ECOSYSTEM ACCOUNTS FOR SOUTH AFRICA

Report of the NCAVES Project

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REPUBLIC OF SOUTH AFRICA

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PREFACE and ACKNOWLEDGMENTS

This report was prepared by the South African National Biodiversity Institute (SANBI) as well as Statistics South Africa (Stats SA), both of which were the implementing partners for the Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES) project in South Africa. The report was made possible with the support of the United Nations Statistical Division (UNSD) and United Nations Environment Programme (UNEP).

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ACRONYMS

ANCA
Advancing Natural Capital Accounting

BSCCRS
Biodiversity Sector Climate Change Response Strategy

BSU
Basic spatial unit

CBD
Convention on Biological Diversity

CITES
Convention on International Trade in Endangered Species

CSIR
Council for Scientific and Industrial Research

CWRR
Centre for Water Resources Research at the University of KwaZulu-Natal

DBSA
Development Bank of Southern Africa

DFFE
Department of Forestry, Fisheries and the Environment

DPME
Department of Planning, Monitoring and Evaluation

DALRRD
Department of Agriculture, Land Reform and Rural Development

DSI
Department of Science and Innovation

DWS
Department of Water and Sanitation

ECI
Ecosystem Condition Index

ECT
Ecosystem Condition Typology

EEI
Ecosystem Extent Index

EEZ
Economic Exclusion Zones

EU
European Union

GDSA
Gaborone Declaration on Sustainability in Africa

GDP
Gross Domestic Product

GET
Global Ecosystem Typology

IIF
Integrated Indicator Framework

IUCN
International Union for the Conservation of Nature

KZN
Province of KwaZulu-Natal

LDN
land degradation neutrality

LSU
commercial livestock units

MDB
Municipal Demarcation Board

MTSF
Medium-Term Strategic Framework

NBA
National Biodiversity Assessment

NBES
National Biodiversity Economy Strategy

NBF
National Biodiversity Framework

NBSAP
National Biodiversity Strategy and Action Plan

NCA
Natural Capital Accounting

NCCAS
National Climate Change Adaptation Strategy

NCAVES
Natural Capital Accounting and Valuation of Ecosystem Services

NDF
non-detriment findings

NDP
National Development Plan

NDVI
Normalised Difference Vegetation Index

NEMA
National Environmental Management Act

NEMPAA
National Environmental Management: Protected Areas Act

NGO
Non-governmental organisations

NLC
National Land Cover

NPAES
National Protected Area Expansion Strategy

NPP
net primary productivity

NPV
net present value

NSDF
National Spatial Development Framework

NSDS National Strategy for the Development of Statistics

NSS
South African National Statistical System

MEC
Members of the Executive Council

MRIS
Moderate Resolution Imaging Spectroradiometer

PRG
Project Reference Group

PSUT
Physical Supply and Use Tables

SAIIAE
South African Inventory of Inland Aquatic Ecosystems

SAG
Strategic Advisory Group

SANBI
South African National Biodiversity Institute

SA-NECS
South African National Ecosystem Classification System

SANParks
South African National Parks

SASQAF
South African Statistical Quality Assessment Framework

SASDI
South African Spatial Data Infrastructure

SDF
Spatial Development Frameworks

SDG
Sustainable Development Goal

SEEA CF
System of Environmental-Economic Accounting Central Framework

SEEA
System of Environmental-Economic Accounting

SEEA EA
System of Environmental-Economic Accounting - Ecosystem Accounting

SNA
System of National Accounts

SOC
Soil organic carbon

Stats SA
Statistics South Africa

SWSA
Strategic Water Source Areas

UNSC
United Nations Statistical Commission

UNEP
United Nations Environment Programme

UNEP-WCMC
UN Environment Programme World Conservation Monitoring Centre

UNFCCC
United Nations Framework Convention on Climate Change

UNSD
United Nations Statistics Division

WRC
Water Research Commission

ANNOTATED OUTLINE

In 2017, the United Nations Statistics Division (UNSD), the United Nations Environment Programme (UNEP), the Secretariat of the Convention on Biological Diversity (CBD) and the EU (EU) launched the project "Natural Capital Accounting and Valuation of Ecosystem Services" (NCAVES). This project, which is funded by the EU through its Partnership Instrument , aims to assist the five participating partner countries, namely Brazil, China, India, Mexico and South Africa, to advance the knowledge agenda on environmental-economic accounting, and in particular ecosystem accounting.

This report presents a synthesis of South Africa's work in the NCAVES project. It is intended primarily to provide information for other countries embarking on ecosystem accounting, and builds on various technical reports that have been compiled.

Section 1 provides an overview of natural capital accounting (NCA) and the System of Environmental Economic Accounting Ecosystem Accounting (SEEA EA) framework at the international level, as well as the specific South African policy context and the status of NCA in South Africa. A summary of the national implementation in South Africa of the NCAVES project, including key milestones and stakeholders, is also provided.

Section 2 provides information on data foundations needed to compile the accounts which are produced through the NCAVES Project. These foundations include the development of the basic spatial unit (BSU) as a fundamental starting point for ecosystem accounting in South Africa, and foundational geospatial data used in the development of accounts.

Section 3 summarizes ecosystem extent accounts, which are a common starting point for ecosystem accounting, and are used to: 1) organize information on the extent of different ecosystem assets (EAs) within a country or other ecosystem accounting area (EAA); and 2) ascertain how that extent is changing over time. Highlight results from the Land and Terrestrial Ecosystem Accounts, 1990 to 2014 are presented. Directions for future work and potential policy applications are then discussed.

Section 4 summarizes the work that was undertaken in the testing of ecosystem condition accounts, including lessons learned and recommendations for moving forward. The ecosystem condition account provides insight about the characteristics and quality of EAs and how they have changed during the accounting period. Terrestrial ecosystem condition accounts and river and estuary ecosystem condition accounts are described.

Section 5 covers ecosystem services accounts expressed in physical units. As part of the NCAVES project, a pilot study was undertaken for the development of ecosystem service accounts for the province of KwaZulu-Natal. These accounts were developed based on the SEEA EA, using spatially explicit estimates of the supply of ecosystem services in physical terms and their benefits in monetary terms. The physical accounts are summarized per ecosystem service in this section.

Section 6 discusses the results of the ecosystem service accounts in monetary terms developed through the valuation of ecosystem services for the Kwa-Zulu-Natal

1 See: https://ec.europa.eu/fpi/what-we-do/partnership-instrument-advancing-eus-core-interests_en

pilot study. The section also discusses the concerns and caveats with respect to the development and interpretation of results from monetary accounts.

Section 7 summarizes the thematic accounts developed as part of the NCAVES project: first, species accounts for black and white rhinoceros as well as for cycad plant group; second, the accounts for protected areas; and finally land accounts for metropolitan municipalities.

Section 8 covers the testing of accounts for deriving indicators (either national or international indictors) for monitoring and reporting on policy at the national and global level. Towards this, South Africa tested the use of information from natural capital accounts produced as part of the NCAVES project, to derive indicators for four Sustainable Development Goal (SDG) indicators: 1) SDG 6.6.1: Change in the extent of water-related ecosystems over time; 2) SDG 11.7.1: Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities; 3) SDG 15.1.1: Forest area as a proportion of total land area; and 4) SDG 15.3.1: Proportion of land that is degraded over total land area.

Section 9 provides conclusions and the way forward for South Africa in terms of the application of accounts in policymaking, including via policy scenario analysis, and outlines the purpose, development process and intended users of South Africa's National NCA Strategy: A ten-year strategy for advancing Natural Capital Accounting (NCA) in South Africa.

Section 1: Introduction

This section provides the overall policy context for natural capital accounting (NCA) in South Africa, an overview of the Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES) project and a brief introduction of the SEEA EA framework, hereby explaining the structure and scope of the report.

1.1 Context

1.1.1 NCA and the SEEA EA

NCA refers to the systematic, reliable and regular measurement of stocks and flows of natural resources and ecosystems, so that their state as well as the benefits they provide to society can be recognized, understood and integrated into policy, planning and decision-making. Just as we have a system of national (economic) accounts to measure Gross Domestic Product (GDP) and track the performance of the economy, and the population census to track progress in social outcomes, we also need a system to track the natural environment, including how it's improving or declining and what that means for people and the economy.

NCA is thus an organising framework for environmental information using an accounting approach. It allows a link with the System of National Accounts (SNA) from which we draw indicators such as the GDP. NCA is a broad term that includes accounting for individual environmental assets or resources, both biotic and abiotic (such as water, minerals, energy, timber, fish), as well as accounting for ecosystem assets and ecosystem services.

A measurement framework and global standard for NCA, called the System of Environmental-Economic Accounting (SEEA) has been developed by the United Nations Statistics Division (UNSD) through a global expert-driven process. South Africa is using the SEEA to develop its natural capital accounts.

The SEEA offers a dependable measurement framework enabling an in-depth understanding of the connections between economic well-being and natural capital. It integrates economic and environmental information using internationally agreed-upon statistical standards developed and applied by governments worldwide. Thus, the SEEA helps to facilitate better and informed decision-making process. It offers a means of monitoring the pressure exerted by the economy on the environment by capturing the abstraction of natural resources and emissions, changes in condition and how the economy responds in terms of expenditure on environmental protection and resource management. It provides a system that can help in generating a wide range of indicators and statistics with different applications in decision-making. The SEEA covers a wide range of environmental assets, including, for example, water, energy, fisheries and timber. It also covers ecosystems.

Quantifying natural capital and its benefits using the SEEA is always done in physical terms, and may be translated into monetary values in cases where this is useful and appropriate. Examples of biophysical metrics include the extent of an ecosystem remaining in natural condition, amount of water produced by a catchment, volume of fish harvested from the marine environment, or number of people visiting protected areas. There are many examples of issues that are important to society that are measured in non-monetary terms, such as literacy rates, unemployment levels or life expectancy. The same is true for ecosystems – their importance and value to people and the economy can be captured in a range of statistics and indicators, many of which are non-monetary.

Regular production of natural capital accounts using the SEEA can provide standardized statistical information (comparable between countries, or between administrative units within a country, and over time) that is regularly spatially explicit. This information is critical for tracking and reporting on progress towards sustainable development, including goals and targets set out in policies, frameworks and plans at international, continental, national, provincial or local levels. Due to its integrated approach the SEEA is well positioned to support South African progress on a range of critical global initiatives, notably Agenda 2030, the post-2020 biodiversity agenda, and international climate policy.

1.1.1.1 The SEEA EA

The System of Environmental-Economic Accounting Ecosystem Accounting (SEEA EA) is a coherent framework for integrating measures of ecosystems and the flows of services arising from them with measures of economic and other human activity. Ecosystem accounting complements, and builds on, the accounting for environmental assets as described in the System of Environmental-Economic Accounting 2012 Central Framework (SEEA CF).

The SEEA Ecosystem Accounting framework provides an integrated information system on (a) ecosystem assets, encompassing ecosystem extent, ecosystem condition, ecosystem services, ecosystem capacity and relevant monetary values; and (b) economic and other human activity and the associated beneficiaries (households, businesses and governments). The integration of ecosystem and economic information is intended to mainstream information on ecosystems in decision-making.

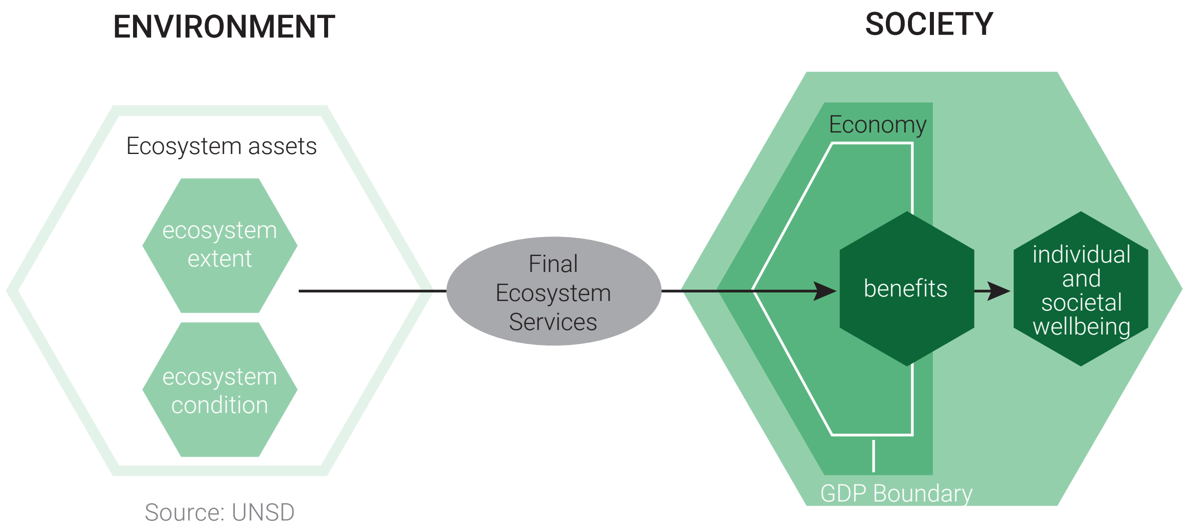
The ecosystem accounting framework was intended for application at the national level, to enable the integration of information on multiple ecosystem types and multiple ecosystem services with macro-level economic information (e.g. measures of national income, value-added, production, consumption and wealth). However, the application of the framework has proven relevant at subnational scales, encompassing, for example, individual administrative areas such as provinces, protected areas and cities; and environmentally defined areas such as water catchments. This report covers both national and subnational applications.

1.1.1.2 Conceptual approach

The essence of ecosystem accounting lies in the potential to represent the biophysical environment in terms of distinct spatial areas each representing ecosystem assets, such as forests, wetlands, agricultural areas, rivers and coral reefs. While focus is commonly on accounting for land areas, including inland waters, ecosystem accounting is also applicable to coastal and marine ecosystems.

Following an accounting logic, each ecosystem asset is understood to supply a stream (bundle) of ecosystem services. The flows of services in any period are related to the extent (i.e. size), condition and of the asset (Figure 1). The intent in ecosystem accounting is to record the supply of all ecosystem services over an accounting period for each ecosystem asset within an ecosystem accounting area, as well as the users of ecosystem services.

Figure 1: Conceptual framework of ecosystem accounting



Source: UNSD

Flows of ecosystem services are distinguished from flows of benefits. The term "benefits", as used in SEEA EA, encompasses: (a) SNA benefits, that is, the products (goods and services) produced by economic units as recorded in the standard national accounts; and (b) the non-SNA benefits that are generated by ecosystems and consumed directly by individuals and societies. The measurement of well-being is not the focus of ecosystem accounting, although the data that are integrated through the ecosystem accounting framework can support such a measurement.

1.1.2 The ecosystem accounts

There is not one single, all-encompassing ecosystem account; instead, there are five core accounts that make up the building blocks of the SEEA EA. These accounts constitute an accounting system which presents a comprehensive and coherent view of ecosystems. The accounts are compiled using a spatially explicit and integrated set of data on ecosystems and ecosystem services. These integrated data may also be presented in the form of maps, used to derive sustainability indicators or applied in various forms of analysis.

Ecosystem extent accounts record the total area of each ecosystem, classified by type within a specified area (ecosystem accounting area), and how this changes over the accounting period. Condition accounts record changes to the condition of ecosystems in terms of selected characteristics that provide valuable information on the health of ecosystems. Both accounts are in physical units.

Ecosystem services are described in physical terms and can be valued in monetary units. Valuation requires the use of a valuation concept that is aligned to the SNA. On the basis of the estimates of ecosystem services in monetary terms, the value of the underlying ecosystem assets can be estimated using net present value (NPV) techniques whereby the value of the asset is estimated as the discounted stream of income arising from the supply of a basket of ecosystem services that is attributable to an asset.

Thematic accounts are standalone accounts, or sets of accounts, that organize data around specific policy-relevant themes. Biodiversity, ocean, urban areas and carbon are the four high profile themes. Other important thematic accounts would include accounting for protected areas, wetlands and forests, or accounts for specific species.

1.1.3 Indicators

The ecosystem accounts can be used to derive a range of aggregates and indicators. The physical accounts on extent, condition, and ecosystem services all derive multiple indicators for monitoring and reporting on global indicators (e.g. SDGs, Biodiversity targets) as well as national indicators (e.g. sectoral plans, development reports – which will be further described in Section 8 of this report).

1.1.4 South Africa's policy context

This section draws on the Assessment Report that was developed in the initial stages of the NCAVES project to assess the state of play for NCA in South Africa (SANBI & Stats SA, 2018).

South Africa has a rich policy context that supports the integration of information from natural capital accounts into policy and decision-making, and has policies and frameworks that provide for the systems and institutional mechanisms through which the production of accounts would be supported.

The management and conservation as well as the sustainable use of South Africa's natural resource base, including ecosystems and biodiversity assets, are all embedded in South Africa's policy. It is seen as part of sustainable development, including in the National Development Plan (NDP) and the Medium-Term Strategic Framework (MTSF), which is the South African government's 5-yearly strategic plan to achieve the vision of the NDP for South Africa to transition to an environmentally sustainable, climate-change resilient, low-carbon economy. The foundation for this is the State's responsibility to respect, protect, promote and fulfil the environmental right contained in the Constitution (Section 24), and the Principles of the National Environmental Management Act (No. 107 of 1998, Section 2), which guide all environmental management decision-making and apply to the actions of all organs of state that may significantly affect the environment. As such, an important policy entry point for NCA is the Presidency and the Department of Planning, Monitoring and Evaluation (DPME) evaluation-related policy frameworks that emphasises the importance of data to support evidence-based decision-making.

At a broad level, linking environmental data with socioeconomic data assists policy makers by:

- Enabling the analysis of the impact of economic policies on the environment and vice versa;
- Providing a quantitative basis for policy design;
- Identifying the socioeconomic drivers, pressures, impacts and responses affecting the environment;
- Supporting greater precision in the development of environmental regulations and resource management strategies;
- Providing indicators that express the relationships between the environment and the economy.

NCA should provide another source of statistical information relevant to the evaluation and consideration of policies and add to the richness of evidence available to policy and decision-makers. Various calls for evidence that include meeting the need for national environmental targets and indicators to support decision- and policy-making, are contained in policies that set the country's national priorities on sustainable development and which also involve the integrated management of environment, society and economy. The management, conservation and sustainable use of South Africa's natural resource base, including ecosystems and biodiversity assets, is embedded in South African policy and seen as part of sustainable development. Relevant national policies include, but are not limited to:

- National Environmental Management Act (NEMA) (No. 107 of 1998, Section 2) Principles which guide all environmental management decision-making and apply to the actions of all organs of state that may significantly affect the environment.
- National Development Plan 2030 (NDP) which requires a set of national indicators for natural resources to inform policy, through which specific and increased needs for official statistics are defined. DFFE is playing a lead role in developing national indicators for natural resources.
- Medium-Term Strategic Framework (MTSF) is the South African government's strategic plan (latest being 2019-2024) to achieve the vision of the NDP to transition to an environmentally sustainable, climate-change resilient, low-carbon economy.
- National Biodiversity Strategy and Action Plan (NBSAP) in which Integrating the value of biodiversity into national accounting and reporting systems is a high priority activity (NBSAP Activity 3.6.2).
- National Biodiversity Framework (NBF) developed in fulfilment of the requirements of the National Environment Management: Biodiversity Act (No. 10 of 2004), Section 38(2) and which recommends the development of a National Strategy for Ecosystem Accounting, as a step towards the integration of the value of biodiversity into national accounting and reporting systems (NBSAP Activity 3.6.2).
- National Biodiversity Economy Strategy (NBES) which provides an implementation framework to achieve economic benefits from the commercialisation of biodiversity targeting the wildlife and bio-prospecting economies.
- National Protected Area Expansion Strategy (NPAES) which sets national-level protected area expansion targets (for ecosystems).
- National Framework for Marine Spatial Planning in South Africa which provides for multi-sectoral spatial planning in South Africa's ocean space.
- National Water and Sanitation Master Plan which sets out a schedule of key urgent actions needed for the period to 2030 to create a water sector that can meet national objectives as set out in the NDP and the SDGs.
- Spatial development planning policies such as municipal and provincial Spatial Development Frameworks (SDFs) and the National SDF (NSDF) which need to track changes over time in a spatially explicit manner evaluating social, economic and environmental implications of decisions.
- Also the District Development Model launched September 2019 by the President, will have new demands for statistical information.
- Climate change related policies such as the National Climate Change Adaptation Strategy (NCCAS), Ecosystem-based Adaptation Strategy, and Biodiversity Sector Climate Change Response Strategy (BSCCRS).
- Relevant regional or international policies to which South Africa is signatory include the SDGs, UN Convention on Biological Diversity (CBD), UN Convention to Combat Desertification (UNCCD), Agenda 2063, Gaborone Declaration on Sustainability in Africa (GDSA), and Paris Agreement within the United Nations Framework Convention on Climate Change (UNFCCC).

In addition, South African government's policies and frameworks that relate to the strengthening of national statistics and improving information on sustainable development for evidence-based policy and decision-making provide for the systems and institutional mechanisms to support the production of natural capital accounts. These include:

- **Evaluation-related policy frameworks** that emphasise the importance of data to support evidence-based decision-making, such as the Policy Framework for the Government-wide Monitoring and Evaluation System.
- **National Treasury's Performance Information-related policy and frameworks** that require the inclusion of financial, economic and environmental sustainability performance information concepts.
- **Statistics South Africa's policy and frameworks** through which official statistics are coordinated, produced, certified and disseminated, including:
  - Stats SA's Strategic Plan (2020/21-2024/25) and Work Plan;
  - South African National Statistical System (NSS);
  - National Strategy for Development of Statistics (NSDS);
  - South African Statistical Quality Assessment Framework (SASQAF);
  - Integrated Indicator Framework (IIF);
  - Statistics governed at the global level by the United Nations Statistical Commission (UNSC) and the Special Data Dissemination Standard, and at a continental level by the African Charter on Statistics.
- **Policy on spatial data infrastructure** administered by the Department of Agriculture, Land Reform and Rural Development (DALRRD) that is important to the compilation of ecosystem accounts in particular, such as the South African Spatial Data Infrastructure (SASDI).

Stats SA's mandate to coordinate the development of statistics, as laid out in the Statistics Act, underpins its role in "assisting organs of state, business, other organisation or the public in planning, monitoring or assessment of policies, decision-making or other actions". Stats SA coordinates the compilation of information and statistics for the SDG reporting. Reporting on SDGs requires coordination and integrative work across departments and other entities. Similar coordination would be required in producing natural capital accounts and could build on the institutional mechanisms that have been established for SDG reporting.

A more comprehensive review of the policy context is provided in Section 3 of the Assessment Report (SANBI & Stats SA, 2018).

1.1.5 Status of NCA in South Africa

South Africa has a relatively long history of producing natural capital accounts following the SEEA Central Framework as well as the country's more recent experience with SEEA Ecosystem Accounting (EA).

Stats SA has been compiling NCA for many years, producing accounts for water, energy, fisheries and minerals since as early as 2000.[2] Stats SA is a key enabler of NCA for South Africa, with a mandate to promote the use of official statistics in policy development, policy monitoring and evaluation as well as decision-making efforts. Stats SA's mandate is also to elevate and sustain the elevation of official statistics throughout the organs of state and civil society and provide a framework for the development of South Africa's National Strategy for Development of Statistics (NSDS). Stats SA has convened the compilation of South Africa's SDG reporting and currently maintains a small unit that has produced environmental accounts.

Since 2014, Stats SA has been co-leading projects with the SANBI on ecosystem accounting as a subset of NCA. These

2 Available from the Stats SA website: www.statssa.gov.za

projects include implementing a country pilot project on ecosystem accounts as part of a global initiative called Advancing Natural Capital Accounting (ANCA)[3] (2014-2015) and the NCAVES Project.

In 2018, SANBI began the implementation of another project, the Ecological Infrastructure for Water Security (EI4WS) Project, which includes an outcome on developing natural capital accounts to enable policy, planning and decision-making in favour of ecological infrastructure. The EI4WS Project is a five-year project, funded by the Global Environment Facility (GEF), implemented by the Development Bank of Southern Africa (DBSA), and executed by SANBI in partnership with others, including the Department of Water and Sanitation (DWS), the World Wide Fund for Nature (WWF-SA) and Stats SA. The accounts that will be developed in the EI4WS Project will be the accounts for Strategic Water Source Areas (SWSAs), ecological infrastructure asset accounts and water resource accounts at a catchment level in the Project's Greater uMngeni and Berg-Breede demonstration catchments.

The Water Research Commission (WRC) has funded research projects related to water accounts over the past several years, including a project on National Water Accounts (in partnership with Stats SA) and two projects on the development of a methodology for compiling catchment level water resource accounts (in partnership with the Centre for Water Resources Research at the University of KwaZulu-Natal). These projects align well with the natural capital component of the EI4WS project.

Foundations that have enabled relatively rapid progress in NCA include years (in some cases decades) of public sector investment in ecosystem, water and land-cover data, as well as existing human capacity, inter-personal relationships, inter-organisational partnerships and other resources. South Africa has substantial amounts of geospatial and non-geospatial data available to enable the production of accounts.

3 In the ANCA Project, South Africa was one of seven pilot countries in this project, which was led by the UNSD in partnership with UN Environment and the Convention on Biodiversity, with funding from the Government of Norway. In this project, Stats SA and SANBI worked in partnership with the CSIR, Ezemvelo KZN Wildlife, DWS and DFFE.

Table 1: List of natural capital accounting work in South Africa that Stats SA has been involved in examples of policy links (Adapted from original source: SANBI & Stats SA 2018)

Account	Lead organisation	Date of publication	Examples of policy links
Water Accounts	Stats SA & WRC	2000, 2002, 2007, 2018	National Water Act, NWRS, National Water and Sanitation Master Plan, NBSAP, SDG targets
Energy accounts	Stats SA	2002, 2009, 2012, 2014-2017	Department of Energy's Post 2015 National Energy Efficiency Strategy, Energy Efficiency Targets
Mineral accounts	Stats SA	2010-2017	Department of Mineral Resources planning
Fisheries accounts	Stats SA	2010, 2012-2017	Fisheries Management, Agriculture, Forestry and Fisheries Market and Trade Development Strategy
KZN Land and Ecosystem Accounts	Stats SA & SANBI in ANCA Project	2015	Provincial SDF, Provincial Protected Area Expansion Strategy
National River Ecosystem Accounts		2015	NWRS, National Water and Sanitation Master Plan, NBSAP, Catchment Management Strategies
KZN ecosystem service accounts	Stats SA & SANBI in NCAVES Project	2020	SDFs, Provincial Growth and Development Strategy, municipal planning, NBSAP
Land and Terrestrial Ecosystem Accounts		2020	NDP, NSDF, sustainable land reform, NBSAP, SDG targets
Accounts for protected areas		2021*	NPAES, biodiversity stewardship programmes, Biodiversity Finance Plan, NBSAP, SDG targets
Land Accounts for Metropolitan Municipalities		2021*	Integrated Development Plans, SDFs (for cities and their peri-urban and rural hinterlands)
Accounts for species: rhinoceros and cycad plant group		2021*	National Strategy for Plant Conservation, Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), managing wildlife trade and poaching, NBSAP, SDG targets
Marine ecosystem accounts		2021/22*	Marine Spatial Planning, NPAES, fisheries management, NBSAP, SDG targets
Accounts for Strategic Water Source Areas	SANBI through EI4WS Project	>2021*	NWRS, National Water and Sanitation Master Plan, city-level water management, Catchment Management Strategies, NBSAP, SDG targets
Sub-national accounts for ecological infrastructure assets		>2023*	NBSAP, National Water and Sanitation Master Plan, Framework for Investing in Ecological Infrastructure, natural resource management programmes
Detailed catchment-level water resource accounts	CWRR	2015, 2019, 2021-2022*	NWRS, National Water and Sanitation Master Plan, Catchment Management Strategies
Estuary accounts	CSIR	2020	Estuary Management Plans, National Water and Sanitation Master Plan
Biodiversity Tourism	Stats SA	Unspecified	
Satellite Account for Biodiversity Economy	DFFE & Stats SA	Unspecified	National Biodiversity Economy Strategy
Ocean Accounts	Nelson Mandela University, Cape Peninsula University of Technology, SAEON, University of the Western Cape and the Human Sciences Research Council	Unspecified	Marine Spatial Planning; indicator metrics to measure ocean wealth (and sustainable resource use), ocean income and inclusivity; evidence-based ocean policy cycles.

