ecosystem type.

In the terrestrial environment, vegetation types identified in the Vegetation Map of South Africa, Lesotho and Swaziland (Mucina & Rutherford 2006) serve as ecosystem types for a range of applications related to planning and policy, and make excellent ecosystem units for ecosystem accounting.

Vegetation types are mapped based on a range of factors, such as geology, soil types, rainfall, temperature and altitude, which determine the composition and structure of plant communities. They are mapped based on potential vegetation, irrespective of current land cover. In this way, ecosystem units are delinked from current land cover, enabling the development of a stable set of ecosystem units based on ecological characteristics, against which changes in extent and condition can be assessed, greatly facilitating the development of ecosystem extent and condition accounts.

Ecosystem types such as vegetation types also provide useful units for ecosystem service accounts because they link directly with functional aspects of ecosystems, which in turn link to ecosystem service generation. The link between ecosystem types and ecosystem services is much more direct and more reliable than the link between land cover classes and ecosystem services, as discussed further in Section 5.

The vegetation map of South Africa has a two-level hierarchy of nine biomes and approximately 440 vegetation types. It includes some wetlands, but these were not mapped systematically across the country as part of the development of the vegetation map. There is also a National Wetland Inventory, which provides a more comprehensive map of wetlands in the country, not all of which are yet integrated into the vegetation map. Rivers are currently mapped separately as linear features, and their extent is measured by length rather than area. In future we would ideally like to map river channels as areas and to embed them in the vegetation map, together with wetlands, creating an integrated or composite map of ecosystem types across the terrestrial and freshwater realms. This is work in progress, so for now we use the vegetation map as the basis for ecosystem extent accounts that cover the terrestrial realm and some wetlands. In the national river ecosystem

[17] This is not always possible for all ecosystem types. For example, it is difficult to map the historical extent of wetlands that were destroyed before they were ever mapped. In such cases the best available data is used, to give as complete as possible a picture as at a certain reference date.

accounts reported on in a companion discussion document to this one, we measure river ecosystem extent by length rather than area, thus avoiding any double-counting of area between the ecosystem extent accounts for KZN and the ecosystem extent account for rivers.

Box 2: Composition, structure and function as key attributes of ecosystems

Noss (1990) proposed a hierarchical conceptual framework for measuring and understanding biodiversity, at the genetic, species, ecosystem and landscape level. At each of these levels it is possible to identify compositional, structural and functional aspects or attributes of biodiversity, as shown in Figure 13. For the purpose of land and ecosystem accounting, we are most interested in the ecosystem level.

The three primary attributes of ecosystems in terms of this conceptual framework are:

- Composition – referring to species composition and species communities within ecosystems,
- Structure – referring to the physiognomy or habitat structure of ecosystems,
- Function – referring to ecological and evolutionary processes in ecosystems, such as disturbances and nutrient cycling.

(Noss 1990, building on Franklin et al 1981)

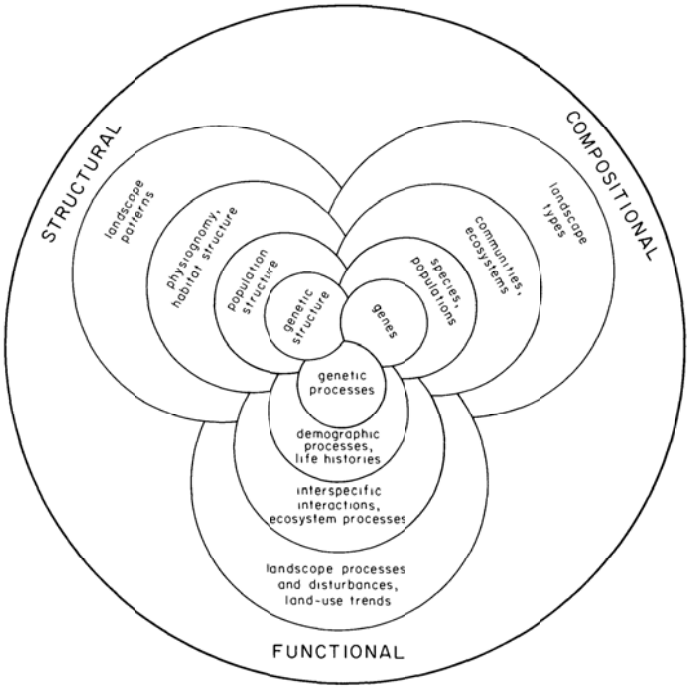

Figure 13: Noss's conceptual framework for compositional, structural and functional aspects of biodiversity at the genetic, species, ecosystem and landscape level
(Source: Noss 1990)

Ezemvelo KZN Wildlife has put considerable effort into more detailed vegetation mapping within the province and better integration of wetlands into the provincial vegetation map than is the case for

the national vegetation map.[18] We have thus used the KZN provincial vegetation map (Scott-Shaw & Escott 2011) as the basis for ecosystem units for these provincial ecosystem accounts.

Four of South Africa's nine biomes occur in KZN (Grassland, Savanna, Indian Ocean Coastal Belt, Forest), with wetlands making a fifth "biome" in the province (
Figure 14). The Forest biome (shown in black in
Figure 14) is very small, making up just over 2% of the province.[19] The KZN provincial vegetation map identifies 101 vegetation types within these biomes, giving us 101 ecosystem units that form the basis for the ecosystem extent accounts presented in Section 4.3 and the land accounts for ecosystems presented in Section 5. All 101 vegetation types are listed in Table 25 in the Appendix.

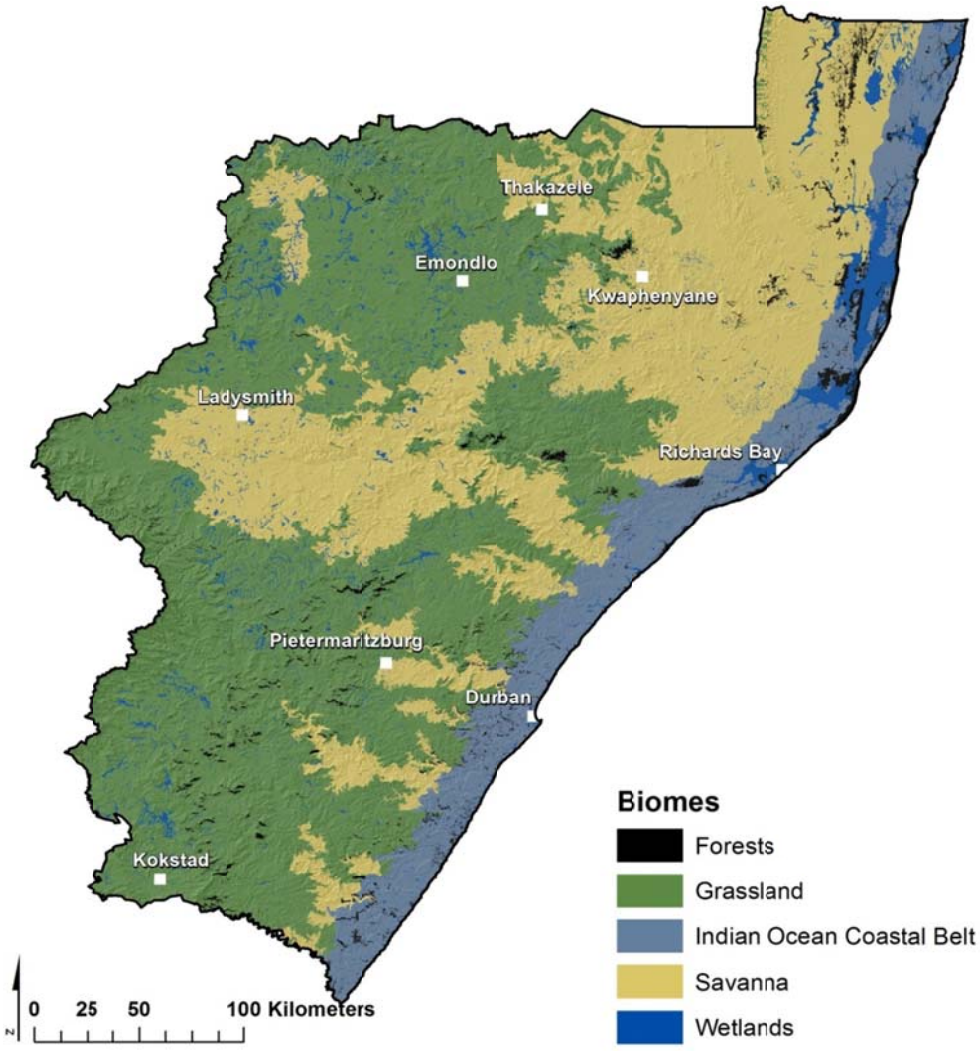

Figure 14: Biomes in KwaZulu-Natal

[18] Note that wetlands have not yet been fully mapped in KZN, and notwithstanding this improvement, their extent is still under-estimated by about 30% in the KZN vegetation map.

[19] Most "tree covered areas" in South Africa, including in KZN, are either exotic timber plantations or stands of woody invasive alien plants, both of which have serious negative impacts on the provision of water-related and several other ecosystem services. The forest biome (i.e. indigenous forest) makes up less than 1% of South Africa's area.

4.3 Ecosystem extent accounts for biomes and vegetation types in KZN

In this section we present extent accounts for biomes and vegetation types in KZN. Extent is calculated for each ecosystem unit, represented by a vegetation type, and can be aggregated to the biome level to get a broader picture. We start by presenting the biome-level results, as they provide a useful overview of trends, before presenting more detailed results at the level of individual ecosystem units represented by vegetation types.

For the accounts presented here, the current extent of an ecosystem unit is considered to be the area within that ecosystem unit that is still natural, i.e. that falls within the land cover class "01 Natural" in the KZN summary land cover classes. It is important to note that the class Natural intentionally includes both natural and near-natural areas – there are few areas in South Africa that have not been subject to at least some human impact, and it is often not practical or necessary, especially from an ecosystem services perspective, to attempt to distinguish systematically between pristine areas and areas that are close to natural.[20] As discussed in Section 3.3, the class Natural is also likely to include some areas that should ideally have been classed as Degraded but that were not possible to distinguish from natural or near-natural areas based on satellite imagery.

Changes in ecosystem extent are measured in relation to the historical extent of each ecosystem unit (vegetation type). We use the year 1840 as the reference date for the historical extent of ecosystem units, as large-scale declines in natural area in KZN are likely to have occurred mainly after the proclamation of the area as the British Colony of Natal in 1843. The current extent of each ecosystem unit is measured by overlaying the map of land cover classes on the map of ecosystem units (vegetation types), and calculating how much of the historical extent of each ecosystem unit falls within the land cover class Natural.[21]

For example, an area classified as Midland Mistbelt Grassland in the map of ecosystem units might appear in the land cover dataset as "dryland cultivation". For ecosystem accounting purposes, the conversion of this area of Midland Mistbelt Grassland to dryland cultivation is viewed as a decline in the extent of that ecosystem unit relative to its historical extent. Figure 15 shows the ecosystem unit Midlands Mistbelt Grassland (one of the largest vegetation types / ecosystem units in the province), with portions that have been converted to other land cover classes in grey and remaining natural area in green.

This analysis is possible because the ecosystem units have been delineated independently of current land cover classes, and also because the KZN land cover classes do not mix natural, semi-natural and

[20] It may sometimes be necessary from a biodiversity conservation perspective, for example if one is interested in certain bulb species that tend to be over-grazed even in otherwise largely natural grasslands.

[21] An argument could be made to include semi-natural classes in the KZN land cover (i.e. degraded, fallow lands and rehabilitated mines) when measuring the current extent of an ecosystem unit. On balance we decided to exclude semi-natural areas from the calculation of current extent because their ecological characteristics at the level of composition, structure and function may be vastly different to the ecosystem unit in its natural or near-natural state. However, another way of approaching this would be to include semi-natural classes in the current extent of an ecosystem unit, and to give them a low condition score. This can only be resolved through constructing a joint set of ecosystem extent and condition accounts to test which of these options gives the most meaningful and useful results. We hope to pursue this in future work.

substantially modified areas in any single class (either at the level of the detailed classes or the summary classes). It would not be possible to do this analysis using the SEEA Central Framework land cover classes, as it is not possible to use them to distinguish natural from modified areas, which are often combined in a single land cover class.

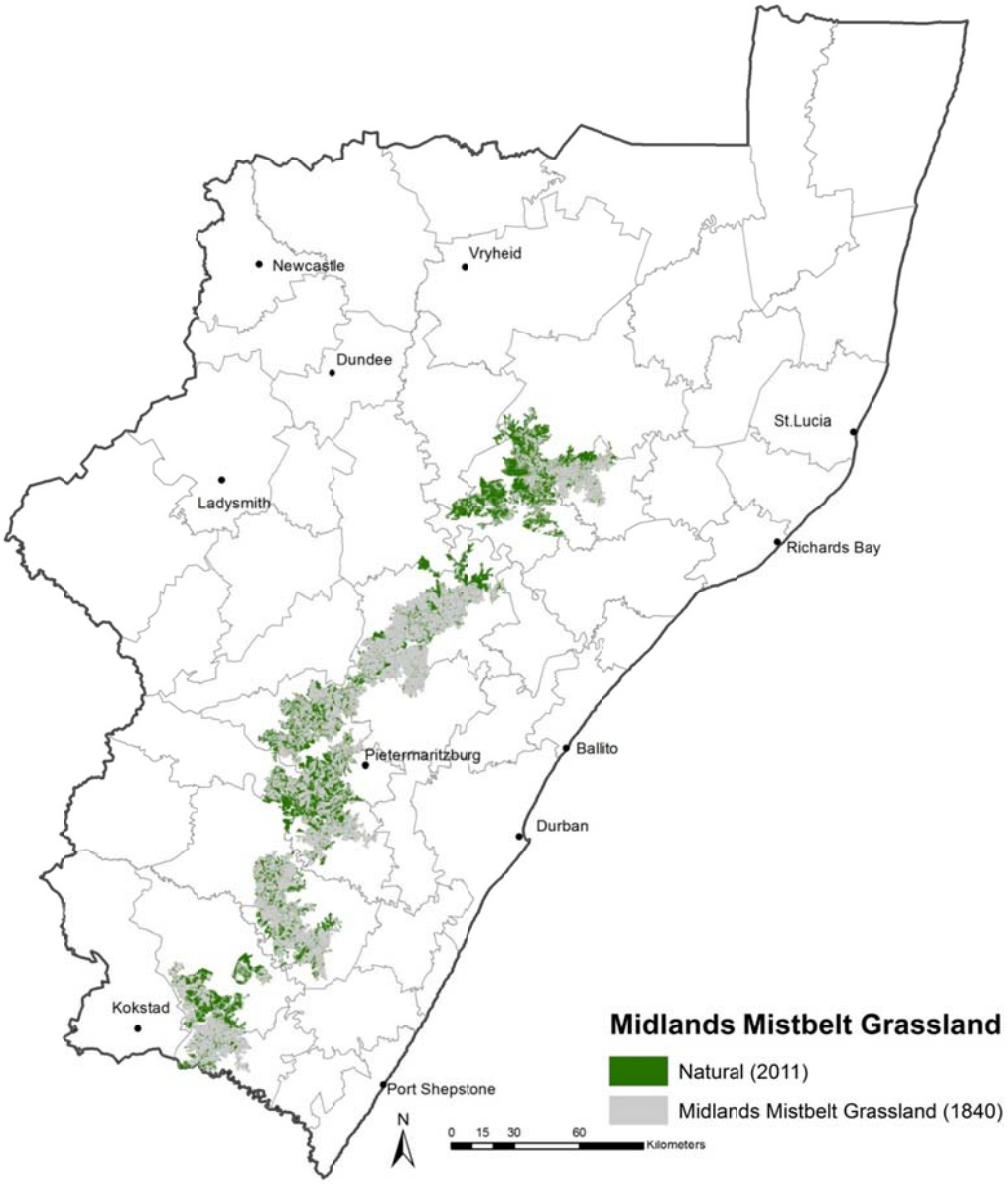

Figure 15: The ecosystem unit Midlands Mistbelt Grassland showing decline in natural area relative to historical extent

The ecosystem extent account tracks how the current extent of each ecosystem unit changes over time in relation to its historical extent, telling us *how much* of the natural area within each ecosystem unit has been replaced by other land cover classes. The issue of *which* land cover classes have replaced natural areas within each ecosystem unit is tracked and reported in land accounts for ecosystems – see Section 5.

Table 12 and Table 13 show two different ways of presenting extent accounts at the biome level, summarising the decline in natural area per biome. Figure 16 and Figure 17 show the results graphically.

Table 12: Ecosystem extent account for biomes in KZN, showing absolute and percentage changes, 1840-2011

(a)

Hectares	1840	2005	2008	2011
Grassland	4 581 933	2 930 197	2 653 090	2 584 998
Savanna	3 259 059	2 418 679	2 210 072	2 175 315
Indian Ocean Coastal Belt	893 967	365 213	305 490	293 708
Wetland	393 718	286 151	267 875	258 793
Forest	202 822	184 614	174 822	171 694

(b)

% of historical extent	1840	2005	2008	2011
Grassland	100	64	58	56
Savanna	100	74	68	67
Indian Ocean Coastal Belt	100	41	34	33
Wetland	100	73	68	66
Forest	100	91	86	85
All biomes	**100**	**66**	**60**	**59**

Table note:

- Wetlands are not technically a biome, but as explained in Section 4.2 they have been relatively well mapped in KZN and integrated into the vegetation map, so it makes sense to summarise results for wetlands along with the terrestrial biomes. Wetlands have not yet been fully mapped in KZN, so this account under-estimates the total area of wetlands.