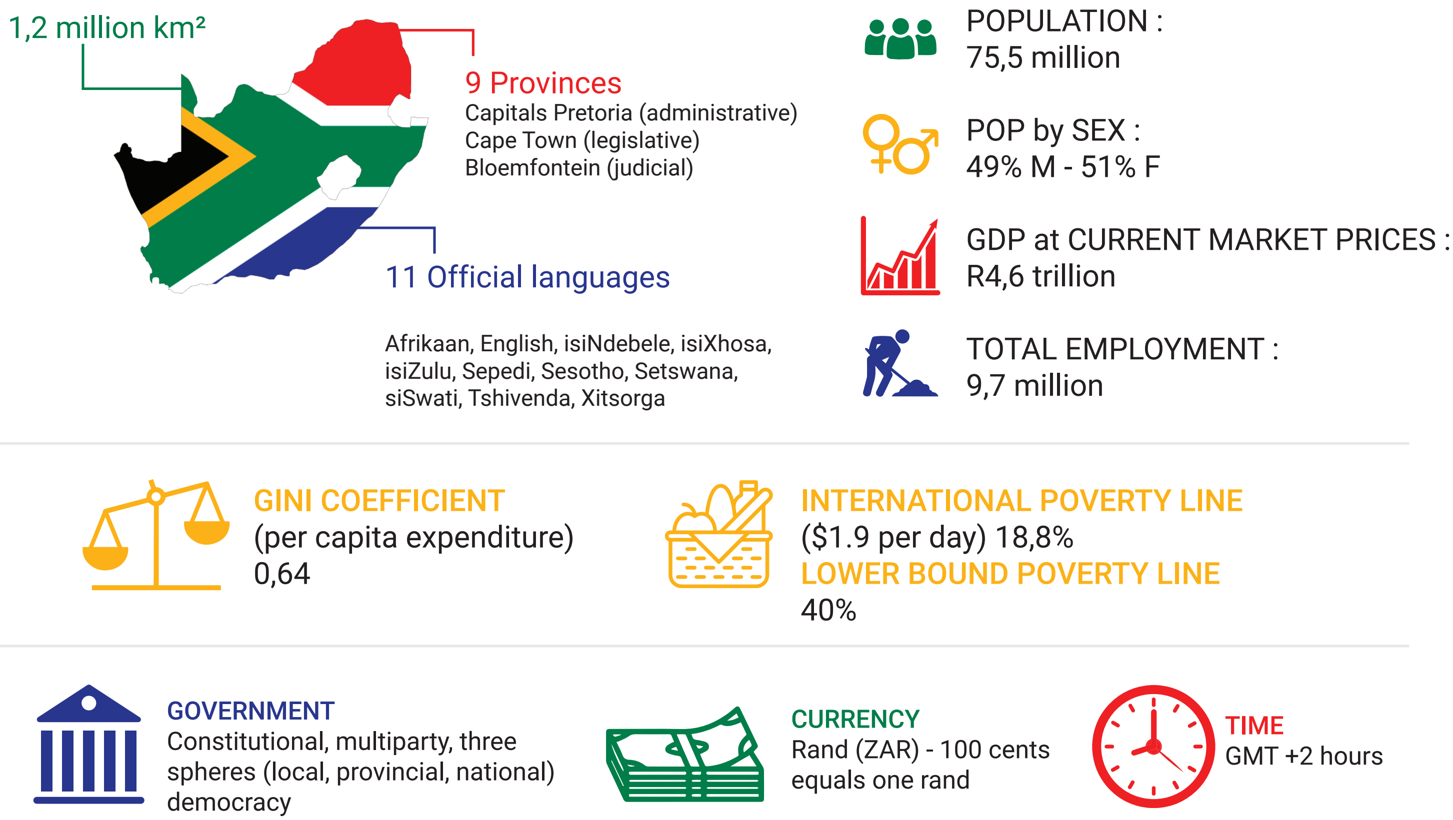
`* Intended year of publication

Adapted from original source: SANBI & Stats SA 2018

1.1.6 South Africa's socioeconomic context

Salient socioeconomic information about South Africa is provided in Figure 2.

Figure 2: South Africa at a glance

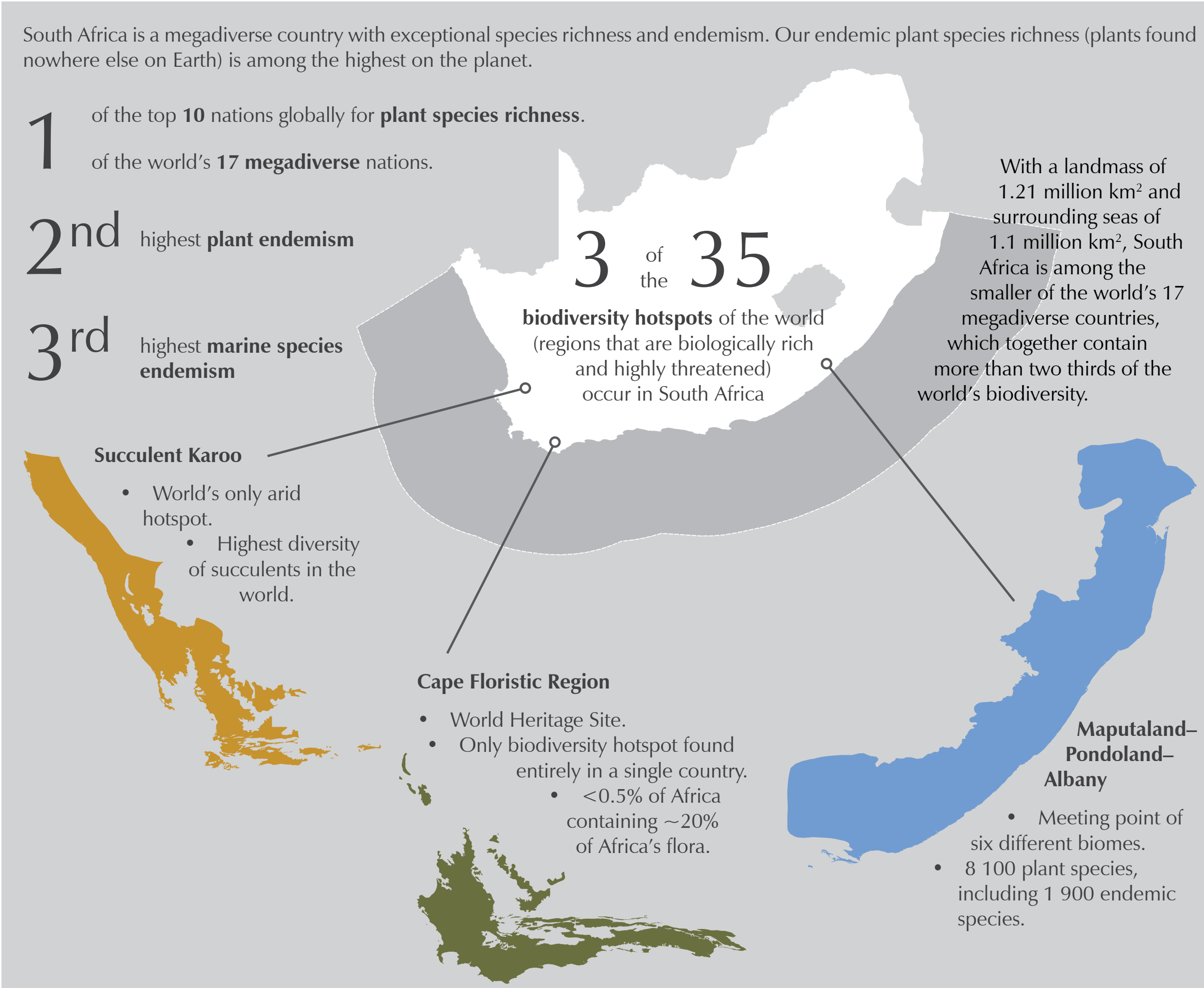


Data Source: Stats in Brief, Stats SA (2018)

1.1.7 Biodiversity and ecosystems in South Africa

South Africa is a megadiverse country with a wide range of ecosystem types, exceptional species richness and endemism (Figure 3 and 4). Its endemic plant species richness (plants found nowhere else on Earth) is among the highest on the planet. South Africa's biodiversity provides an array of benefits to the economy, society and human well-being. These benefits that nature provides are dependent on intact ecosystems, healthy species populations and genetic diversity. The status of South Africa's ecosystems and biodiversity is monitored and reported on in the National Biodiversity Assessment (NBA) (SANBI, 2019). The following facts, findings and messages are drawn from the NBA 2018.

Figure 3: Biodiversity in South Africa



Source: SANBI (2019)

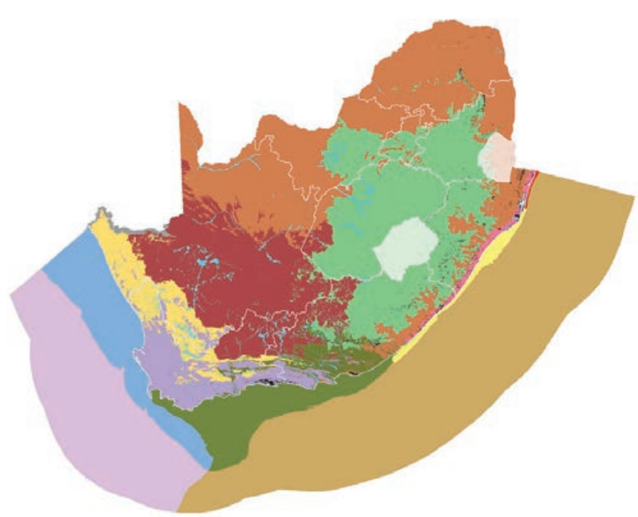
Figure 4: South Africa's rich ecosystem diversity

South Africa has a wide range of bioclimactic, oceanographic, geological and topographical settings. Together, these create high ecosystem diversity and endemism across all realms.

TERRESTRIAL realm : nine biomes and 458 ecosystem types, approximately 80% of which are endemic.

MARINE realm : exceptional marine biodiversity and a wide array of ecoregions with 150 distinct ecosystem types

FRESHWATER realm : high variability of rainfall leads to diverse freshwater ecosystems. **Inland wetlands** are classified into 135 distinct types; **rivers** are classified into 222 distinct types.



ESTUARINE realm : South Africa's 290 estuaries and 42 micro-estuaries are classified into 22 estuarine ecosystem types.

An ecological definition of the **COAST** draws from the terrestrial, marine and estuarine ecosystem maps and includes 186 ecosystem types.

South Africa's **SUB-ANTARCTIC TERRITORY** (situated 1 700 km south-east of the mainland) consists of Prince Edward Island, Marion Island and surrounding seas. There are five terrestrial and 29 marine ecosystem types.

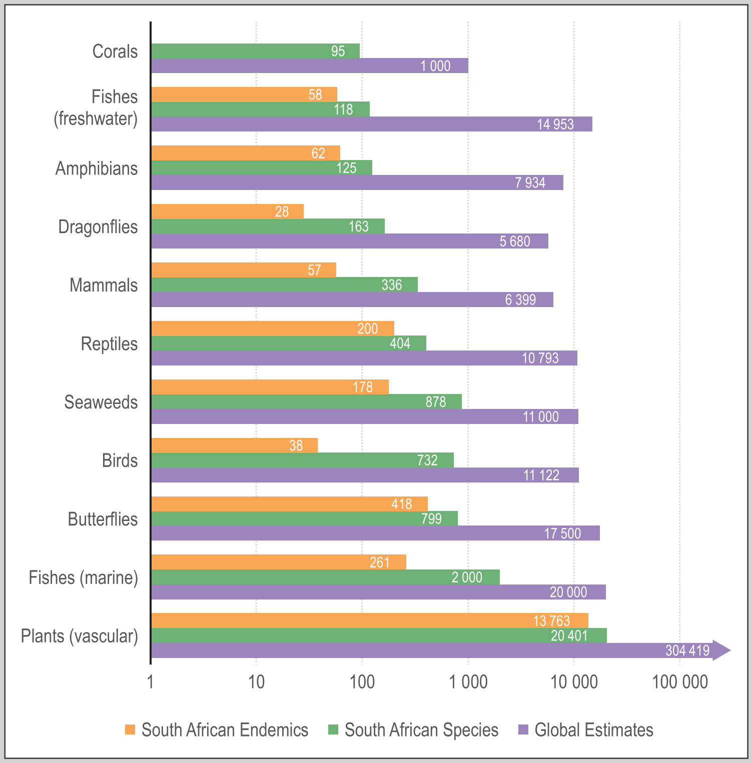
South Africa's rich species diversity

The number of South African animal species is estimated at 67 000 and over 20 400 plant species have been described. Approximately 7% of the world's vascular plant species, 5% of mammal, 7% of bird, 4% of reptile, 2% of amphibian, 1% of freshwater fish and 16% of shark, skate and ray species are found in the country.

South Africa has nearly 10% of the world coral species and almost a quarter of the global cephalopod species (octopus, squid, cuttlefish). Some terrestrial invertebrate groups have high richness relative to global statistics, e.g. 13% of the world's sunspiders (Solifugae) and nearly 5% of butterflies occur in South Africa.

Around half of the South African species of reptiles, amphibians, butterflies and freshwater fish are endemic. Almost two thirds of South Africa's plant species are endemic – mostly linked to the unique Cape Floristic Region.

Approximately 40% of South Africa's estimated 10 000 marine animal species are endemic, the vast majority of which are invertebrates.

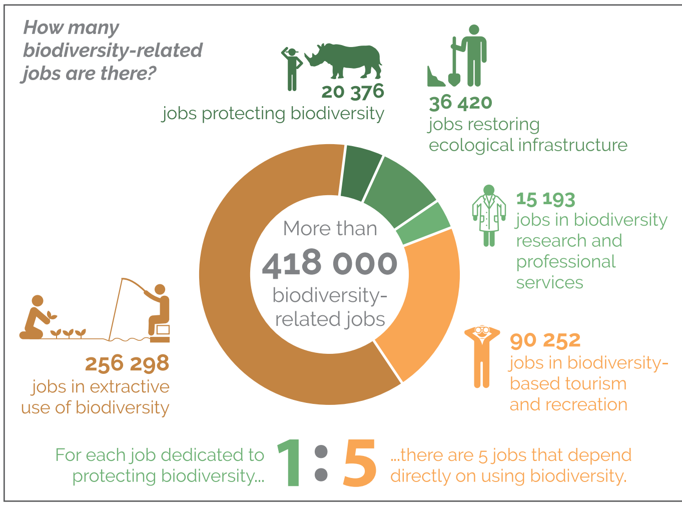


Source: SANBI (2019)

In the context of national development goals such as inclusive growth, reducing poverty and unemployment, water security and rural development, the NBA emphasises that biodiversity assets and ecological infrastructure provide benefits for people and the economy. Some of the key messages from the NBA are highlighted below in Figure 5. Ecosystem accounting can contribute to quantifying these benefits to people and the economy, building on the information base provided by the NBA.

Figure 5: Key messages from National Biodiversity Assessment relating to ecosystem accounting

Biodiversity provides jobs



South Africa's biodiversity provides substantial employment in a range of sectors. Continued investment in managing and conserving biodiversity is essential so that jobs that depend on biodiversity can continue to increase. Jobs directly related to biodiversity are often outside urban centres and labour intensive, contributing to rural development, poverty alleviation and inclusive growth.

For more info: Part 3 of the synthesis report; the technical reports; compendium of benefits of biodiversity.

Biodiversity-related employment is based on a renewable resource that, if appropriately managed, can provide the foundation for long-term economic activity and sustainable growth.

Healthy ecosystems are essential for water security

Rivers, wetlands and their catchment areas are crucial ecological infrastructure for water security, often complementing built infrastructure, but the benefits of some of these ecosystems are currently compromised by their poor ecological condition. Water security can be improved through integrated management of natural resources in Strategic Water Source Areas (SWSAs) and other key catchments. SWSAs make up only 10% of South Africa's land area but deliver 50% of all surface water, supporting half of South Africa's population and nearly two-thirds of its economy. Only 12% of the extent of SWSAs falls within protected areas.

For more info: Part 3.2 of the synthesis report; inland aquatic technical report.

Poor ecological condition in rivers and wetlands makes expensive water treatment necessary before human use. The eutrophication of this water flowing from the Hartebeestpoort Dam is caused by excessive nutrients in the water from pollution. © Eric Nathan / Alamy Stock Photo.

Small, high-value ecosystem types provide disproportionate benefits to people

Certain small ecosystem types function as crucial ecological infrastructure and provide multiple benefits to society. Managing, protecting and restoring these small, high-value ecosystems gives a large return on investment. Indigenous forests, inland wetlands, lakes, estuaries, mangroves, dunes, beaches, rocky shores, kelp forests, reefs, seamounts, pinnacles and islands together take up less than 5% of South Africa's territory, but contribute disproportionately to a large number of benefits such as water purification, nutrient cycling, carbon storage, storm protection, recreation and food.

For more info: Part 3 of the synthesis report; all technical reports.

Mangrove habitats are found in only a few estuaries on the east coast. They are crucial ecological infrastructure as they protect coastal settlements from storms, provide nursery habitat for fish, and also store carbon and stabilise sediments. © Janine Adams.

Climate change is impacting on people and ecosystems; healthy ecosystems can help us adapt to climate change

Impacts of climate change are evident across all realms and within most species groups. Biodiversity provides resilience against the worst effects. Restoring ecosystems and maintaining them in good ecological condition means they are better able to support natural adaptation and mitigation processes, offering increased protection to human communities and reducing the economic burden of climate disasters. Temperature increases of more than 1°C have been observed in the past 50 years, accompanied by the intensification of extreme events such as droughts, heavy rainfall, coastal storm surges, strong winds and wildfires.

For more info: Parts 2, 3.1.3, 3.2.3, 3.3.3, 3.4.3 of the synthesis report; all technical reports.

THealthy wetlands act like sponges in the landscape and are able to slow the flow of water from floods, which are likely to become more frequent as the climate changes. © Georg Wandrag.

Protected areas: investment success in the ocean and on land

Protected areas have expanded in the ocean and on land, and are a source of pride for South Africans. Continued expansion will help to ensure biodiversity conservation, ecological sustainability and even more social and economic benefits from biodiversity. The 20 new Marine Protected Areas declared in 2019 ensure that 5% of the country's mainland marine territory and 87% of marine ecosystem types have some protection. The protected area estate of South Africa's terrestrial mainland now covers nearly 9% of land area and 75% of terrestrial ecosystem types have some form of protection.

For more info: Part 2.2 of the synthesis report.

South Africa's new Marine Protected Areas will ensure benefits for ecosystems, people and the economy , including contributing to sustainability of fisheries, adaptation to climate change and tourism. © Peter Chadwick.

Source: SANBI (2019)

1.2 NCAVES project

1.2.1 Workstreams

The project was organized along several workstreams:

- **Compiling ecosystem accounts** in physical and monetary terms in the project countries;
- Applying the accounts in **scenario analysis** based on national policy priorities;
- Development of **guidelines and methodology** that contribute to national and global implementation of NCA;
- Development and testing of a set of **indicators** in the context of the post-2020 Biodiversity Agenda and other international initiatives;
- **Business accounts** that contribute to the alignment between SEEA and corporate sustainability reporting;
- **Communications** that increase awareness of NCA both in project countries and beyond through developing a range of products;
- Enhanced **capacity building and knowledge sharing** among the community

of practitioners on NCA by e-Learnings and training workshops (in country and regional).

In parallel, within project countries, inter-institutional mechanisms around NCA will be established or strengthened through a country assessment that feeds into developing a national roadmap.

1.2.2 National implementation

Stats SA and SANBI co-lead the national implementation of the NCAVES project in South Africa, in collaboration with the DFFE other national and sub-national stakeholders, to further develop ecosystem accounts for South Africa.

The project was launched during the inception mission in November 2017, during which the project coordination mechanism was formed. A Project Management Unit comprised of Stats SA, SANBI, UNSD and UNEP was established. A Project Reference Group (PRG) was formed to provide overall guidance to the project, including representatives from Stats SA, SANBI, DFFE, the Delegation of the EU to South Africa, UNSD, and UNEP. In addition, regular trilaterals have been held between Stats SA, SANBI and DFFE and an NCA Strategic Advisory Group has been formed.

A national stakeholder workshop was held in March 2018 in Pretoria, which was attended by more than 70 participants from over 30 organizations, representing all three spheres of government, research institutions, NGOs and the private sector. The workshop introduced stakeholders to NCA, including its relevance to policy and decision-making, and gave participants an overview of NCA work to date in South Africa and introduced the current project. Participants discussed prioritization of the accounts, for inclusion in a future National NCA Strategy; ongoing stakeholder engagement; initiatives related to NCA that could benefit from the NCA approach; how to make a case for ecosystem accounts; and possible scenario analyses to be conducted as part of the project. The workshop formed part of the assessment phase of the project. *It was followed up by a national assessment report for advancing environmental-economic accounting in South Africa* published in November 2018 (SANBI & Stats SA, 2018) that assessed the national situation in terms of policy priorities, country interests, data availabilities, existing initiatives, statistical infrastructure and operations, relevant stakeholders and capacities for the SEEA implementation in South Africa.[4] The assessment report was shared with the project's stakeholder distribution list of 200 people from more than 60 organizations.

South Africa's first national NCA Forum was held in Pretoria at iSibalo House at Statistics South Africa in July 2019, hosted by Stats SA and SANBI. The forum explored how NCA can support South Africa's progress towards a green economy, including its linkages to South Africa's NDP and the SDGs. The two-day meeting convened a range of actors including DFFE, the Departments of Planning Monitoring and Evaluation, Rural Development and Land Reform, Water and Sanitation, as well as National Treasury, the private sector and NGOs.

Stats SA and SANBI have co-led the development of a national strategy for advancing NCA in South Africa (see Section 9). As part of its development, broader stakeholder engagement took place leading up to a virtual workshop in November 2020. This consultation included trilaterals with National Treasury, DFFE, DPME, and DWS.

As part of the NCAVES project, five ecosystem accounts have been compiled at the national level, namely:

4 See: https://seea.un.org/sites/seea.un.org/files/nca_assessment_report_final_for_distribution_dec_2_2018.pdf

1) Land and Terrestrial Ecosystem Accounts, 1990 to 2014;
2) Accounts for Protected Areas, 1900 to 2020;
3) Accounts for Species: Cycads, 1970 to 2010;
4) Accounts for Species: Rhinos, 1970 to 2017;
5) Land Accounts for Metropolitan Municipalities, 1990 to 2014.

Section 3 summarizes the methodology and results from the land and terrestrial ecosystem extent accounts, which were published by Stats SA in December 2020. The publication of the accounts launched Stats SA's new Natural Capital Series. Section 7 covers the methods of the remaining four accounts which are considered thematic accounts, namely accounts for species, accounts for protected areas, and accounts for metropolitan municipalities. Results are provided for the protected area accounts, but because the species accounts and accounts for metropolitan municipalities would not have yet been published by Stats SA when this report is released, they have not been included here. Section 2 provides an overview of the data foundations for these accounts. Further detail on these accounts is available from Stats SA.

In addition to the above, the NCAVES Project also explored the compilation of ecosystem condition accounts. This was explored in the terrestrial realm and in the freshwater realm. The findings and discussion of which is summarized in Section 4.

Further, the province of KwaZulu-Natal (KZN) was selected for a pilot study area for the compilation of physical and monetary accounts on selected ecosystem services, hereafter referred to as the KZN pilot (contributing to the valuation of ecosystem services workstream of the project). The results of the KZN pilot on the mapping of a suite of ecosystem services and measurement in physical and monetary terms have been presented and released during the SEEA Ecosystem Accounting Forum on 25 June 2020[5] and have been highlighted in a UNEP news article.[6] Section 5 and Section 6 contain an overview of this work. Valuation requires the use of a valuation concept that is aligned to the accounting principles of the SNA. The results from the KZN pilot serve the basis for policy scenario analysis of landscape restoration measures in the Thukela river basin, KZN, drawing on the accounts developed as part of the project as well as scoping discussions with DFFE, Ezemvelo KZN Wildlife (EKZNW) and other stakeholders. The analysis attempts to assess ecological restoration programmes in KZN whereby the costs of implementing these programmes are weighed against the potential benefits of improved ecosystem services under different scenarios.

The ecosystem accounts can be used to derive a range of aggregates and indicators for monitoring and reporting on global indicators (e.g. SDGs, biodiversity targets) as well as national indicators. The NCAVES Project in South Africa undertook a study to assess the usefulness of the accounts compiled thus far in informing four SDG indicators identified by UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) (2019) as

5 See: https://seea.un.org/content/towards-method-accounting-ecosystem-services-and-asset-value-pilot-accounts-kwazulu-natal

6 See: https://www.unenvironment.org/news-and-stories/story/groundbreaking-study-maps-and-values-south-africas-wild-spaces

priorities for testing. The study considered data requirements and calculations as well as the intended purpose and meaning of the indicators. The study aimed to inform both national and international decision-making on SDG indicator reporting. Section 8 summarizes the findings.

This publication summarizes the main results achieved during the period 2017-2020 with the first and third workstream. Results of other workstreams are reported elsewhere, for instance on the NCAVES project site.[7]

[7] See: https://seea.un.org/home/Natural-Capital-Accounting-Project

Section 2: Data Foundations

This section provides information on data foundations needed to compile the accounts produced through the NCAVES Project.

2.1 Basic spatial unit for ecosystem accounting

The basic spatial unit (BSU) is a fundamental starting point for ecosystem accounting in South Africa. The BSU is a geometrical construct representing a small spatially defined area. It provides a unit for analysis, to which a range of data can be synthesized as a way to begin spatially harmonizing different data sets. The BSU facilitates the analysis of various spatially-related data in an independent and consistent framework.

The NCAVES project catalysed the development and formalization of the BSU spatial data layer for South Africa, which included collaboration with other stakeholders, particularly the National Geospatial Information component of the DALRRD, which has the mandate for establishing and maintaining South Africa's Spatial Data Infrastructure. The BSU layer has potentially broad applications beyond ecosystem accounts, and is available to be used for other spatial assessment and planning processes at the national and sub-national level.

The coverage of the BSU was designed to comprehensively cover the extent that might be included in ecosystem accounts in the terrestrial, estuarine, marine, or freshwater realms. The BSU thus covers the full sovereign extent of South Africa's:

- **Terrestrial and estuarine realm,** which includes on the mainland South Africa and South Africa's sub-Antarctic territory, namely the Prince Edward Islands (1700 km from the mainland);
- **Marine realm,** which includes the associated Economic Exclusion Zones (EEZ) and the continental shelf claim around both the mainland and Prince Edward Islands;
- **Freshwater realm,** which includes the mainland South Africa and the full extent of drainage basins of river systems in South Africa (including, for hydrological comprehensiveness, the drainage basins that extend into neighbouring countries).

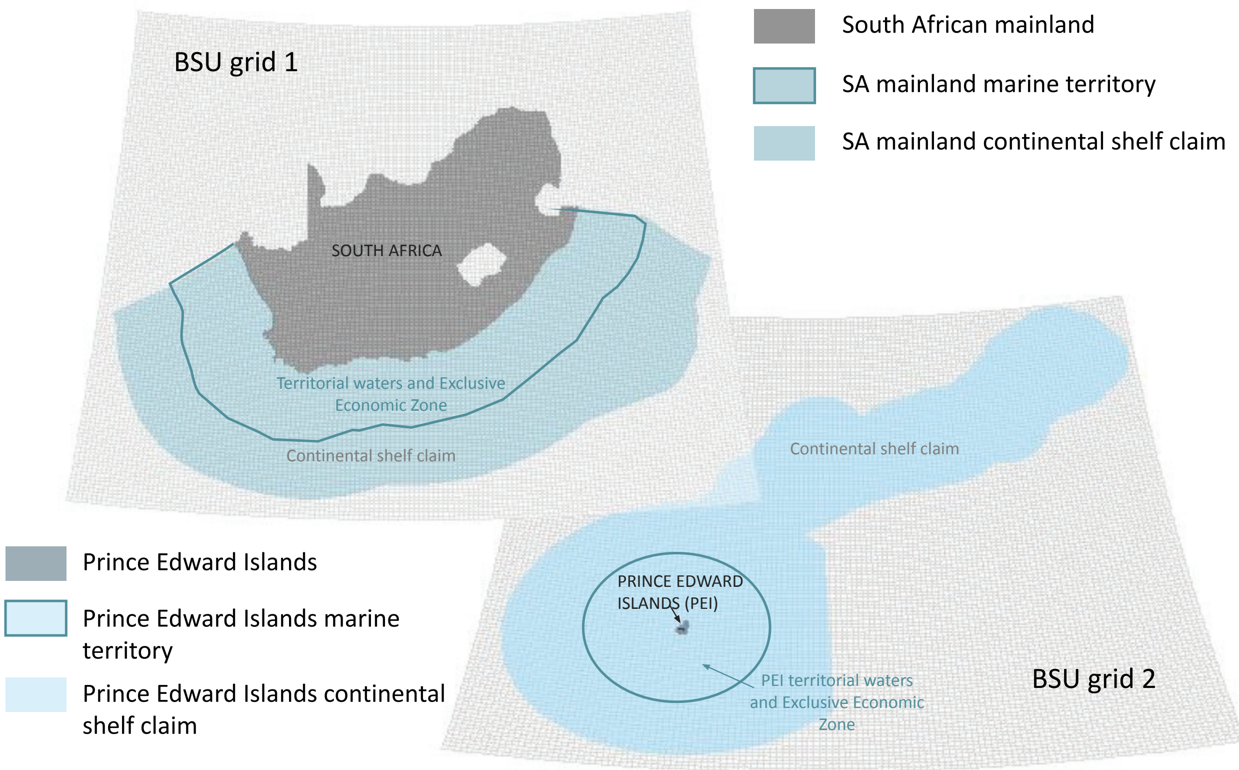
This results in a very large extent of area to cover and necessitated the development of two separate grids, BSU grid 1 and BSU grid 2, as illustrated in Figure 6.

The BSU grids consist of equal sized cells (100 x 100m) which are square i.e. Cartesian. A 100 x 100m grid cell resolution (which equates to one-hectare cell area) was deemed suitable to facilitate aggregation and disaggregation of data at national level reporting and assessment.

Stats SA is the coordinating custodian of the BSU layer in terms of the South African Spatial Data Infrastructure Act (Act 2 of 2000). While the BSU layer is a fixed data set, custodianship is needed to maintain consistency in allocation of grids to national data sets (e.g. allocation of grids to provinces, municipalities, or along the coastline) and providing access to the official data set.

A technical report for the Basic Spatial Unit in South Africa provides a detailed description of the nature of the BSU, its coordinate system, projection system, and naming convention (Stats SA, 2021).

Figure 6: Basic spatial unit in South Africa



Source: Stats SA (2021a)

2.2 Foundational geospatial data

Several sets of accounts were developed in South Africa through the NCAVES Project. These accounts make use of several national-level spatial data sets which are described in this section of foundational data, as shown in Table 2. For example, the foundational geospatial data used in the development of the Land and Terrestrial Ecosystem Accounts, 1990 to 2014 were National Land Cover, terrestrial ecosystem types, administrative boundaries and population census data. Each of the foundational data sets will be briefly described below.

Table 2: Foundational data sets used (illustrated by the shaded cell) in accounts developed through NCAVES Project

Foundational data sets	Land and terrestrial ecosystem accounts, 1990 to 2014	Land accounts for metropolitan municipalities, 1990 to 2014	Accounts for protected areas, 1990 to 2020	Accounts for species: Cycads	Accounts for species: Rhinos
National Land Cover (Section 2.2.1)					
Terrestrial ecosystem types (Section 2.2.2)					
Land-based protected areas (Section 2.2.3)					
Administrative boundaries (Section 2.2.4)	National, provinces, district and metro municipalities	Metropolitan municipalities	National, provinces	National	National
Population census data (Section 2.2.5)					
Cycad population and threat status data (Section 2.2.6)				Non-spatial	
Rhino population estimates (Section 2.2.7)					Non-spatial

Source: Author (2021)

2.2.1 National Land Cover

South Africa's National Land Cover (NLC) data set is derived, as is typical, from remotely sensed imagery. At the beginning of the NCAVES Project, National Land Cover data sets had been produced for the year 1990 (GTI, 2016) and 2014 (GTI, 2015) using equivalent methods to allow for comparability between the two data sets. More recently, NLC for the year 2018 (GTI, 2019) has been produced and will be used to update future accounts. The data sets are derived using operationally proven, semi-automated modelling procedures developed specifically for the generation of these data sets, based on repeatable and standardised modelling routines (GTI, 2015). The 1990 and 2014 NLC data set contain 72 land-cover classes covering a wide range of natural and human-modified landscape characteristics, with each 30 x 30m cell assigned a single code which represents the dominant land-cover class (determined from an analysis of multiple images with high levels of accuracy) . For the purposes of simplifying analysis, as well as presentation of results from the land accounts, the 72 NLC classes are aggregated into groups across four hierarchical tiers as illustrated in Table 3.

....

8 GTI (2015) highlights that the term "land cover" is used "loosely to incorporate both land-cover and land-use information in the context of the GTI 14-2013 South African National Land Cover data set". This also applies to the 1990 National Land Cover data set. For simplicity the term "land-cover classes" is used throughout these accounts, rather than referring each time to "land-cover/land-use classes".

9 The overall map accuracy is 81.73 per cent, with a mean land-cover class accuracy of 91.27 per cent. The accuracy levels for many of the intensively modified land-cover classes are higher than the average map accuracy (for example, 100 per cent for cultivated sugarcane pivots and >96 per cent for urban township, village, residential, informal, and schools and sports fields).

Table 3: Grouping of National Land Cover classes into four tiers

Broad land-cover classes	Main land-cover classes	Detailed land-cover classes	National Land Cover (NLC) classes
Tier 1: 4 classes	*Tier 2: 8 classes*	*Tier 3: 20 classes*	*Tier 4: 72 classes*
Natural or semi-natural	Natural or semi-natural	Natural or semi-natural	8 land cover classes
Cultivated	Commercial crops	Cultivated commercial fields	4 land-cover classes
		Cultivated commercial pivots	3 land-cover classes
		Sugarcane	6 land-cover classes
	Subsistence crops	Subsistence crops	3 land-cover classes
	Orchards and vines	Orchards	3 land-cover classes
		Vines	3 land-cover classes
	Timber plantations	Timber plantations	3 land-cover classes
Built-up	Urban	Urban parkland	4 land-cover classes
		Urban industrial	1 land-cover class
		Urban commercial	1 land-cover class
		Urban built-up	4 land-cover classes
		Urban residential	4 land-cover classes
		Urban township	4 land-cover classes
		Urban informal	4 land-cover classes
		Urban smallholding	4 land-cover classes
		Urban village	4 land-cover classes
		Urban school and sports ground	1 land-cover class
	Mines	Mines	5 land-cover class
Waterbodies	Waterbodies	Waterbodies	3 land-cover class

Source: Stats SA (2020)

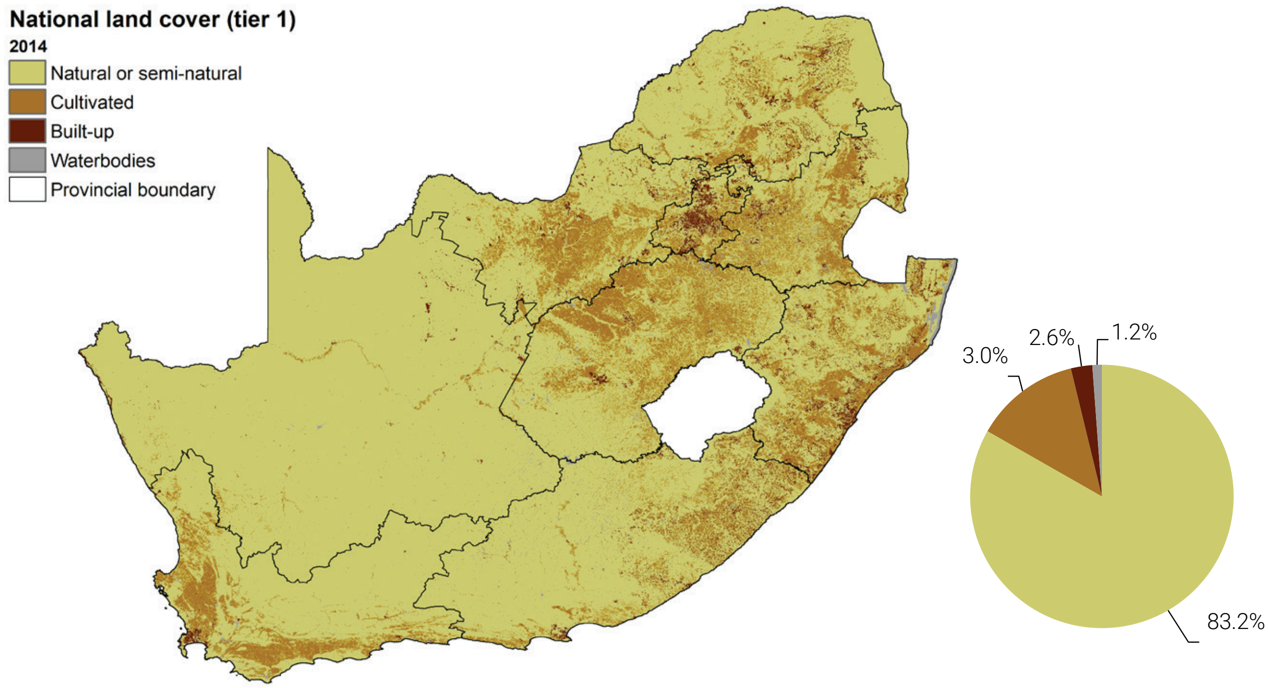
This aggregation of land-cover classes was done specifically for the purpose of land accounts, in such a way that the classes in tiers 1, 2 and 3 are aligned with likely intensity of ecological impact and also linked to socioeconomic drivers in the landscape, as far as possible. This is important for linking land accounts to ecosystem extent and condition accounts as well as enabling analysis of demographic and economic information in relation to land-cover change.

The natural or semi-natural land-cover class covers the majority of South Africa's mainland extent as illustrated in Figure 7. While the NLC data set identifies eight NLC classes based on structural forms identifiable from satellite imagery, these are not used to disaggregate "natural or semi-natural" at tier 1, 2 and 3. This is because terrestrial ecosystem types based on the National Vegetation Map delineate the type of ecosystem more meaningfully and accurately than these eight NLC classes[10] - this will be further explained in Section 2.2.2 below. Not included at this stage is information about the condition of terrestrial ecosystems. Assessing the condition of ecosystem assets is not straightforward, and considerable further work is required to reliably determine

[10] The natural or semi-natural land-cover classes in the full set of National Land Cover classes include: Indigenous Forest, Woodland/Open bush, Thicket/Dense bush, Low shrubland, Shrubland fynbos, Grassland.

the condition of terrestrial ecosystems. In future terrestrial ecosystem accounts it would be ideal to distinguish spatially between natural areas and semi-natural areas, which will likely require non-satellite derived data to be incorporated. Natural areas would be considered to be in good ecological condition, while semi-natural areas would generally be considered to be in fair ecological condition relative to a reference condition of natural. Such spatial information would not be used directly in the ecosystem extent account but would feed into the development of an ecosystem condition account and Ecosystem Condition Index (ECI) for terrestrial ecosystems.

Figure 7: Broad land-cover classes (tier 1) in 2014 with associated proportion of total mainland area



Source: Stats SA (2020)

It is also important to note that "waterbodies" are not disaggregated in the hierarchy of land-cover classes. Land-cover data are not well suited to mapping inland water ecosystems, which requires non-satellite derived data. South Africa has more comprehensive and accurate sources of data for inland water ecosystems, including rivers and wetlands, and for artificial waterbodies such as dams, that will be used to develop accounts for freshwater ecosystems in the future.

2.2.2 Terrestrial ecosystem types

Terrestrial ecosystem types are defined according to the South African National Ecosystem Classification System (SA-NECS), which includes classification systems and maps of all ecosystem types in the country, across the terrestrial, freshwater (river and inland wetland), estuarine and marine realms.[11] Around one thousand distinct ecosystem types are recognized altogether. The SA-NECS aligns relatively well with the IUCN Global Ecosystem Typology (GET).[12]

....

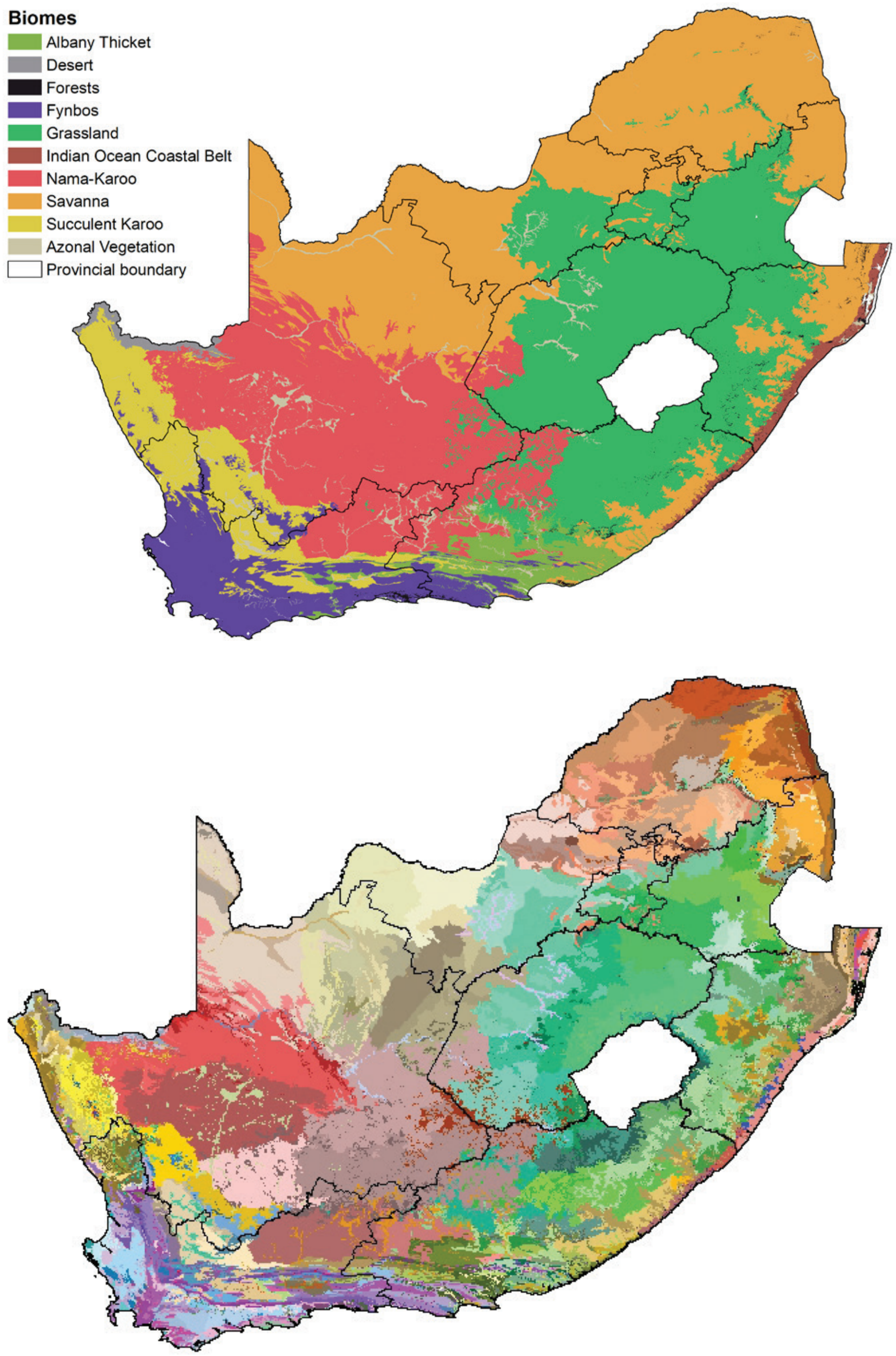
[11] SANBI is the custodian of the South African National Ecosystem Classification System (SA-NECS), as part of its mandate under the National Environmental Management: Biodiversity Act (Act 10 of 2004). Spatial data and other information from the SA-NECS is freely available on SANBI's Biodiversity GIS website (http://bgis.sanbi.org). A handbook for the SA-NECS is in development and will be available in the course of 2021.

[12] See: https://portals.iucn.org/library/node/49250

This means that while South Africa will continue to use its own ecosystem classification system for national accounts, it can be cross-walked to the IUCN GET, which is the reference classification for ecosystem types in the SEEA EA.

In the terrestrial realm, terrestrial ecosystem types are represented by 458 vegetation types identified in the South African portion of the Vegetation Map of South Africa, Lesotho and Swaziland (SANBI, 2018) (referred to as the National Vegetation Map). The 458 vegetation types in South Africa are grouped into nine terrestrial biomes based on similar characteristics (Figure 8).

Figure 8: Terrestrial ecosystem types are (a) aggregated into nine biomes, within which (b) 458 vegetation types in the National Vegetation Map are nested



Source: SANBI (2018)

Vegetation types are relatively homogenous units in the landscape, identified based on their biophysical characteristics such as species distribution, community composition, underlying geology and soil types, altitude, and rainfall gradients.

Vegetation types are delineated based on their historical or potential extent, prior to major human modification. They are therefore regarded as a stable set of ecosystem units based on ecological characteristics, against which changes in ecosystem extent over time can be assessed. Vegetation types also provide useful spatial units for ecosystem accounts because they link directly with functional aspects of ecosystems, which in turn link to the supply of some ecosystem services.

Terrestrial ecosystem types based on the National Vegetation Map delineate ecosystem types more meaningfully and accurately than the different natural or semi-natural classes within the NLC. For example, areas classified as "Low shrubland" in the NLC could be areas within the Nama-Karoo biome or the Succulent Karoo biome or could represent degraded areas within other biomes (such as Fynbos). Areas classified as "Woodland/Open bush" in the NLC could be part of the Savanna biome or could be areas within the Grassland biome that have become bush encroached or invaded by exotic woody plants. From an ecological perspective these are very different, both in terms of ecosystem condition and with respect to the supply of some ecosystem services. There is thus not a one-to-one match between the natural or semi-natural classes in the NLC data set and the natural or semi-natural ecosystem types and biomes, either conceptually or spatially, even though in some cases the National Land Cover classes share a name with one of the biomes.

2.2.3 Land-based protected areas

Protected areas are areas of land or ocean that are protected by law through the National Environmental Management: Protected Areas Act, No. 57 of 2003 (NEMPAA).

NEMPAA recognizes several categories/types of protected area (which differ in their functions by law[13]), including National Parks, Nature Reserves, Special Nature Reserves, Protected Environments, Forest Nature Reserves, Forest Wilderness Areas, Mountain Catchment Areas and World Heritage Sites. Further, conservation is a concurrent competence across the national and provincial spheres of government in terms of the Constitution. There are several conservation authorities in South Africa responsible for protected areas. These include the nine provincial departments with responsibility for the environment, four of which have additional boards dealing with conservation (CapeNature, Eastern Cape Parks and Tourism Agency, Ezemvelo KZN Wildlife, Mpumalanga Tourism and Parks Agency). At the national level, conservation authorities include South African National Parks (SANParks) and the iSimangaliso Wetland Park Authority. Protected areas are not necessarily owned and managed by government. An important provision in the Protected Areas Act is that protected areas can be declared on private and communal land, and that the landowner (rather than a conservation authority) can be the management authority of the protected area.

The protected area dataset used for compiling these accounts was derived from the South African Protected Areas Database (SAPAD), which is a spatial data inventory of protected areas in South Africa that is developed and maintained by DFFE. DFFE acquires several protected area datasets from outside sources,

[13] This definition is narrower than that of the CBD and IUCN, as it does not include other effective area-based conservation measures – which are areas of land not formally protected by law but informally protected by current land users or owners.

such as national and provincial conservation authorities, audits these against official gazettes, and makes gradual improvements and updates in the accuracy of the database. Accuracy is generally good from 2000 onwards but less so prior to 2000 for a range of reasons. SAPAD is updated and released quarterly. These accounts include declarations up until the end of 2020. SAPAD also formed the core of the protection level analysis in the NBA 2018 (SANBI, 2019). For compiling the accounts for protected areas presented here, SAPAD formed the core of the protected area data, but the data was restructured to align with the data structure for the protected area layer used in the NBA.

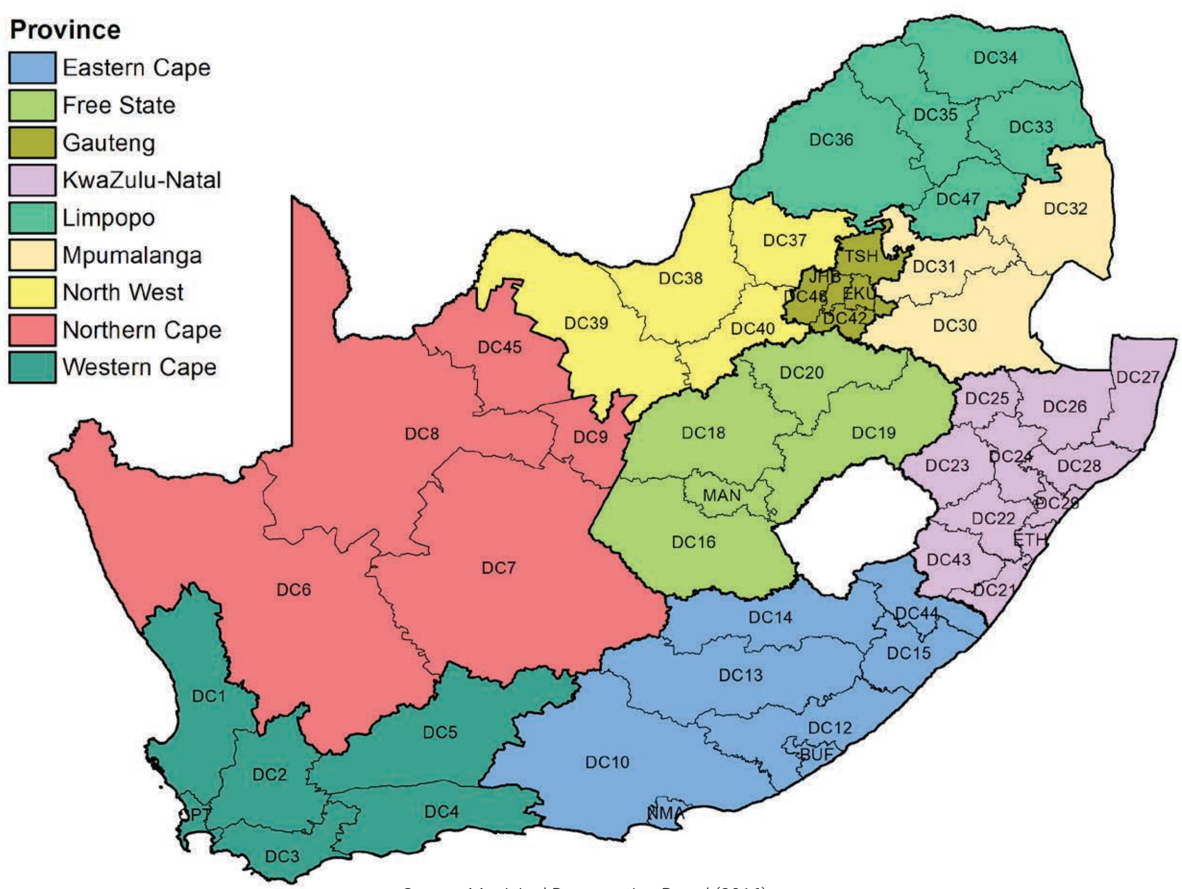
The Accounts for Protected Areas, 1900 to 2020, that were produced in the NCAVES Project, focused on land-based protected areas only[14]. In future these will be expanded to include marine protected areas[15].

2.2.4 Administrative boundaries

South Africa's terrestrial area is divided into nine provinces and within these, 44 district municipalities and eight metropolitan municipalities (Figure 9). District municipalities are further divided into local municipalities, of which there are 205. Provincial and municipal boundaries occasionally undergo changes which are determined by the Municipal Demarcation Board (MDB).

Figure 9: District and metropolitan municipalities within South Africa's nine provinces.

The codes are identifiers assigned by the Municipal Demarcation Board (MDB) and metropolitan municipalities are highlighted in bold.



Source: Municipal Demarcation Board (2016)

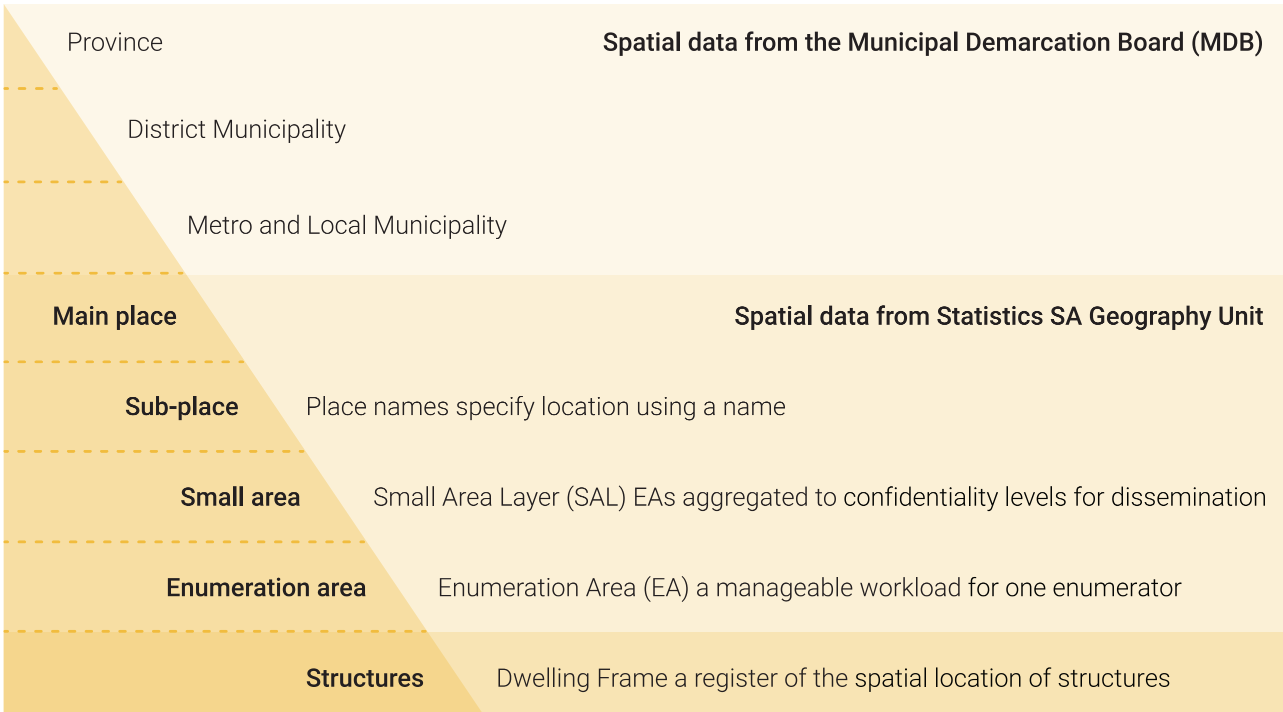
. . . .

14 Land-based protected areas protect terrestrial ecosystems, inland water ecosystems (rivers and wetlands) and occasionally estuarine ecosystems. The Accounts for Protected Areas compiled explore key findings in relation to terrestrial ecosystem types only.

15 Marine protected areas protect marine and coastal ecosystems.

Stats SA further disaggregates these administrative boundaries following the Stats SA Geospatial Information Frame illustrated in Figure 10. Metropolitan and local municipalities are broken down into smaller areas namely main places, sub-places, small areas and enumerator areas. There is a range of population census data that is collected at the level of the enumerator area that could be useful in making socioeconomic linkages with land and terrestrial ecosystem accounts.

Figure 10: Geospatial information frame used by Statistics South Africa



`Source: Stats SA (2016)

2.2.5 Population census data

Population Census data in South Africa are collected by Stats SA in enumerator areas that are spatially explicit. This makes it possible in principle to compare changes in land cover with spatial changes in the distribution of people and with a range of demographic indictors that are collected as part of the Population Census, such as income and employment status. Although it has not been possible to explore this in detail as part of the accounts produced in the NCAVES Project, this could be a valuable direction for future work.

2.2.6 Cycads

Cycads are ancient, long-lived plants that have barely evolved in the last ~135 million years. Today, cycads are immensely valuable species of global conservation concern. Within South Africa, the cycads are represented by 38 species (one species of *Stangeria* and 37 species of *Encephalartos*), among which there is a high degree of endemism (they occur nowhere else on earth). This group was chosen as a charismatic plant group species of conservation concern. Although information about cycads includes geospatial data, the accounts are non-spatial to protect the species.

The foundational data sets used to develop Cycad accounts were:

- In-depth information on cycad populations is only available for a sub-set of the group, namely for 12 critically endangered species with non-detriment findings (NDFs)[16], which included data ranging from 1970 onwards. This was supplemented with additional population data supplied by SANBI. Timing of counts varied between species, most species had around five counts spanning the time period. Data were summarised into a single population estimate per decade (from the 1970s to the 2010s). The value chosen for each decade was the most complete and/or recent estimate.

- The International Union for the Conservation of Nature (IUCN) threat status data for each of the 38 cycad species from 1996 and 2009, sourced from the SANBI Plant Red List[17].To enable comparability of the IUCN categories between 1996 and 2009, the categories were grouped into Extinct/Extinct in the Wild, Critically Endangered/Endangered, Vulnerable and Not threatened/Rare/Least Concern.

As to be expected with any data not specifically collected for the purpose of populating species accounts, there were limitations with the data compiled. Understanding how the data are collected and the limitations that come along with it, enables robust interpretation. Limitations included the lack of reliable estimates for benchmark populations before significant human intervention (i.e. no data were available on the numbers of each species that existed under "reference" or "natural" conditions). Many of the critically-endangered cycad species were only formally described in the 1980s, by which time extensive poaching had already occurred. Estimates from panels of local experts could provide useful or likely reference population estimates.

2.2.7 Rhinoceros

Rhinoceros (hereafter referred to as rhinos) offer a good opportunity to examine population changes of large charismatic species of global conservation concern. South Africa has reliable records for both the black rhino (Diceros bicornis) and white rhino (Ceratotherium simum) numbers at a national level over a relatively long time period. The black rhino includes three sub-species: the south-central black rhinoceros D. b. minor, the south western black rhinoceros D. b. bicornis (both indigenous sub-species) and the eastern black rhinoceros D. b. michaeli (an extralimital sub-species). While geospatial data exist on the location of populations across the country, stakeholders requested the accounts to be non-spatial to protect the populations as both groups are under significant threat from illegal poaching.

The accounts of rhino species therefore use readily available population statistics and threat status information for both the white and black rhinos species supplied by the DFFE, IUCN Species Survival Commission African Rhino Group and the Rhino Management Group. Additional information was sourced from the IUCN joint report to CITES for CoP17 (Emslie et al., 2015) as well as directly from the CITES trade database[18]. While it was not

16 NDFs are science-based risk assessments that are carried out by the Scientific Authority in South Africa (namely SANBI) to support the listing of species under the different appendices of the Convention on International Trade in Endangered Species of wild fauna and flora (CITES). The Scientific Authority is required to make non-detriment findings on the impact of actions relating to the international trade in specimens of threatened or protected species and species included in the Appendices to CITES. Factors considered include the biological characteristics of the species and its national status (distribution, abundance, trends and threats), as well as factors relating to management such as harvest control and monitoring, protection of the species from harvest, and incentives and benefits arising from harvest.

17 See: http://redlist.sanbi.org/

18 See: See: https://trade.cites.org/

possible to disaggregate rhino populations by protected area due to the sensitivity of location-based information, information regarding the ownership (private or state owned) of land on which rhino populations occurred could be included. Additionally, data on the nature of population offtake (due to hunting, exporting and poaching) was also used.