Table 13: Ecosystem extent account for biomes in KZN – alternative format, 1840-2011

Hectares	Grassland	Savanna	Indian Ocean Coastal Belt	Wetland	Forest
Opening balance 1840	4 581 933	3 259 059	893 967	393 718	202 822
Total reductions in stock	1 651 736	840 380	528 754	107 567	18 208
Total reductions as a % of 1840	36	26	59	27	9
Opening balance 2005	2 930 197	2 418 679	365 213	286 151	184 614
Total reductions in stock	277 108	208 607	59 723	18 276	9 792
Total reductions as a % of 1840	6	6	7	5	5
Opening balance 2008	2 653 090	2 210 072	305 490	267 875	174 822
Total reductions in stock	68 092	34 757	11 782	9 082	3 128
Total reductions as a % of 1840	1	1	1	2	2
Opening balance 2011	2 584 998	2 175 315	293 708	258 793	171 694

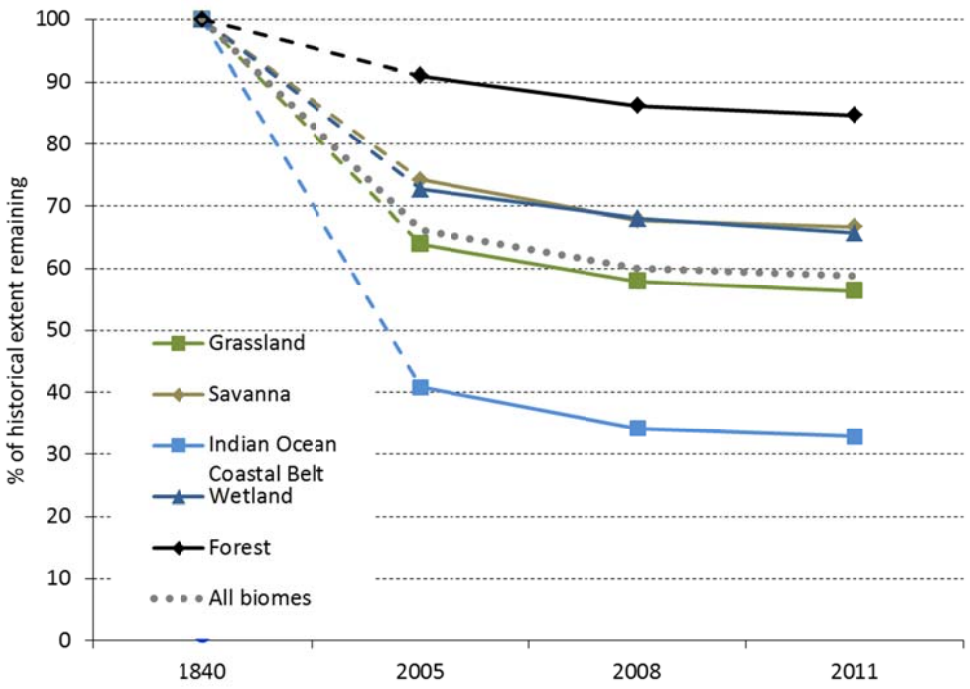

Figure 16: Percentage natural area remaining relative to historical extent of the biomes of KZN, 1840-2011

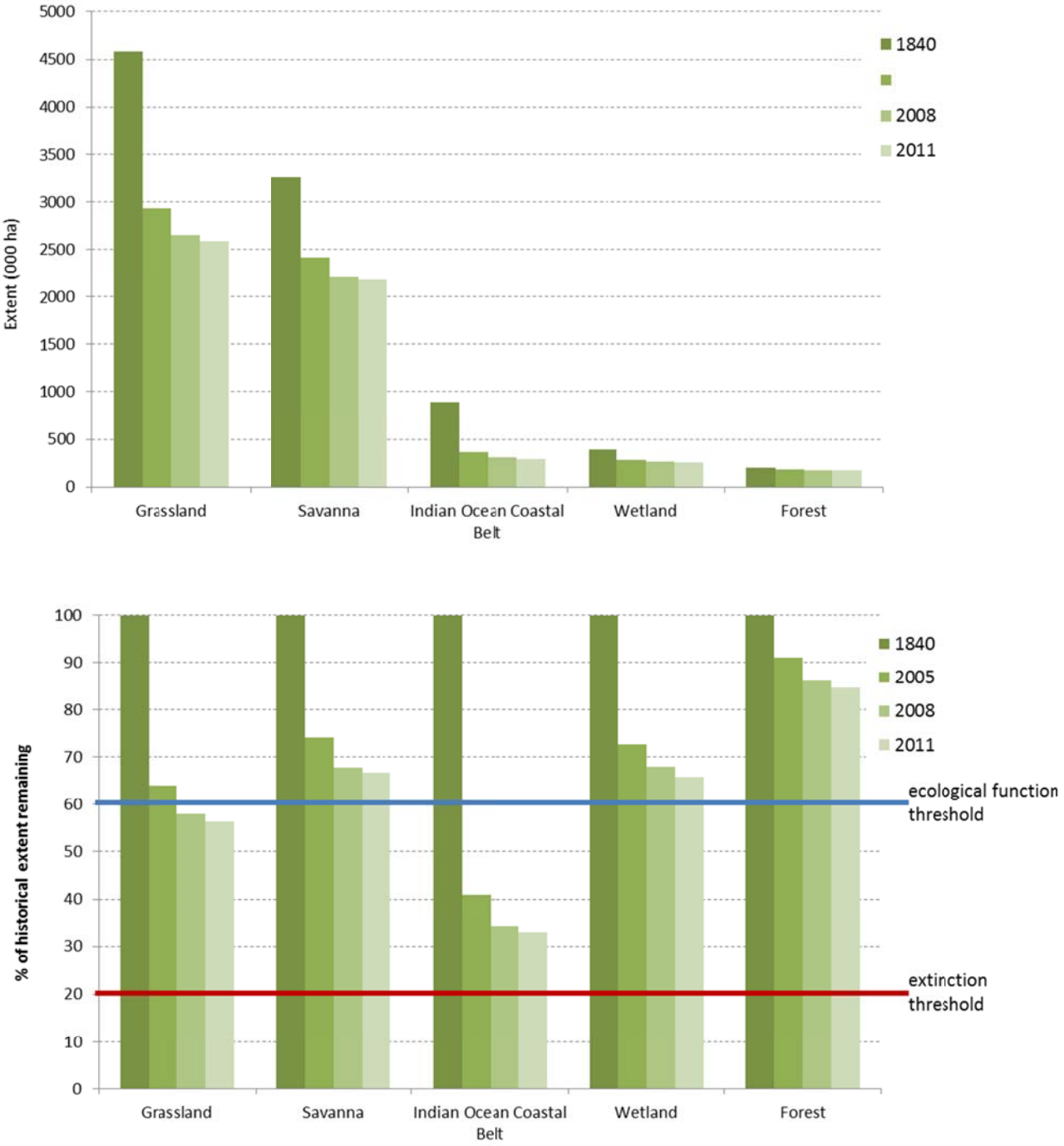

Figure 17: Absolute and proportional decline in natural area in the biomes of KZN, relative to historical extent, 1840-2011

The ecosystem extent account summarised at the biome level shows clearly that the remaining natural area in all biomes in KZN has declined substantially relative to their historical extent.[22] The largest declines in absolute terms have occurred in the Grassland biome, which is also the largest biome in the province (and South Africa). The biggest proportional declines have occurred in the Indian Ocean Coastal Belt, followed by Grassland. The rate of change seems to have slowed since the mid-2000s – it is not yet clear whether this is a long-term trend or related to, for example, cyclical movements in the economy (see Jewitt et al 2015). In Section 5 we explore what land cover changes are causing these declines and whether this differs across biomes.

The two thresholds shown in Figure 17, an ecological function threshold at 60% of historical extent and an extinction threshold at 20% of historical extent, are important thresholds in ecological terms. Ecosystems can tolerate a certain amount of decline in natural area before their essential characteristics are compromised. Critical thresholds are often difficult to determine even in retrospect, and almost always difficult to predict. Nevertheless, the ecological literature[23] suggests two critical thresholds: as a rule of thumb, when less than approximately 60% of the natural area within an ecosystem remains, its ecological functioning begins to break down; and if less than approximately 20% of natural area remains, loss of species associated with that ecosystem type can be expected.[24] In practice the exact level of each of these thresholds varies between ecosystems depending on landscape structure and other characteristics, but they are nevertheless useful as a guide.[25] We can see from Figure 17 that both Indian Ocean Coastal Belt and Grasslands have crossed the 60% ecological function threshold, while the Savanna biome is approaching it. Indian Ocean Coastal Belt is approaching the 20% extinction threshold.

The aggregated biome view hides detail about what is happening to different vegetation types within each biome – it is likely that decline in natural habitat is not distributed evenly throughout each biome but rather higher within some vegetation types than others. Biomes are also too heterogeneous within themselves (e.g. from high to low altitude, from deep to shallow soil) to be good surrogates for ecosystem service modelling. Vegetation types are much better surrogates than biomes for ecosystem functioning and therefore for the generation of ecosystem services. For this reason it is useful to look in more detail at extent accounts for vegetation types.

Because there are 101 vegetation types within KZN, we have focused on those with the largest declines in natural area relative to their historical extent. Table 14 shows the vegetation types that have had the largest absolute decline in natural area relative to their historical extent – those vegetation types with declines of greater than 100 000 ha are included. Table 15 shows the vegetation types that have had the largest percentage decline relative to their historical extent –

[22] The results shown here are conservative, and likely to underestimate the decline in natural area, given that areas classed as natural are likely to include some degraded areas, as discussed earlier in this section.
[23] e.g. Andren 1999, Fahrig 2001
[24] These two thresholds form the basis for assessment of ecosystem threat status in South Africa, in which ecosystem types are categorised as Critically Endangered, Endangered, Vulnerable or Least Threatened based on the proportion of natural area that remains intact in each ecosystem type relative to those thresholds. Ecosystem threat status in turn links to a range of policy and legislative mechanisms aimed at reducing further loss of natural area in threatened ecosystems.
[25] Jewitt et al (2015) have used slightly different thresholds in their analysis, but still within similar ranges.

those vegetation types with declines of 40% or more (i.e. that have crossed the ecological function threshold discussed above) are included. The results can also be viewed graphically, as shown in Figure 18 and Figure 19. The full set of results for all 101 vegetation types is provided in Table 25 in the Appendix.

Table 14: Ecosystem extent account for vegetation types in KZN, showing the vegetation types with largest absolute decline in natural area (>100 000 ha) relative to their historical extent

Vegetation type	Biome	Decline in extent 1840-2011 (ha)	Decline in extent 1840-2011 (%)	Decline in extent 2005-2011 (ha)	Decline in extent 2005-2011 (%)
Midlands Mistbelt Grassland	Grassland	364 205	67	53 666	10
KwaZulu-Natal Coastal Belt Grassland	IOCB	305 331	74	27 056	7
Northern KwaZulu-Natal Moist Grassland	Grassland	263 636	38	55 151	8
Income Sandy Grassland	Grassland	235 252	54	21 344	5
Zululand Lowveld	Savanna	233 798	35	62 115	9
Moist Coast Hinterland Grassland	Grassland	225 776	52	35 910	8
KwaZulu-Natal Highland Thornveld	Savanna	182 351	36	42 150	8
Maputaland Coastal Belt	IOCB	147 862	67	23 390	11
KwaZulu-Natal Sandstone Sourveld	Grassland	142 639	79	10 577	6
Paulpietersburg Moist Grassland	Grassland	139 302	49	21 181	7
Northern Zululand Sourveld	Savanna	137 464	29	53 729	11
Dry Coast Hinterland Grassland	Grassland	124 568	45	27 792	10
Drakensberg Foothill Moist Grassland	Grassland	117 425	33	25 351	7
Southern KwaZulu-Natal Moist Grassland	Grassland	115 091	50	24 923	11
Mooi River Highland Grassland	Grassland	105 188	39	24 874	9

Table note:

- Red highlighted values in the % decline columns indicate vegetation types that have among the largest percentage declines as well as the largest absolute declines.

Table 15: Ecosystem extent account for vegetation types in KZN, showing the vegetation types with the largest percentage decline in natural area (>40%) relative to their historical extent

Vegetation type	Biome	Historical extent 1840 (ha)	Decline in extent 1840-2011 (ha)	Decline in extent 1840-2011 (%)	Decline in extent 2005-2011 (ha)	Decline in extent 2005-2011 (%)
Mabela Sandy Grassland	Grassland	443	391	88	144	32
Delagoa Lowveld	Savanna	8 748	7 004	80	-102	-1
KwaZulu-Natal Sandstone Sourveld	Grassland	179 675	142 639	79	10 577	6
KwaZulu-Natal Coastal Belt Grassland	IOCB	411 494	305 331	74	27 056	7
Maputaland Wooded Grassland	IOCB	107 919	74 373	69	10 791	10
Alluvial Wetlands 16	Wetland	7 610	5 128	67	1 213	16
Pondoland-Ugu Sandstone Coastal Sourveld	IOCB	37 223	24 955	67	2 644	7
Alluvial Wetlands 10	Wetland	22 957	15 361	67	712	3
Maputaland Coastal Belt	IOCB	221 170	147 862	67	23 390	11
Granite Lowveld	Savanna	3 657	2 433	67	84	2
Midlands Mistbelt Grassland	Grassland	547 430	364 205	67	53 666	10
KaNgwane Montane Grassland	Grassland	8 245	5 313	64	838	10
Zululand Coastal Thornveld	Savanna	67 136	41 103	61	16 815	25
Lebombo Summit Sourveld	Grassland	11 723	7 132	61	1 347	11
Western Maputaland Clay Bushveld	Savanna	152 662	92 855	61	11 354	7
Alluvial Wetlands 18	Wetland	207	114	55	15	7
Income Sandy Grassland	Grassland	437 808	235 252	54	21 344	5
Moist Coast Hinterland Grassland	Grassland	437 499	225 776	52	35 910	8
Southern KwaZulu-Natal Moist Grassland	Grassland	231 824	115 091	50	24 923	11
Paulpietersburg Moist Grassland	Grassland	283 998	139 302	49	21 181	7
East Griqualand Grassland	Grassland	133 961	63 715	48	15 367	11
Alluvial Wetlands 1	Wetland	17 083	7 964	47	881	5
Freshwater Wetlands 8	Wetland	13 966	6 509	47	903	6
Northern Zululand Mistbelt Grassland	Grassland	52 891	24 107	46	3 705	7
Dry Coast Hinterland Grassland	Grassland	276 403	124 568	45	27 792	10
Muzi Palm Veld and Wooded Grassland	Savanna	52 927	22 792	43	-3 256	-6
Alluvial Wetlands 6	Wetland	147 263	62 788	43	15 275	10
KwaZulu-Natal Coastal Belt Thornveld	IOCB	111 922	47 217	42	7 173	6
Western Maputaland Sandy Bushveld	Savanna	15 130	6 021	40	1 044	7

Table notes:

- Red highlighted values the hectare decline columns indicate vegetation types that have among the largest absolute declines as well as the largest percentage declines.
- Although Mabela Sandy Grassland and Delagoa Lowveld are the vegetation types with the laargest percentage declines, they have extensive ranges outside of the province of KZN and are thus not as much of a concern as the vegetation types with the majority of their ranges within KZN, such as the KwaZulu-Natal Sandstone Sourveld and KwaZulu-Natal Coastal Belt Grassland which also have very large percentage declines (>70%).

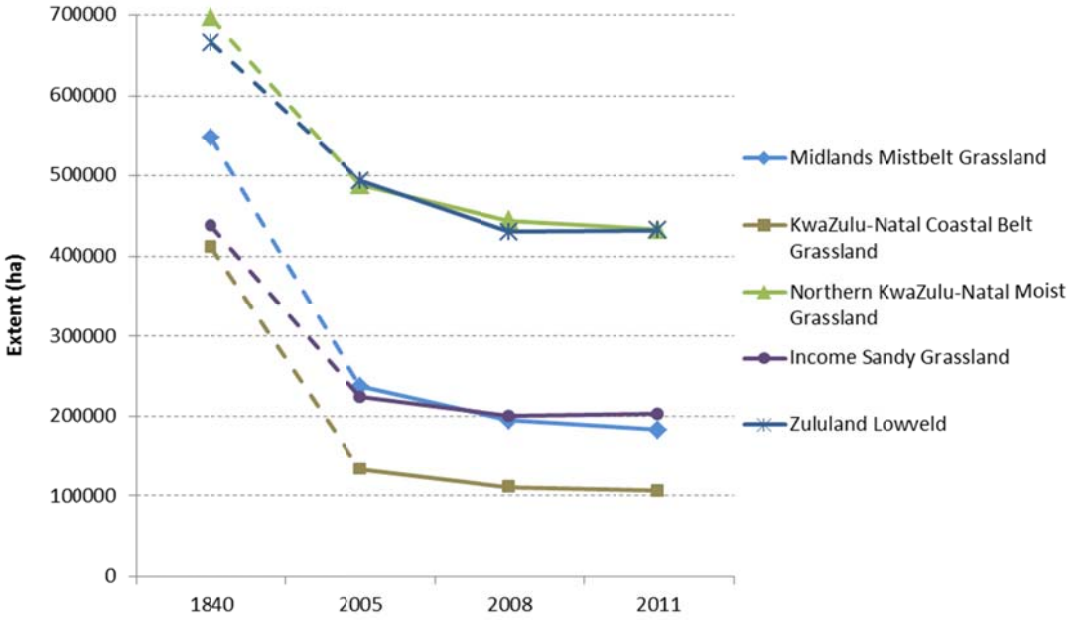

Figure 18: Vegetation types with largest absolute decline in extent, 1840 – 2011

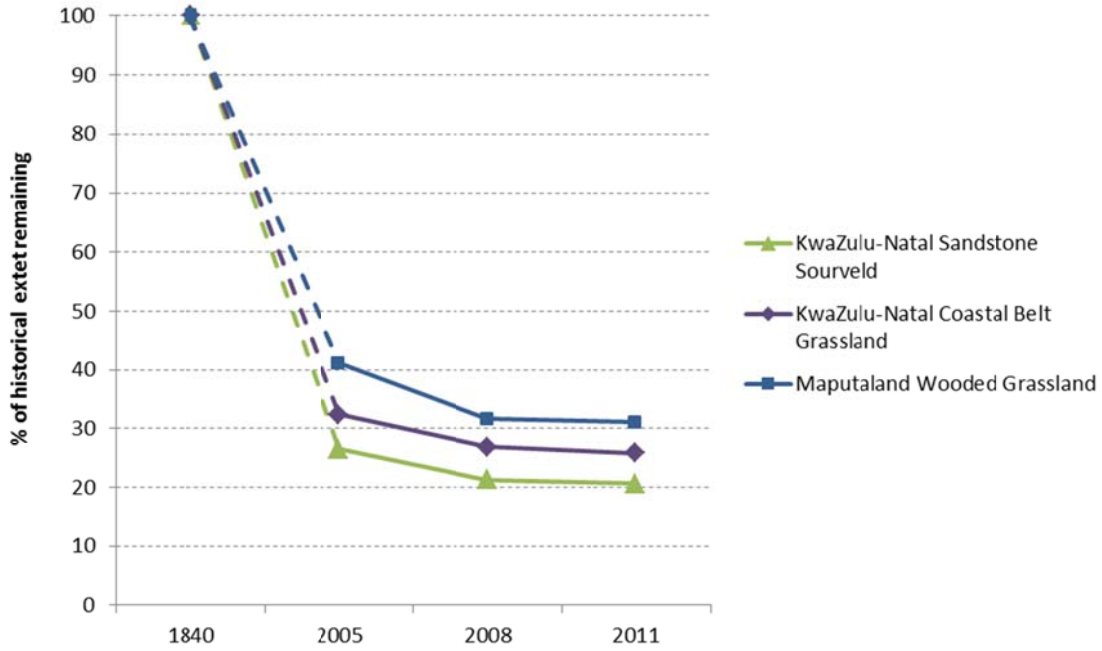

Figure 19: Vegetation types with the largest proportional decline in extent, 1840 - 2011

Figure note:

- Mabela Sandy Grassland and Delagoa Lowveld are not reflected in the graph, as their decline is an artefact of the KZN provincial boundary. These vegetation types are more extensive beyond the boundary of KZN, as explained in the second note below Table 15.

The vegetation types that have experienced the largest declines in extent, in absolute or percentage terms, are mainly Grassland vegetation types. The historical extent of many of these vegetation types was relatively large. The land cover classes to which these vegetation types are being converted vary, as discussed in Section 5.

On average across the province, by 2011 vegetation types had declined by 32% or a third relative to their historical extent, with a decline of 6% in relation to historical extent in the period 2005-2011. Rates of decline in natural area for most vegetation types slowed or stabilised between 2008 and 2011. The following vegetation types show rates of decline in natural area that have not slowed:

- Mabela Sandy Grassland (rare in KZN, but more extensive beyond the provincial boundary)
- Marine Saline Wetlands, including Saline Grassland & Mud Flats
- Alluvial Wetlands, including Subtropical Alluvial Vegetation, Lowveld Floodplain Grasslands, Short Grass/Sedge Wetlands
- Lebombo Summit Sourveld
- Lowveld Riverine Forest
- Zululand Coastal Thornveld

In most of these vegetation types in which the rate of decline in natural area has not slowed down, the continued rate of decline is caused mainly by subsistence agriculture, also with some low density settlement and built-up areas. This analysis starts to take us into the realm of integrating land accounts with ecosystem extent accounts, explored further in Section 5.

5. Land accounts for ecosystems in KwaZulu-Natal

Land accounts for ecosystems bring together the perspectives of both land accounts and ecosystem extent accounts to look at land cover change within ecosystem assets, and the consequences of these changes for the flow of ecosystem services and human wellbeing. To understand changes in ecosystem assets and ecosystem services, we need to examine changes in land cover in relation to different ecosystem types rather than just in relation to other land cover categories. This is because different ecosystem types respond differently in terms of their ecological functioning to the same change in land cover, as discussed further below. Bringing together land accounts and ecosystem extent accounts adds value, telling us more than the "traditional" land accounts presented in Section 3 and more than the "plain" ecosystem extent accounts presented in Section 4.

In this section we present a summary of land cover change in ecosystem assets in KZN, at the biome level and for some vegetation types, and identify key themes and trends that emerge. We discuss the fact that this approach also takes us partway towards a condition account for ecosystems. We are not yet in a position to make the link to full ecosystem service accounts, but the work presented here will lay the basis for this.

We start with a summary at the biome level, which is helpful for providing an overview. Table 16 shows a matrix that integrates ecosystem extent and land cover change for biomes in KZN, with the rows representing biomes and the columns representing the KZN summary land cover classes. Reading along each row shows the change in each land cover class within that biome.

The key pattern that emerges from Table 16 is that subsistence agriculture is the dominant cause of decline in extent for every biome except Forest. In the Indian Ocean Coastal Belt built-up areas also played a significant role, reflecting the expansion of coastal development.

As mentioned in Section 4.2, wetlands have not been as comprehensively mapped as some other ecosystem types, and in many cases it is difficult to map the full historical extent of wetlands. This means that the historical extent of wetlands is likely to be inadequately captured in the vegetation map, and the decline in the extent of wetlands reflected in these tables is likely to be an under-estimate. Table 16 shows that wetlands are being converted to both subsistence agriculture and dryland cultivation. This is of great concern from the point of view of negative impacts on wetland functioning and the provision of ecosystem services from wetlands (such as water purification and flood regulation), with profound consequences for social-ecological vulnerabilities. Ideally there should be tighter policy and implementation of controls on land cover change in these ecosystem types. The subsistence agriculture and dryland cultivation activities that dominate these changes often have marginal economic returns and sometimes have poor social returns too, yet impose significant social costs.

Table 16: Integrated ecosystem and land cover change matrix for biomes in KZN, 2005 to 2011

Hectares	Increases (positive numbers) and decreases (negative numbers) from other land cover classes within each biome																
Biome	Natural	Degraded	Fallow lands	Plantation	Subsistence agriculture	Dryland agriculture	Irrigated agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dams	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network
Forest	-12 920	9 317	500	1 006	3 278	31	17	-3 125	872	1	53	306	-5	-32	269	394
Grassland	-345 200	34 047	9 743	35	130 480	73 077	8 571	-27 924	24	11 905	6 866	30 267	460	7 777	967	23 476
				482												
IOCB	-71 505	14 166	8 819	5 029	59 965	344	3 499	-50 101	841	11	356	14 154	215	6 576	175	7 406
Savanna	-243 364	-26 697	1 114	1 975	222 089	13 612	205	-32 508		15 858	2 926	28 587	70	1 478	746	13 925
Wetland	-27 358	820	1 365	611	13 859	7 352	1 226	-4 159	3	1 181	2 689	882	47	170	169	1 086

%	Increases (positive numbers) and decreases (negative numbers) from other land cover classes within each biome															
Biome	Natural	Degraded	Fallow lands	Plantation	Subsistence agriculture	Dryland agriculture	Irrigated agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dams	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network
Forest	-17	9		1	8			-3								
Grassland	-8	1		1	3	2		-1				1				1
IOCB	-8	2	1	1	7			-6				2		1		1
Savanna	-7	-1			7			-1				1				
Wetland	-7				4	2		-1			1					

Table note:

- The largest percentage changes in each row (other than percentage decrease in natural area) are highlighted in red.

Even at the aggregated biome level, this is a useful summary analysis for indicating broadly where and why ecological functioning is being compromised. However, as with the presentation of results at the biome level in Section 4.3, the biome-level summary in Table 16 hides a great deal of variation within each biome. Also as discussed previously, biomes are too heterogeneous to link systematically and reliably to ecosystem service flows, whereas at the level of ecosystem units represented by vegetation types it is possible to link functional ecosystem characteristics directly to the provision of ecosystem services. For example, land cover changes such as over-grazing or hardening of a grassland vegetation type on a slope will have a much more dramatic impact on sediment retention and run-off than the same land cover change in a grassland vegetation type on a plain. *Ecosystem units defined on the basis of vegetation types provide the ability to link ecosystem units, changes in land cover and metrics for ecosystem services with some precision*.

In Table 17 we show a breakdown of land cover change within a few vegetation types in KZN. These vegetation types were selected based on their potential contributions to ecosystem services or biodiversity. Freshwater Wetlands and Alluvial Wetlands are known for their capacity to regulate water quality and quantity; the Southern and Northern Highland Grassland vegetation types fall within a water source area that generates over 90% of the water supply for the greater eThekwini region (the second largest economic centre of South Africa, including the city of Durban); the Subtropical Dune Thicket and KZN Dune Forests offer an important buffering capacity in the event of coastal storms; and the KZN Coastal Belt Grassland and Sandstone Sourveld are examples of important biodiversity that is critically endangered. The account in Table 17 offers valuable information that can be used as a starting point for identifying drivers of land cover change that can point towards the most appropriate management or regulatory interventions, and ensure the continued provision of the ecosystem services generated by these ecosystem assets. For example, increases in built-up areas and the transport network need to be monitored in the highland grasslands because these land cover changes result in catchment hardening, which ultimately affects the regulation of water supply to downstream areas. Likewise, loss of natural dune thicket and forest reduces the buffering capacity of these ecosystems to coastal storms, with built-up areas and transport networks being particularly vulnerable to resulting damages. The results for all vegetation types are provided in Table 26 in the Appendix.

Table 17: Integrated ecosystem and land cover change matrix for selected vegetation types in KZN, 2005 to 2011

Hectares		Increases (positive numbers) and decreases (negative numbers) from other land cover classes within each vegetation type															
Vegetation type	**Biome**	Natural	Degraded	Fallow lands	Plantation	Subsistence agriculture	Dryland agriculture	Irrigated agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dams	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network
Freshwater Wetlands (all)	Wetland	-8336	1039	563	365	3104	2331	548	-1102	-193	-1873	2500	521	-596	594	-206	731
Alluvial Wetlands (all)	Wetland	-18363	-344	775	209	10066	5045	680	-2710	-1961	-7854	11512	1967	-683	864	-828	1589
Southern Drakensberg Highland Grassland	Grassland	-1053	895	0	50	1	30	0	0	0	-32	35	37	1	4	-63	92
Northern Drakensberg Highland Grassland	Grassland	-1744	1685	0	-13	-27	1	0	0	-68	64	-274	350	-28	41	-15	28
Subtropical Dune Thicket	IOCB	-285	293	0	1	1	0	0	-11	0	0	-2	3	-7	8	0	0
KwaZulu-Natal Dune Forests (all)	Forest	-2535	1806	19	438	57	0	0	-218	413	-5	-23	44	-208	-132	215	130
KwaZulu-Natal Coastal Belt Grassland	IOCB	-27056	1190	2501	-31	37574	142	2348	-33535	0	-798	-22303	29021	-57394	62998	-7869	13209
KwaZulu-Natal Sandstone Sourveld	Grassland	-10577	3256	492	873	4047	845	410	-3861	0	-252	-11888	14493	-5800	6879	-2530	3612

Table notes:

- Vegetation types in this table were selected based on the specific contribution they are known to make to biodiversity and ecosystem services.
- Freshwater Wetlands in this table combine 12 different vegetation types from the KZN vegetation map; Alluvial Wetlands combine seven; and KwaZulu-Natal Dune Forest combines two.

Patterns and trends in land cover change within ecosystems units can be summarised to a range of reporting units, such as municipalities or catchments. They can then be compared with trends in socio-economic indicators. South Africa's population census includes questions about household energy and water sources, as well as dwelling types and income levels. Results for Census 2011, summarised at the local municipal level, are shown in Figures 20, 21 and 22 below. The high proportion of households in some municipalities that are directly dependent on rivers for water and on wood for energy is notable, as is the high proportion of traditional huts rather than brick houses in some municipalities. Annual household income is highest in the metropolitan municipality of Ethekwini, and tends to be lower in municipalities that are predominantly rural.

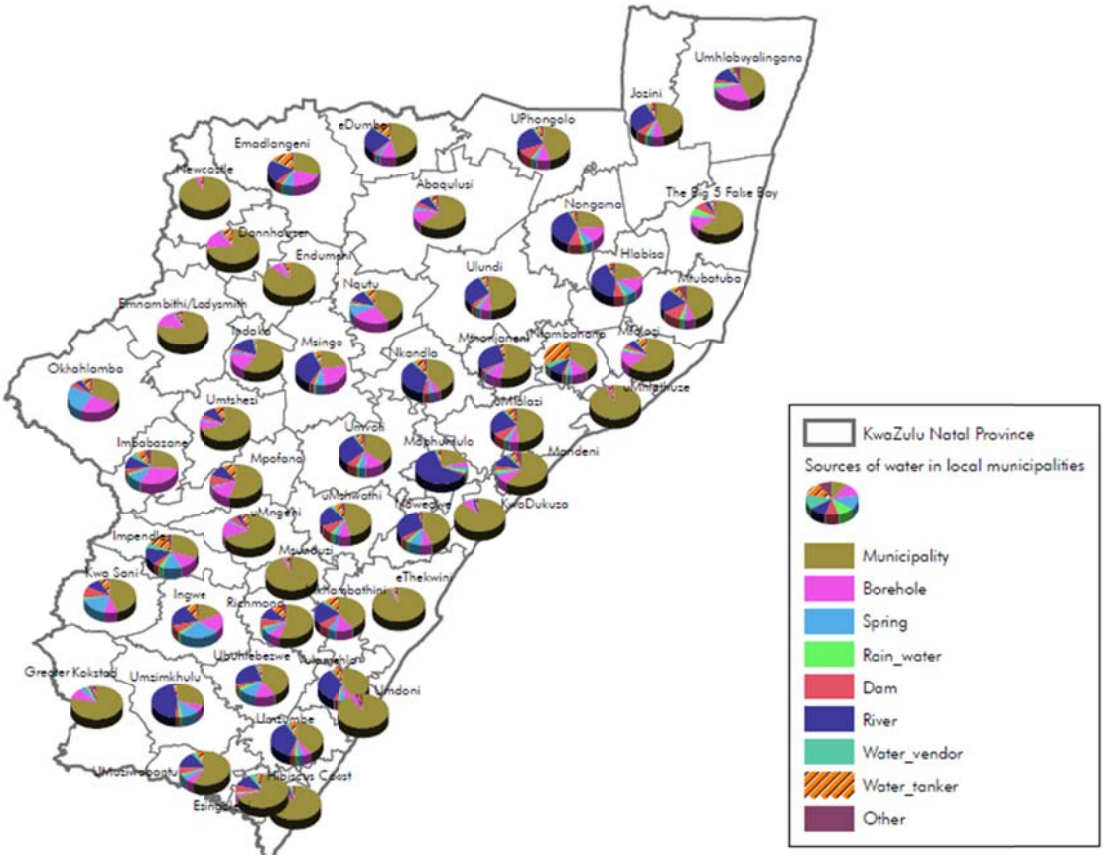

Figure 20: Household water source by local municipality in KZN, based on Population Census 2011

(Source: map provided by Stats SA)