Section 3:
Ecosystem Extent Accounts

3.1 Introduction

A common starting point for ecosystem accounting is the organization of information on the extent of different ecosystem assets (EAs) within a country or other ecosystem accounting area (EAA), and how that extent is changing over time. This information is summarized in an ecosystem extent account. Accounting for ecosystem extent is relevant for several reasons. An ecosystem extent account provides a common basis for discussion among stakeholders of the composition of, and changes in, ecosystem types within a country. Thus, an extent account can support the derivation of coherent indicators of deforestation, desertification, agricultural conversion, urbanization and other forms of ecosystem change. Extent accounts also support the measurement of ecosystem diversity, fragmentation, and the derivation of indicators of changes in biodiversity. The spatial data required to compile an ecosystem extent account provides an underlying infrastructure for the other accounts and will be a direct input for the modelling of many ecosystem services.

An ecosystem extent account is compiled for the total area of an EAA. Thus, an ecosystem extent account records the areas, and changes in areas, of all of the EAs within an EAA. Most commonly, in an extent account data on the area of individual EAs are presented using a classification of ecosystem types (ETs) such that the areas of all EAs of the same ET are aggregated.

In concept, at the national level, the EAA extends to cover all terrestrial, freshwater and marine ecosystems with a boundary set by the country's border with other countries and its exclusive economic zone (EEZ). Compilers may choose to use an EAA of smaller scope – for example for various states or provinces.

South Africa chose to use the extent of the South Africa's terrestrial mainland area as the EAA for producing extent accounts in the *Land and Terrestrial Ecosystem Accounts, 1990 to 2014.*

3.2 Methodology for the Land and Terrestrial Ecosystem Accounts, 1990 to 2014

South Africa compiled land and terrestrial ecosystem accounts for the EAA. All data were resampled to the BSU grid for analysis.

The land accounts focus primarily on measuring changes in the spatial extent of intensively modified land-cover classes, such as cultivated, urban and mined areas, which are defined based on the National Land Cover produced using equivalent methods for the year 1990 (GTI, 2016) and 2014 (GTI, 2015) (Section 2.2.1). Land accounts are compiled at national, provincial and district municipal level, using land-cover class groupings at the broad (tier 1), main (tier 2) and detailed (tier 3) land-cover classes outlined in *Table 3. Grouping of National Land Cover classes into four tiers.*

The terrestrial ecosystem accounts focus primarily on measuring changes in the spatial extent of terrestrial ecosystem types defined in the South African National Ecosystem Classification System (SA-NECS). Terrestrial ecosystem types take the form of vegetation types, which are grouped into nine biomes. These are mapped are not based on current land-cover classes but rather on a range of abiotic and biotic factors that reflect their historical extent (prior to major human modification of the landscape). The terrestrial ecosystem extent account uses the historical extent of each of these ecosystem types as a constant historical baseline, and then reflects how much of each ecosystem type was still in natural or semi-natural condition in 1990 and 2014, relative to its historical extent and derived from the NLC data. This means that although terrestrial ecosystem types might align spatially with land-cover classes in some instances, they are conceptually distinct.

Both the land-cover account and the terrestrial ecosystem extent account together enable an analysis of which intensively modified land-cover classes have replaced natural or semi-natural land cover in which terrestrial ecosystem types. This is a powerful approach owing to 1) different intensively modified land-cover classes have widely varying ecological impacts which can often be linked to socioeconomic drivers in the landscape, and also to 2) different natural or semi-natural terrestrial ecosystem types which can be linked to some (although not all) ecosystem services based on their ecological characteristics.

A dual perspective is taken on intensively modified areas, which include cultivated areas and built-up areas. For the purpose of the land account, they are seen as land-cover classes, while for the purpose of the ecosystem extent account they are seen as ecosystem types that have a historical extent of zero.

In addition to the accounting tables, land-cover change matrices show changes between land-cover classes over the accounting period.

3.3 Results

3.3.1 Land accounts

The extent of South Africa's mainland is nearly 122 million hectares (ha). At the highest level of aggregation, South Africa's land account is summarized for the whole mainland territory by a broad land-cover class (tier 1), namely natural or semi-natural, cultivated, built-up and waterbodies.

Table 4 shows the land account with the opening stock in 1990 and the closing stock in 2014 for the country as a whole, together with the additions, reductions and net changes in each class. These are used to derive three indicators:

- **Percentage change per land-cover class**, which reflects and points to a range of social and economic dynamics;
- **Percentage land cover unchanged,** which reflects how "stable" or unchanged each land-cover class has been, by calculating the number of hectares that have not changed relative to the opening stock for that class;
- **Percentage turnover in land cover,** which reflects the degree of spatial turnover or spatial "churn" in the landscape from one land-cover class to another, calculated as the sum of both the additions and reductions in each class relative to its opening stock. This highlights areas where it is likely that rapid socioeconomic changes are taking place.

Table 4: Land account for broad land-cover classes (tier 1) at the national level, 1990–2014, in hectares.

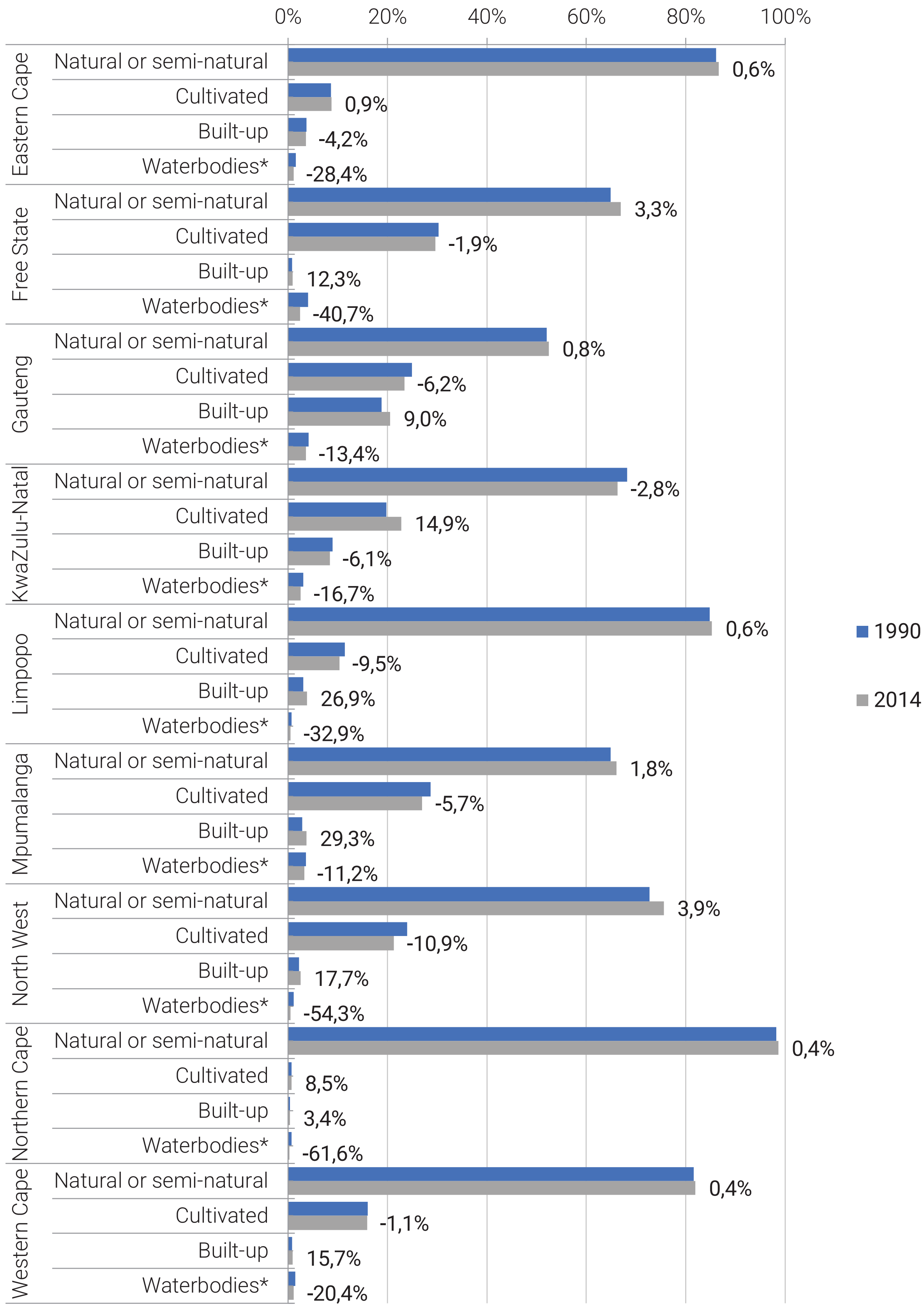
Broad land-cover classes (tier 1)	Natural or semi-natural	Cultivated	Built-up	Waterbodies*	TOTAL
Opening stock 1990	**100 710 016**	**16 156 026**	**3 003 883**	**2 096 528**	**121 966 453**
Additions to stock	3 366 559	1 991 959	597 238	288 754	6 244 510
Reductions in stock	2 540 175	2 339 226	400 503	964 606	6 244 510
Net change in stock	826 384	(347 267)	196 735	(675 852)	
Net change as % of opening	*0.8%*	*-2.1%*	*6.5%*	*-32.2%*	
Unchanged (opening - reductions)	98 169 841	13 816 800	2 603 380	1 131 922	
Unchanged as % of opening	*97.5%*	*85.5%*	*86.7%*	*54.0%*	
Turnover (additions + reductions)	5 906 734	4 331 185	997 741	1 253 360	
Turnover as % of opening	*5.9%*	*26.8%*	*33.2%*	*59.8%*	
Closing stock 2014	**101 536 400**	**15 808 759**	**3 200 618**	**1 420 676**	**121 966 453**

*The large net decrease in the extent of waterbodies reflects primarily that 1990 was a much wetter year than 2014.

Source: Stats SA (2020)

At this aggregated level, the majority of South Africa's land area (83 per cent) is natural or semi-natural, with 13 per cent cultivated and 3 per cent built-up. Additionally, natural or semi-natural land cover remained largely unchanged over the accounting period of 1990 to 2014 (97.5 per cent unchanged) and turnover was relatively low (5.9 per cent). However, the proportion of natural and semi-natural land is much lower in some parts of the country than others. This is evident when land accounts are disaggregated to sub-national ecosystem accounting areas, such as provinces or municipalities. Figure 11 summarizes the provincial level land accounts to provide the proportional breakdown of broad land-cover classes within each province. It is evident that the province of Gauteng, South Africa's largest economic hub, has only 52 per cent remaining natural or semi-natural, while the extensive, largely arid Northern Cape province has nearly 99 per cent remaining natural or semi-natural.

Figure 11: Proportional breakdown of broad land-cover classes (tier 1) within each province in 1990 and 2014 (net percentage change for each class shown at the end of each pair of bars)



*Changes in the extent of waterbodies reflect primarily that 1990 was a much wetter year than 2014.

Source: Stats SA (2020)

Land-cover accounts were also compiled for each of the 52 districts and metropolitan municipalities. Changes in land cover per district are summarized in the form of maps. Figure 12 shows the net percentage change in natural or semi-natural land cover per district municipality and Figure 13 shows the net percentage change in cultivated land cover, and Figure 14 shows the net percentage change in built-up land cover.

Of the ten districts with the greatest net decrease in natural or semi-natural land cover, seven were within KwaZulu-Natal (Figure 12). Nationally, Harry Gwala (previously Sisonke) District (DC43[19]) had the greatest decrease in natural or semi-natural land cover (7.7 per cent), followed by Zululand (DC26; 5.3 per cent), and Amajuba (DC25; 3.8 per cent). Outside of KwaZulu-Natal province, the Johannesburg (JHB) and Tshwane (TSH) metropolitan municipalities (metros), as well as Sekhukhune District (DC47) in Limpopo complete the ten districts with the highest net percentage decreases in natural or semi-natural land cover.

Large percentage increases in cultivated land cover took place in most of the districts in KwaZulu-Natal, with seven of the ten districts that had the largest net increases in cultivated land (Figure 13) occurring in this province. Districts in Northern Cape also showed net percentage increases in cultivated land cover, except for John Taolo Gaetsewe District (DC45), which had a 4 per cent decrease in cultivated land cover. Although the opening stock of cultivated land cover in metros (such as Ekurhuleni (EKU)), City of Johannesburg (JHB) and Nelson Mandela Bay (NMA) was low, this decreased further between 1990 and 2014. The Vhembe District (DC34) in Limpopo province had a 22 per cent net decrease in cultivated land cover.

Built-up land showed a net percentage increase in two thirds of South Africa's districts (Figure 14). The greatest percentage increases were in the Nkangala District (DC31; 45 per cent) in Mpumalanga and the Sekhukhune District (DC47; 34 per cent) in Limpopo. Six of the ten districts with the largest net decreases in built-up land cover were in KwaZulu-Natal. eThekwini (ETH) was the only metro where a net decrease in built-up land cover was recorded. All districts in Eastern Cape had a decrease in built-up land cover, with only the two metros in the province showing an increase in built-up land.

Figure 15 shows the percentage change in population by district municipality between 1996 and 2011, based on data from the Population Census. A simple visual comparison between percentage changes in population and percentage changes in built-up land cover per district between (Figure 14) shows some similarities and some differences in spatial patterns. The net decreases in built-up land cover in most of Eastern Cape, for example, may be related to the net decreases in population in parts of the province, possibly linked to urbanisation. Further work would be required, including at a finer spatial scale than districts, to investigate these possible links.[20]

[19] District municipalities are assigned a district code (DC) and metropolitan municipalities are assigned a code associated with the municipality name. These codes are used on the maps.

[20] Population Census data have been intersected with the Basic Spatial Unit (BSU) layer (see Section 2), which provides a consistent spatial framework for integrating data on land and ecosystems as well as demographic and economic data. This will enable such further work.

Figure 12: Net percentage change in natural or semi-natural land cover (tier 1) by district municipality, 1990–2014

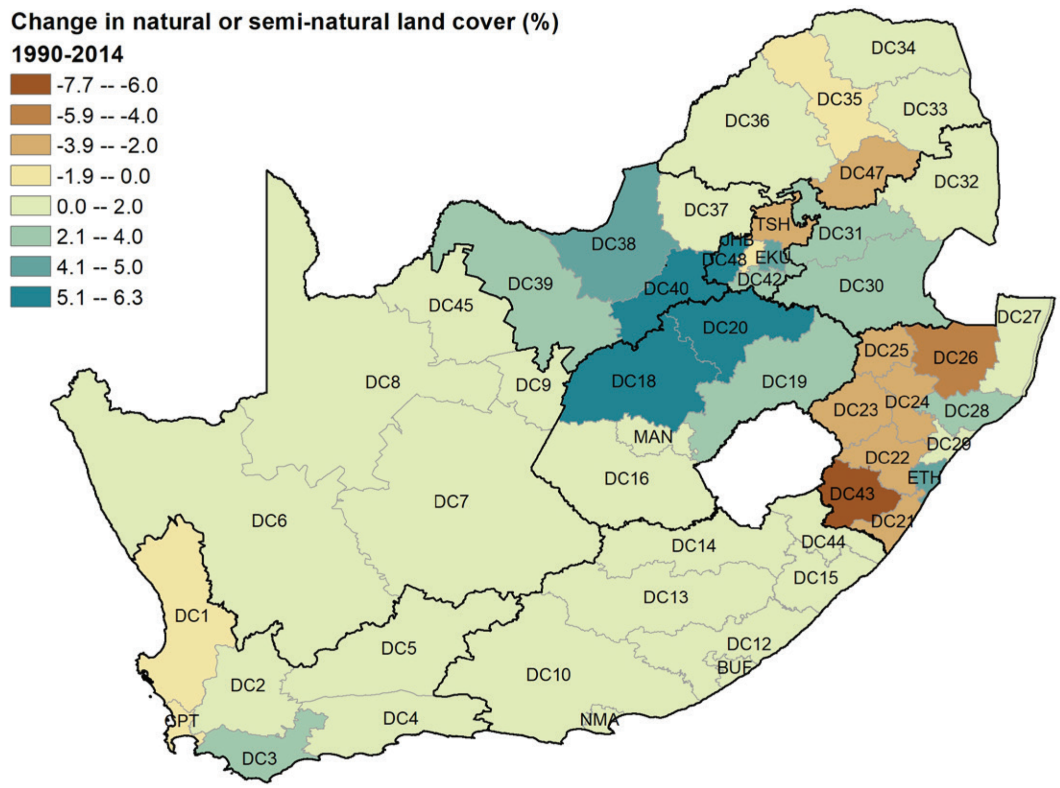


Figure 13: Net percentage change in cultivated land cover (tier 1) by district municipality, 1990–2014

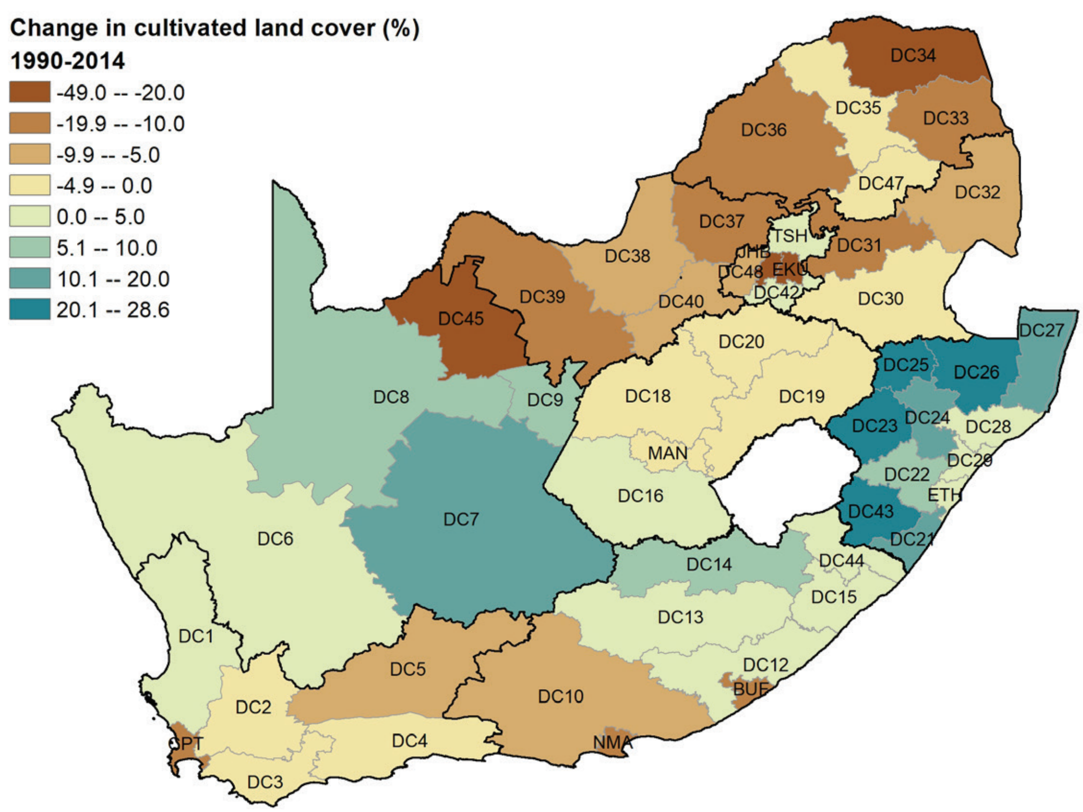


Figure 14: Net percentage change in built-up land cover (tier 1) by district municipality, 1990–2014

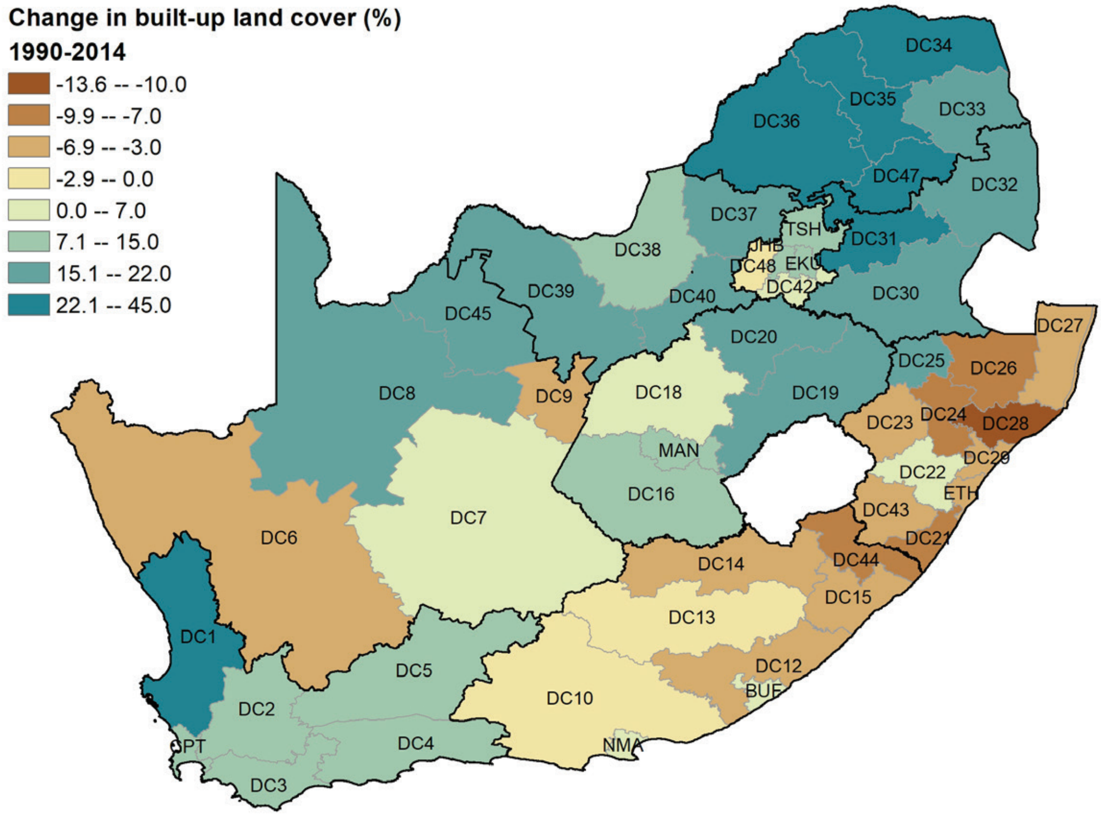
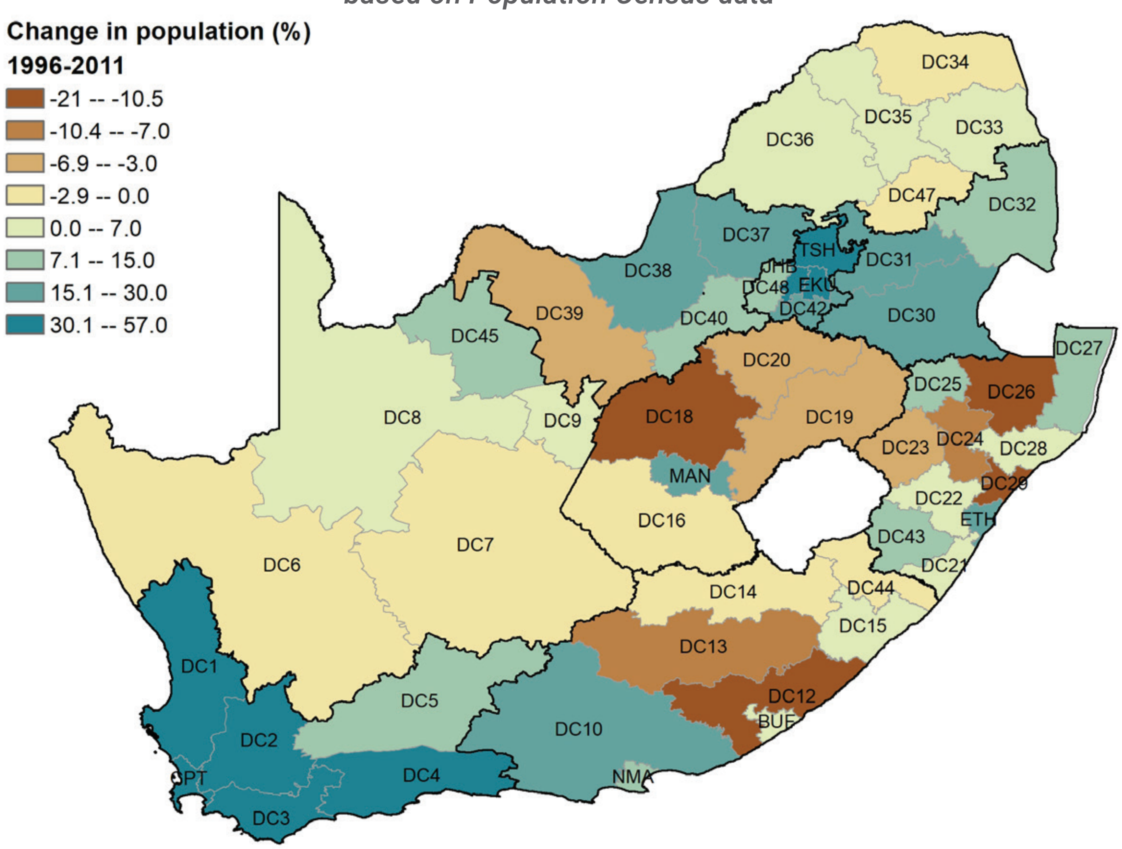


Figure15: Percentage change in population by district municipality, 1996–2011, based on Population Census data



Source: Stats SA (2020)

The trends in changes of broad land-cover classes per district municipality can be further disaggregated to more detailed land-cover classes (provided in Stats SA, 2020[21]). Some of the key findings are distilled for land-cover classes that are of particular social or economic interest, by drawing together findings from across the different spatial scales of analysis (national, provincial and district municipality) and across all levels of the land-cover hierarchy (broad, main and detailed land-cover classes).

3.3.1.1 Urban

At the national level, urban land cover increased by nearly 6 per cent between 1990 and 2014, to just under 2.9 million ha. Most change was from natural or semi-natural land cover while nearly 16 000ha of timber plantations were converted to urban land cover. Limpopo province accounted for the highest absolute and percentage increase in urban land cover.

As the national population has increased and become more urbanized, there has been an expansion of urban land-cover classes such as urban residential, townships, informal areas, parkland and commercial. Urban informal areas increased by nearly 96 per cent as more people seek opportunities around urban centres. While urban informal areas expanded by over 11 000ha in absolute terms in Gauteng, it was Free State, Limpopo, Northern Cape and Mpumalanga that had the highest net percentage increases between 1990 and 2014.

Urban land cover, as a whole, decreased only in Eastern Cape and KwaZulu-Natal, where there were large decreases in the urban village land-cover class (which includes dense rural settlements).

3.3.1.2 Mining

At the national level, mining land cover increased from 270,000ha in 1990 to 313 000ha in 2014. More than 83 000ha of land was converted from natural or semi-natural land to mines, and over 37 500ha of commercial crops and over 3 500ha of timber plantations were converted to mines. The majority of this change took place in Mpumalanga and North West. Overall the highest net change was from commercial crops (primarily fields rather than pivots).

Looking at net change across the provinces, there were notable differences. In percentage terms, Mpumalanga, Western Cape and North West experienced the largest increase in mining land cover with increases of 74.5 per cent, 67.6 per cent and 36.4 per cent, respectively. Mpumalanga had the highest absolute additions to mining areas (nearly 32 000ha being converted from different land-cover classes to mines), particularly in the Nkangala District (DC31), which had by far the greatest absolute increase in mining land cover, with over 30 000ha more mining land cover in 2014 than in 1990. This is substantially higher than the next highest, Bojanala Platinum District Municipality (DC37) at 7 511ha. These increases highlight the expansion of mining activity in the coalfields of Mpumalanga and platinum belt of North West. GCIS (2019) reports that the eMalahleni area in the Nkangala District Municipality (DC31) produces more coal than anywhere in Africa, while the Bojanala Platinum District Municipality (DC37) contributes 94 per cent of South Africa's platinum, the highest for any area globally.

[21] See: http://www.statssa.gov.za/publications/D04011/D040111990to2014.pdf

3.3.1.3 Cultivation

Nationally there was a net decrease in cultivated land cover (including commercial crops, subsistence crops, orchards and vines, and timber plantations) between 1990 and 2014, from just over 16 million ha to 15.8 million ha. The net decrease was around 350 000ha or 2 per cent. There was a notable net decrease in cultivated commercial fields. These areas either fell fallow and reverted to a semi-natural state, or in many areas shifted to more intensive pivot agriculture systems where more crop tonnage can be produced on a smaller area. Cultivated commercial pivots area more than doubled from just under 240 000ha to just under 770 000ha. Pivot-irrigated agriculture requires more intensive infrastructural investments, nutrient applications and significantly greater water use.

The overall net decrease in cultivated land-cover disguises some increases. The clearest addition to cultivated land cover was the expansion of cultivated areas in KwaZulu-Natal, primarily from natural or semi-natural areas. Every district municipality in the province had a net increase in cultivated land cover. Although cultivated commercial crops decreased nationally, KwaZulu-Natal was a distinct exception. Four of the five highest percentage increases at the district level were in KwaZulu-Natal district municipalities.

The increase in cultivated commercial pivots was seen across all provinces, with Free State and Eastern Cape having the highest percentage increases (>400 per cent). Free State's net increase was 135 422ha, the highest absolute increase of any province. Sugarcane crops increased in both provinces in which they occur, KwaZulu-Natal (19.6 per cent) and Mpumalanga (70.7 per cent), but there were no new sugarcane crops in any other provinces.

Although subsistence crop land cover increased by just over 21 000ha, only three provinces had net additions; Free State (59.9 per cent), Eastern Cape (5.2 per cent) and KwaZulu-Natal (28.1 per cent). KwaZulu-Natal in particular had a very large increase in subsistence crop area, with net additions of 111 754ha, while two Free State district municipalities, Xhariep (DC16) and Thabo Mofutsanyane (DC19), had the highest percentage increases in the country. Subsistence crop area decreased by more than 25 per cent in Gauteng, Western Cape and Mpumalanga, and by 16.3 per cent in Limpopo.