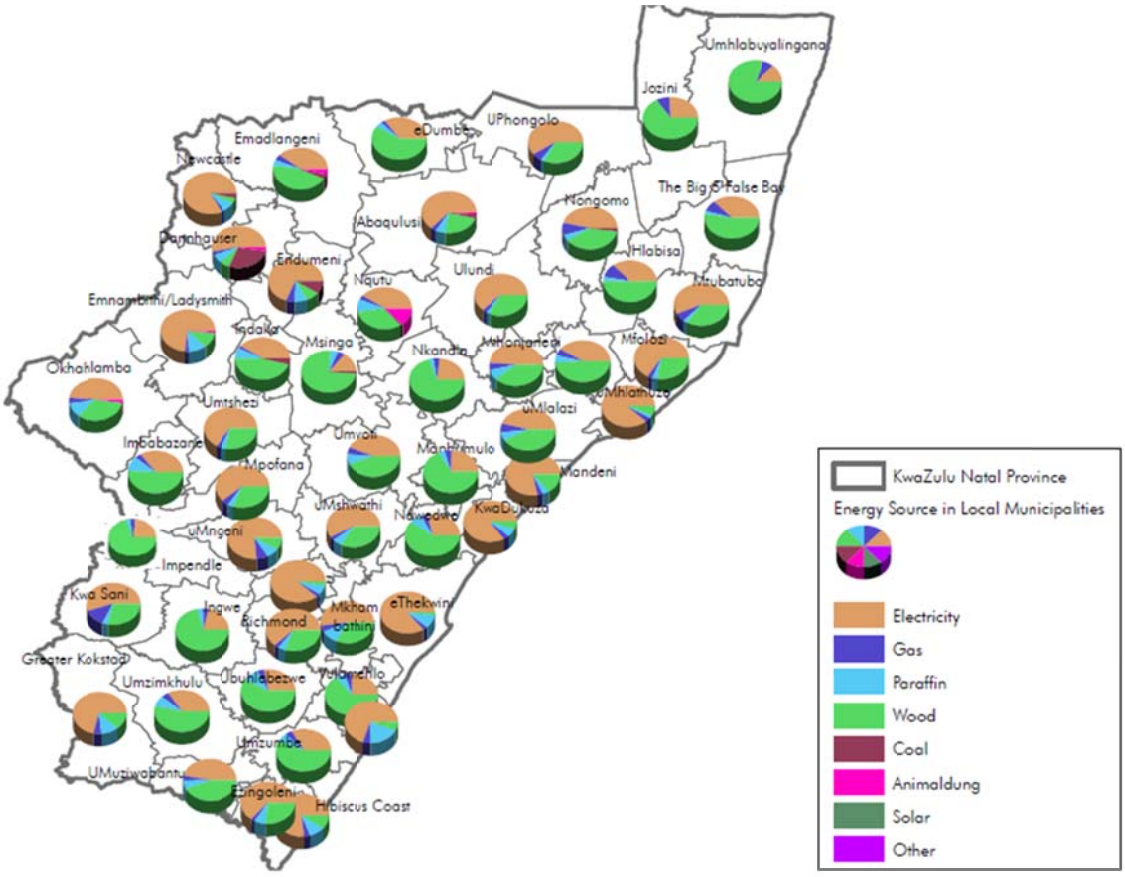

Figure 21: Household energy source by local municipality in KZN, based on Population Census 2011

(Source: map provided by Stats SA)

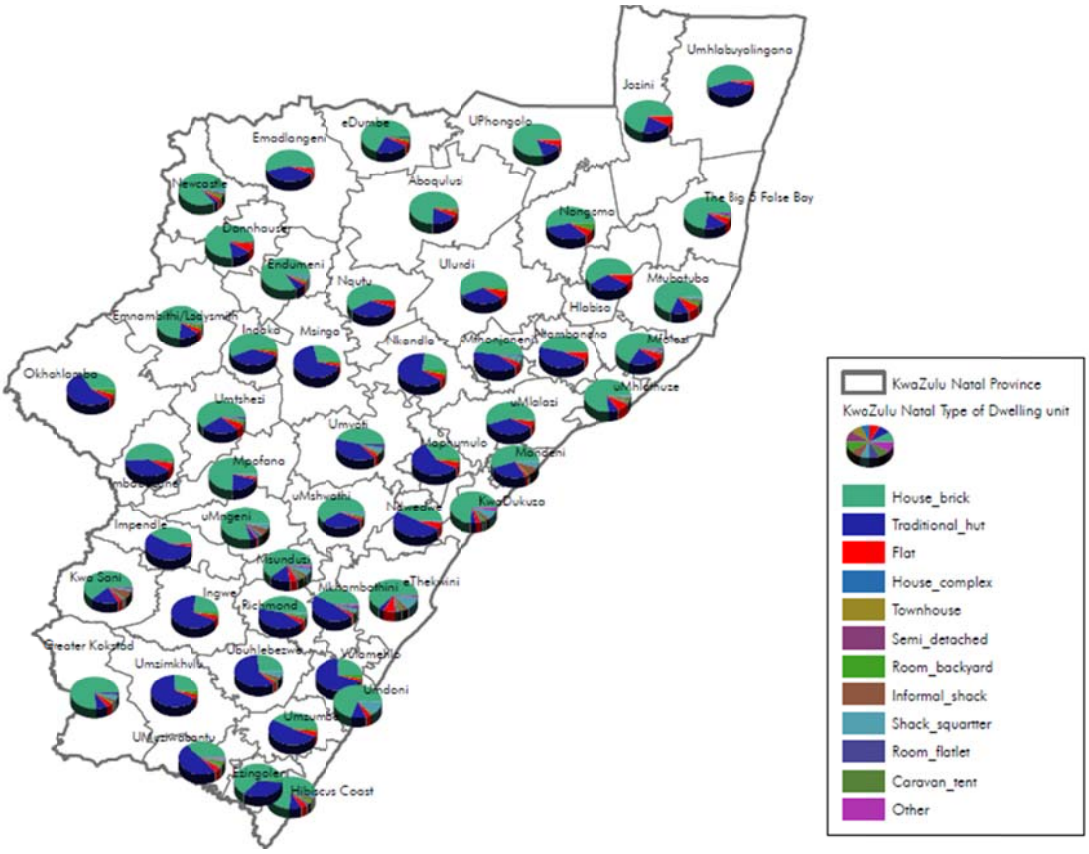

Figure 22: Household dwelling type by local municipality in KZN, based on Population Census 2011

(Source: map provided by Stats SA)

The information provided by integrated matrices of ecosystem types and land cover change such as in Table 16 and Table 17, especially if combined with spatially disaggregated socio-economic information, can be used to **inform land-use planning and decision-making**. For example, the loss of wetlands to commercial and subsistence agriculture as well as built infrastructure such as dams suggests the need for better planning and regulation in the agriculture and water sectors, as it diminishes the ability of the wetlands to attenuate floods and improve water quality while also putting infrastructure at risk.

South Africa is fortunate to have well developed capacity for producing spatial biodiversity plans that identify **biodiversity priority areas**. Most provinces have biodiversity plans that identify Critical Biodiversity Areas (CBAs) in which natural habitat should be kept intact (from the point of view of composition, structure and function), and Ecological Support Areas (ESAs) in which at least ecological functioning should be maintained even if composition and structure are modified. CBAs and ESAs are identified based on the need to keep at least 20% of each ecosystem type in a natural or near-natural state, and the need to support ecological functioning at the landscape level. Figure 23 shows the map of CBAs and ESAs for KZN. Land and ecosystem accounts combined with biodiversity plans that identify CBAs and ESAs provide a powerful combination of tools for informing land-use planning

and decision-making. Land accounts point to areas or sectors where land cover is changing substantially, and biodiversity plans provide spatial information about where interventions should be made to ensure that natural areas are kept intact.

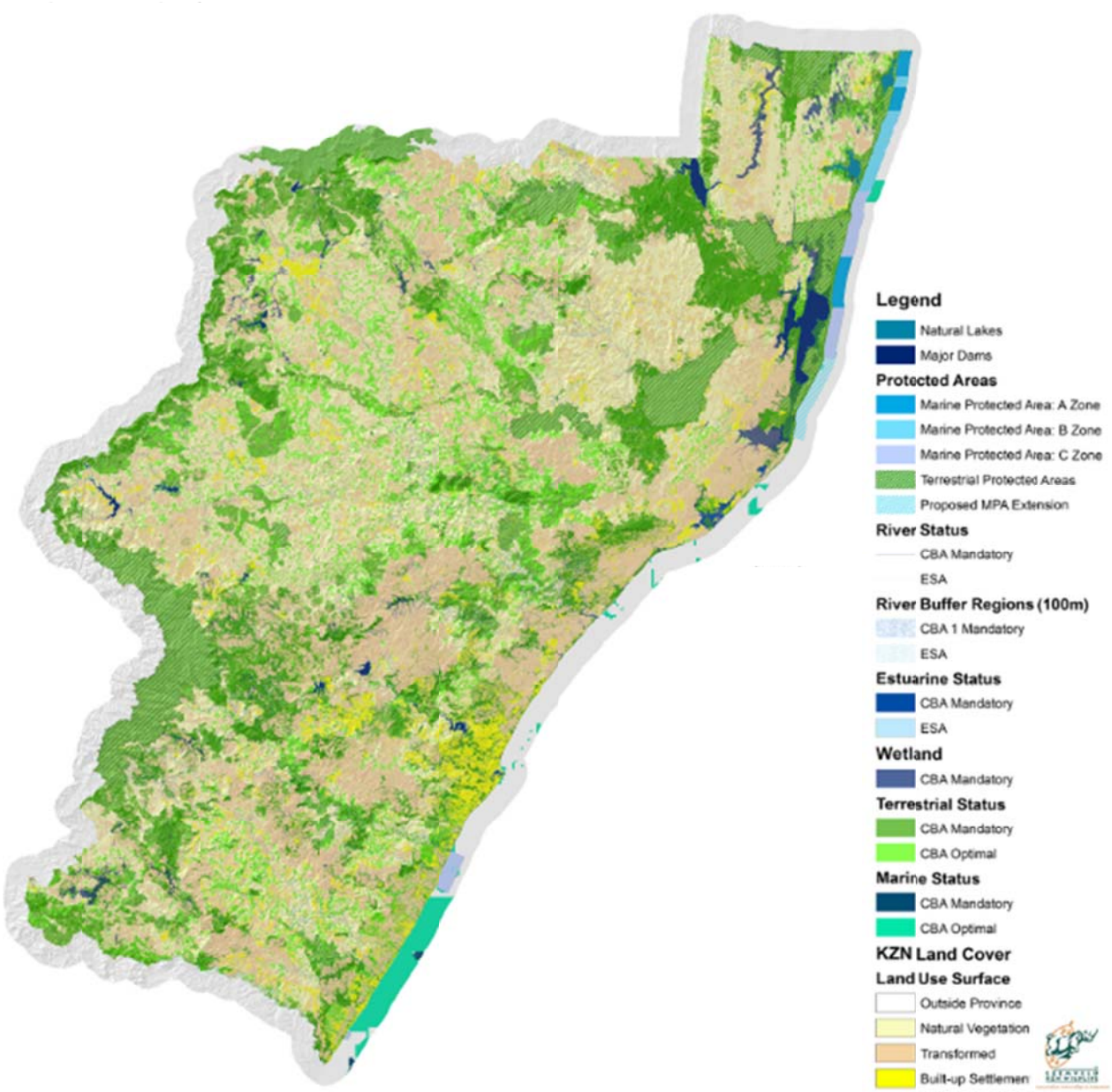

Figure 23: Map of Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs) for KZN

Ecosystem extent accounts and land accounts for ecosystems also take us partway towards constructing **ecosystem condition accounts**. Changes in land cover often cause changes in ecological condition, which will affect ecosystem service delivery differently in different ecosystem types. *Land cover data can thus serve as a proxy for ecosystem condition, especially where no better data on ecosystem condition exists*. In order to get a first take on ecosystem condition, we can simplify the land cover map by allocating each land cover class to one of three ecological condition categories:

natural, semi-natural, and substantially or irreversibly modified, as shown in Table 18. This is of course possible only if land cover classes do not intentionally mix natural, semi-natural and substantially modified areas in a single class. As discussed previously, it is important for land cover classes to distinguish, for example, between timber plantations and natural forest, between fallow lands previously ploughed and natural grasslands, between natural water bodies and dams. These should not be combined in the same land cover class, even in high-level classes, if a link is to be maintained between land cover classes, ecological condition and ultimately the provision of ecosystem services.

Land cover data works well for identifying substantial or irreversible conversion or loss of natural areas. However, land cover data tends to under-represent degraded or semi-natural areas as it is often difficult to identify slight or moderate levels of degradation of natural land from remote images. This means that land cover data should ideally be supplemented with other data relating to the composition, structure and functioning of ecosystems to get a more complete assessment of condition.

Table 18: Relationship between KZN summary land cover classes, degree of modification from natural, and associated ecological condition classes

Degree of modification from natural →		Natural	Semi-natural	Substantially or irreversibly modified
Ecological condition class →		Good	Fair	Poor
KZN summary land cover class ↓				
01	Natural	✓		
02	Degraded		✓	
03	Fallow lands		✓	
04	Timber plantations			✓
05	Subsistence agriculture			✓
06	Dryland cultivation			✓
07	Irrigated cultivation			✓
08	Sugarcane			✓
09	Rehabilitated mines		✓	
10	Severe erosion			✓
11	Dams			✓
12	Low density settlement			✓
13	Turfed recreation areas			✓
14	Built-up areas			✓
15	Mines			✓
16	Transport network			✓

As a priority for further work we suggest it would be useful to construct combined ecosystem extent and condition accounts for KZN, based on ecosystem units represented by vegetation types, which would help to provide the basis for ecosystem service generation accounts.

6. Recommendations and priorities for further work

In this section we draw together some recommendations for integrated land and ecosystem accounting based on our experience of undertaking the work presented here. We then suggest further testing that could be done based directly on these pilot accounts, further ecosystem accounting work that could be undertaken for KZN, and priorities for national land and ecosystem accounting work in South Africa.

6.1 Recommendations for integrated land and ecosystem accounting, including suggested principles

The way land cover classes and ecosystem units are identified, and the relationship between them, is foundational for ecosystem accounting. Drawing from the experience of producing the accounts presented in this discussion document, we suggest three principles that may be helpful in moving towards integrated land and ecosystem extent accounts that in turn lay the basis for ecosystem condition accounts and ecosystem service generation accounts. We suggest these as **principles for enabling integrated land and ecosystem accounting**:

- **Land cover classes and ecosystem units should be distinct**. Land cover classes are not ecologically meaningful proxies for ecosystem assets, and the identification of ecosystem units should be separated from the identification of land cover classes. Ecosystem units should be delineated based on ecosystem types. Ecosystem types can be mapped and classified based on a range of data representing physical factors (such as geology, soil types, altitude, rainfall) that are important in determining the structural and functional characteristics of ecosystems. If information on species distribution and abundance is available, this is also useful for mapping and classifying ecosystem types and can be used in combination with data on physical factors, but it is not essential. Land cover data may be useful for delineating boundaries between some ecosystem types, but land cover classes and ecosystem types should not be conflated, even if they align in some cases. These ecosystem types should form the basis of ecosystem units for ecosystem accounting. (This principle is summarised diagrammatically in Figure 12 in Section 4.) Ecosystem units defined on the basis of ecosystem types (such as vegetation types) provide the ability to link ecosystem units, changes in land cover and metrics for ecosystem services with some provision.

- **Land cover classes should link to socio-economic drivers in the landscape**. This usually requires using enhanced land cover data that allows for inclusion of elements of land use in a detailed set of land cover classes. It is also likely to require an iterative process to identify the most suitable way to group detailed land cover classes into a set of summary or high-level classes that are meaningful for a particular socio-economic and ecological context. We recognise this may result in challenges in reaching a standard international land cover classification across all countries, especially a standard high-level classification. However, it may be possible to aim for standard land cover classification at an intermediate or detailed level, allowing countries to group a standard set of detailed land cover classes in various ways for presenting and reporting the accounts, depending on their socio-economic context.

- **As far as possible, land cover classes should link to ecological impact.** Land cover can be a useful proxy for ecological condition, especially where no better data on condition exists. This requires that a consistent distinction be maintained between land cover classes that are natural, semi-natural and substantially modified. In other words, as far as possible, a single land cover class should not intentionally mix natural, semi-natural and substantially modified features or areas in the landscape. We recognise that in practice these are not three distinct categories but rather form a continuum, and also that it is sometimes difficult to distinguish between them, especially between natural and semi-natural areas. However, aiming for this distinction and even partly achieving it helps enormously in laying the basis for ecosystem extent and condition accounts and for ecosystem service accounts. Ideally the distinction between natural, semi-natural and substantially modified land cover classes should track all the way through the land cover classification, from the detailed classes to the high-level classes.

For fully integrated land, ecosystem asset and ecosystem services accounts, **several elements are required**:

- Land cover classes that link to socio-economic drivers of change and to ecological impacts,
- Stable ecosystem units based on ecosystem types that have been mapped and classified to reflect ecological characteristics related to composition, structure and function,
- An understanding of how these ecosystem units link to ecosystem services (via their functional characteristics),
- An understanding of how conversion of each ecosystem unit (or groups of similar ecosystem units) from natural to various semi-natural or substantially modified land cover classes impacts on its ability to provide ecosystem services.

Having these elements in place would allow for the construction of an integrated set of accounts for land cover, ecosystem extent, ecosystem condition and ecosystem service supply. All of these elements are closely related and interlinked; it is nevertheless useful to keep each of them distinct. Keeping spatial information on land cover classes, ecosystem extent, ecological condition and ecosystem services supply distinct will ultimately support better integration of the accounts.

A further recommendation is that percentage turnover in land cover and percentage land cover unchanged could provide useful **headline indicators** that could be extracted from land accounts and compared across different reporting units (at a range of spatial scales) and across time periods. For ecosystem extent accounts, percentage decline in natural area relative to historical extent could be a useful headline indicator, especially when evaluated against critical ecological thresholds (such as an ecological function threshold and an extinction threshold).