Nationally, orchards expanded by nearly 18.0 per cent, and across all provinces but Western Cape. Limpopo accounted for the highest net increase (30,247ha), with orchards replacing large areas of natural or semi-natural land and cultivated commercial crops. The biggest increases were in the Mopani and Vhembe Districts. Although relatively small in absolute terms, Gauteng had the highest percentage increase in orchards (68.1 per cent), with their extent more than doubling in the three metropolitan municipalities in Gauteng. Vines areas expanded in both provinces in which they are found, Northern Cape (8.4 per cent) and Western Cape (18.7 per cent), but there were no new vineyards in any other provinces. Both the Namakwa (DC6) and Cape Winelands (DC2) Districts had percentage increase in vines of over 25 per cent.

3.3.2 Terrestrial ecosystem extent accounts

The terrestrial ecosystem extent account uses the historical extent of each terrestrial ecosystem type as a constant historical baseline. The natural, or semi-natural, land-cover class is then used to determine how much of each terrestrial ecosystem type remains in a natural or semi-natural state, by overlaying current land cover on terrestrial ecosystem types.

The fact that terrestrial ecosystem types have been mapped based on their historical extent, which remains constant, provides a stable set of spatial units against which to assess changes in extent, for example as natural and semi-natural ecosystem types are converted to intensive land uses.

The portion of each ecosystem type that remains in a natural or semi-natural state, and which is not converted to intensive land uses, is referred to as the **remaining extent**. Tracking the remaining natural or semi-natural extent of terrestrial ecosystem types relative to their historical extent and from one accounting period to another is useful because it enables an analysis of which ecosystem types are under most pressure from loss of natural vegetation. This in turn may have negative impacts on the supply of ecosystem services associated with those ecosystem types.

Table 5 shows a summary of the terrestrial ecosystem extent account by biome. The account opens with historical extent, prior to major human modification of the landscape, and then reflects the extent of each biome that remained in a natural or semi-natural state in 1990 and 2014. There is no reliable spatial information on the historical extent of waterbodies, subsistence cultivation or habitation.

The extent account includes the nine biomes (as identified in the National Vegetation Map) and that are classified as natural or semi-natural in the National Land Cover. These are referred to as the "natural or semi-natural" biomes. Cultivated areas, built-up areas and waterbodies are treated as biomes for the purpose of the ecosystem extent account table. The "cultivated" and "built-up" biomes, to which parts of the natural or semi-natural biomes have been converted, are referred to as intensively modified biomes and have a historical extent of zero, as by definition they are created through major human modification of the landscape. Waterbodies are treated as a biome and include natural or semi-natural waterbodies (such as wetlands) and artificial waterbodies (such as dams). They are not disaggregated at this time, as land-cover data is not well suited to mapping inland water ecosystems. Moreover, South Africa has more comprehensive and accurate sources of data for inland water ecosystems, including rivers and wetlands, and for artificial waterbodies such as dams, that will be used to develop accounts for freshwater ecosystems in the future.

The link between the land account presented in Table 4 and the ecosystem extent account presented in Table 5 is the intensively modified areas, which appear as broad land-cover classes in Table 4 and as intensively modified biomes in Table 5. They are delineated in exactly the same way, so the switch is simply in perspective, with no impact on the measurement of their spatial extent. In the land account in Table 4, the nine natural or semi-natural biomes are grouped in the broad land-cover class "natural or semi-natural".

It is important to note that Table 55 is not simply a land account presented as an ecosystem extent account. This is because only the intensively modified biomes in the ecosystem extent account are derived from the NLC. The natural or semi-natural biomes are defined based on the National Vegetation Map.

*Table 5: Extent account for terrestrial ecosystem types summarised by biome, 1990 and 2014, in hectares**

Biomes	Albany Thicket	Desert	Forest	Fynbos	Grassland	IOCB	Nama-Karoo	Savanna	Succulent Karoo	Azonal vegetation	Cultivated**	Built-up**	Water-bodies***	TOTAL
Historical extent	**3531 231**	**626 207**	**462 518**	**8165 366**	**33 090 325**	**1171 284**	**24 936 548**	**39 418 522**	**7821 579**	**2742 873**	**-**	**-**	**-**	**121 966 453**
Additions to extent	0	0	0	0	0	0	0	0	0	0	16 156 026	3 003 883	2 096 528	21,256 437
Reductions in extent	230 091	8 237	70 673	2253 375	11,330 606	619 656	420 995	5 396 119	251 373	675 312	-	-	-	21,256 437
Net change in extent	(230 091)	(8 237)	(70 673)	(2 253 375)	(11 330 606)	(619 656)	(420 995)	(5 396 119)	(251 373)	(675 312)	-	-	-	
Net change as % of historical	**-6.5%**	**-1.3%**	**-15.3%**	**-27.6%**	**-34.2%**	**-52.9%**	**-1.7%**	**-13.7%**	**-3.2%**	**-24.6%**	**-**	**-**	**-**	
Closing extent 1990	**3301 140**	**617 970**	**391 845**	**5 911 991**	**21 759 719**	**551 628**	**24 515 553**	**34 022 403**	**7 570 206**	**2 067 561**	**16 156 026**	**3 003 883**	**2 096 528**	**121 966 453**
Opening extent 1990	3301 140	617 970	391 845	5911 991	21 759 719	551 628	24 515 553	34 022 403	7570 206	2 067 561	16 156 026	3 003 883	2 096 528	121 966 453
Additions to extent	44 432	1 142	24 900	241 184	1 444 446	75 114	146 910	1160 055	38 422	189 954	1991 959	597 238	288 754	6 244 510
Reductions in extent	36 008	1 260	7 689	196 035	1180 183	63 783	78 038	885 303	33 631	58 021	2 339 226	400 503	964 606	6 244 286
Net change in extent	8 424	(118)	17 211	45 149	264 263	11 331	68 872	274 752	4 791	131 933	(347 267)	196 735	(675 852)	
Net change as % of opening	**0.3%**	**0.0%**	**4.4%**	**0.8%**	**1.2%**	**2.1%**	**0.3%**	**0.8%**	**0.1%**	**6.4%**	**-2.1%**	**6.5%**	**-32.2%**	
Net change in relation to historical extent	(221 667)	(8 355)	(53 462)	(2 208 226)	(11 066 343)	(608 325)	(352 123)	(5 121 367)	(246 582)	(543 379)	-	-	-	
Net change as % of historical	**-6.3%**	**-1.3%**	**-11.6%**	**-27.0%**	**-33.4%**	**-51.9%**	**-1.4%**	**-13.0%**	**-3.2%**	**-19.8%**	**-**	**-**	**-**	
Closing extent 2014	**3 309 564**	**617 852**	**409 056**	**5 957 140**	**22 023 982**	**562 959**	**24 584 425**	**34 297 155**	**7 574 997**	**2 199 270**	**15 808 759**	**3 200 618**	**1 420 676**	**121 966 453**

* Blank cells represent no data.

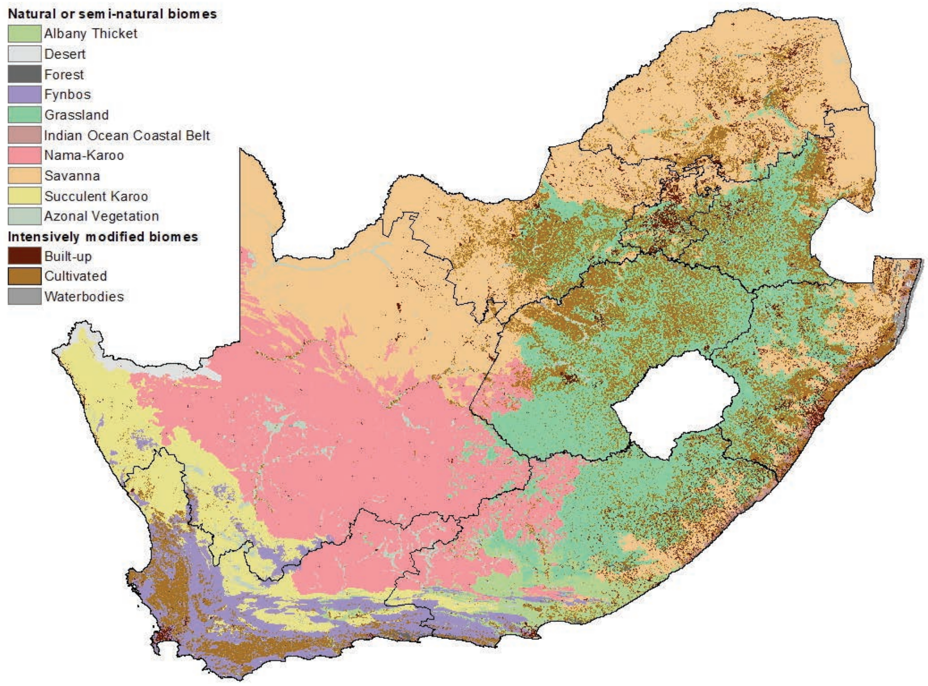
** Cultivated areas, built-up areas and waterbodies are treated as biomes for the purpose of the ecosystem extent account table. There is no reliable spatial information on the historical extent of waterbodies, subsistence cultivation or habitation.

*** The large net decrease in the extent of waterbodies reflects primarily that 1990 was a much wetter year than 2014. Waterbodies include both natural and artificial water bodies (such as dams).

Source: Stats SA (2020)

The results of these accounts are visualised in Figure 36, which shows the extent of each biome in 2014, including intensively modified biomes that have replaced and fragmented the natural and semi-natural biomes.

Figure 16: Extent of biomes in 2014, including intensively modified biomes that have replaced portions of the natural or semi-natural biomes



Source: Stats SA (2020)

The ecosystem extent account is used to derive an Ecosystem Extent Index (EEI), calculated as the remaining extent[22] of an ecosystem type as a proportion of its historical extent. The EEI can be evaluated against critical thresholds for ecosystem functioning, to identify those ecosystem types that are close to or beyond such thresholds. The EEI can be calculated per ecosystem type, per biome (as in Figure 17), per province (as in Figure 58), or for any EAA.

The EEI can be viewed in relation to ecological thresholds. 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 that, as a rule of thumb, when less than approximately 60 per cent of the natural area within an ecosystem remains (i.e. remaining extent is less than 60 per cent of its original extent), then its ecological functioning begins to break down. In practice the exact level of this threshold varies between ecosystems depending on landscape structure and other characteristics but is nevertheless useful as a guide, especially at the landscape scale.[24]

[22] The portion of each ecosystem type that remains in a natural or semi-natural state, not converted to intensive land uses, is referred to as the remaining extent.

[23] For example, Andren (1999), Desmet (2018), Fahrig (2001), SANBI (2013).

[24] The application of this landscape-level threshold in an ecosystem accounting context was initially explored in the land and terrestrial ecosystem accounts piloted in KwaZulu-Natal (Driver et al., 2015) as part of the Advancing Natural Capital Accounting (ANCA) project.

In Figure 47, the EEI for each biome is compared with an ecological function threshold of 60 per cent. It shows that by 2014 the Grassland biome was approaching the 60 per cent threshold with an EEI of 67 per cent, while the Indian Ocean Coastal Belt had crossed it with an EEI of 48 per cent. The Grassland biome is the second largest biome in South Africa and plays an important role in water provision as well as providing extensive agricultural rangelands. Several ecosystem types within the Indian Ocean Coastal Belt ecosystems play an important role in buffering settlements and infrastructure in the event of coastal storms. The Fynbos biome, which has the next lowest EEI at 73 per cent, is of global biodiversity significance because of its exceptional species diversity.

Figure 17: Ecosystem Extent Index for natural or semi-natural biomes, historically, in 1990 and in 2014, in relation to an ecological function threshold

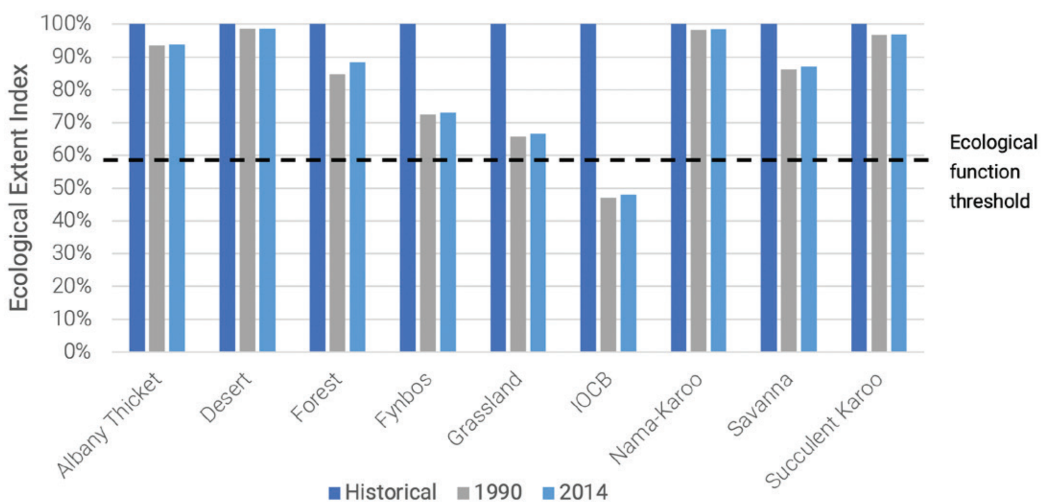
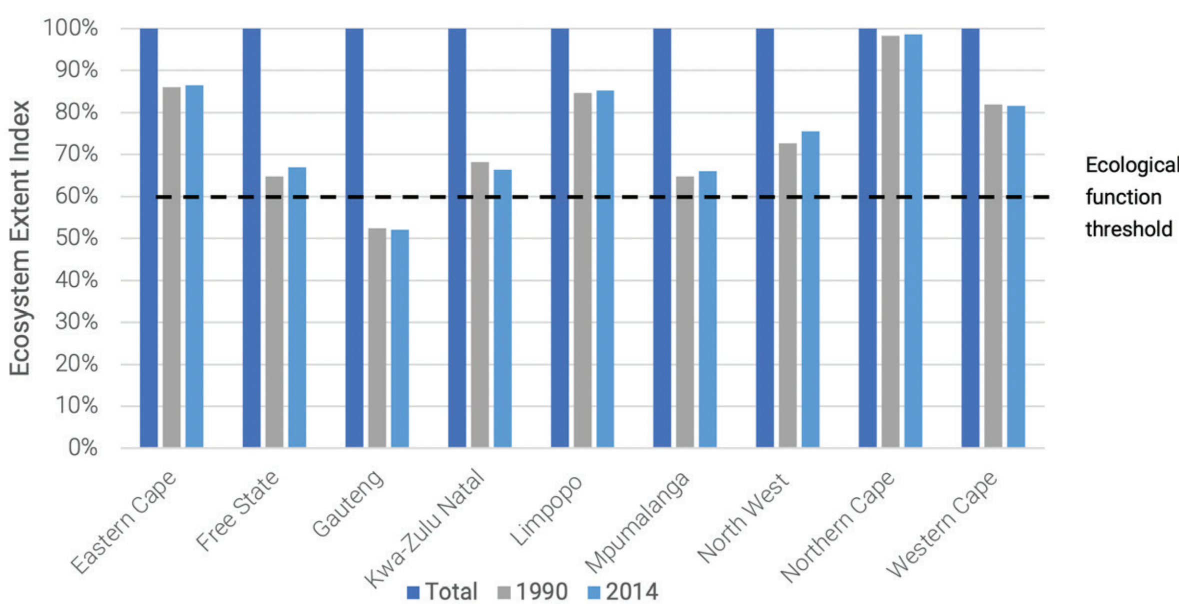


Figure18: Ecosystem Extent Index for provinces, historically, in 1990 and in 2014, in relation to an ecological function threshold

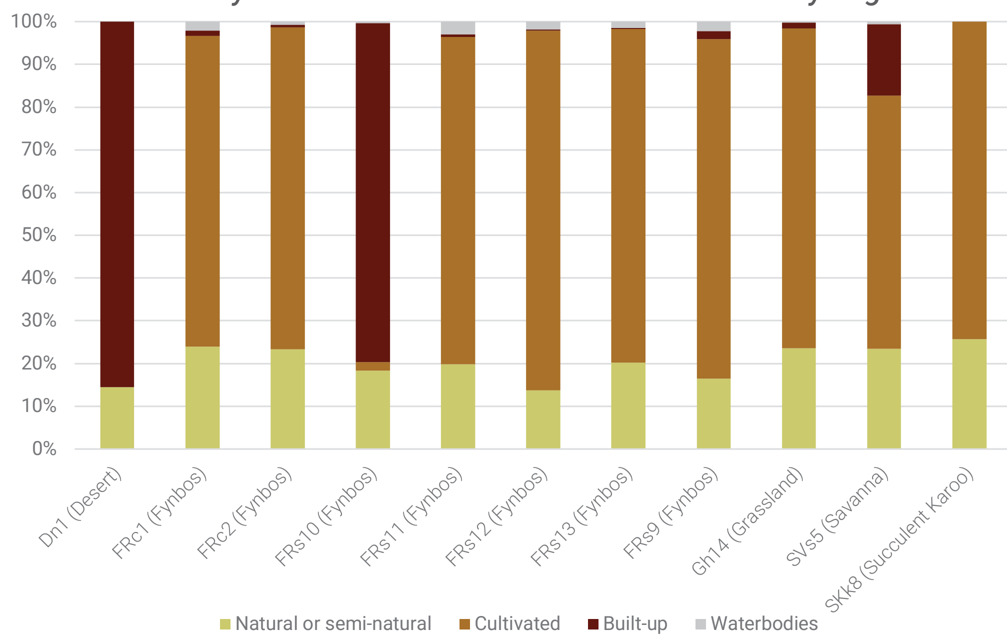


Source: Stats SA (2020)

The EEI at the level of individual ecosystem types can provide important information from a biodiversity perspective. As part of the South African National Ecosystem Classification System (SA-NECS), every ecosystem type in South Africa is assigned a biodiversity target. The biodiversity target represents the minimum proportion of the historical extent of each ecosystem type that should remain in a natural or near-natural state in order to maintain a viable representative sample of all the country's ecosystem types and the species associated with them.[25] The EEI can be evaluated against the biodiversity target to show which ecosystem types are nearing or below their biodiversity target.[26] The EEI can highlight those ecosystem types that have experienced large losses of natural cover, indicated by large declines in the EEI. This provides a useful tool for identifying specific ecosystem types that are in need of management or conservation interventions.

Figure 19 shows the 11 terrestrial ecosystem types that had an EEI of less than their biodiversity target in 2014. Seven of these are part of the Fynbos biome, with an additional one each in the Desert, Grassland, Savanna and Succulent Karoo biomes. Of particular concern are the ecosystem types that were very small to begin with (i.e. that have a very small historical extent), in which several species may be highly range-restricted or only found within that ecosystem type, which are more predisposed to impacts resulting from conversion to intensive land uses. This is the case for many ecosystem types within the Fynbos biome, which is highly diverse both in structure and species composition.

Figure 19: Land-cover composition by broad land-cover class (tier 1) in 2014 for ecosystem types with an Ecosystem Extent Index less than their biodiversity target.[27]



Source: Stats SA (2020)

. . . .

[25] For terrestrial ecosystem types, the biodiversity target is based on the species-area relationship and ranges from 16 per cent (for ecosystem types that are less species rich) to 36 per cent (for ecosystem types that are more species rich).

[26] This information is useful for Red List of Ecosystem assessments, particularly for criterion A, which deals with reduction in geographic distribution. The Ecosystem Extent Index is similar to Criterion A3 in the Red List of Ecosystems, which is reduction in geographic distribution since 1750.

[27] Names of ecosystem types, represented here by codes with the relevant biome in brackets: Dn-1 Alexander Bay Coastal Duneveld; FRc1 - Swartland Silcrete Renosterveld; FRc2 - Ruens Silcrete Renosterveld; FRs10 - Peninsula Shale Renosterveld; FRs11 - Western Ruens Shale Renosterveld; FRs12 - Central Ruens Shale Renosterveld; FRs13 - Eastern Ruens Shale Renosterveld; FRs9 - Swartland Shale Renosterveld; Gh14 - Western Highveld Sandy Grassland; SVs5 - KwaZulu-Natal Sandstone Sourveld; SKk8 - Piketberg Quartz Succulent Shrubland.

3.4 Discussion

In presenting land account and terrestrial ecosystem extent account as distinct from each other, South Africa's extent account highlights the value of mapping ecosystem types based on their historical extent and the derivation of an EEI.

3.4.1 Mapping ecosystem types based on their historical extent

The historical extent of each terrestrial ecosystem type is used as the constant historical baseline or reference extent for the terrestrial ecosystem extent account. This provides the baseline against which change in ecosystem types can be monitored, and enables the EEI to be derived.

The dual perspective on intensively modified areas as both land-cover classes and ecosystem types provides the link between the land account and the ecosystem extent account. For further discussion on this see Driver et al. (2020).

3.4.2 Ecosystem Extent Index

The EEI is a headline indicator from the extent accounts, measuring the proportion of an ecosystem type that remains in natural or semi-natural condition relative to its historical extent. It provides a number of advantages:

- It is computationally simple and easy to understand;
- It is versatile, in that it can be evaluated against a range of thresholds that are important for different purposes to identify those ecosystem types that are close to or beyond such thresholds, and can thus inform a range of difference planning and decision-making needs;
- It is scalable, in that it can be calculated for individual ecosystem types at the local level or for ecosystem accounting areas at a range of spatial scales, up to the national level;
- It is value-neutral, in that there is no inherently "correct" level for the index – a desired minimum EEI can be determined based on policy and management objectives, and might vary for different ecosystem types in different contexts.

An important limitation of the EEI is that it does not provide information about the ecological condition of those portions of an ecosystem type that remain natural or semi-natural. This means that the EEI should ideally be complemented by an ECI based on the ecosystem condition account, discussed in Section 4:.

3.4.3 Directions for future work

Through the process of developing these accounts, several directions for future work have been identified, which would further enhance and add richness to the work undertaken so far. These include:

- Updating the accounts with the National Land Cover 2018, with further investigation of presenting the results at finer spatial scales, for instance accounts for local municipalities.
- Aligning future updates in National Land Cover with the Population Census, along with exploring the use of change analysis of NLC data to inform large sample surveys and the Population Census. In preparing and planning for undertaking large sample surveys and the Population Census, Stats SA bases decisions regarding what information to gather and where to gather it on a range of factors. Areas of high land-cover change could be used to indicate areas likely to be undergoing high levels of social and economic change and thus inform planning for large sample surveys.
- Collaborating with other organisations to map and measure ecosystem condition in a sufficiently consistent way so as to develop ecosystem condition accounts for inclusion in future terrestrial ecosystem accounts.

- Developing accounts focused on the small high-value ecosystem types highlighted as vital ecological infrastructure in South Africa's National Biodiversity Assessment (SANBI, 2019). These occur across aquatic and terrestrial realms and include indigenous forests, wetlands, lakes, estuaries, mangroves, dunes, beaches, rocky shores, kelp forests, reefs, seamounts, pinnacles and islands. Together these ecosystem types make up less than 5 per cent of South Africa's territory, but contribute disproportionately to a large number of benefits to people and the economy, such as water purification, carbon storage, storm protection, recreation and food (SANBI, 2019). Declines in the EEI or ECI (see Section 4) for these small high-value ecosystem types would be of particular concern from the perspective of the services and benefits they provide to people and the economy.
- Exploring areas of high net change, for instance at district Municipality level, in more detail, with further analysis of detailed land-cover classes for these areas.
- Exploring in more detail linking the accounts to social and economic data to further highlight linkages between environment, people and economy.

3.4.4 Policy application

Ecosystem accounts, and the indicators drawn from them, are flexible, multi-purpose tools with a range of potential applications. The land and terrestrial ecosystem extent accounts provide several statistics and indicators, such as net change in land-cover classes, percentage turnover in land-cover classes, and the EEI, reported at various spatial scales (such as provinces, district municipalities and biomes).

Examples of policy applications of these accounts include environmental indicators for the National Development Plan, the National Spatial Development Framework (NSDF), and municipal land-use planning. They could also support South Africa's country reporting on the UN SDGs, post-2020 biodiversity targets and other international obligations. Exploring the application of these indicators for reporting on national and international obligations is a direction for further work.

It is important to note that natural capital accounts have to be interpreted for policy application. The accounts in themselves simply provide systematic information on what has happened to date. Interpretation in relation specific policy issues or objectives is a separate and subsequent step to compiling and publishing the accounts. This interpretive step is primarily the role of relevant line Ministries, which can draw information from the accounts and interpret it to provide the "so what" for their policies and programmes.

Section 4: Ecosystem Condition Accounts

4.1 Introduction

The ecosystem condition account provides insights about the characteristics and quality of EAs and how they have changed during the accounting period. Measurement of ecosystem condition is of significant interest in supporting environmental policy and decision-making that is commonly focused on protecting, maintaining and restoring ecosystem condition.

Ecosystem condition accounts complement environmental monitoring systems by using data from different monitoring systems, for example concerning biodiversity, water quality and soil properties. The intention of the ecosystem condition account is therefore to build upon, rather than replace, existing monitoring systems. Ecosystem condition accounts provide a means to mainstream a wide range of ecological data into economic and development planning processes.

Ecosystem condition accounts record data on the state and functioning of EAs within an EAA using a combination of relevant variables and indicators. The selected variables and indicators reflect changes over time in the key characteristics of each EA. Ecosystem condition accounts are compiled in biophysical terms and the accounting structure provides the basis for organizing the data, aggregating across both EAs of the same ecosystem type and across ecosystem types within an EAA, and measuring change over time between the opening and closing points of accounting periods.

The SEEA ecosystem condition typology (ECT) outlined in Table 6 below is a hierarchical typology for organizing data on ecosystem condition characteristics. By describing a meaningful ordering and coverage of characteristics, it can be used as a template for variable and indicator selection and provide a structure for aggregation. The ECT also establishes a common language to support increased comparability among different ecosystem condition studies.

The typology describes a set of groups and classes with the common aim of being exhaustive (i.e. broad and inclusive enough to be able to host all variables and indicators that meet relevant selection criteria) and mutually exclusive (i.e. each variable and indicator can be assigned to a unique class). Ecosystem condition accounts are commonly compiled by ecosystem type because each type has distinct characteristics. For example, the characteristics of forests may include tree density and age while for wetlands characteristics concerning water quality and riparian zones will be relevant. However, some characteristics may be common across a number of ecosystem types.

Table 6: SEEA Ecosystem Condition Typology (SEEA ECT)

SEEA ECT groups and classes

Group A: Abiotic ecosystem characteristics

Class A1. Physical state characteristics: physical descriptors of the abiotic componentss of the ecosystem (eg. soil structure, water availability)

Class A2. Chemical state characteristics: chemical composition of abiotic ecosystem compartments (eg. soil nutrient levels, water quality, air pollutant concenrations)

Group B: Biotic ecosystem characteristics

Class B1. Compositional state characteristics: composition / diversity of ecological communities at a given location and time (eg. presence / abundance of key species, diversity of relevant species groups)

Class B2. Structural state characteristics: aggregate properties (eg. mass, density) of the whole ecosystem or its main biotic components (eg. total biomass, canopy coverage, annual maximum NDVI)

Class B3. Functional state characteristics: summary statistic (eg. frequency, intensity) of the biological, chemical and physical interactions between the main ecosystem compartments (eg. primary productivity, community age, disturbance frequency)

Group C: Landscape level characteristics

Class C1. Landscape and seascape characteristics: metrics describing mosaics of ecosystem types at coarse (landscape, seascape) spatial scales (eg. landscape diversity, connectivity, fragmentation)

Source: UN (2021; Table 5.1)

4.2 Terrestrial ecosystem condition in South Africa

Ecosystem condition accounts were originally planned to be included in the *Land and Terrestrial Ecosystem Accounts, 1990 to 2014.* However, assessing the condition of terrestrial ecosystem assets is not straightforward, and considerable further work is required to reliably determine the condition of terrestrial ecosystems.

A primary challenge faced in developing an ecosystem condition account in the terrestrial realm is the difficulty in distinguishing between natural and semi-natural condition in terrestrial ecosystems. Natural and semi-natural areas exist on a continuum, so drawing a definitive line between natural, near-natural and semi-natural is challenging. In comparison, the line between semi-natural areas and intensively modified areas (such as cultivated fields and urban areas), which is required to develop the terrestrial ecosystem extent account, is much easier to draw based on remotely sensed imagery.

To compile an ecosystem condition account, the condition of terrestrial ecosystems would need to be assessed based on a set of indicators aligned with the SEEA Ecosystem Condition Typology. However, there is not yet agreement on such a set of indicators for measuring ecosystem condition in the terrestrial realm, and the indicators may differ for different biomes.[28]

[28] For South Africa's river ecosystem condition accounts (Nel and Driver, 2015) and estuary ecosystem condition accounts (Van Niekerk et al., 2020), the set of condition indicators is guided by a conceptual model of the functioning of these ecosystems and their responses to pressures. The indicators crosswalk well to the SEEA Ecosystem Condition Typology.

Globally, normalised difference vegetation index (NDVI), (an indicator of net primary productivity or "greenness" of the land surface), is often used as an indicator of, or proxy for, condition in the terrestrial realm. The potential use of NDVI to assess terrestrial ecosystem condition in South Africa was explored as part of the NCAVES project, and has also been explored elsewhere (Venter and Desmet, 2019), including the use of direct analysis of NDVI data and outputs from global data sets such as Trends.Earth.