Finally, and perhaps most importantly, a concerted **investment in land cover datasets in time series** is required, as this is an essential foundation for land and ecosystem accounts. If at all possible, land cover products in time series should be developed and reviewed as a collective, in order to ensure consistency between products and therefore improved time series analyses. Ezemvelo KZN Wildlife's experience has generated several lessons about maintaining the integrity of a time series of land cover products, which could usefully be applied in other provinces and nationally. For example,

earlier land cover products should be updated to reflect new information about historic land uses that comes to light in more accurate later products, such as fallow lands that were initially identified as natural areas and then subsequently distinguished as fallow lands. Other rules should also be considered, such as maintaining the maximum extent of natural water bodies through all products, so that time series analyses do not simply reflect wet and dry cycles.

6.2 Priorities for further testing based on the accounts presented here

Further work and testing that could be done based on the data and information already compiled for the accounts presented in this discussion document includes:

- Testing the implications of using different spatial resolution, for example, redoing the analysis using basic spatial units of 100m rather than 20m,
- Exploring whether reappraisals could be incorporated into the European format for presenting the land accounts,
- Including more explicit information about uncertainty levels in reporting the results,
- Testing the use of specialised ecosystem accounting software to produce the same set of accounts,
- Constructing the accounts at municipal level, to determine percentage turnover in land cover as a useful indicator for all municipalities, and to provide municipalities with individualised land and ecosystem accounts,[26]
- Summarising the accounts for other reporting units, such as catchments, and by land tenure or ownership arrangements, such as communal vs privately owned land,
- Exploring various ways of presenting the accounts to illuminate key patterns and trends, including in the form of maps and graphs.

6.3 Suggested further ecosystem accounting work for KZN

Further work and testing that could be done to extend and build on the accounts presented in this discussion document includes:

- Developing ecosystem condition accounts for terrestrial ecosystems in KZN, building on the information on ecological condition that is already embedded in the land cover classes,
- Developing ecosystem service generation accounts, building on models that link ecosystem types and land cover change to ecosystem services,[27]
- Linking land and ecosystem accounts to the river ecosystem accounts presented in the companion discussion document to this one, as well as to water accounts, to explore patterns and relationships,

[26] A suggestion was made by stakeholders to summarise the accounts for local municipalities to three very broad land cover classes of natural, agricultural and urban-industrial, and to characterise municipalities according to which of these is dominant. This could give insight into the dominant economies in each local municipality, and could be a useful basis for comparison with a range of social and economic statistics.

[27] There are several existing models, such as InVEST. The uMngeni Green Fund project, underway at the time of writing, is developing a detailed model of this type for the uMngeni catchment in KZN with a view to guiding investment in restoring and maintaining ecological infrastructure in the catchment as part of the uMngeni Ecological Infrastructure Partnership, a multi-partner landscape-scale initiative aimed at improving water security for the city of Durban.

- Linking land and ecosystem accounts to demographic data and other socio-economic data, such as priority agricultural land, to explore patterns and relationships.

6.4 Priorities for national ecosystem accounting work

This initial set of land and ecosystem accounts for KZN has been undertaken with a view to informing subsequent development of national land and ecosystem accounts, as well as accounts for other classes of ecosystem assets in South Africa, such as wetlands, rivers, coastal and marine ecosystems. We hope to continue the collaboration between the range of partners involved in this work, including but not limited to SANBI, Stats SA, CSIR, DEA, DWS and Ezemvelo KZN Wildlife.

Priorities for national ecosystem accounting work include:

- *Developing national land and ecosystem accounts*, based on current mapping and classification of national ecosystem types.
- *Developing ecosystem condition accounts* and integrating them with ecosystem extent accounts, as done for river ecosystems as part of this project.
- *Working towards an integrated map of ecosystem types across terrestrial and aquatic realms*, to enable a single integrated set of ecosystem extent accounts nationally. This is a longer term undertaking, which is closely related to ongoing work on the National Ecosystem Classification System, mentioned in Section 4.2.
- *Developing land accounts for key ecological infrastructure features*, such as strategic water source areas, riparian zones, and wetlands.
- *Developing land accounts for strategic biodiversity assets,* such as protected areas and Critical Biodiversity Areas.
- *Developing metrics of ecosystem service supply* for ecosystem types in different ecological condition classes (e.g. natural, semi-natural, substantially modified), which can be used in ecosystem service accounts, especially those linked to water security or food security.
- *Piloting the development of the full set of physical ecosystem accounts,* including extent and condition accounts, as well as ecosystem service generation and use accounts.
- *Linking land, water and ecosystem accounts*, with a view to examining relationships between land use, water use, changes in ecosystems, and the supply and use of ecosystem services, at the scale of municipalities, provinces and catchments as well as nationally.
- *Using ecological indicators from ecosystem accounts together with socio-economic indicators* from national accounts, the Census and other national survey data, to monitor the implementation of Sustainable Development Goals in South Africa.

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Appendix

Box 3: Accuracy assessment of the KZN 2011 land cover dataset

Unedited extract from technical report on KZN 2011 land cover dataset (Ezemvelo KZN Wildlife & GTI 2013, p12-13).

7. Land-Cover Mapping Accuracy

Validation of land-cover mapping accuracies was determined using statistical analysis and comparison between the map accuracy field reference data and the 2011 satellite image derived land-cover data. All land-cover classification accuracies were calculated on the final filtered version of the 2011 KZN Province Land-Cover dataset.

A total of 966 reference points were used to calculate the overall land-cover mapping accuracy values. The location and distribution of all reference points are shown in Appendix 7. Note that some land-cover codes associated with the field observations (i.e. reference aerial photos) were modified after comparison to the image derived classification in order to account for seasonal and temporal differences between aerial photo and satellite image acquisition dates, in order to ensure standardised data comparisons. For example, "wetlands" were deemed to have been correctly identified regardless of whether the image and/or aerial photo interpretation recorded open water or floating / emergent vegetation, so long as these cover types were located correctly within the wetland boundary. Likewise, river or tidal features were assumed to have been correctly classified if the image and/or aerial photo recorded class was "water" or "bare sand", as could result from tide or river height variability.

Final land-cover accuracy statistics were calculated using standard contingency matrices to compare land-cover codes for equivalent reference and image classified sample points. Matrix outputs included land-cover classification accuracy, omission and commission error percentages for the full classification (i.e. all land-types) as well as for individual land-cover classes. A kappa value is provided as an indication of overall statistical reliability.

7.1 Land-Cover Mapping Results

The *overall* land-cover mapping accuracy for the full 2011 KZN Province Land-Cover dataset, derived from single date 2011 SPOT5 satellite imagery was 83.51 % (81.95 – 85.07 % @ 90 percent confidence limits), with a Kappa Index of 82.92. This represents a good mapping accuracy with a reliable level of confidence in terms of repeatable mapping accuracy, and is comparable to those achieved in the previous provincial land-cover mapping exercises.

Individual land-cover class mapping accuracies, defined in terms of class specific **user and producer accuracy** values show in many cases significantly higher classification accuracies, with 37 of the 45 *evaluated* cover types having *users* accuracies > 70 %, 32 having *users* accuracies > 80 %, and 25 having *users* accuracies > 90 %. Appendix 8 provides a tabulated summary of the classification accuracy statistics. A separate digital copy of the map accuracy tables, including the contingency matrix is supplied in Excel spreadsheet format.

7.2 Land-Cover Mapping Results: Discussion

Analysis of the contingency matrix illustrated in Appendix 7 shows that in the majority of cases the individual mapping accuracies (i.e. users, producers, commission and omission errors) associated with specific land-cover classes are significantly higher than the overall mapping accuracy. The overall mapping accuracy has been (statistically) influenced to a large degree by the low mapping accuracies of a few select classes, which in most cases show logical confusion with closely associated cover characteristics. For example, grassland, grassland/bush clump mix, degraded bushland (all types) and degraded grassland are the information classes with the highest levels of intra-class confusion and thus lowest mapping accuracies.

Table 19: Land cover classification, basic rules and descriptions from the SEEA Central Framework

Category		Basic rule	Description
01	Artificial surfaces (including urban and associated areas)	The category is composed of any type of artificial surfaces.	The class[28] is composed of any type of areas with a predominant artificial surface. Any urban or related feature is included in this class, for example, urban parks (parks, parkland and laws). The class also includes industrial areas, and waste dump deposit and extraction sites.
02	Herbaceous crops	The category is composed of a main layer of cultivated herbaceous plants.	The class is composed of a main layer of cultivated herbaceous plants (graminoids or forbs). It includes herbaceous crops used for hay. All the non-perennial crops that do not last for more than two growing seasons and crops like sugar cane, where the upper part of the plant is regularly harvested while the root system can remain for more than one year in the field, are included in this class.
03	Woody crops	The category is composed of a main layer of cultivated tree or shrub plants.	The class is composed of a main layer of permanent crops (trees or shrub crops) and includes all types of orchards and plantations (fruit trees, coffee and tea plantation, oil palms, rubber plantation, Christmas trees, etc.).
04	Multiple or layered crops	The category is composed of at least two layers of cultivated woody and herbaceous plants or different layers of cultivated plants combined with natural vegetation.	This class combines two different land cover situations: *Two layers of different crops*. A common case is the presence of one layer of woody crops (trees or shrubs) and another layer of herbaceous crop, e.g., wheat fields with olive trees in the Mediterranean area and intense horticulture, or oasis or typical coastal agriculture in Africa, where herbaceous fields are covered by palm trees. *Presence of one important layer of natural vegetation (mainly trees) that covers one layer of cultivated crops*. Coffee plantations shadowed by natural trees in the equatorial area of Africa are a typical example.
05	Grassland	The category is composed of a main layer of natural herbaceous vegetation with a cover from 10 to 100 per cent.	This class includes any geographical area dominated by natural herbaceous plants (grasslands, prairies, steppes and savannahs) with a cover of 10 per cent or more, irrespective of different human and/or animal activities, such as grazing or selective fire management. Woody plants (trees and/or shrubs) can be present, assuming their cover is less that 10 per cent.
06	Tree-covered areas	The category is composed of a main layer of natural trees with a cover from 10 to 100 per cent.	This class includes any geographical area dominated by natural tree plants with a cover of 10 per cent or more. Other types of plants (shrubs and/or herbs) can be present, even with a density higher than that of trees. Areas planted with trees for afforestation purposes and forest plantations are included in this class. This class includes areas seasonally or permanently flooded with freshwater. It excludes coastal mangroves (→07).

[28] The terms "category" and "class" seem to be used interchangeably in the SEEA, for example "category" in the first column but "class" here. The intended meaning seems to be the same.

Category		Basic rule	Description
07	Mangroves	The category is composed of natural trees with a cover from 10 to 100 per cent in aquatic or regularly flooded areas in salt and brackish water.	This class includes any geographical area dominated by woody vegetation (trees and/or shrubs) with a cover of 10 per cent or more that is permanently or regularly flooded by salt and/or brackish water located in the coastal areas or in the deltas of rivers.
08	Shrub-covered areas	The category is composed of a main layer of natural shrubs with a cover from 10 to 100 per cent.	This class includes any geographical area dominated by natural shrubs having a cover of 10 per cent or more. Trees can be present in scattered form if their cover is less than 10 per cent. Herbaceous plants can also be present at any density. The class includes shrub-covered areas permanently or regularly flooded by inland fresh water. It excludes shrubs flooded by salt or brackish water in coastal areas (→07).
09	Shrubs and/or herbaceous vegetation, aquatic or regularly flooded	The category is composed of natural shrubs or herbs with a cover from 10 to 100 per cent in aquatic or regularly flooded areas with water persistence from 2 to 12 months per year.	This class includes any geographical area dominated by natural herbaceous vegetation (cover of 10 per cent or more) that is permanently or regularly flooded by fresh or brackish water (swamps, marsh areas, etc.). Flooding must persist for at least two months per year to be considered regular. Woody vegetation (trees and/or shrubs) can be present if their cover is less than 10 per cent.
10	Sparsely natural vegetated areas	The category is composed of any type of natural vegetation (all growth forms) with a cover from 2 to 10 per cent.	This class includes any geographical areas were the cover of natural vegetation is between 2 per cent and 10 per cent. This includes permanently or regularly flooded areas.
11	Terrestrial barren land	The category is composed of abiotic natural surfaces.	This class includes any geographical area dominated by natural abiotic surfaces (bare soil, sand, rocks, etc.) where the natural vegetation is absent or almost absent (covers less than 2 per cent). The class includes areas regularly flooded by inland water (lake shores, river banks, salt flats, etc.). It excludes coastal areas affected by the tidal movement of saltwater (→14).
12	Permanent snow and glaciers	The category is composed of any type of glacier and perennial snow with persistence of 12 months per year.	This class includes any geographical area covered by snow or glaciers persistently for 10 months or more.
13	Inland water bodies	The category is composed of any type of inland water body with a water persistence of 12 months per year.	This class includes any geographical area covered for most of the year by inland water bodies. In some cases, the water can be frozen for part of the year (less than 10 months). Because the geographical extent of water bodies can change, boundaries must be set consistently with those set by class 11, according to the dominant situation during the year and/or across multiple years.
14	Coastal water bodies and intertidal areas	The category is composed on the basis of geographical features in relation to the sea (lagoons and estuaries) and abiotic surfaces subject to water persistence (intertidal variations).	The class is defined on the basis of geographical features of the land in relation to the sea (coastal water bodies, i.e., lagoons and estuaries) and abiotic surfaces subject to water persistence (intertidal areas, i.e., coastal flats and coral reefs).

(Source: UN 2014a, Annex 1, p299-301)

Table 20: Allocation of 47 KZN detailed land cover classes to 16 KZN summary land cover classes and the 14 SEEA land cover classes

KZN detailed land cover class		KZN summary land cover class		Land cover class in SEEA Central Framework	
1	Water (natural)	01	Natural	07	Regularly flooded areas
2	Plantation	04	Timber plantations	02	Crops
3	Plantation - clear-felled	04	Timber plantations	02	Crops
4	Wetlands	01	Natural	07	Regularly flooded areas
5	Wetlands - mangrove	01	Natural	05	Mangroves
6	Orchards - permanent, irrigated, bananas and citrus	07	Irrigated cultivation	02	Crops
7	Orchards - permanent, dryland, cashew nuts	06	Dryland cultivation	02	Crops
8	Orchards - permanent, dryland, pineapples	06	Dryland cultivation	02	Crops
9	Sugarcane, commercial, irrigated & dryland	08	Sugarcane	02	Crops
10	Sugarcane, semi-commercial, emerging farmer, irrigated & dryland	08	Sugarcane	02	Crops
11	Mines and quarries	15	Mines	01	Artificial surfaces
12	Built-up / dense settlement	14	Built-up areas	01	Artificial surfaces
13	Golf courses	13	Turfed recreation areas	01	Artificial surfaces
14	Low density settlements	12	Low density settlement	08	Sparse natural vegetated areas
15	Cultivation, subsistence, dryland	05	Subsistence agriculture	02	Crops
16	Cultivation, commercial, annual crops, dryland	06	Dryland cultivation	02	Crops
17	Cultivation, commercial, annual crops, irrigated	07	Irrigated cultivation	02	Crops
18	Forest (indigenous)	01	Natural	04	Tree covered area
19	Dense thicket & bush (70 – 100% cc)	01	Natural	04	Tree covered area
20	Medium bush (< 70% cc)	01	Natural	06	Shrub covered areas
21	Woodland & Wooded Grassland	01	Natural	04	Tree covered area
22	Bush Clumps / Grassland	01	Natural	06	Shrub covered areas
23	Grassland	01	Natural	03	Grassland
24	Bare sand	01	Natural	09	Terrestrial barren land
25	Degraded forest	02	Degraded	04	Tree covered area
26	Degraded bushland (all types)	02	Degraded	04	Tree covered area
27	Degraded grassland	02	Degraded	03	Grassland

KZN detailed land cover class		KZN summary land cover class		Land cover class in SEEA Central Framework	
28	Old fields (previously grassland)	03	Fallow lands	03	Grassland
29	Old fields (previously bushland)	03	Fallow lands	06	Shrub covered areas
30	Smallholdings	12	Low density settlement	08	Sparse natural vegetated areas
31	Erosion	10	Severe erosion	09	Terrestrial barren land
32	Bare rock	01	Natural	09	Terrestrial barren land
33	Alpine grass-heath	01	Natural	06	Shrub covered areas
34	KZN national roads	16	Transport network	01	Artificial surfaces
35	KZN main & district roads	16	Transport network	01	Artificial surfaces
36	Water (dams)	11	Dams	10	Permanent snow, glaciers and inland water bodies
37	Water (estuarine)	01	Natural	11	Coastal water and inter-tidal areas
38	Water (sea)	01	Natural	11	Coastal water and inter-tidal areas
39	Bare sand (coastal)	01	Natural	09	Terrestrial barren land
40	Forest glade	01	Natural	04	Tree covered area
41	Outside KZN boundary	9999	No Data	9999	No Data
42	KZN railways	16	Transport network	01	Artificial surfaces
43	Airfields	16	Transport network	01	Artificial surfaces
44	Old plantation- high vegetation	3	Fallow lands	02	Crops
45	Old plantation - low vegetation	3	Fallow lands	02	Crops
46	Rehabilitated mines - high vegetation	9	Rehabilitated mines	06	Shrub covered areas
47	Rehabilitated mines - low vegetation	9	Rehabilitated mines	06	Shrub covered areas

Table 21: Descriptions of KZN detailed land cover classes

KZN detailed land cover class		Description
1	Water (natural)	All areas of natural open water, excluding estuarine, and coastal waters.
2	Plantation	All areas of non-natural timber plantations.
3	Plantation – clear-felled	All temporary clear-felled stands awaiting re-planting within non-natural timber plantations.
4	Wetland	All permanent, near permanent or daily freshwater, brackish or saline wetland areas.
5	Wetland - mangrove	Mangrove wetlands
6	Orchards - permanent, irrigated, banana's and citrus	Permanent, irrigated orchards comprising primarily banana and citrus's trees and shrubs. Also includes tea plantations.
7	Orchards - permanent, dryland, cashew nuts	Permanent, non-irrigated orchards comprising primarily cashew nut trees
8	Orchards - permanent, dryland, pineapples	Permanent, non-irrigated orchards / plantations comprising primarily pineapple crops
9	Sugarcane, commercial, irrigated & dryland	Commercial, large scale sugarcane cultivation, including both irrigated and dryland crops
10	Sugarcane, semi-commercial, emerging farmer, irrigated & dryland	Commercial, small scale sugarcane cultivation, including both irrigated and dryland crops. Emerging farmers are defined on the basis of field sizes being typically larger than subsistence field units but smaller than commercial field units, on a locally defined basis.
11	Mines & Quarries	Major surface-based mineral and rock excavation sites
12	Built-up / dense settlement	All major urban and built-up areas, irrespective of associated residential, commercial or industrial use, defined in terms of local high building densities. Also includes associated covers such as land-fills, rubbish dumps and cemeteries, and other built-up features such as chicken and pig battery farms.
13	Golf courses	Golf courses and golf estates (includes all grass and tree areas within boundary), and other major areas of non-agricultural improved grasslands such as sports fields and race tracks.
14	Low density settlements	Areas of low density settlement, typically in rural or urban periphery locations, that do not in terms of size or density belong in the denser Built-Up settlement. Often associated with subsistence cultivation activities.
15	Cultivation, subsistence, dryland	Identifiable areas of scattered or clustered, small-scale, dryland cultivation for local or household consumption, typically associated with rural dwelling cover classes. Can include some subsistence level dryland sugarcane fields, if field sizes are small, and the sugarcane crop cannot be defined as a "pure" unit in each case.
16	Cultivation, commercial, annual crops, dryland	Commercial, medium-large scale dryland cultivation of annual crops.
17	Cultivation, commercial, annual crops, irrigated	Commercial, medium-large scale irrigated cultivation of annual crops.
18	Forest (indigenous)	Dense, tall tree dominated forest communities with > 70% canopy closure.
19	Dense thicket & bush (70 – 100 % cc)	Dense, medium / tall, tree and shrub dominated communities with > 70 % canopy closure.

KZN detailed land cover class		Description
20	Medium bush (< 70% cc)	Medium / tall shrub dominated communities with 40 – 70 % canopy closure.
21	Woodland & Wooded Grassland	Tree based communities with an open grass layer, with tree canopy closure between 10 – 70 %.
22	Bush Clumps / Grassland	Grassland dominated areas with scattered bush and thicket clumps.
23	Grassland	Open grassland areas.
24	Bare Sand	Natural non-vegetated areas of exposed sand (e.g. river sand). Also includes areas of exposed sands on the Maputoland Coastal Plain that appear to be the result of either historical wildfires and cleared exotic forest plantations on the Eastern Shores of St Lucia. Specifically excludes coastal beach and dune deposits, which are mapped as a separate sub-class.
25	Degraded Forest	Areas of Forest (class 18) that show a significant loss of tree and shrub canopy cover, when compared to surrounding areas of natural Forest.
26	Degraded Bushland (all types)	Areas of Bushland (all types, classes 19,20, 22)) that show a significant loss of tree and/or shrub canopy cover, when compared to surrounding areas of natural Bushland. If tree loss is not significant, “degraded woodland and wooded grassland” areas will be included in this class.
	Degraded Grassland	Areas of Grassland (class 23) that show a significant loss of grass canopy cover, when compared to surrounding areas of grassland. If tree loss is significant, “degraded woodland and wooded grassland” areas will be included in this class.
28	Old Fields (previously grassland)	Old fields, not recently cultivated, which are identifiable on the basis of remnant fence-line effects, and which appear to have been previous grassland areas.
29	Old Fields (previously bushland)	Old fields, not recently cultivated, which are identifiable on the basis of remnant fence-line effects, and which appear to have been previous bushland areas.
30	Smallholdings	Semi-rural areas on the fringes of major urban areas that contain a combination of large residential cadastral parcel and / or “recreational” semi-commercial farming activities, within a previously grass or bushland-dominated landscape.
31	Erosion	Non-vegetated areas (or areas of very low vegetation in comparison to the surrounding natural vegetation), that are primarily the result of gully-type erosional processes, occurring through either natural and / or anthropogenic actions.
32	Natural Bare Rock	Natural non-vegetated areas of exposed hard rock (e.g. sandstone paving, cliffs).
33	Alpine Grass - Heath	Communities of low shrubland and grassland typically associated with the high altitude Drakensberg Escarpment Plateau regions.
34	KZN National Roads	National class road lines as defined within the KZN Provincial Dept of Transport’s GIS database.
35	KZN Main & District Roads	Main & District class road lines as defined within the KZN Provincial Dept of Transport’s GIS database.
36	Water (dams)	All areas of open water within man-made impoundments, ranging from farm dams to major reservoirs.
37	Water (estuarine)	All areas of natural open water, associated with the estuarine reaches of a river.

KZN detailed land cover class		Description
38	Water (sea)	All areas of natural open water, associated with the coastal and sea areas.
39	Bare Sand (coastal)	Natural non-vegetated areas of exposed sand associated specifically with coastal dunes and beaches.
40	Forest glade	Naturally occurring open grassy regions, enclosed within closed canopy indigenous forests.
41	Outside KZN Province	Areas not classified since they fall outside the KZN Provincial boundary.
42	KZN Railways	All railway lines located within the KZN Provincial, and visible on the SPOT5 imagery.
43	Airfields	Rural airfields and airstrips (often grass).
44	Old plantations – high vegetation	Former tree plantations that have been cleared and are now covered in tall regrowth vegetation.
45	Old plantations – low vegetation	Former tree plantations that have been cleared and are now covered in low regrowth vegetation.
46	Rehabilitated mines – high vegetation	Former mining areas that are now covered in tall regrowth vegetation.
47	Rehabilitated mines – low vegetation	Former mining areas that are now covered in low regrowth vegetation.

(Source: Ezemvelo KZN Wildlife & GTI 2013, Appendix 6, page 24)

Table 22: Relationship between land cover lasses in the SEEA Central Framework and KZN detailed land cover classes

SEEA land cover class		KZN detailed land cover class	
01	Artificial surfaces (including urban and associated areas)	11	Mines and quarries
		12	Built-up / dense settlement
		13	Golf courses
		34	KZN national roads
		35	KZN main & district roads
		42	KZN railways
		43	Airfields
02 03 04	Crops (including herbaceous, woody, and multiple or layered crops)	2	Plantation
		3	Plantation – clear-felled
		6	Orchards - permanent, irrigated, bananas and citrus
		7	Orchards - permanent, dryland, cashew nuts
		8	Orchards - permanent, dryland, pineapples
		9	Sugarcane, commercial, irrigated & dryland
		10	Sugarcane, semi-commercial, emerging farmer, irrigated & dryland
		15	Cultivation, subsistence, dryland
		16	Cultivation, commercial, annual crops, dryland
		17	Cultivation, commercial, annual crops, irrigated
		44	Old plantation- high vegetation
		45	Old plantation - low vegetation
05	Grassland	23	Grassland
		27	Degraded grassland
		28	Old fields (previously grassland)
06	Tree-covered areas	18	Forest (indigenous)
		19	Dense thicket & bush (70 – 100 % cc)
		21	Woodland & Wooded Grassland
		25	Degraded forest
		26	Degraded bushland (all types)
		40	Forest glade
07	Mangroves	5	Wetlands - mangrove
08	Shrub-covered areas	20	Medium bush (< 70% cc)
		22	Bush clumps / Grassland
		29	Old fields (previously bushland)
		33	Alpine grass-heath
		46	Rehabilitated mines - high vegetation
		47	Rehabilitated mines - low vegetation
09	Regularly flooded areas	1	Water (natural)
		4	Wetlands
10	Sparsely natural vegetated areas	14	Low density settlements
		30	Smallholdings
11	Terrestrial barren land	24	Bare sand
		31	Erosion
		32	Bare rock
		39	Bare sand (coastal)
12	Permanent snow and glaciers		(none in South Africa)
13	Inland water bodies	36	Water (dams)
14	Coastal water bodies and intertidal areas	37	Water (estuarine)
		38	Water (sea)

Table 23: Physical account for land cover in KZN using KZN land cover classes and SEEA Central Framework format, 2005-2011

Hectares	Natural	Degraded	Fallow lands	Timber plantations	Subsistence agriculture	Dryland agriculture	Irrigated agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dams	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network	No data
Opening stock 2005	**6 187 163**	**641 270**	**43 114**	**694 126**	**240 492**	**251 003**	**119 380**	**503 760**		**66 185**	**52 467**	**258 714**	**3 108**	**191 937**	**4 524**	**76 475**	**1 420**
Additions to stock																	
Managed expansion	83 733	176 067	26 289	66 319	398 724	67 898	23 290	52 252	3 036	27 494	9 088	54 646	1 509	27 557	1 862	43 569	
Natural expansion																	
Upward reappraisal																	1 164
Total additions to stock	83 733	176 067	26 289	66 319	398 724	67 898	23 290	52 252	3 036	27 494	9 088	54 646	1 509	27 557	1 862	43 569	1 164
Reductions in stock																	
Managed regression	658 074	110 929	3 743	23 067	26 965	10 025	4 162	169 945		8 622	1 206	21 229	375	19 209	350	6 346	126
Natural regression																	
Downward reappraisal	106	8		4		1	1				2						
Total reductions in stock	658 180	110 937	3 743	23 070	26 965	10 026	4 163	169 945		8 622	1 208	21 230	375	19 209	350	6 347	126
Opening stock 2008	**5 612 716**	**706 400**	**65 660**	**737 375**	**612 250**	**308 874**	**138 507**	**386 067**	**3 036**	**85 056**	**60 347**	**292 130**	**4 243**	**200 285**	**6 035**	**113 698**	**2 457**
Additions to stock																	
Managed expansion	95	8 003	2 382	5 449	65 963	51 846	4 290	3 634	288	11 234	5 354	47 301	138	8 075	1 146	9 078	17
Natural expansion																	
Upward reappraisal	10															6	
Total additions to stock	105	8 003	2 382	5 449	65 963	51 846	4 290	3 634	288	11 234	5 354	47 301	138	8 075	1 146	9 084	17
Reductions in stock																	
Managed regression	126 981	41 474	3 387	4 596	8 051	15 302	9 900	3 759	1 584	1 149	343	6 493	486	450	332	21	
Natural regression																	
Downward reappraisal																	
Total reductions in stock	126 981	41 474	3 387	4 596	8 051	15 302	9 900	3 759	1 584	1 149	343	6 493	486	450	332	21	
Opening stock 2011	**5 485 839**	**672 929**	**64 655**	**738 228**	**670 162**	**345 418**	**132 898**	**385 943**	**1 740**	**95 140**	**65 358**	**332 937**	**3 894**	**207 910**	**6 849**	**122 761**	**2 474**

Table 24: Physical account for land cover in KZN, summarised by municipality, 2005-2011

Hectares		Natural	Degraded	Fallow lands	Timber plantations	Subsistence agriculture	Dryland agriculture	Irrigated agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dams	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network	Area (ha)
Municipality ↓																		
1.	Ethekwini	-23 371	237	1 488	293	5 538	286	217	-4 796	-3	-2 230	-13 425	22 029	-61 640	70 596	-4 065	8 697	228 957
2.	Vulamehlo	-5 494	2 250	85	459	4 572	61	59	-4 107	0	-46	-5 240	6 850	-697	745	-1 008	1 511	95 999
3.	Umdoni	531	1 062	21	-56	360	21	34	-2 403	0	-70	-1 617	1 705	-3 111	3 211	-701	1 006	25 090
4.	Umzumbe	-15 301	1 233	54	86	15 046	297	63	-4 551	0	-20	-9 811	11 902	-2 061	2 347	-1 590	2 306	125 890
5.	UMuziwa-bantu	-17 070	2 036	105	882	9 850	677	-238	1 773	0	-134	-5 496	6 487	-1 973	2 481	-1 381	1 974	109 006
6.	Ezingoleni	-6 477	885	222	-103	3 345	428	422	-340	0	-117	-3 441	4 735	-234	115	-562	1 113	64 829
7.	Hibiscus Coast	-7 379	1 189	194	-567	6 730	62	2 241	-4 807	0	-191	-6 709	8 155	-8 851	9 009	-1 888	2 694	83 765
8.	uMshwathi	-9 153	5 615	202	1 413	1 295	301	124	-2 135	0	-2 277	-3 879	7 377	-1 320	1 499	-1 896	2 834	181 800
9.	uMngeni	-18 812	4 213	12	3 777	0	5 977	1 797	-49	0	-3 822	2 104	3 388	-2 774	3 191	-1 710	2 708	156 689
10.	Mpofana	-16 330	5 227	107	383	377	7 045	736	-57	-674	-455	1 086	1 830	-498	573	-1 315	1 965	182 001
11.	Impendle	-11 407	3 942	164	1 621	2 011	1 959	243	0	-8	-371	-1 704	2 915	-489	672	-739	1 191	152 835
12.	Mkhambathini	-5 557	2 017	723	235	1 217	1 730	217	-2 732	0	-667	-3 233	5 049	-987	1 218	-1 043	1 813	89 087
13.	Richmond	-9 668	2 531	266	3 168	572	1 891	1 288	-1 449	-1	-509	-1 704	2 896	-1 710	1 915	-1 104	1 618	125 569
14.	Emnambithi	-16 318	-110	1 563	284	3 098	3 799	25	0	-8 709	9 562	-3 635	7 983	-4 365	5 224	-2 136	3 732	296 581
15.	Indaka	-4 639	-4 274	57	8	7 677	-735	-30	0	-1 898	2 242	-2 662	3 626	-1 763	1 918	-701	1 174	99 153
16.	Umtshezi	-14 768	4 776	707	334	1 778	1 081	659	0	-8 001	10 186	-346	2 420	-1 361	1 595	-1 335	2 275	197 311
17.	Okhahlamba	-17 488	-2 654	680	525	5 307	5 670	2 017	0	-3 063	-2 978	836	9 336	-1 554	1 832	-2 491	3 998	397 207
18.	Imbabazane	-7 346	199	194	314	1 912	1 985	-245	0	-1 404	1 168	-5 528	7 255	-1 332	2 203	-882	1 506	142 637
19.	Endumeni	-10 999	1 940	1 911	257	585	3 026	-190	0	-2 805	3 891	-313	1 635	-1 497	1 609	-788	1 738	161 054