The output of Trends.Earth categorizes the productivity state as degraded, stable or improving (Figure 20), based on whether NDVI is decreasing, stable or increasing. In other words, increases in NDVI are assumed to represent improvements in condition, and decreases in NDVI are assumed to represent declines in condition. In the South African context, NDVI is an unreliable measure of condition. This is because a declining NDVI does not consistently indicate declining condition, and an increase in NDVI often represents a decline rather than an improvement in condition. For example, a decline in condition due to bush encroachment or increased biomass of invasive alien plant species in South Africa, involves an increase in NDVI. In addition, some changes in condition would not necessarily be reflected in terms of a change in NDVI (e.g. invasion of thicket by alien cactus). A change in NDVI in a particular direction cannot, therefore, be reliably labelled as a decline or improvement in condition. This issue is now recognized in the guidance on SDG indicator 15.3.1, which highlights that the decision on which ecosystem type changes are indicative of degradation or improvement is undertaken in close coordination with all relevant national stakeholders.[29]

In a recent national assessment of changes in condition based on NDVI data, Venter and Desmet (2019) interpreted areas of moderate and high increases in biomass as bush encroachment or spread of invasive alien plants. The resulting map (Figure) is considered a reasonable estimate of terrestrial ecosystem condition at the national level. However, this approach also has limitations, in that not all positive changes in NDVI are a result of declines in condition. Another key limitation relating to finding a measure of condition for terrestrial ecosystems is that NDVI cannot be compared to a reference condition. NDVI data only go back to the 1980s at best (with earlier data at a relatively coarse resolution of 250m).

Comparing the map outputs from Trends. Earth (Figure 20) and an analysis of NDVI trends over 30 years by Venter and Desmet (2019) (Figure 21) shows that in several parts of the country the results are diametrically opposite. For instance, the area north of Lesotho in the inland eastern part of the country shows "improvement" in Figure 20 and decline in rangeland condition in Figure 1.

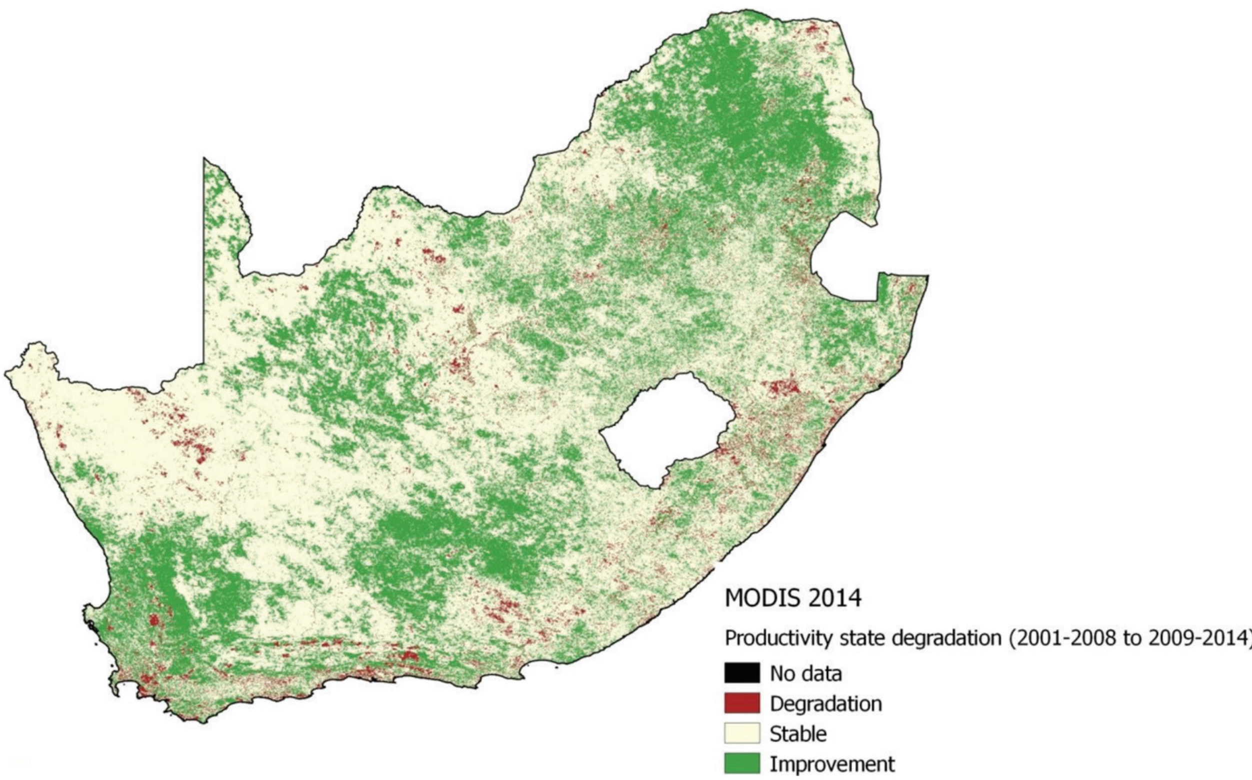
The conclusion of investigations during the NCAVES project was that NDVI trends alone cannot reliably be used to indicate condition in terrestrial ecosystems, and that neither NLC data nor NDVI provide a suitable single measure for ecosystem condition. Furthermore, at this stage, it is not possible to reliably distinguish natural from semi-natural areas or to measure ecosystem condition based on remotely sensed imagery alone. Analysis of NDVI data provides one layer of information, but a more reliable assessment of condition, or changes in condition, is needed rather than one that is solely based on positive or negative change in NDVI.

[29] See: https://seea.un.org/sites/seea.un.org/files/documents/Indicators/3._using_the_seea_ea_for_calculating_selected_sdg_indicators.pdf

This will require combining analysis of NDVI with additional analyses, e.g. using field data, ground-truthing, early aerial photography and machine learning, in order to be properly interpreted in relation to a reference condition. In addition, an indicator based on NDVI would need to be complemented with other indicators of condition.

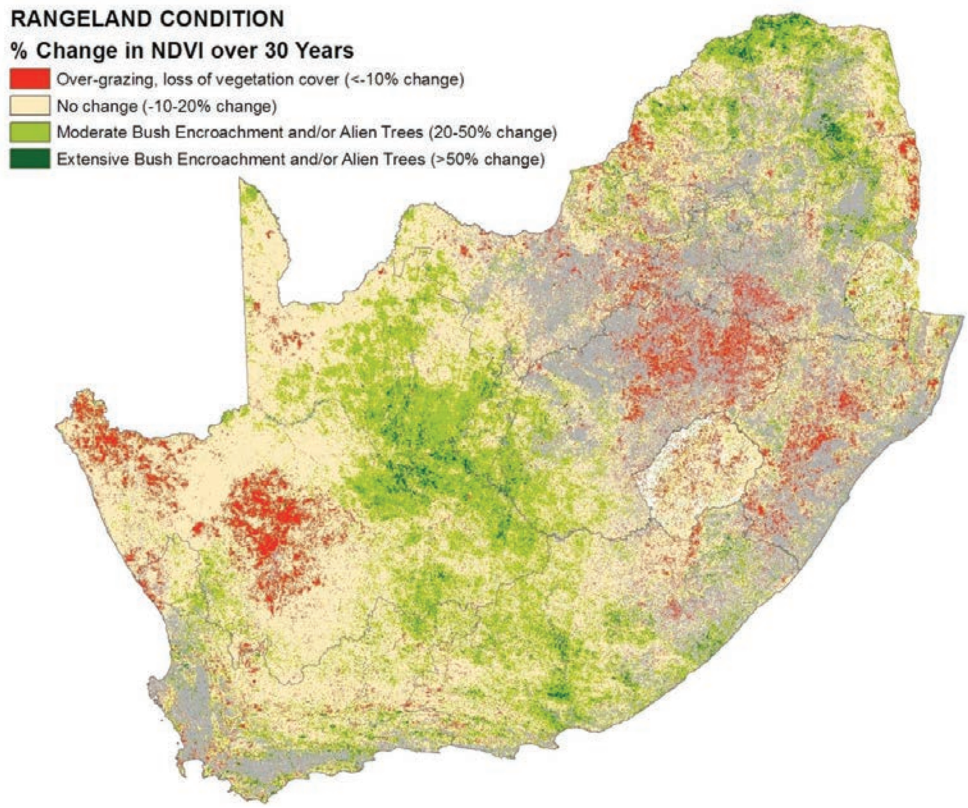
Substantial discussion and further work is needed to develop a reliable and consistent methodology to assess terrestrial ecosystem condition in South Africa, in a consistent enough way for accounting purposes. However, this should be feasible with a combination of existing, new and developing technology. It will require collaboration between a range of government departments and agencies, as well as research institutions. An ecosystem condition account will be included at a future stage, preferably including a retrospective assessment for 1990 and 2014 to match the extent accounts produced, and will provide an ECI to complement the EEI derived from the ecosystem extent account.

Figure 20: Productivity 'state' 2014 using Moderate Resolution Imaging Spectroradiometer NDVI data comparing 2001-2008 with 2009-2014, based on Trends.Earth



Turpie et al. (2019) (unpublished)

Figure 21: Estimated condition based on percentage change in NDVI over 30 years, giving the authors' initial interpretations of the cause of change. Areas under built-up or intensive agricultural land cover are shown in grey (Venter and Desmet, 2019)



Venter & Desmet (2019)

4.3 River and estuary ecosystem condition accounts

In contrast to the challenges faced in the terrestrial realm, methods and indicators for measuring ecosystem condition in the freshwater and estuarine realms are well established in South Africa, which has made it possible to develop national ecosystem condition accounts for rivers (Nel and Driver, 2015)[30] and estuaries (Van Niekerk et al., 2020).[31] Both of these sets of accounts are consistent with the approach recommended in the global consultation draft of the revised SEEA Ecosystem Accounting, with indicators that are aggregated to sub-indices and then to an overall ECI.

In the national river ecosystem accounts (Nel and Driver, 2015), an ECI was developed based on four indicators of the condition of rivers (dealing with flow of water, water quality, condition of instream habitat and condition of riparian habitat). Indicators were assessed relative to a reference condition of natural, on a scale of 0 (critically modified) to 100 (natural). The aggregated ECI for all rivers in South Africa was 72 per cent in 2011.

In the national estuary ecosystem accounts, an Ecosystem Condition Account was developed based on four abiotic indicators

30 The national river ecosystem accounts were developed by SANBI and Stats SA in collaboration with the Department of Water and Sanitation (DWS) as part of the Advancing Natural Capital Accounting (ANCA) project that preceded the NCAVES project.

31 The national estuary ecosystem accounts were developed by the Council for Scientific and Industrial Research (CSIR).

(dealing with hydrology, hydrodynamics, water quality and physical habitat) and five biotic indicators of estuarine condition (including macrophytes, invertebrates, fish and birds). As for rivers, these indicators were assessed relative to a reference condition of natural, on a scale of 0 (critically modified) to 100 (natural). The aggregated ECI for all estuaries in South Africa was 64 per cent in 2018.

4.3.1 Methodology

As part of the NCAVES project, the South African team tested the revised SEEA Ecosystem Accounting guidance for compiling ecosystem condition accounts by taking the data and indicators from the previously developed national river ecosystem accounts and applying the SEEA Ecosystem Accounting approach to compiling condition accounts. South Africa's national river ecosystem accounts were one of 14 case studies of existing ecosystem condition accounts reviewed as part of the research that informed the revision of SEEA Ecosystem Accounting (Maes et al., 2020). Overall, there is good compatibility and alignment between the approach taken in South Africa's river ecosystem condition accounts and the approach proposed in the revised SEEA Ecosystem Accounting, although with some differences. The testing process is outlined below, highlighting these differences.

4.3.1.1 EAA and ecosystem types

The ecosystem accounting area (EAA) was mainland South Africa and the scope of the river condition account was thus all rivers in South Africa, including main rivers and their tributaries. The spatial data layer, representing these rivers, was provided by the DWS.

South African river ecosystem types are defined according to a hierarchical classification framework. Rivers are classified according to eight functional groups that are very similar to the IUCN GET Level 3 functional groups for rivers. These are further differentiated within 32 ecoregions which guide the setting of specific reference levels (see Box 1 in section 4.3.1.3 below), particularly for water quality and sediment variables.

The data on ecosystem condition came from two national assessments of the ecological condition of rivers that had been undertaken by DWS, the first in 1999 and the second in 2011. These national assessments provided a condition score, known in South Africa as Present Ecological State[32], for each river reach at the quaternary catchment scale, based on several indicators of condition. The two national assessments were undertaken primarily to inform management decisions and therefore had not been designed for use as a time series. This presented some challenges for compiling the accounts, and lessons learnt from the process will inform future national assessments of the condition of rivers, the next of which is planned for 2021/2.

4.3.1.2 Ecosystem condition variables or indices

The Present Ecological State of rivers was assessed based on four indicators of the condition of rivers, dealing with flow of water, water quality, condition of instream habitat and condition of riparian habitat.[33]

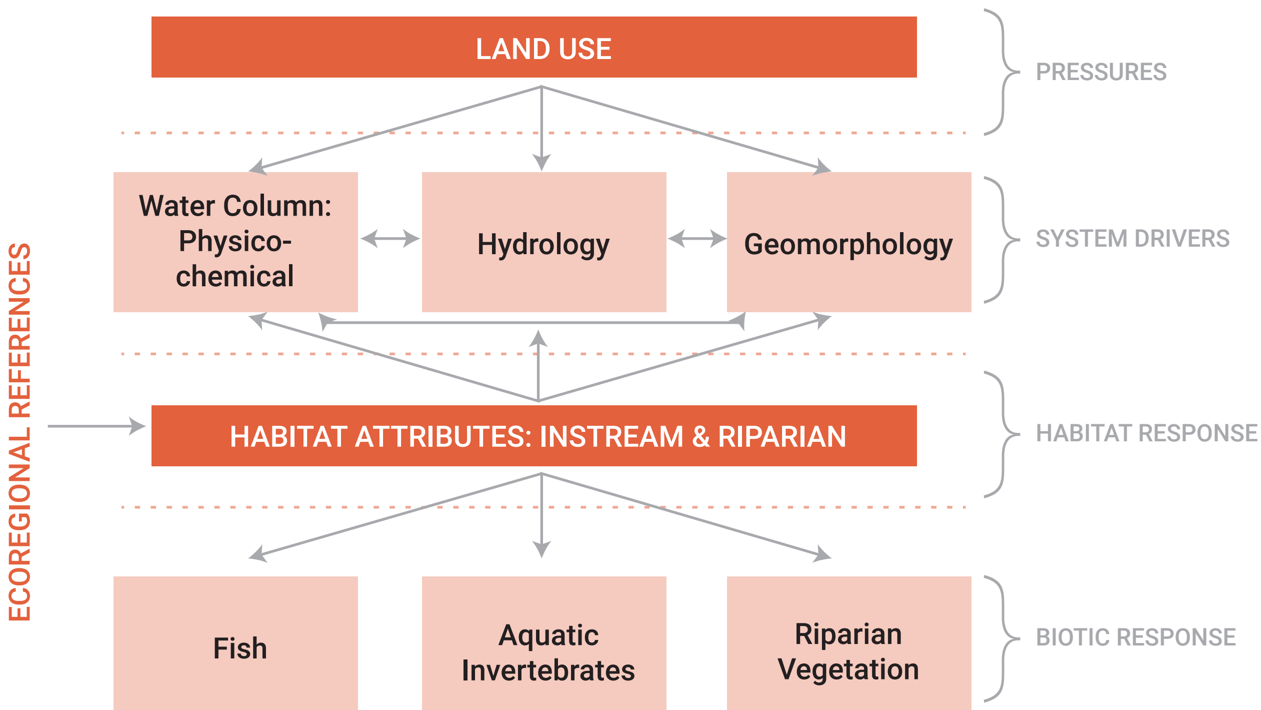
South Africa uses a four-level conceptual framework to guide the assessment of river ecosystem condition (Kleynhans and Louw,

[32] Present Ecological State refers to the present state of a river in terms of six biophysical components in the context of the EcoClassification process (Kleynhans and Louw, 2007). See: http://www.wrc.org.za/wp-content/uploads/mdocs/TT-20%20329%CONSERVATION.pdf

[33] This is a simplification. In fact, six indicators were used in each of the national assessments of Present Ecological State of rivers, but because the assessments were not designed to be used as a time series, the indicators used in 1999 did not correspond exactly to those used in 2011. The four indicators used for the national river ecosystem accounts were the four that were consistent across both national assessments.

2007) (Figure 22), including the selection of condition indicators. The framework is based on 30 years of global river science and has similar characteristics to the SEEA EA Ecosystem Condition Typology (ECT) but differs in that it follows a driver-response framework rather than the framework of biotic, abiotic and landscape-level characteristics used in the ECT. The indictors of river condition relate to drivers of condition (flow of water and water quality) and responses to changes in these drivers (instream habitat and riparian habitat).

Figure 22: South Africa's conceptual framework to guide assessment of river ecosystem condition



Source: Kleynhans and Louw (2007)

This conceptual framework is implemented in assessments of river condition at a range of different levels of detail and confidence. These include desktop assessments (the process for which is described below) and comprehensive assessments (which are more detailed and resource intensive). The two national assessments of Present Ecological State that were used to compile the condition account for rivers utilized a desktop assessment approach, in which a Present Ecological State is assigned to main rivers and tributaries at a quaternary catchment scale using information drawn from best available data combined with expert knowledge and judgement. Expert knowledge and judgement is used to estimate the degree of change to a particular indicator using a rule-based approach. This is necessary due to partial or patchy empirical data. Experts involved include those with particular specialities relevant to all the indicators, such as hydrology, geomorphology, riparian vegetation, aquatic invertebrate or fish experts. The desktop assessment process is conducted region by region, drawing on experts from different parts of the country who have on-the-ground knowledge of rivers in a particular region. Available data for all indicators is gathered for each river reach and then synthesised by the experts into an overall score, drawing on their on-the-ground knowledge and experience. This involves a process of discussion to reach consensus on the score for each river reach.

Although this desktop assessment process involving expert consensus may sound time-consuming, it is much less resource intensive than doing comprehensive assessments, which makes it possible to do a country-wide assessment of all rivers in a relatively short space of time. Country-wide desktop assessments of river condition have been undertaken twice by the national Department of Water and Sanitation – once in 1999 and again in 2011. A third one is planned for 2021/2. The 1999 and 2011 assessments each involved roughly 20 experts in a series of work sessions for clusters of catchments with similar biophysical and ecoregional characteristics. These work sessions were held over the course of several weeks, followed by data processing by a small team. An alternative to this desktop approach is a more comprehensive assessment based on more complete empirical data, but it was not possible to undertake this approach for all rivers in the country because of resource constraints. Comprehensive assessments are thus piecemeal and have been done only for some rivers.

It is important to note that each of these "indicators" (flow, water quality, instream habitat and riparian habitat) is more accurately referred to as a sub-index. Already at this stage, a large amount of data and information is synthesized in each indicator/sub-index, as shown in Table 8, which gives examples of the variables used for each sub-index. If detailed empirical data is not available for a variable, a proxy can be used. For example, presence of dams and weirs can be used to estimate changes in flow of water in the absence of measured data on flows. In the discussion that follows they are referred to as sub-indices. The four sub-indices are eventually aggregated to an overall index of condition in the condition account.

Table 7: Indicators used for the South African river ecosystem condition account in relation to the SEEA EA Ecosystem Condition Typology

Ecosystem condition	**Abiotic characteristics**	Phyical state ✓
		Chemical state ✓
	Biotic characteristics	Composition (including species-based indicators)
		Structure (including vegetation, biomass, food chains) ✓
		Function (including ecosystem processes, disturbance regimes) ✓
	Landscape and seascape level characteristics	Landscape diversity of biotic or abiotic characteristics *
		Spatial distribution of characteristics such as connectivity, fragmentation **(✓) - Assessed in 2011 but not in 1999; to be included in future national river condition assessments and thus also in future accounts**

* This is assessed for rivers in South Africa but is used in determining ecological importance rather than condition.

Source: Nel et al. 2020 (unpublished), adapted from UNSD (2020)

Table 8: Sub-indices used in South Africa's river ecosystem condition account, with examples of associated variables or proxies used in the absence of detailed empirical data on variables

SUB-INDICES OF RIVER CONDITION			
FLOW	***WATER QUALITY***	***RIPARIAN HABITAT***	***INSTREAM HABITAT***
Changed flow and flood regimes	Changed physico-chemical conditions	Changed riparian and river wetland zones due to flow modification and physical changes (assesses structure for biota and functioning)	Temporal and spatial change to runs, rapids, riffles, pools (assesses structure for biota and functioning)
EXAMPLES OF ASSOCIATED VARIABLES OR PROXIES FOR VARIABLES			
• Presence of urban and agriculture land use • Presence of inter basin transfers, weirs, dams • Water abstraction data • Agricultural return flows • Sewage releases	• Extent of algal growth and invasive macrophytes (e.g. water hyacinth) • Activities such as mining, cultivation, irrigation (i.e. agricultural return flows) • Presence of sewage works, urban areas, industries, etc.	• Land use/cover quantified 10m, 50m and 100 m from river • Activities such as agriculture, mining, urban areas, inundation etc. • Presence and impact of invasive alien woody vegetation	• Land use/cover on erosion • Water abstraction data, presence of weirs and dams • Presence of habitat modifying introduced biota (e.g. carp, crustacea and molluscs) • Presence of eutrophication and associated algal growth and invasive macrophyte expansion (e.g. water hyacinth)

Source: Nel et al. 2020 (unpublished)

4.3.1.3 Reference condition and reference levels

The reference condition against which current ecosystem condition is assessed in South Africa is always "natural". This applies across all realms. For rivers, there are six categories which were assessed for each sub-index according to expert-assessed distance from a natural reference condition:

- None (scored as 0)
- Small (1)
- Moderate (2)
- Large (3)
- Serious (4)
- Critical (5)

Ideally in the future, a numerical score on a scale of 100 (natural) to 0 (irreversibly modified) would be given for each sub-index rather than a category. This would likely require more empirical data than is currently consistently available for all rivers.

In parts of the country for which comprehensive assessments of river condition have been done (as opposed to simply a desktop assessment), reference levels and thresholds have been identified for a range of individual indicators of condition. This is illustrated in the example below from King and Brown (2006) (Table 9). Although this type of detail was not available for the national river accounts, it would be informative to pilot the SEEA EA tables at sub-national level for catchments in which comprehensive assessments for rivers have been done and where more quantitative data thus exist.

Table 9: Example of reference levels and thresholds for river condition indicators for a specific river ecosystem type

Indicator	Category A	Category B	Category C	Category D	Category E/F
	Pristine	**Near natural**	**Moderately modified**	**Significantly modified**	**Severely modified**
GEOMORPHOLOGY/HYDRAULICS					
Instream habitat diversity	Full natural diversity	5-15% loss in diversity	15-40% loss in diversity	40-70% loss in diversity	>70% loss in diversity
Pool depth	Natural	5-15% loss in depth	15-40% loss in depth	40-70% loss in depth	>70% loss in depth
Bank erosion or collapse	<5% of bank area	5-10% of bank area	10-20% of bank area	20-40% of bank area	>40% of bank area
WATER QUALITY					
Change in mean monthly temperature	Natural	<3°C	<4°C	<5°C	<6°C
Change in annual pH range	Natural	<0.5 pH units	<1.0 pH units	<1.5 pH units	<2 pH units
Rapid Biological Assessment (SASS) Score	Total Score: Unknown	Total Score: 95	Total Score: 94-70	Total Score: 69-45	Total Score: <45
VEGETATION					
Zone Definition	All present and distinct	All present and distinct	Loss of 2 zones and/or zone definition less distinct	Loss of 3 zones and/or zone definition indistinct	No definition
Species composition of riparian vegetation	Full complement	Change in ratios of indigenous species	Dominated by hardy indigenous species and/or exotic species	Dominated by exotics and/or weedy indigenous species	Dominated by one or two species, often >80% exotics OR no plants
Structure	Full array of growth forms	5-10% reduction in growth forms	11-25% reduction in growth forms	26-50% reduction in growth forms	>50% reduction in growth forms
FISH					
Community composition	Full complement of native species in natural proportions. No exotic species.	Full complement of native species, plus very low numbers of exotic species.	Noticeable shifts in structure of native fish community, moderate numbers of exotic species.	Very few native fish species and/or exotic fish dominate.	Very few fish species dominated by exotic species.

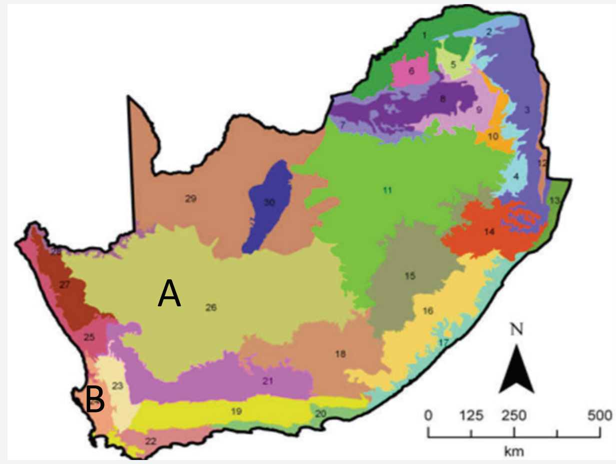
Source: King and Brown (2006)

For a particular indicator of river condition, the reference level associated with a condition of "natural" might differ for rivers in different parts of the country. An example is provided in the Box 1 below.

Box 1: Why specific reference levels per ecoregion is important

The importance of setting specific reference levels for ecosystem condition variables per ecoregion is illustrated by two examples of rivers in ecoregions denoted on the map as:

- **A:** Rivers in this ecoregion have a high natural salinity and would be considered in poor condition if a uniform reference level for salinity was applied.
- **B:** Rivers in this ecoregion have a much lower natural salinity range.



4.3.1.4 Aggregation

As part of the national assessment of the condition of rivers, the sub-indices for flow, water quality, riparian habitat and instream habitat were aggregated for each quaternary mainstem river. Aggregation was achieved by taking the median of the sub-index scores for each quaternary mainstem. The median was then assigned to one of six ecological condition categories (A to F) (see 10). For the purposes of compiling the accounts (to make them simpler to present), these six ecological condition categories were grouped into four categories as illustrated by the colours in Table 10. This ecological condition category was then verified through expert discussions as part of the desktop assessment processes described above and assigned a confidence value.

Table 10: Ecological condition categories from the national assessment of river condition, grouped into four (shown by the colours) for the purpose of compiling the river condition account

Ecological category	Description	
A	Natural	Unmodified
B	Largely natural, few modifications	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C	Moderately modified	Loss and change of natural habitat and biota has occurred but the basic ecosystem functions are still predominantly unchanged.
D	Largely modified	A large loss of natural habitat, biota and basic ecosystem functions has occurred.
E	Seriously modified	Loss of natural habitat, biota and basic ecosystem functions is extensive.
F	Critically/Extremely modified	System has been modified completely with an almost complete loss of natural habitat and biota.

Source: Modified from Kleynhans et al. (2009) in Nel and Driver (2015)

4.3.2 Results

Compilation of the following accounting tables following accounting tables, as suggested per the SEEA EA chapters on ecosystem condition Were tested:

- Accounting tables for variables
- Accounting tables for indicators
- Accounting tables for sub-indices

The accounting table for variables was not possible to complete with the data that was available as variables were not always individually or explicitly quantified and data were often not consistently available for all rivers. The desktop assessments used to assess ecological condition of rivers across the country used available data on variables, which was "integrated" by experts to estimate how a sub-index may have changed from its natural reference condition. This "integration" is about combining information, tacit knowledge and also scaling impact of a particular variable in terms of its spatial extent and intensity. Expert knowledge is essential in the absence of empirical data on all variables, both to fill in gaps and to make sense of the data that do exist.

The step suggested in SEEA EA of converting a single variable to a single indicator was effectively skipped during the assessment of river condition in South Africa. Instead, available (often partial) data for several variables was integrated directly to a sub-index. For rivers, the proposed accounting table for variables would be best applied to record variables at a monitoring site within a given ecosystem asset, in this case each quaternary mainstem. Arguably the readings for a single variable across different sites could be aggregated or summarized to an ecosystem type, but it makes more ecological sense to interpret several different variables to provide a set of indictors for each site first, and then to summarize the results of the indicators across sites or EAs within an ecosystem type. Variables are therefore best considered as underpinning data for each monitoring site, not as an account per se. It is not necessarily useful to report on the variables as an account, summarized per ecosystem type. Variables make most sense at a site-monitoring scale, where a range of variables can be integrated to assess the ecological condition at that site and/or for the related ecosystem asset; then the condition across different sites and/or different ecosystem assets can be generalised to the ecosystem type. The table for variables may be more useful as a systematic table to prepare account-ready data rather than being considered an accounting table in its own right.

It was not possible to complete the second table, the ecosystem condition indicator account, with the available data from the national desktop assessment for river ecosystem condition. As discussed above, the expert-based desktop assessment process does not convert individual variables to individual indicators and instead integrates available (often partial) data for a range of variables directly to a sub-index. It may be possible to compile ecosystem condition indicator tables with data from South Africa's comprehensive assessments of river condition, but these are available only for some rivers in the country.

It was possible to compile the accounting table for sub-indices relative to reference condition using information directly from the existing national river ecosystem accounts and "repackaging" it to fit the table format proposed in SEEA EA. This is shown in Table 1010. This format becomes cumbersome if there is a large number of different ecosystem types, so in some cases it may be useful to invert the table.