Hectares **Municipality ↓**		Natural	Degraded	Fallow lands	Timber plantations	Subsistence agriculture	Dryland agriculture	Irrigated agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dams	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network	Area (ha)
20.	Nqutu	-26 215	351	0	140	18 603	193	0	0	-8 793	11 951	-8 494	11 131	-1 711	1 966	-1 155	2 033	196 217
21.	Msinga	-19 802	-4 859	649	207	17 943	-266	71	92	-4 996	6 269	-7 124	10 803	-462	493	-1 518	2 500	250 151
22.	Umvoti	-13 635	4 641	20	1 671	622	4 027	530	-2 013	-745	767	-3 274	5 797	-1 413	1 730	-2 008	3 283	251 558
23.	Newcastle	-9 900	-108	141	1 852	1 018	4 394	-237	0	-1 483	494	-1 247	3 089	-11 182	11 391	-787	2 544	185 615
24.	Emadlangeni	-17 796	19	1 765	1 458	3 004	9 523	-702	0	-6 133	4 174	1 448	2 335	-821	112	-1 352	2 955	353 947
25.	Dannhauser	-8 725	-1 885	713	635	416	5 140	-663	0	-2 047	-35	-1 723	6 474	-2 145	2 332	-507	2 017	151 638
26.	eDumbe	-10 665	806	87	2 413	3 263	2 325	-686	0	-85	-422	-1 524	3 472	-1 478	1 519	-1 274	2 246	194 252
27.	UPhongolo	-12 328	4 009	225	-17	3 267	1 259	369	-386	-495	-10 065	6 770	6 386	-1 669	1 867	-2 042	2 815	323 878
28.	Abaqulusi	-29 199	3 076	1 078	3 127	10 149	4 860	-658	-6	-6 368	8 503	-3 106	6 492	-5 021	4 735	-2 216	4 554	418 489
29.	Nongoma	-40 790	-2 230	-37	16	37 108	-76	-1	-42	-1 898	3 905	-9 358	11 847	-1 531	1 808	-2 259	3 538	218 241
30.	Ulundi	-26 643	1 070	292	-179	17 727	173	-23	0	-4 014	7 739	-7 600	10 054	-3 039	2 835	-2 078	3 686	325 026
31.	Umhlabuyalingana	-15 249	-11 967	9	5 207	23 325	3	0	226	0	-41	-8 468	12 365	-1 565	855	-1 749	-2 951	440 196
32.	Jozini	-24 082	-15 465	-183	-21	35 024	77	-1 206	494	-11	-1 019	-9 997	14 937	-1 160	1 271	-2 604	3 873	344 222
33.	The Big 5 False Bay	-11 713	6 258	-2 076	361	2 806	2 951	28	-43	-8	-417	-1 263	2 670	-359	328	-1 189	1 666	248 638
34.	Hlabisa	-18 069	2 097	9	45	16 554	12	0	-1 798	-125	-219	-3 445	4 460	-329	306	-629	1 131	155 552
35.	Mtubatuba	-25 809	782	7 021	1 148	30 272	101	16	-16 429	-1	-62	-5 911	8 120	-3 650	3 269	-1 043	2 176	196 996
36.	Mfolozi	-15 118	937	132	199	14 598	3	33	-5 077	1 718	-266	-3 450	5 738	-3 096	1 659	352	1 612	120 965
37.	uMhlathuze	-8 821	3 245	-222	115	6 337	27	221	-4 121	0	-312	-2 753	4 283	-7 584	7 962	-339	1 887	79 256
38.	Ntambanana	-13 628	823	339	84	10 360	29	73	-162	-50	-98	-1 697	3 328	-1 827	1 748	-865	1 543	108 308
39.	uMlalazi	-7 983	-3 071	-200	878	27 092	28	353	-19 545	0	-835	-5 829	8 192	-5 233	5 041	-2 188	3 287	221 382
40.	Mthonjaneni	-4 763	1 239	99	849	1 564	277	25	-244	-42	-458	-710	1 790	-409	399	-726	1 110	108 587

Hectares **Municipality ↓**		Natural	Degraded	Fallow lands	Timber plantations	Subsistence agriculture	Dryland agriculture	Irrigated agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dams	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network	Area (ha)
41.	Nkandla	-15 483	492	8	59	13 495	6	-27	-2 144	-210	519	-6 214	8 453	-458	577	-1 597	2 524	182 758
42.	Mandeni	-1 639	908	222	159	10 258	0	0	-10 910	0	-106	-2 975	3 653	-2 994	2 872	-791	1 269	54 491
43.	KwaDukuza	2 689	1 305	765	114	1 010	23	211	-6 978	0	-124	-1 154	1 494	-6 063	6 251	-1 044	1 477	73 425
44.	Ndwedwe	-5 563	-445	422	187	12 174	0	111	-9 684	0	-20	-7 143	9 331	-878	826	-1 665	2 347	109 291
45.	Maphumulo	1 271	253	108	-55	5 968	0	0	-9 161	0	27	-3 238	4 554	-1 520	1 433	-1 044	1 404	89 601
46.	Ingwe	-20 559	-1 149	335	2 082	10 797	3 000	1 451	1	-1 126	1 013	-7 571	10 048	-946	1 167	-1 999	3 456	197 705
47.	Kwa Sani	-9 775	494	204	890	131	2 841	3 398	0	-28	-1 527	1 499	1 148	-144	228	-1 108	1 740	185 189
48.	Greater Kokstad	-23 826	4 618	141	475	141	13 941	1 745	6	-170	-1 246	1 330	1 630	-1 244	1 302	-1 674	2 700	268 079
49.	Ubuhlebezwe	-13 822	3 059	399	1 611	6 023	4 653	-49	-4 158	-40	-445	-6 000	7 796	-1 550	1 751	-1 645	2 417	160 414
50.	Umzimkhulu	-25 692	435	224	4 614	15 962	-951	-101	-34	-579	1 921	-11 374	13 048	-4 923	5 908	-707	2 249	243 632
51.	Msunduzi	-6 966	764	-49	348	1 537	412	-163	71	0	-172	-6 863	7 665	-13 467	15 588	-856	2 151	63 402

Table 25: Ecosystem extent account for vegetation types in KZN, 2005 – 2011

Veg ID	Vegetation type	Biome	Historical extent 1840 (ha)	Decline in extent 1840-2011 (ha)	Decline in extent 1840-2011 (%)	Decline in extent 2005-2011 (ha)	Decline in extent 2005-2011 (%)
1	Alluvial Wetlands: Subtropical Alluvial Vegetation	Wetland	17 083	7 964	47	881	5
2	Subtropical Coastal Lagoons: Estuary	Wetland	40 138	376	1	64	
3	Freshwater Wetlands: Subtropical Freshwater Wetlands: Coastal Lakes & Pans	Wetland	7 595	363	5	93	1
4	Alluvial Wetlands: Subtropical Alluvial Vegetation: Lowveld Floodplain Grasslands : Tall Reed Wetland	Wetland	2 565	766	30	184	7
5	Freshwater Wetlands: Subtropical Freshwater Wetlands: Short Grass/ Sedge Wetlands	Wetland	47 004	15 545	33	2 990	6
6	Alluvial Wetlands: Temperate Alluvial Vegetation	Wetland	147 263	62 788	43	15 275	10
7	Freshwater Wetlands: Subtropical Freshwater Wetlands: Tall Grassland/ Sedge/ Reed Wetlands	Wetland	14 811	537	4	260	2
8	Freshwater Wetlands: Subtropical Freshwater Wetlands	Wetland	13 966	6 509	47	903	6
9	Freshwater Wetlands: Subtropical Freshwater Wetlands: Short Grass/ Sedge Wetlands: Dune Slack	Wetland	275	91	33	3	1
10	Alluvial Wetlands: Subtropical Alluvial Vegetation: Lowveld Floodplain Grasslands	Wetland	22 957	15 361	67	712	3
11	Freshwater Wetlands: Drakensberg Wetlands	Wetland	5 759	1 039	18	256	4
12	Freshwater Wetlands: Eastern Temperate Wetlands	Wetland	44 745	14 803	33	3 813	9
13	Marine Saline Wetlands: Saline Grassland & Mud Flats	Wetland	4 209	1 017	24	572	14
14	Inland Saline Wetlands: Subtropical Salt Pans	Wetland	2 557	410	16	22	1
15	Lowveld Riverine Forest	Azonal Forest	10 074	3 851	38	1 345	13
16	Alluvial Wetlands: Subtropical Alluvial Vegetation: Lowveld Floodplain Grasslands : Short Grass/ Sedge Wetlands	Wetland	7 610	5 128	67	1 213	16
17	Freshwater Wetlands: Subtropical Freshwater Wetlands: Short Grass/ Sedge Wetlands: Coastal Plain Depression	Wetland	782	287	37	-66	-8

Veg ID	Vegetation type	Biome	Historical extent 1840 (ha)	Decline in extent 1840-2011 (ha)	Decline in extent 1840-2011 (%)	Decline in extent 2005-2011 (ha)	Decline in extent 2005-2011 (%)
18	Alluvial Wetlands: Temperate Alluvial Vegetation: Midland Alluvial Woodland & Thicket	Wetland	207	114	55	15	7
19	Marine Saline Wetlands	Wetland	1 764	685	39	-86	-5
20	Dry Coast Hinterland Grassland	Grassland	276 403	124 568	45	27 792	10
21	Maputaland Wooded Grassland	IOCB	107 919	74 373	69	10 791	10
22	Alluvial Wetlands: Temperate Alluvial Vegetation: Midland Floodplain Grasslands	Wetland	1 781	481	27	82	5
23	Freshwater Wetlands: Eastern Temperate Wetlands: Lakes & Pans	Wetland	40	5	13	-1	-3
24	Freshwater Wetlands: Lesotho Mires	Wetland	1				
25	Muzi Palm Veld and Wooded Grassland	Savanna	52 927	22 792	43	-3 256	-6
26	Marine Saline Wetlands: Saline Reed & Sedge Beds	Wetland	964	38	4	28	3
27	Freshwater Wetlands: Subtropical Freshwater Wetlands: Coastal Lakes & Pans: Endorheic	Wetland	7 000	197	3	84	1
28	Inland Saline Wetlands: Subtropical Salt Pans: Floodplain Pans (Open)	Wetland	2 103	295	14	40	2
29	Zululand Coastal Thornveld	Savanna	67 136	41 103	61	16 815	25
30	Thukela Valley Bushveld	Savanna	268 483	91 439	34	13 765	5
31	Mabela Sandy Grassland	Grassland	443	391	88	144	32
32	Wakkerstroom Montane Grassland	Grassland	131 587	17 692	13	6 903	5
33	Southern Lebombo Bushveld	Savanna	116 508	24 311	21	8 757	8
34	Drakensberg-Amathole Afromontane Fynbos	Grassland	1 424	7		7	
35	Amersfoort Highveld Clay Grassland	Grassland	13 171	3 604	27	1 267	10
36	Drakensberg Afroalpine Heathland	Grassland	6 116	30		3	
37	Drakensberg Foothill Moist Grassland	Grassland	359 954	117 425	33	25 351	7
38	Basotho Montane Shrubland	Grassland	2 734	136	5	69	3
39	East Griqualand Grassland	Grassland	133 961	63 715	48	15 367	11
40	Eastern Free State Sandy Grassland	Grassland	4 052	279	7	98	2
41	Income Sandy Grassland	Grassland	437 808	235 252	54	21 344	5
42	Ithala Quartzite Sourveld	Grassland	82 013	17 791	22	5 091	6
43	KaNgwane Montane Grassland	Grassland	8 245	5 313	64	838	10
44	KwaZulu-Natal Sandstone Sourveld	Grassland	179 675	142 639	79	10 577	6
45	Lebombo Summit Sourveld	Grassland	11 723	7 132	61	1 347	11
46	Lesotho Highland Basalt Grassland	Grassland	1 052	18	2	6	1

Veg ID	Vegetation type	Biome	Historical extent 1840 (ha)	Decline in extent 1840-2011 (ha)	Decline in extent 1840-2011 (%)	Decline in extent 2005-2011 (ha)	Decline in extent 2005-2011 (%)
47	Low Escarpment Moist Grassland	Grassland	133 895	14 868	11	5 856	4
48	Maputaland Coastal Belt	IOCB	221 170	147 862	67	23 390	11
49	Midlands Mistbelt Grassland	Grassland	547 430	364 205	67	53 666	10
50	Moist Coast Hinterland Grassland	Grassland	437 499	225 776	52	35 910	8
51	Mooi River Highland Grassland	Grassland	266 942	105 188	39	24 874	9
52	Northern Drakensberg Highland Grassland	Grassland	70 612	3 962	6	1 744	2
53	Northern KwaZulu-Natal Moist Grassland	Grassland	696 910	263 636	38	55 151	8
54	Northern Zululand Mistbelt Grassland	Grassland	52 891	24 107	46	3 705	7
55	Paulpietersburg Moist Grassland	Grassland	283 998	139 302	49	21 181	7
56	Pondoland-Ugu Sandstone Coastal Sourveld	IOCB	37 223	24 955	67	2 644	7
57	KwaZulu-Natal Coastal Belt Grassland	IOCB	411 494	305 331	74	27 056	7
58	Southern Drakensberg Highland Grassland	Grassland	89 672	2 958	3	1 053	1
59	Southern KwaZulu-Natal Moist Grassland	Grassland	231 824	115 091	50	24 923	11
60	uKhahlamba Basalt Grassland	Grassland	119 898	1 848	2	933	1
61	Eastern Valley Bushveld	Savanna	313 672	79 026	25	11 467	4
62	Granite Lowveld	Savanna	3 657	2 433	67	84	2
63	KwaZulu-Natal Highland Thornveld	Savanna	500 495	182 351	36	42 150	8
64	KwaZulu-Natal Hinterland Thornveld	Savanna	152 545	43 885	29	4 239	3
65	Makatini Clay Thicket	Savanna	32 329	6 550	20	2 390	7
66	Maputaland Pallid Sandy Bushveld	Savanna	61 423	15 852	26	1 192	2
67	KwaZulu-Natal Coastal Belt Thornveld	IOCB	111 922	47 217	42	7 173	6
68	Northern Zululand Sourveld	Savanna	470 389	137 464	29	53 729	11
69	Swaziland Sour Bushveld	Savanna	50 481	15 526	31	-1 671	-3
70	Tembe Sandy Bushveld	Savanna	110 658	22 222	20	2 102	2
71	Thukela Thornveld	Savanna	215 907	59 109	27	17 188	8
72	Western Maputaland Clay Bushveld	Savanna	152 662	92 855	61	11 354	7
73	Western Maputaland Sandy Bushveld	Savanna	15 130	6 021	40	1 044	7
74	Zululand Lowveld	Savanna	665 908	233 798	35	62 115	9
75	Subtropical Seashore Vegetation	IOCB	2 981	172	6	165	6
76	Subtropical Dune Thicket	IOCB	1 258	349	28	285	23
77	Delagoa Lowveld	Savanna	8 748	7 004	80	-102	-1

Veg ID	Vegetation type	Biome	Historical extent 1840 (ha)	Decline in extent 1840-2011 (ha)	Decline in extent 1840-2011 (%)	Decline in extent 2005-2011 (ha)	Decline in extent 2005-2011 (%)
78	KwaZulu-Natal Dune Forests: Maputaland Dune Forest	Forest	16 352	3 835	23	2 488	15
79	KwaZulu-Natal Dune Forests: East Coast Dune Forest	Forest	2 497	531	21	47	2
80	KwaZulu-Natal Coastal Forests: Southern Moist Coastal Lowlands Forest	Forest	3 174	507	16	-5	
81	Pondoland Scarp Forests	Forest	4 868	615	13	476	10
82	KwaZulu-Natal Coastal Forests: Maputaland Moist Coastal Lowlands Forest	Forest	13 654	2 203	16	1 412	10
83	Swamp Forests: Ficus trichopoda Swamp Forest	Azonal Forest	7 719	1 781	23	701	9
84	KwaZulu-Natal Coastal Forests: Dukuduku Moist Coastal Lowlands Forest	Forest	8 479	2 213	26	-130	-2
85	KwaZulu-Natal Coastal Forests: Maputaland Mesic Coastal Lowlands Forest	Forest	8 960	1 199	13	799	9
86	KwaZulu-Natal Coastal Forests: Southern Mesic Coastal Lowlands Forest	Forest	10 703	1 741	16	77	1
87	Mangrove Forests	Azonal Forest	2 521	305	12	245	10
88	Swamp Forests: Voacanga thouarsii Swamp Forest	Azonal Forest	463	140	30	1	
89	Eastern Scarp Forests: Southern Coastal Scarp Forest	Forest	11 380	1 088	10	319	3
90	Swamp Forests: Raphia Swamp Forest	Azonal Forest	370	88	24	50	13
91	Swamp Forests: Barringtonia Swamp Forest	Azonal Forest	94	16	17	5	5
92	Licuati Sand Forests: Eastern Sand Forest	Forest	25 464	2 721	11	1 973	8
93	Drakensberg Montane Forests	Forest	6 399	228	4	142	2
94	Eastern Scarp Forests: Ngome-Nkandla Scarp Forest	Forest	8 593	613	7	261	3
95	Eastern Mistbelt Forests	Forest	44 452	5 860	13	1 612	4
96	Eastern Scarp Forests: Northern Coastal Scarp Forest	Forest	5 635	455	8	262	5
97	Eastern Scarp Forests: Northern Zululand Lebombo Scarp Forest	Forest	7 655	603	8	536	7
98	Licuati Sand Forests: Western Sand Forest	Forest	909	23	3	16	2

Veg ID	Vegetation type	Biome	Historical extent 1840 (ha)	Decline in extent 1840-2011 (ha)	Decline in extent 1840-2011 (%)	Decline in extent 2005-2011 (ha)	Decline in extent 2005-2011 (%)
99	KwaZulu-Natal Coastal Forests: Maputaland Dry Coastal Lowlands Forest	Forest	2 406	511	21	289	12
100	Inland Saline Wetlands: Subtropical Salt Pans: Rain fed (Endorheic) Pans (Closed)	Wetland	539	125	23	20	4

Table 26: Integrated ecosystem and land cover change matrix for vegetation types in KZN, 2005 – 2011

Veg ID	Vegetation type (hectares)	Natural	Increases (positive numbers) and decreases (negative numbers) in land cover classes within each vegetation type														
			Degraded	Fallow lands	Plantation	Subsistence agriculture	Dryland Agriculture	Irrigated Agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dam	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network
1	Alluvial Wetlands: Subtropical Alluvial Vegetation	-881	103	96	-74	1 192	9	3	-708	-274	161	171	131	-65	92	-76	121
2	Subtropical Coastal Lagoons: Estuary	-64	64	-4	14	13			-85	2	-5	-2	29	-61	86	-21	31
3	Freshwater Wetlands: Subtropical Freshwater Wetlands: Coastal Lakes & Pans	-93	40	-11		29	2		-7		-48	74	11	-1	1		1
4	Alluvial Wetlands: Subtropical Alluvial Vegetation: Lowveld Floodplain Grasslands: Tall Reed Wetland	-184	86		14	224			-200		-10	-17	36	-22	7	9	25
5	Freshwater Wetlands: Subtropical Freshwater Wetlands: Short Grass/ Sedge Wetlands	-2 990	932	288	254	1 816	5	-3	-513	-29	-73	171	143	-163	130	-107	141
6	Alluvial Wetlands: Temperate Alluvial Vegetation	-15 275	285	431	155	5 283	5 024	675	-600	-1 682	-7 823	11 245	1 583	-477	618	-690	1 243
7	Freshwater Wetlands: Subtropical Freshwater Wetlands: Tall Grassland/ Sedge/ Reed Wetlands	-260	187	29	22	48			-30		-2	4	3	-25	21	-4	5
8	Freshwater Wetlands:	-903	266	66	47	542	5	6	-405		-169	68	154	-330	360	88	201

Veg ID	Vegetation type (hectares)	Increases (positive numbers) and decreases (negative numbers) in land cover classes within each vegetation type															
		Natural	Degraded	Fallow lands	Plantation	Subsistence agriculture	Dryland Agriculture	Irrigated Agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dam	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network
	Subtropical Freshwater Wetlands																
9	Freshwater Wetlands: Subtropical Freshwater Wetlands: Short Grass/ Sedge Wetlands: Dune Slack	-3	11		2	4			-15				1			-1	2
10	Alluvial Wetlands: Subtropical Alluvial Vegetation: Lowveld Floodplain Grasslands	-712	193	246	98	1 060		-5	-1 115		-79	-24	192	-113	146	-65	177
11	Freshwater Wetlands : Drakensberg Wetlands	-256	4	108	1	19	4	49			-314	374	8		1	-4	6
12	Freshwater Wetlands: Eastern Temperate Wetlands	-3 813	-432	83	33	602	2 315	498	-84	-162	-1 255	1 812	201	-77	81	-177	374
13	Marine Saline Wetlands: Saline Grassland & Mud Flats	-572	33		24	566			-67			-21	35	-2	1	-3	6
14	Inland Saline Wetlands: Subtropical Salt Pans	-22	4	25	3	16	-24		-2			1			-1		
15	Lowveld Riverine Forest	-1 345	158			1 405	2		-267		-5	-22	21	-8	15	-16	23
16	Alluvial Wetlands: Subtropical Alluvial Vegetation: Lowveld Floodplain Grasslands: Short Grass/ Sedge Wetlands	-1 213	-1 023		-1	2 317			-83			-11	11			-11	14
17	Freshwater Wetlands: Subtropical Freshwater Wetlands: Short Grass/ Sedge Wetlands: Coastal Plain	66	-65		5	42			-48				1				

Veg ID	Vegetation type (hectares)	Increases (positive numbers) and decreases (negative numbers) in land cover classes within each vegetation type															
		Natural	Degraded	Fallow lands	Plantation	Subsistence agriculture	Dryland Agriculture	Irrigated Agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dam	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network
	Depression																
18	Alluvial Wetlands: Temperate Alluvial Vegetation: Midland Alluvial Woodland & Thicket	-15	1		14		-1	-1			-1	1					
19	Marine Saline Wetlands	86	39	4	-5	18		-1	-195		-3	-22	9	-32	82	-53	73
20	Dry Coast Hinterland Grassland	-27 792	5 201	1 333	446	14 743	1 509	342	-3 768	-23	-1 767	-12 025	17 945	-11 238	12 817	-2 484	4 762
21	Maputaland Wooded Grassland	-10 791	2 459	2 733	2 099	1 968		14	-426	-9	-85	-2 032	3 609	-1 301	1 299	-564	1 028
22	Alluvial Wetlands: Temperate Alluvial Vegetation: Midland Floodplain Grasslands	-82	12	2	2	-11	13	7	-5	-5	-102	146	14	-5	1	5	9
23	Freshwater Wetlands: Eastern Temperate Wetlands: Lakes & Pans	1						-1				-2	1				
24	Freshwater Wetlands: Lesotho Mires																
25	Muzi Palm Veld and Wooded Grassland	3 256	-8 617		757	4 148	2			0	-2	-341	820	-226	93	-360	471
26	Marine Saline Wetlands: Saline Reed & Sedge Beds	-28	26	2	1						-1		1				
27	Freshwater Wetlands: Subtropical Freshwater Wetlands: Coastal Lakes & Pans: Endorheic	-84	96								-13						

Veg ID	Vegetation type (hectares)	Natural	Increases (positive numbers) and decreases (negative numbers) in land cover classes within each vegetation type															
			Degraded	Fallow lands	Plantation	Subsistence agriculture	Dryland Agriculture	Irrigated Agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dam	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network
28	Inland Saline Wetlands: Subtropical Salt Pans : Floodplain Pans (Open)	-40	-22			36			5		-3	4				-2	3
29	Zululand Coastal Thornveld	-16 815	945	-196	-47	21 553	27	-8	-7 249		-171	-4 559	6 172	-2 150	1 991	-649	1 156
30	Thukela Valley Bushveld	-13 765	-4 376	-68	5	10 877	-704	849	-338	-9 848	13 376	-6 205	9 184	-505	540	-1 169	2 148
31	Mabela Sandy Grassland	-144	-98		-1		215	16	0		0	-3	7	-2	0	-9	18
32	Wakkerstroom Montane Grassland	-6 903	2 997		550	990	2 204	-381		-250	-993	1 210	363	-140	-6	-551	911
33	Southern Lebombo Bushveld	-8 757	3 764	45	-2	3 461	50		-103		-789	-1 717	3 690	-271	304	-631	957
34	Drakensberg-Amathole Afromontane Fynbos	-7	7														
35	Amersfoort Highveld Clay Grassland	-1 267	122	54	90	91	959	-193		-24	4	-126	206	-62	68	-126	202
36	Drakensberg Afroalpine Heathland	-3	4							-11	11						-15
37	Drakensberg Foothill Moist Grassland	-25 351	4 476	210	3 499	3 476	6 426	2 949		-219	-639	-4 690	7 818	-1 543	2 010	-2 278	3 852
38	Basotho Montane Shrubland	-69	41		6	9						-22	27	-4	5	-11	18
39	East Griqualand Grassland	-15 367	3 059	83	61	102	8 843	1 515	7	-92	-335	-31	1 291	-1 173	1 227	-1 136	1 936
40	Eastern Free State Sandy Grassland	-98	28		7							14	27		12	-36	46
41	Income Sandy Grassland	-21 344	-17 171	4 486	492	13 974	6 834	-51		-16 527	21 289	-13 091	17 296	-12 939	13 901	-2 597	5 447
42	Ithala Quartzite Sourveld	-5 091	2 999	120	21	1 270	30	16	-80	-86	104	-1 230	1 707	-569	575	-300	513

Veg ID	Vegetation type (hectares)	Natural	Increases (positive numbers) and decreases (negative numbers) in land cover classes within each vegetation type															
			Degraded	Fallow lands	Plantation	Subsistence agriculture	Dryland Agriculture	Irrigated Agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dam	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network
43	KaNgwane Montane Grassland	-838	1		-3	576	-17	-10	0	-17	25	-668	860	-267	311	-126	173
44	KwaZulu-Natal Sandstone Sourveld	-10 577	3 256	492	873	4 047	845	410	-3 861		-252	-11 888	14 493	-5 800	6 879	-2 530	3 612
45	Lebombo Summit Sourveld	-1 347	-264	-63	-13	1 186					-23	-1 966	2 325	-147	176	-284	418
46	Lesotho Highland Basalt Grassland	-6	7													-2	
47	Low Escarpment Moist Grassland	-5 856	2 996		948	234	1 082	-246		-219	239	-616	1 169	-150	148	-505	773
48	Maputaland Coastal Belt	-23 390	7 278	3 155	2 891	9 835	39	266	-5 739	841	-168	-8 709	12 689	-8 872	7 844	-1 170	3 211
49	Midlands Mistbelt Grassland	-53 666	8 033	334	13 143	12 296	11 508	1 619	-2 785	-124	-805	-16 207	21 007	-9 155	10 857	-5 947	9 891
50	Moist Coast Hinterland Grassland	-35 910	1 916	434	2 755	37 001	1 241	348	-17 473	-70	-339	-21 211	27 673	-10 188	11 185	-5 500	8 131
51	Mooi River Highland Grassland	-24 874	6 863	498	2 084	540	10 214	2 220		-79	-872	-1 763	3 865	-842	1 024	-2 171	3 293
52	Northern Drakensberg Highland Grassland	-1 744	1 685		-13	-27	1			-68	64	-274	350	-28	41	-15	28
53	Northern KwaZulu-Natal Moist Grassland	-55 151	2 586	1 634	2 539	17 153	14 646	621	1	-8 947	6 597	-9 208	22 201	-7 907	8 196	-4 109	9 148
54	Northern Zululand Mistbelt Grassland	-3 705	1 706		1 276	504	95	-250		-2	-100	-234	506	-283	284	-323	525
55	Paulpietersburg Moist Grassland	-21 181	5 092	10	4 078	5 283	4 326	-1 138		-270	646	-3 329	4 870	-2 126	2 131	-2 090	3 699
56	Pondoland-Ugu Sandstone Coastal Sourveld	-2 644	794	172	-193	723	107	813	-492		-104	-1 296	1 844	-2 582	2 682	-646	820

Veg ID	Vegetation type (hectares)	Natural	Increases (positive numbers) and decreases (negative numbers) in land cover classes within each vegetation type														
			Degraded	Fallow lands	Plantation	Subsistence agriculture	Dryland Agriculture	Irrigated Agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dam	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network
57	KwaZulu-Natal Coastal Belt Grassland	-27 056	1 190	2 501	-30	37 574	142	2 348	-33 535		-798	-22 303	29 021	-57 394	62 998	-7 869	13 209
58	Southern Drakensberg Highland Grassland	-1 053	895		50	1	30				-32	35	37	1	4	-63	92
59	Southern KwaZulu-Natal Moist Grassland	-24 923	-3 302	117	2 596	17 025	2 084	785	33	-1 638	659	-10 820	14 860	-3 778	4 601	-1 931	3 631
60	uKhahlamba Basalt Grassland	-933	913		-1	6	1	-1		-96	92	3	6			-22	28
61	Eastern Valley Bushveld	-11 467	2 980	254	107	10 349	768	69	-8 923	-39	-2 616	-7 273	14 340	-5 371	5 376	-2 454	3 888
62	Granite Lowveld	-84	-282	-81		274	15	-1	57	-3	2	-454	492	-273	313	-67	92
63	KwaZulu-Natal Highland Thornveld	-42 150	3 033	2 296	632	15 471	8 557	203	-66	-14 078	14 839	-4 612	12 188	-6 299	6 524	-3 975	7 437
64	KwaZulu-Natal Hinterland Thornveld	-4 239	2 651	-104	74	4 126	1 477	-139	-6 919	-38	-272	-3 529	5 392	-4 181	4 880	-1 217	2 037
65	Makatini Clay Thicket	-2 390	-168	-27		2 388	1		-18		-23	-396	594	-7	4	-58	100
66	Maputaland Pallid Sandy Bushveld	-1 192	-3 053	-153	180	3 287	145		-54		-23	-1 117	1 883	-153	73	-557	734
67	KwaZulu-Natal Coastal Belt Thornveld	-7 173	2 123	259	257	9 864	57	57	-9 898		-40	-6 566	8 314	-12 854	14 503	-975	2 071
68	Northern Zululand Sourveld	-53 729	6 323	206	126	38 307	-151	109	-321	-2 550	6 105	-12 915	16 425	-3 847	3 932	-3 193	5 173
69	Swaziland Sour Bushveld	1 671	-2 739	48	13	814	-81	-125		-244	-291	280	600	-60	77	-74	110
70	Tembe Sandy Bushveld	-2 102	-5 193	-131	36	6 268	213		-4		-11	-2 525	3 305	-193	110	-420	648
71	Thukela Thornveld	-17 188	4 084	378	-13	7 676	-137	-69		-5 075	6 361	-3 707	6 139	-3 277	3 920	-1 230	2 138

Veg ID	Vegetation type (hectares)	Increases (positive numbers) and decreases (negative numbers) in land cover classes within each vegetation type															
		Natural	Degraded	Fallow lands	Plantation	Subsistence agriculture	Dryland Agriculture	Irrigated Agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dam	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network
72	Western Maputaland Clay Bushveld	-11 354	-19 895	-1 067	38	27 916	215	-1 062	1 707	-52	-10 146	6 223	6 663	-716	761	-1 452	2 221
73	Western Maputaland Sandy Bushveld	-1 044	-1 152	-27		1 613			2			-1 729	2 256	-79	81	-155	233
74	Zululand Lowveld	-62 115	-5 013	-367	69	63 557	3 267	330	-9 968	-3 303	3 822	-13 033	19 497	-6 608	6 440	-4 762	8 187
75	Subtropical Seashore Vegetation	-165	28		4				-1				54	-3	30		2
76	Subtropical Dune Thicket	-285	293		1				-11			-2	3	-7	8		
77	Delagoa Lowveld	102	12	109	1	2	-53	49	-313		-51	-62	151	-111	147	-141	160
78	KwaZulu-Natal Dune Forests: Maputaland Dune Forest	-2 488	1 713	17	437	49			-85	413	-4	10	10	-28	-323	263	16
79	KwaZulu-Natal Dune Forests: East Coast Dune Forest	-47	92	2	1	8			-133			-33	34	-181	191	-48	114
80	KwaZulu-Natal Coastal Forests: Southern Moist Coastal Lowlands Forest	5	100	1	3	9		2	-158		-3	-21	17	-137	152	-54	83
81	Pondoland Scarp Forests	-476	436	1	4	1		18	-1		-4	1	4	-3	1	-5	23
82	KwaZulu-Natal Coastal Forests: Maputaland Moist Coastal Lowlands Forest	-1 412	556	43	-31	3			-5	459	-25	48	18	-99	-159	586	18
83	Swamp Forests: Ficus trichopoda Swamp Forest	-701	575	44		103			-40		-11	-10	20	-15	18	-10	27
84	KwaZulu-Natal Coastal Forests: Dukuduku Moist Coastal	130	197	11	12	1 023		5	-1 536		-1	-266	382	-42	22	-40	103

Veg ID	Vegetation type (hectares)	Natural	Increases (positive numbers) and decreases (negative numbers) in land cover classes within each vegetation type															
			Degraded	Fallow lands	Plantation	Subsistence agriculture	Dryland Agriculture	Irrigated Agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dam	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network
	Lowlands Forest																
85	KwaZulu-Natal Coastal Forests: Maputaland Mesic Coastal Lowlands Forest	-799	482	258	68	18		2	-44		-4	-10	8	-15	17	-14	34
86	KwaZulu-Natal Coastal Forests: Southern Mesic Coastal Lowlands Forest	-77	479	5	1	72		2	-568		-7	-101	128	-272	290	-66	115
87	Mangrove Forests	-245	233		-3	39			-2			-3	0	-46	25	-1	2
88	Swamp Forests: Voacanga thouarsii Swamp Forest	-1	15		-5	17			-35			-4	9	-5	6	-3	6
89	Eastern Scarp Forests: Southern Coastal Scarp Forest	-319	304	9	12	42		1	-108		-2	-44	70	-92	97	-36	67
90	Swamp Forests: Raphia Swamp Forest	-50	36			4			0			-16	28	-4	1	-4	5
91	Swamp Forests: Barringtonia Swamp Forest	-5	7		1	1			-4							-1	2
92	Licuati Sand Forests: Eastern Sand Forest	-1 973	1 534	109	5	275	16		-1			-57	86	-17	6	-36	52
93	Drakensberg Montane Forests	-142	116		17	1	2	1				3	2	-1	1	-1	2
94	Eastern Scarp Forests: Ngome-Nkandla Scarp Forest	-261	215		18	2		5	-10			-2	4			-15	42
95	Eastern Mistbelt Forests	-1 612	1 085		458	27	9	-19	-15	-2	-9	-1	51	-8	10	-47	71
96	Eastern Scarp Forests: Northern Coastal Scarp Forest	-262	261		3	9			-25				2	-2	3	-8	19

Veg ID	Vegetation type (hectares)	Natural	Increases (positive numbers) and decreases (negative numbers) in land cover classes within each vegetation type															
			Degraded	Fallow lands	Plantation	Subsistence agriculture	Dryland Agriculture	Irrigated Agriculture	Sugarcane	Rehabilitated mines	Severe erosion	Dam	Low density settlement	Turfed recreation areas	Built-up areas	Mines	Transport network
97	Eastern Scarp Forests: Northern Zululand Lebombo Scarp Forest	-536	464		3	61					-1	-18	21	-4	4	-13	19
98	Licuati Sand Forests: Western Sand Forest	-16	14			2											
99	KwaZulu-Natal Coastal Forests: Maputaland Dry Coastal Lowlands Forest	-289	246		2	106	2		-90			-60	85	-8	3	-5	10
100	Inland Saline Wetlands: Subtropical Salt Pans : Rain fed (Endorheic) Pans (Closed)	-20	-19			40			-2			-2	1			-1	1