Table 11: Ecosystem condition account for river ecosystems, showing sub-indices of condition with reference condition and aggregated to longitudinal zones

			Permanent mountain streams		Non-permanent mountain streams		Permanent upper foothills		Non-permanent upper foothills		Permanent lower foothills		Non-permanent lower foothills		Permanent lowland river		Non-permanent lowland river		No Data		All rivers	
Class	**Sub-index**	**Condition interval relative to reference condition**	**1999 River length (km)**	**2011 River length (km)**	**1999 River length (km)**	**2011 River length (km)**	**1999 River length (km)**	**2011 River length (km)**	**1999 River length (km)**	**2011 River length (km)**	**1999 River length (km)**	**2011 River length (km)**	**1999 River length (km)**	**2011 River length (km)**	**1999 River length (km)**	**2011 River length (km)**	**1999 River length (km)**	**2011 River length (km)**	**1999 River length (km)**	**2011 River length (km)**	**1999 River length (km)**	**2011 River length (km)**
Physico-chemistry	*Water quality*	None (0)/Small (1)	810	673	311	265	9 673	7 996	4 584	4 417	13 359	12 208	6 739	6 196	3 811	2 824	1 292	231	0	0	40 579	34 810
		Moderate (2)	296	283	98	95	3 883	3 873	1 665	1 421	10 760	8,216	2 685	2 360	5 154	4 266	94	529	0	0	24 634	21 043
		Large (3)	36	125	22	58	759	1 861	272	565	2 788	5 410	423	864	1 219	2 476	0	308	0	0	5 518	11 667
		Serious (4)/Critical (5)	15	19	5	9	244	530	107	112	773	1 338	171	343	597	1 071	30	17	0	0	1 943	3 439
		No data	0	57	0	9	0	299	0	112	0	509	0	255	0	143	0	332	3,637	3,637	3,637	5,352
Structure	*Riparian habitat*	None (0)/Small (1)	327	389	95	186	3 686	4 562	1 874	3 225	7 715	7 361	4 190	4 273	3 674	2 308	909	117	0	0	22 471	22 421
		Moderate (2)	498	412	231	116	6 973	5 567	3 285	2005	12 787	11 775	4 009	3 409	4 898	5 323	270	719	0	0	32 951	29 328
		Large (3)	259	263	95	105	3 097	3 336	1 328	1 114	5 960	6 269	1 629	1 731	1 584	2 386	213	215	0	0	14 164	15 420
		Serious (4)/Critical (5)	72	92	15	28	802	1 069	141	231	1 218	2 208	190	398	626	696	24	32	0	0	3 088	4 755
		No data	0	0	0	1	0	24	0	52	0	67	0	207	0	68	0	332	3,637	3,637	3,637	4,388
	Instream habitat	None (0)/Small (1)	706	628	221	217	8 897	6 579	3 587	3 599	14 030	9 425	6 292	5 058	5 049	2 493	954	491	0	0	39 738	28 491
		Moderate (2)	334	329	173	115	4 337	5 229	2 650	1 929	10 519	10 938	3 308	3 144	4 435	4 423	432	506	0	0	26 188	26 612
		Large (3)	96	165	35	88	1 137	2 158	323	817	2 593	5 768	350	1 288	905	3 260	8	76	0	0	5 446	13 620
		Serious (4)/Critical (5)	21	36	6	15	188	568	67	230	538	1 483	67	320	392	538	23	11	0	0	1 301	3 200
		No data	0	0	0	1	0	24	0	52	0	67	0	207	0	68	0	332	3 637	3 637	3 637	4 388
Function	*Flow*	None (0)/Small (1)	687	470	185	173	8 470	5 493	2 997	3 020	12 633	7 701	5 283	4 638	2 882	1 565	948	478	0	0	34 084	23 538
		Moderate (2)	318	331	177	130	3 773	4 381	2 681	1 969	8 183	7 527	3 592	3 061	3 674	2 711	417	389	0	0	22 814	20 499
		Large (3)	118	233	53	95	1 717	2 907	684	1 254	4 341	6 704	667	1 632	2 738	3 317	10	204	0	0	10 328	16 345
		Serious (4)/Critical (5)	34	66	22	29	599	1 479	265	272	2 522	5 240	476	432	1 487	3 045	41	13	0	0	5 447	10 576
		No data	0	57	0	9	0	299	0	112	0	509	0	255	0	143	0	332	3 637	3 637	3 637	5 352
Ecological condition Index		Natural/semi-natural	844	505	297	177	10 312	5 540	4 742	2 930	16 343	7 100	7 340	3 829	5 373	1 832	1 290	528	0	0	46 541	22 441
		Moderately modified	272	417	111	141	3 762	5 827	1 609	2 467	9 537	12 637	2 283	4 239	4 640	5 263	101	792	0	0	22 315	31 782
		Heavily modified	25	214	21	107	412	2 730	209	1 140	1 422	6 627	293	1 737	407	3 326	2	80	0	0	2 791	15 960
		Unacceptably modified	16	21	6	11	73	462	67	90	378	1 317	102	213	361	361	23	17	0	0	1 026	2 492
		No data	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3 637	3 637	3 637	3 637

Source: Driver and Nel (2015)

4.4 Discussion

The South African experiences supports the idea of a staged approach to condition accounts as proposed in the SEEA EA, but with modifications. Testing suggested that a separate variables account may not be required. In the process of retrospectively fitting the national river ecosystem accounts to the proposed condition tables of the SEEA EA, it was realised that in practice aggregation was conducted directly from variables to sub-indices rather than via the route of indicators. Also, proxies were often used for variables where data for a particular variable is not available. Data for many variables is partial (even when proxies are used) and different for different EAs, so in practice it is not possible to be fully systematic about moving from variables to indicators to sub-indices. Rather, this requires gathering whatever data is available on a range of variables, and then putting this through a sense-making and synthesis process involving experts.

In the South Africa context, the steps for compiling data on variables can be seen as an organizing framework for information on ecosystem condition to produce accounts-ready data. In other words, they can be seen as preparatory steps for developing condition accounts, not as a first stage of the accounts themselves. While identifying variables relevant for a particular indicator or sub-index and systematically recording available data for these variables in spreadsheets or databases is a critical step for developing condition accounts, it is unlikely to provide a meaningful accounting table by itself.

The table produced for the testing process (Table 11) was also compared to the format used in the original national river ecosystem accounts (Table 12), which provided useful additional information in the form of increases and decreases in kilometres and expressed as per cent of opening stock and as a per cent of total river length. The table shown here aggregates the results for all rivers, but could also be disaggregated for each of the eight ecosystem types as in Table 11.

Table 12: Accounting tables for sub-indices in the format followed in South Africa's National River Ecosystem Accounts, 1999 to 2011

	Degree of modification from natural					
Kilometres	**None/ small**	**Moderate**	**Large**	**Serious/ Critical**	**No Data**	**Total**
FLOW						
Opening stock 1999	**34 084**	**22 814**	**10 328**	**5 447**	**3 637**	**76 310**
Opening stock as a % total river length	45	30	14	7	5	100
Increase/decreases	-10 546	-2 316	6 017	5 129	1 715	
Increases/decreases as % opening stock	-31	-10	58	94	47	
Opening stock 2011	**23 538**	**20 499**	**16 345**	**10 576**	**5 352**	**76 310**
Opening stock as a % total river length	31	27	21	14	7	100
WATER QUALITY						
Opening stock 1999	**40 579**	**24 634**	**5 518**	**1 943**	**3 637**	**76 310**
Opening stock as a % total river length	53	32	7	3	5	100
Increase/decreases	-5 769	-3 591	6 149	1 496	1 715	
Increases/decreases as % opening stock	-14	-15	111	77	47	
Opening stock 2011	**34 810**	**21 043**	**11 667**	**3 439**	**5 352**	**76 310**
Opening stock as a % total river length	46	28	15	5	7	100
STREAM BANK/RIPARIAN HABITAT						
Opening stock 1999	**22 469**	**32 951**	**14 164**	**3 088**	**3 639**	**76 310**
Opening stock as a % total river length	29	43	19	4	5	100
Increase/decreases	-50	-3 612	1 255	1 667	740	
Increases/decreases as % opening stock		-11	9	54	20	
Opening stock 2011	**22 418**	**29 339**	**15 420**	**4 755**	**4 379**	**76 310**
Opening stock as a % total river length	29	38	20	6	6	100
INSTREAM HABITAT						
Opening stock 1999	**39 736**	**26 188**	**5 446**	**1 301**	**3 639**	**76 310**
Opening stock as a % total river length	52	34	7	2	5	100
Increase/decreases	-11 245	426	8 180	1 898	740	
Increases/decreases as % opening stock	-28	2	150	146	6 840	
Opening stock 2011	**28 491**	**26 615**	**13 626**	**3 200**	**4 379**	**76 310**
Opening stock as a % total river length	37	35	18	4	6	100

Source: Nel and Driver (2015)

4.4.1 Lessons and recommendations from testing condition accounts

A recommendation from the testing process described above is that it may not be necessary to compile a condition account for variables as the first step in compiling ecosystem condition accounts, but rather to focus directly on the condition account for indicators and/or sub-indices. This may be especially the case in a developing country context where comprehensive data on condition variables is patchy or absent and where expert knowledge and interpretation is required to derive meaningful indicators of condition.

There is a huge amount of variation in the types of data that can be used for ecosystem condition variables, and in how the data needs to be processed and compiled. This is compounded by the fact that the nature of variables themselves may differ widely between countries and ecological contexts. Also, available data for many variables will be partial or patchy. It is important to systematically note data gaps to inform future monitoring and data collection, but this does not necessarily have to be done in the form of an account.

Data for some variables will be collected at site level, and it is often not possible or useful to aggregate from site-level measurement of a variable to an average value for a whole ecosystem type, as is required by the proposed structure of the table for ecosystem condition variables.

The interpretation of raw data on variables is not just about applying a reference level to convert a variable into an indicator. In practice, there is almost always a sense-making step that requires expert knowledge and judgement, no matter how complete and high quality the data on variables is.

It is suggested that instead of a variable account, it may be more useful to have a technical manual for developing datasheets for variables on ecosystem condition. Such a manual could provide guidance on how to collate and record data on variables and how to interpret them. Different countries are likely to have at least partial systems in place to do this already, and there is no need to standardize the way this is done across countries. A technical manual could illustrate different examples and decision points that might be considered by countries for different ecosystems and types of information, including decisions related to aggregation. Such decisions might be influenced, for example, by the policy application of interest, the relevance/application of information for ecosystem service accounts.

A further recommendation is that the selection of indicators or sub-indices for condition accounts should ideally be guided by a conceptual framework that represents the ecological functioning of the ecosystem types concerned, not only by the Ecosystem Condition Typology. In the case of rivers in South Africa, this conceptual framework (shown in Figure 8 above) was developed by river ecologists drawing on global science.

4.4.2 Directions for future work

Future terrestrial ecosystem accounts in South Africa will build on the existing terrestrial ecosystem extent account to include a terrestrial ecosystem condition account. As in the river ecosystem condition account, the intention is that the terrestrial ecosystem condition account will provide an aggregated ECI, which will complement the EEI.

Initially the focus will be on an ECI for natural or semi-natural ecosystem types. It may be possible in the future to develop an ECI for intensively modified ecosystem types (such as cultivated and urban areas), but this would need to be based on a different set of condition indicators to those for natural or semi-natural ecosystem types, and would be assessed against a reference condition related to societal or management objectives rather than a reference condition of natural (which is not meaningful for intensively modified ecosystem types). For example, a condition indicator for urban areas may relate to the quantity and quality of open green space, and a condition indicator for cultivated ecosystems may relate to the farming practices used. For now the priority is to develop ecosystem condition accounts for natural or semi-natural ecosystem types.

Section 5:
Ecosystem Service Accounts: Physical Units

5.1 Introduction

Ecosystem services are defined in the SEEA EA as the contributions of ecosystems to benefits used in economic and other human activities, and they are categorized into provisioning, regulating and cultural services.

The measurement focus lies on so-called final ecosystem services i.e. flows of ecosystem services between ecosystem assets and economic units. The ecosystem accounting framework also supports the recording of flows of intermediate ecosystem services, which are flows of services between ecosystem assets, such as nursery services or pollination.

For accounting purposes, and in order to estimate a contribution from each ecosystem asset to the total supply, it is assumed that it is possible to attribute the supply of ecosystem services to individual ecosystem assets (e.g. timber from a forest) or, where the supply of services is more complex. For each recorded supply of ecosystem services, there must be a corresponding use. The attribution of the use of final ecosystem services to different economic units is a fundamental element of accounting. Depending on the ecosystem service, the user (e.g. a household, business or government) may receive that service where it is located either in the supplying ecosystem asset (e.g. when catching fish from a lake) or elsewhere (e.g. when receiving air filtration services from a neighbouring forest). The supply and use of ecosystem services is captured in Physical Supply and Use Tables (PSUTs).

As part of the NCAVES project, a pilot study was undertaken for the development of ecosystem service accounts for the province of KwaZulu-Natal. These accounts were developed based on the SEEA EA, using spatially explicit estimates of the supply of ecosystem services in physical terms and their benefits in monetary terms. The physical accounts are summarized by ecosystem service in this section. The monetary accounts are summarized in Section 6. Full results of the study are available in Turpie et al. (2021).

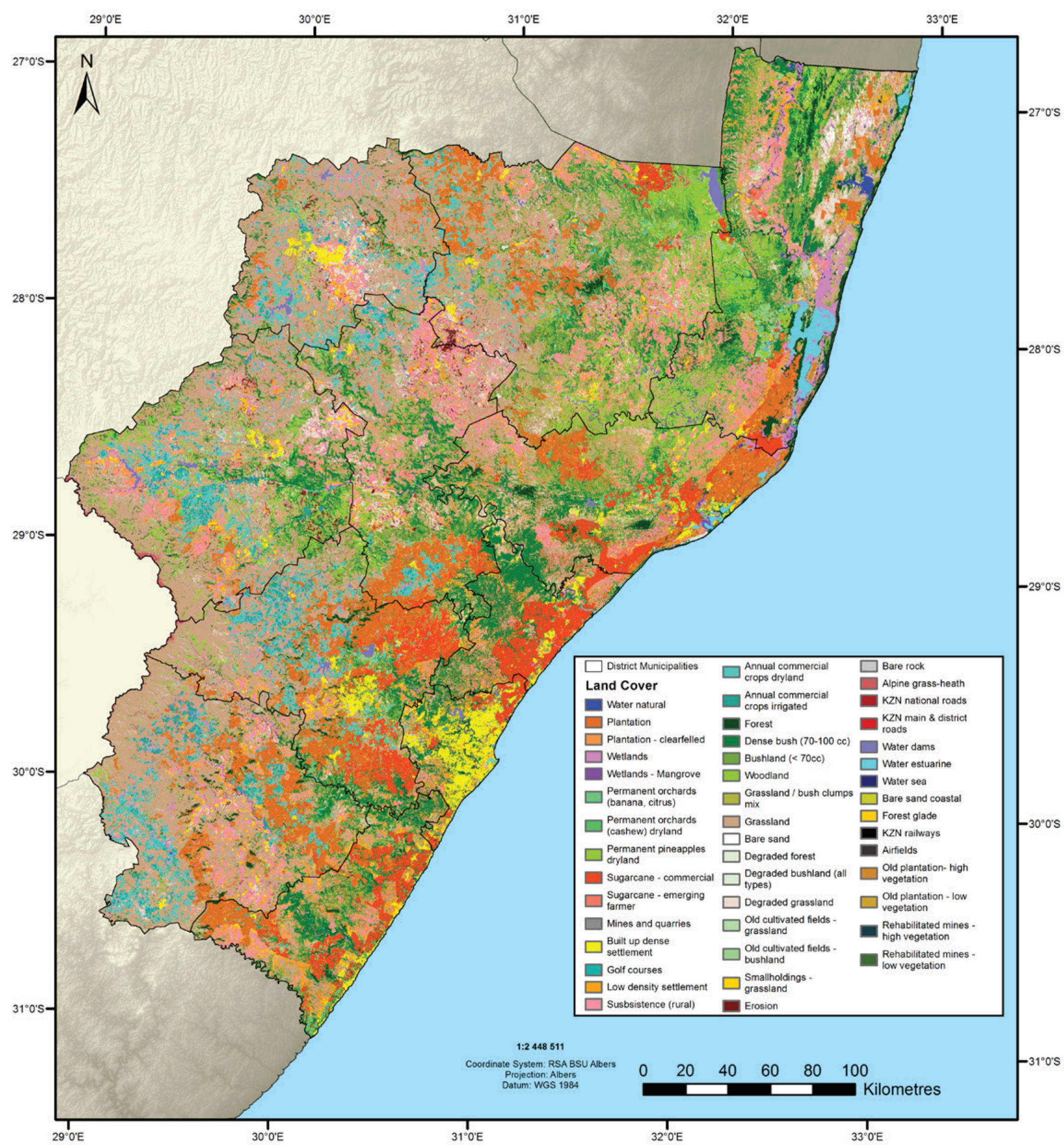
KwaZulu-Natal was selected as a pilot province because of both its biodiversity and economic importance.[34] KwaZulu-Natal has among the highest diversity of ecosystem types in the country and supports a wealth of biodiversity. The province includes representation of most major terrestrial biomes, including grassland, savanna, forests, Indian Ocean Coastal Belt, as well as a large variety of freshwater ecosystems and estuaries. KwaZulu-Natal is the second largest contributor to South Africa's economy contributing 15.8 per cent of GDP in 2011 (accounts were developed for 2005 and 2011 due to data availability). The main environmental issues facing KwaZulu-

34 See: https://seea.un.org/content/towards-method-accounting-ecosystem-services-and-asset-value-pilot-accounts-kwazulu-natal

Natal include loss of natural habitat due to land-use change, such as conversion to intensive agriculture and urban expansion; land degradation through invasive alien plants, bush encroachment and erosion associated with loss of vegetative cover; hydrological alteration; overexploitation and poaching of endangered species; and pollution. Drivers of change include changes in patterns of production and consumption, poor land management, poor spatial planning, poverty and climate change.

The accounts are presented at the scale of the province of KwaZulu-Natal disaggregated by biome (the broadest aggregation of ecosystem types). A spatial framework was created using data on land cover, land use and ecosystem extent (Figure 24). This spatial framework was supported through defining a basic spatial unit (BSU) that is internally homogenous in terms of its biophysical properties. A 100 x 100m (1ha) BSU grid, constructed by Statistics South Africa (Stats SA) that covers the entire South African land area, was used for this analysis (Figure 23).

Figure 23: KwaZulu-Natal Land-Cover map for 2011



Source: Ezemvelo KZN Wildlife

5.2 Methods

A list of major ecosystem services was devised based on the international literature and classification systems as well as an understanding of ecosystem services and the study area (Table 13). The list does not include water as a provisioning service, since it is not produced by ecosystems. Rather, ecosystem services pertaining to water supply are regarded as being those that regulate the timing and location of water flows, and those that affect water quality, both of which affect the costs of collecting and producing potable water for use. The flows and use of water are usually accounted for separately as a resource account (e.g. see South Africa's National Water Accounts[35]). Within crop and animal production (eco)systems, the ecosystem service is considered to be the in situ environmental input to production, rather than the value of crop and animal production. This facilitates accounting for pollination and pest control services as an input from surrounding ecosystems.

Table 13: Ecosystem services considered in this study, with brief explanations of the services. Those that are included in this study are highlighted with an asterisk

Broad category	Ecosystem service	Description and physical measure
Provisioning services	Production of **wild biomass***	Wild natural resources harvested from ecosystems for subsistence or small-scale production, in terms of **kg or m^3 per ha per year.**
	In situ ecosystem inputs to **reared animal** production*	Numbers of livestock or ranched wildlife supported per ha, standardized in terms of **Large Stock Units per ha**. We do not express this in terms of production, since the wildlife farms have a mix of consumptive and non-consumptive activities.
	In situ ecosystem inputs to **crop** production*	Total output in terms of **kg per ha per year**
	In situ ecosystem inputs to **plantation forestry** production*	Total output in terms of **m^3 per ha per year**
	Genetic resources	Genes and varieties obtained and their influence on pharmaceutical sales and crop and livestock production.
Cultural services	**Experiential value** associated with active or passive use*	Experiential fulfilment associated with active or passive use, through any type of activity ranging from adventure sport to birdwatching to religious activities or cultural ceremonies. Valued in three ways which are considered to be additive: (a) Contribution to **property value*** (b) Net income generated and consumer surplus generated through **local use** (c) Net income (all) and consumer surplus (domestic only) generated through **tourism***
	Existence value	Fulfilment associated with knowledge of **existence** for intrinsic value or for present or future generations.

[35] See: http://www.statssa.gov.za/?page_id=1854&PPN=D0405.1

Broad category	Ecosystem service	Description and physical measure
Regulating services	**Flood attenuation ***	Smoothing of fluvial flows during storm events through interception, infiltration, storage and landscape roughness, reducing the flood peak volume, velocity and flood height in the receiving area, and reduction of coastal flooding by the sea through dampening storm surges and limiting run-up distance by coastal ecosystems such as coral reefs, mangroves and dunes. Estimated in terms of flooding characteristics under different storm return periods or categories.
	Seasonal flow regulation*	Smoothing of flow over the longer duration through infiltration and storage, reducing need for storage to achieve a given yield. Measured in terms of higher dry season flows relative to without-service situation.
	Sediment retention*	Reducing soil loss and sediment transportation to downstream environments (including mudslides) through holding soils in situ (by vegetative cover) or through trapping eroded sediments (by slowing down movement of water through the landscape, e.g. in a wetland). Measured in terms of the difference in amount of sediment retained (m3 per year) at key points between the observed land cover and a situation of bare and degraded landscape (for wetlands this means loss of holding capacity).
	Water quality amelioration*	Reducing nutrients transported to downstream environments as a result of uptake in the environment. Measured in terms of the difference in the nutrient loads (kg per year) delivered at key points between the observed land-cover situation and a situation of fully transformed and degraded landscape (for wetlands this means loss of holding capacity).
	Carbon storage and sequestration*	Stocks of carbon in each time period, expressed as tons of carbon per ha; annual additions and subtractions are not estimated but net changes are tabulated between two time periods.
	Agricultural support services*	Pollination of crops and control of crop pests by animals living in surrounding environments. Measured as difference in output of the serviced areas. Note that this requires attributing some of the ecosystem inputs to crop production to surrounding habitat rather than the land under crops.
	Critical habitat for fisheries and wildlife	Provision of critical habitat for populations that are utilised in other locations, such as fish nursery areas; wildlife breeding areas or migratory staging areas. As for the above service, this requires attributing some of the ecosystem inputs to these activities to the critical habitat areas rather than the areas in which the activities take place.

Source: Turpie et al (2021)

5.3 Results and discussion

The analysis conducted enables the mapping of selected ecosystem services (Figures 24) as well as supply tables by ecosystem type (Tables 14 and 15), and use tables by economic user (Tables 16 and 17).

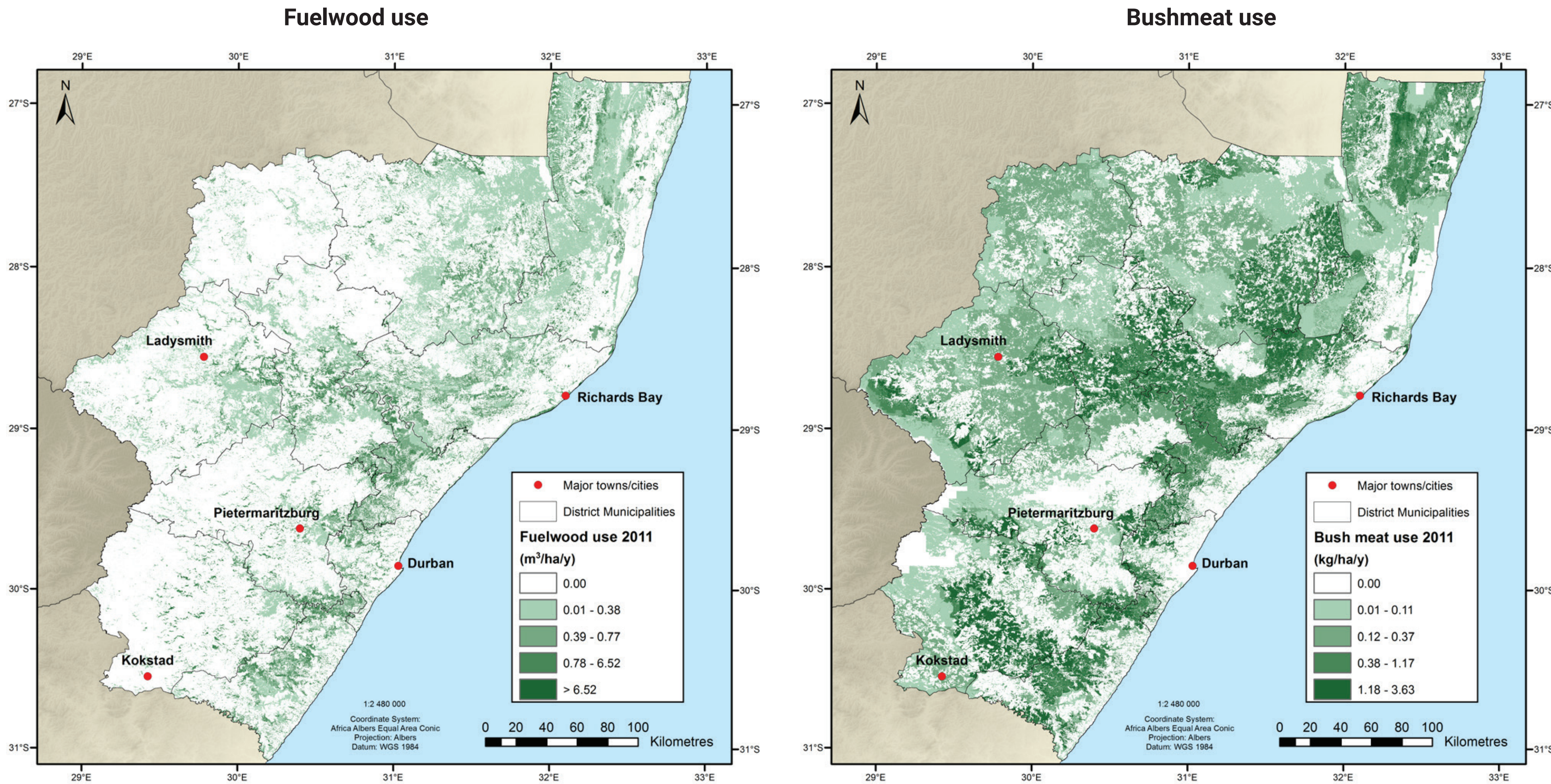
The results indicate a decline in the provision of most ecosystem services between 2005 and 2011, with the notable exception of crop production and experiential value. The losses in ecosystem services from natural ecosystems were due to a combination of the overharvesting of resources, overgrazing leading to denudation in some areas and bush encroachment in other areas, the spread of invasive alien plants, and the loss of natural habitat due to expanding cultivation, human settlements and other activities such as mining. While these trends in which provisioning services increase at the expense of regulating services are generally well-known, this study has shown that their aggregate impact can be substantial. Loss and degradation of natural habitat, which largely comes about in the poorly managed pursuit of provisioning services, has had a measurable negative effect on the supply of every type of regulating service, including carbon storage which is of global concern. Given the significant losses in value of ecosystem services from natural ecosystem types over only six years, further research is required to validate these findings and to seek urgent solutions.

Figure 24 shows the estimated spatial variation in the informal harvesting of fuelwood and wild animals as bushmeat (such as small mammals, birds and antelope) in cubic metres per hectare and in kilos per hectare, respectively, for 2011. The estimated harvests of fuelwood, bushmeat and thatching grass were high across most of the communal areas of the province. Fuelwood, which consists of a combination of wood harvested from invasive alien trees and from indigenous trees, was estimated to be the most valuable resource harvested across the province followed by thatching grass and wild foods and medicines. Fuelwood is used for heating and cooking.

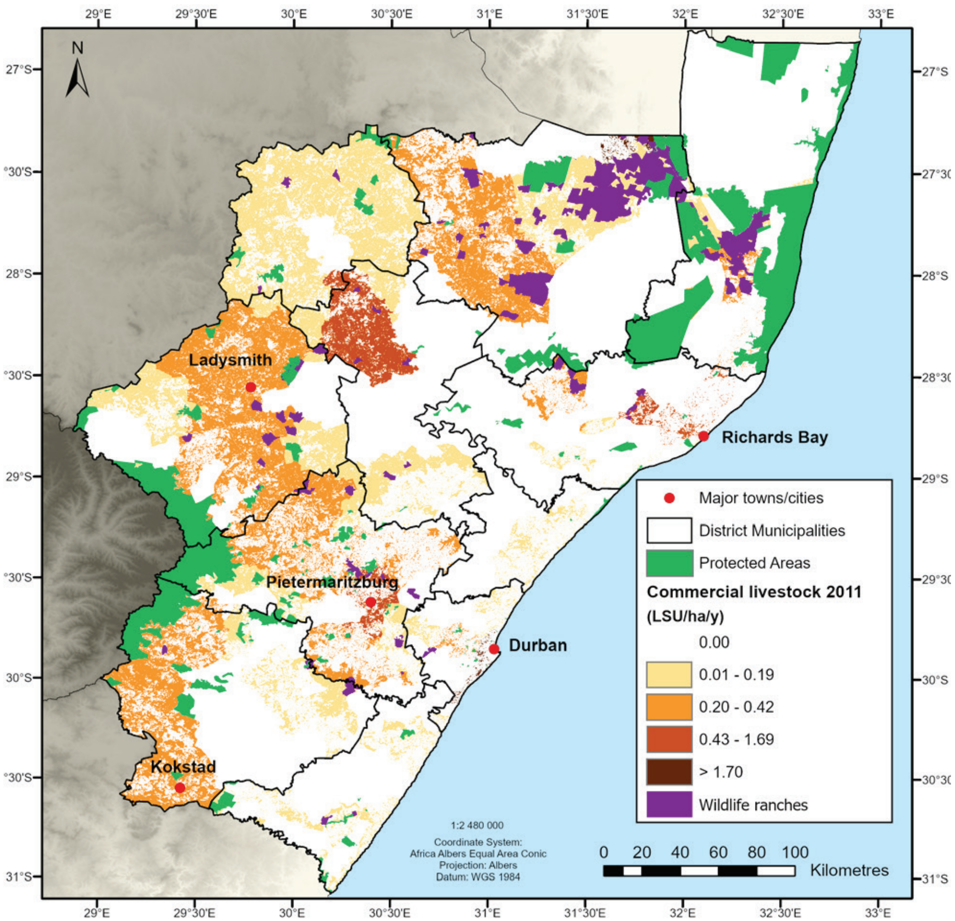
Maps of commercial livestock and crop cultivation production in 2011 are shown in Figure 24, measured in commercial livestock units (LSU) and tons per hectare, respectively. For cultivation, production in tons per hectare was mapped using the cultivated land cover classes and the most appropriate data available for the classes.

Figures 24 also shows water retention and sediment retention ecosystem services. Water retention is the estimated average increment in water retention by ecosystems, per sub-catchment area in 2011 (m3 per ha per year) as measured relative to a barren catchment. Sediment retention estimates the average annual soil loss from the quaternary catchments of KwaZulu-Natal and the extent to which natural vegetation and cultivated land retains and captures sediment. Total sediment loss for each quaternary catchment was calculated in 2005 and 2011 relative to a barren landscape scenario in which the retention capacity of the natural vegetation and cultivated land was reduced. The difference in the sediment loss between the baseline and barren scenario provided the total amount of sediment being retained by the vegetated areas in each catchment.

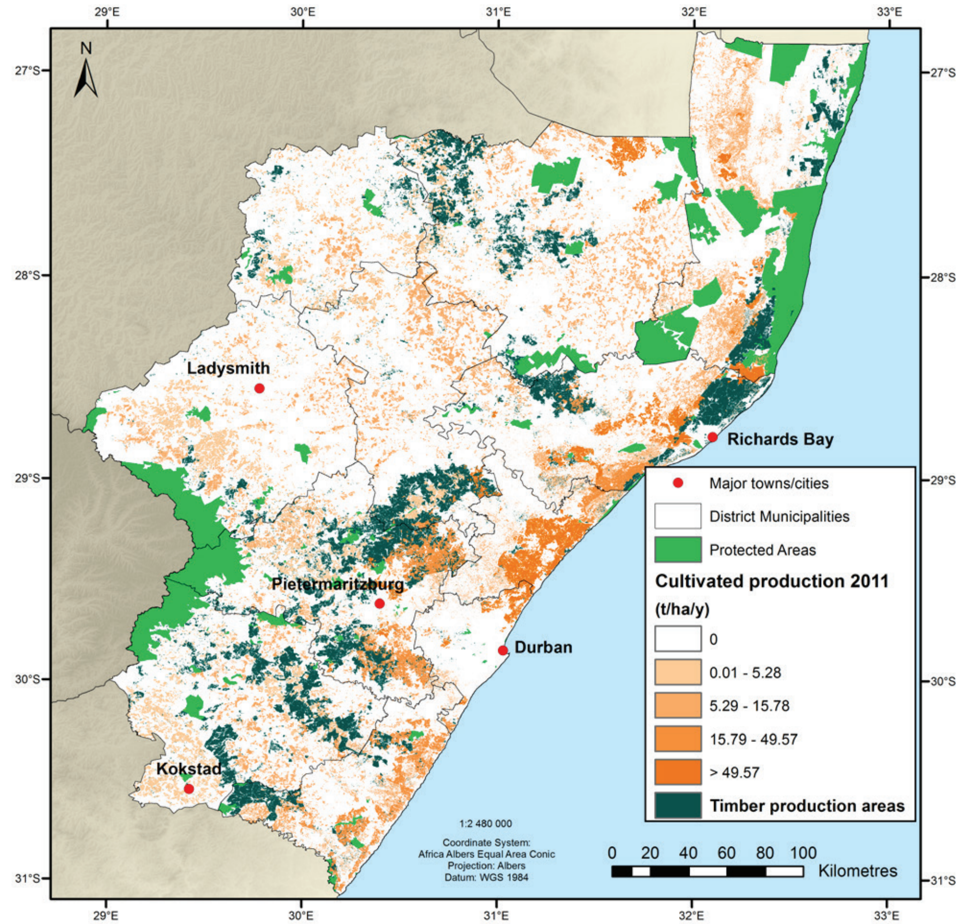
Figure 24: Spatial distribution of selected physical ecosystem services in 2011



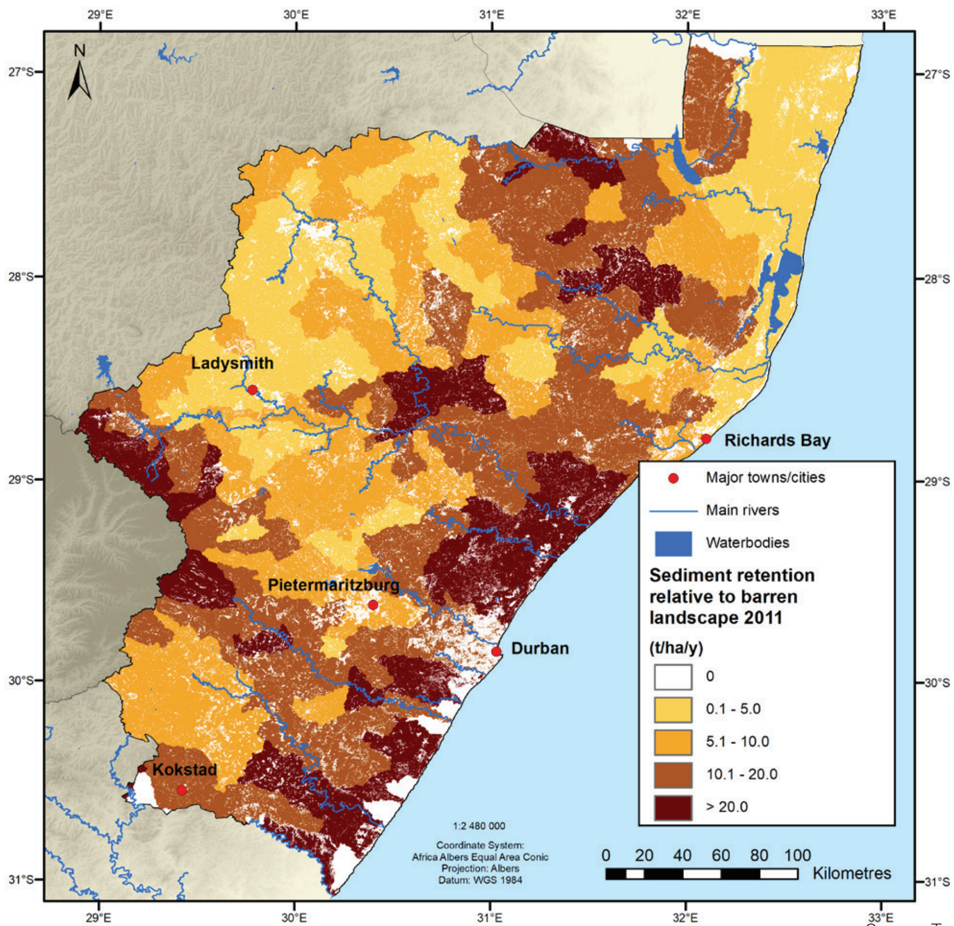
Commercial livestock



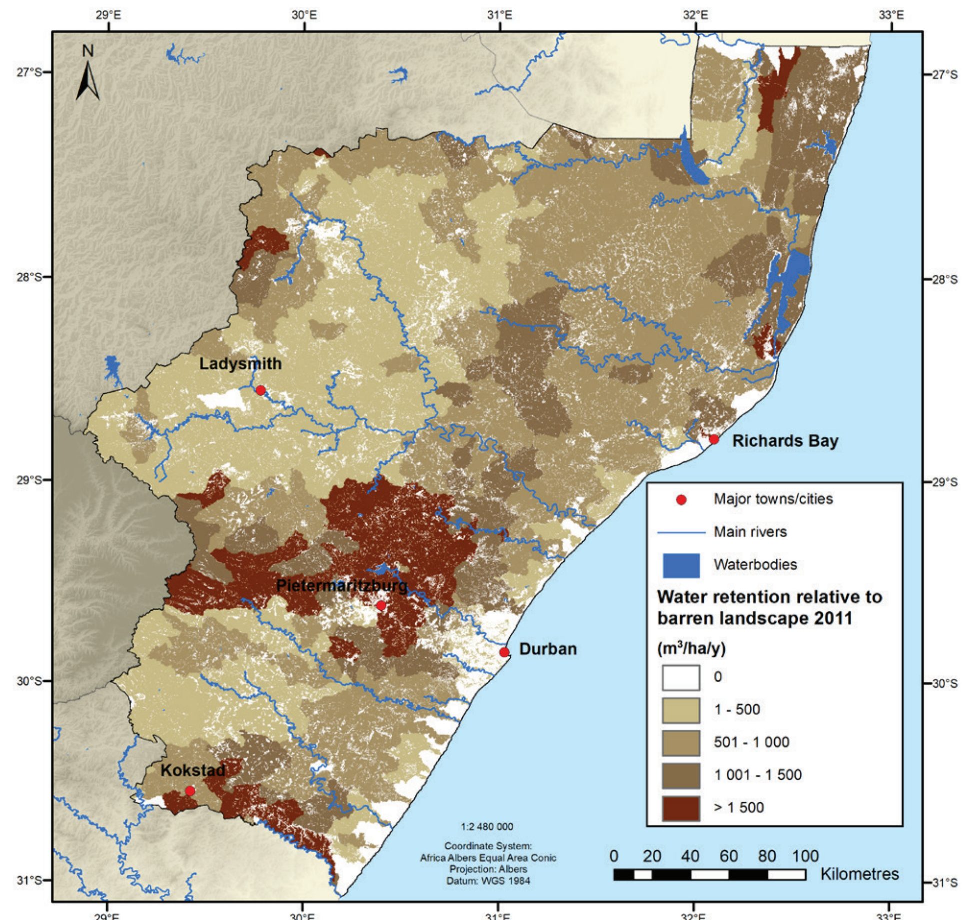
Cultivated production



Water retention



Sediment retention



Source: Turpie et al. (2021)

Table 14: Total biophysical supply per ecosystem type 2005

	Biome								
Resource	**Freshwater ecosystems**	**Grassland**	**Indian Ocean Coastal Belt**	**Savanna**	**Forests**	**Estuaries**	**Cultivated**	**Urban green space**	**Total**
Wild harvested wood products (m^3)	3 523	695 638	235 125	787 294	267 047	169			**1 988 796**
Wild harvested non-wood products (tons)	834	46 494	11 489	34 952	2 911	38			**96 718**
Livestock production (LSU)	1 716	684 698	52 162	289 663	2 010	340			**1 030 589**
Crop production (tons)							43 305 781		**43 305 781**
Experiential value (R millions)	14	237	179	218	55	24	85	885	**1 698**
Carbon storage (Tg C)	5	512	61	348	33	0	279		**1 237**
Pollination (R millions)	0	12	6	31	2	0			**51**
Flow regulation (million m^3)	78	3 315	421	2 198	634	36			**6 682**
Flood attenuation (R millions)								31	**31**
Sediment retention (million tons)	2	45	6	27	18	2			**99**
Water quality amelioration (tons P)	-	3 829	525	5 394	97	6			**9 850**

Table 15: Total biophysical supply per ecosystem type 2011

	Biome								
Resource	**Freshwater ecosystems**	**Grassland**	**Indian Ocean Coastal Belt**	**Savanna**	**Forests**	**Estuaries**	**Cultivated**	**Urban green space**	**Total**
Wild harvested wood products (m^3)	3 801	606 438	209 311	711 853	247 102	190			**1 778 695**
Wild harvested non-wood products (tons)	797	41 514	8 544	26 819	3 054	27			**80 755**
Livestock production (LSU)	1 931	649 341	46 529	228 654	2 629	284			**929 368**
Crop production (tons)							43 611 653		**43 611 653**
Experiential value (R millions)	21	326	194	297	81	36	162	1 009	**2 217**
Carbon storage (Tg C)	5	459	49	312	3	0.2	341		**1 197**
Pollination (R millions)	0	11	5	30	2	0.00			**48**
Flow regulation (million m^3)	50	3 236	446	2 224	157	0.67			**6 113**
Flood attenuation (R millions)								24	**24**
Sediment retention (million tons)	1	38	5	22	9	0.07			**75**
Water quality amelioration (tons P)	-	3 068	381	4 348	75	4			**7 876**

Table 16: Total biophysical use per economic user (2005)

	Economic User							
Ecosystem Service	**Agriculture, Forestry & Fisheries**	**Water supply**	**Trade, catering & accommodation**	**Other sectors**	**House-holds**	**Government**	**Rest of world**	**Total**
Wild harvested wood products (m³)					1 988 797			1 988 796
Wild harvested non-wood products (tons)					96 718			96 718
Livestock production (LSU)	669 423				361 166			1 030 589
Crop production (tons)	41 859 229				1 466 552			43 305 781
Experiential value (R millions)			812	885				1 698
Carbon storage (Tg C)							1 237	1 237
Pollination (R millions)					51			51
Flow regulation (million m³)	6 682							6 682
Flood attenuation (R millions)					31			31
Sediment retention (million tons)		99						99
Water quality amelioration (tons P)		9 850						9 850

Table 17. Total biophysical use per economic user (2011)

	Economic User							
Ecosystem Service	**Agriculture, Forestry & Fisheries**	**Water supply**	**Trade, catering & accommodation**	**Other sectors**	**House-holds**	**Government**	**Rest of world**	**Total**
Wild harvested wood products (m³)					1 778 695			1 778 695
Wild harvested non-wood products (tons)					80 755			80 755
Livestock production (LSU)	640 389				288 977			929 366
Crop production (tons)	39 659 499				4 006 242			43 665 741
Experiential value (R millions)			1 117	1 009				2 217
Carbon storage (Tg C)							1 197	1 197
Pollination (R millions)					48			48
Flow regulation (million m³)	6 113							6 113
Flood attenuation (R millions)					24			24
Sediment retention (million tons)		75						75
Water quality amelioration (tons P)		7 876						7 876

Source: Turpie et al (2021)

Section 6:
Ecosystem Service Accounts: Monetary Units

6.1 Introduction

Quantifying social and economic dependencies and impacts on ecosystems can be done using a range of different metrics, both physical and monetary. As Section 5 illustrates, the development of ecosystem services accounts in biophysical terms provides important information on the contributions of ecosystems to benefits[36] used in economic and other human activities, changes over time and their drivers, all of which can usefully inform environmental policymaking. In addition, developers of accounts have the option to transform these measures of the physical flow of services into monetary terms, using accounting principles.

Several caveats are in order with respect to such monetary ecosystem accounts. Monetary valuation of ecosystems is based on accounting principles in order to be compatible with the measures used in the SNA. SEEA expresses the value of ecosystems in terms of "exchange values", which is the amount that is paid by the users of ecosystem services to the owners of those services, or that would be paid if a market existed. Note that this differs from the welfare measures used in conventional economic valuation of ecosystem services, e.g. for use in project or policy appraisal methods such as cost-benefit analysis. In the latter, the economic value used is the sum of producer and consumer surplus, where producer surplus is the producer's net income (turnover minus all costs of production) and consumer surplus is the difference between aggregate willingness to pay and the aggregate expenditure, for a given good or service. The SNA is concerned with income, but not consumer surplus.

In most circumstances values for ecosystem services are not revealed because they are unpriced and not transacted in markets. A range of techniques have been developed for the valuation of non-market transactions that can be applied for the purpose of providing estimates of the exchange value of the supply and use of ecosystem services in monetary terms. However, it should be noted that a range of challenges exists with respect to the implementation of these techniques and interpretation of the values that they yield.[37] As such, **the results presented are the first experimental (or preliminary) outcomes for the province of KwaZulu-Natal and should be interpreted with due caution.** Improvements will need to be made as data improve, valuation techniques develop and best practice with the compilation in ecosystem accounts progresses.

36 Section 6.2.2 provides a discussion of benefits: https://unstats.un.org/unsd/statcom/52nd-session/documents/BG-3f-SEEA-EA_Final_draft-E.pdf

37 See: https://seea.un.org/content/towards-method-accounting-ecosystem-services-and-asset-value-pilot-accounts-kwazulu-natal for detailed discussion.

Intrinsic values and existence values of nature fall outside the scope of monetary accounting and hence were not included as part of the KwaZulu-Natal pilot study. As such, these monetary values need to be communicated with diligence and clarity over which dimensions are included, acknowledging that values are a lower bound rather than "true value". Interpretation of results are best focussed not on absolute values, but instead on how values change over time.

In addition, because the scope of monetary accounting is limited to exchange values, these values do not necessarily reflect how important a particular ecosystem service, ecosystem asset or ecosystem type is to people and the economy. Such welfare-based approaches can be included as part of complementary valuations. Ecosystem services, and ecosystem assets with relatively small monetary values, may, nevertheless, be critically important for supporting the well-being of large numbers of people and essential for the functioning of certain economic sectors. A range of monetary metrics and non-monetary metrics are needed to assess the importance of ecosystems to people and the economy, for example, the number of households dependent on particular ecosystem services, the share of livelihoods based on ecosystem services, or amount of employment in industry sectors that depend on ecosystem services or assets. Metrics on the numbers of people or households that depend directly or indirectly on ecosystem services can provide powerful complements or alternatives to monetary valuation of ecosystem services, especially in cases where monetary values are relatively low but levels of social dependence on ecosystems are high. This means that if monetary values for ecosystems are used to support decision-making, they should preferably be considered in conjunction with physical ecosystem accounts as well as other metrics that quantify the importance of ecosystems for people and the economy in non-monetary (social) terms.

6.2 Methods

Each of the 11 ecosystem services, as described in the previous section, were valued using a method that produces values that are consistent with the SNA (Table 18). For more details on valuation methods for each of services, please see Turpie et al. (2021).

The value of ecosystems is expressed in terms of exchange values (consistent with the principles of the SNA) rather than welfare values, but the study points out that exchange values go a large part of the way to informing welfare values. The value of each ecosystem service was expressed in terms of an annual flow (for 2005 and 2011). These were then summed to estimate a total annual flow of value from each spatial unit and aggregated by various ecosystem types

This total value flow was then used to estimate the asset value of that spatial unit in terms of its net present value (NPV). A social discount rate of 3.66 per cent and a time period of 25 years were applied. For the asset valuation, the actual use of ecosystem services (rather than the ecosystem's capacity to supply) is valued, but the asset valuation takes the effect of unsustainable use into account. All other factors (population, economic output, climate, other ecological or socioeconomic factors) are assumed to be constant. The supply and use of ecosystem services after valuation is captured in Monetary Supply and Use Tables.

Table 18: Summary of the valuation methods used for each ecosystem service

Category	Ecosystem service type	Values and valuation methods used
Provisioning	Production of wild biomass	Resource rent, based on market prices
	In situ inputs to reared animal production	Resource rent, based on market prices
	In situ inputs to cultivation (including silviculture)	Resource rent of agri/silvicultural commercial and subsistence production, based on market or imputed prices, less contribution of pollination service
Cultural	Experiential value: nature's contribution to tourism and property values*	Resource rent for nature-based tourism, based on market prices. Proportion of the annualised capital value of property attributed to environment, based on market prices using the hedonic pricing method
Regulating	Carbon storage	Annualised avoided damage costs using social cost of carbon
	Crop pollination**	Contribution to agricultural resource rent, based on benefit transfer of a production function
	Seasonal flow regulation	Annualised avoided costs of water supply infrastructure for existing supply systems plus avoided costs of purchasing water from vendors for those people that depend on instream flows for their domestic water supplies.
	Sediment retention	Annualised avoided cost of replacement of lost storage capacity
	Water quality amelioration	Water treatment costs avoided, based on a cost function

*Note these are two out of three elements that should be valued and does not include local recreation
**Note that this study does not include pest control as an input to agriculture due to lack of data

Source: Turpie et al (2021)

6.3 Results and discussion

The combined value of the annual flow of ecosystem services was R47.3 billion in 2005 and R52.5 billion in 2011, which was equivalent to 13 per cent and 12 per cent of provincial GDP in those years if global carbon values are used, and R17.6 billion and R18.2 billion or 5 per cent and 4 per cent of provincial GDP if the social cost of carbon to South Africa is used (Table 19). Because of the large difference between the global and national values, and because the global carbon values dwarf the other ecosystem services, the aggregate ecosystem service flow table was compiled using each of these values. However, the following discussion is based on the results associated with global carbon values.

Table 19: Value of ecosystem service flows and associated asset values in 2005 and 2011; values in 2010 R millions

Class	Ecosystem service	2005		2011	
		Annual flow	Asset value	Annual flow	Asset value
		R millions	*R millions*	*R millions*	*R millions*
Provisioning	Wild resources	3 722.16	32 032.23	3 180.25	28 440.48
	Animal production	1 672.99	27 100.67	1 472.87	23 859.03
	Cultivation	6 456.70	104 591.91	7 535.43	122 066.22
Cultural	Nature-based tourism	532.83	8 631.31	798.83	12 940.22
	Property	1 164.97	18 871.27	1 327.78	21 508.60
Regulating	Carbon storage (global value)	29 922.56	484 745.42	34 579.34	560 185.33
	Pollination	51.26	830.33	47.69	772.50
	Flow regulation	3 247.87	52 612.12	3 166.78	51 298.55
	Flood attenuation	31.02	502.49	23.50	380.68
	Sediment retention	435.79	7 059.28	330.40	5 352.18
	Water quality amelioration	20.40	330.46	16.03	259.67
Total		**47 258.53**	**737 307.48**	**52 478.90**	**827 063.46**
Value of flows and asset values in 2005 and 2011 when using national carbon values					
Regulating	Carbon storage (national)	236.39	3 829.49	273.18	4 425.46
Total		**17 572.38**	**256 391.56**	**18 172.74**	**271 303.59**

Note that the table shows both the global carbon values as well as national carbon values and the respective total flows and asset values associated with each.

Source: Turpie et al (2021)

In 2011, the bulk of the value of ecosystem services was produced by regulating services (73 per cent). Provisioning services and cultural services accounted for 23 per cent and 4 per cent of the total value, respectively. The global value of carbon storage dominated the estimated value of ecosystem services, accounting for 66 per cent of the total value in 2011; however, if national carbon values are considered this is less than 1 per cent. This was followed by the land contribution to crop production (14 per cent), the provisioning of wild resources (6 per cent), flow regulation (6 per cent) and experiential value (4 per cent). The other hydrological services accounted for just 1 per cent of the total value of ecosystem service flows in 2011. It is possible that these values are underestimated due to the very conservative methods used.

Just under two thirds of the provisioning services value in 2011 was produced by cultivated land (62 per cent). Most of the value of regulating services was produced in the grassland biome (41 per cent), savanna biome (27 per cent) and cultivated land (26 per cent). The Indian Ocean Coastal Belt biome accounted for 4 per cent which was mainly due to the importance of forest and dense savanna vegetation in this biome for carbon storage and pollination services. Landscaped urban parks produced 48 per cent of the value of cultural ecosystem services. Grassland and savanna ecosystems were important for nature-based tourism. Within forest ecosystems, cultural services (in particular, nature-based tourism) accounted for the highest percentage share of the value followed by regulating services.

The asset value of ecosystems, as derived from the value of annual flows using the net present value approach, was estimated at R737 billion and R827 billion, respectively (Table 19), an increase in value of 12.2 per cent over six years. The net change is the result of a

2 per cent overall loss of value due to reduction in the extent of ecosystems, combined with a net increase of 10 per cent of value which is attributed to the changes in capacity for supply or the demand for services. The effect of increased demand is reduced by decreased capacity through reduction in ecosystem extent and/or ecosystem degradation. Natural areas have been reduced by the expansion of cultivation and settlements. Of the remaining natural areas, degradation has been driven largely by poor grazing management and poor agricultural practices, particularly in the communal areas. Poor land management has exacerbated bush encroachment and the spread of invasive alien plants. These processes are being exacerbated by poverty and the adverse impacts of climate change. It is important to note that change in the asset value of ecosystems can occur as a result of change in the extent and condition of ecosystems affecting the capacity to supply services, or a change in the demand for the services due to a number of socioeconomic factors. A change in asset value is therefore not straightforward in its interpretation.

The combined value of the annual flow of the ecosystem services valued was R52.5 billion in 2011, equivalent to 12 per cent of the provincial GDP. While this is a significant contribution, it is apparent that the values of many of the services have decreased over time, particularly the grassland and savanna biomes which dominate the landscape. The annual value of harvested wild resources decreased by over R500 million in these two biomes, ecosystem contribution to livestock production by just over R200 million, and hydrological services by just under R200 million (Tables 20 and 21). While the carbon storage value increased between 2005 and 2011 this was due to the changing price of carbon and not an overall increase in the change of total ecosystem carbon stored. In fact, ecosystem carbon decreased by 40.1 TgC over the six-year period. Nature-based tourism increased by some R189 million over the same period. Cultivated land also increased in extent and aggregate value over the six-year period.

The **main users** of the ecosystem services quantified were the rest of the world (66 per cent; carbon storage as an exported service in the form of avoided damage costs to the rest of the world), followed by the agriculture, forestry and fisheries sector (19 per cent) and households (11 per cent) (Tables 22 and 23) Approximately 2 per cent of the total value flows to the trade, catering and accommodation sector, which is also an important source of employment in the province. Reductions in ecosystem stocks and the associated loss in ecosystem services will have the highest impact for these economic users. This is an important result to consider given that a significant number of households across KwaZulu-Natal are reliant on natural ecosystems for maintaining livelihoods and food security.

However, as discussed above, **interpretation of these results needs to be moderated with the caveat that the services modelled do not capture the complete set of benefits that ecosystems provide to humans.** Provisioning services are the most comprehensively valued services. The estimate of the cultural value provided by ecosystems is a partial estimate, including only a partial estimate of experiential value and not including existence value. While a broad coverage of regulating services was conducted in order to pilot these methods, it has not captured all aspects and all locations. Estimates of pollination and hydrological estimates are particularly likely to be underestimates due to data and methodological constraints.

This study shows that it is feasible to compile monetary accounts for ecosystems using various statistical data sources and valuation methods. It provides a framework for extending this to a national scale in South

Africa, should this be identified as a priority. Although the values are preliminary and incomplete, the study demonstrates that the ecosystem supply and use accounts can be used to answer a number of policy-relevant questions, such as how much ecosystems contribute to economic outputs, who the main users of ecosystem services are, and how values have changed over time and where decreases have been greatest.

Setting up monetary ecosystem accounts requires considerable effort and resources in collating appropriate monitoring data as well as in compiling reliable modelling frameworks for the estimation of physical supply of services and then their values. At least initially, the accounts require at least 15-20 person months over a 2- to 3-year period. This requires sufficient expertise given the highly technical nature of the work in a field that is rapidly evolving. Further discussion is also needed to refine the way in which the accounting tables are compiled and summarized in order to be useful for decision and policymakers. Finally, there will be some considerations in terms of land-cover data should this provincial-scale pilot be extended to a national-scale effort.

Table 20: Total supply per ecosystem type 2005 in monetary values (R millions)

	Biome (ha)								
	Freshwater ecosystems	Grassland	Indian Ocean Coastal Belt	Savanna	Forests	Estuaries	Cultivated	Built	Total
Resource	57 127	3 677 202	434 070	2 549 702	185 908	39 531	1 822 632	564 354	**9 330 526**
Wood products	3.03	598.13	202.09	677.90	233.39	0.15			**1 714.69**
Non-wood products	22.08	982.22	238.23	715.06	49.09	0.78			**2 007.47**
Livestock production	2.60	1 038.27	106.73	521.00	3.75	0.64			**1 672.99**
Crop production							6 456.70		**6 456.70**
Experiential value	14.08	236.77	178.92	218.22	55.47	24.18	84.79	885.37	**1 697.80**
Carbon storage	121.15	12 375.43	1 473.67	8 407.37	797.29	4.91	6 742.74		**29 922.56**
Pollination	0.07	11.87	6.07	31.35	1.88	0.00			**51.26**
Flow regulation	0.74	2 112.36	27.19	1 078.64	28.93	-			**3 247.87**
Flood attenuation								31.02	**31.02**
Sediment retention	12.26	204.30	20.66	107.30	86.83	4.43			**435.79**
Water quality amelioration	-	16.52	0.17	3.21	0.50	-			**20.40**
Total R millions	**176.02**	**17 575.86**	**2 253.74**	**11 760.04**	**1 257.14**	**35.10**	**13 284.23**	**916.39**	**47 258.53**
Value R/ha	**3 081.20**	**4 779.68**	**5 192.11**	**4 612.32**	**6 762.16**	**887.88**	**7 288.49**	**1 623.79**	**5 064.94**

Table 21: Total supply per ecosystem type 2011 in monetary values (R millions)

	Biome (ha)								
	Freshwater ecosystems	Grassland	Indian Ocean Coastal Belt	Savanna	Forests	Estuaries	Cultivated	Built	Total
Resource	54 901	3 354 881	362 944	2 292 315	181 604	39 425	2 361 582	682 874	**9 330 526**
Wood products	3.27	520.67	179.74	612.69	216.18	0.16			**1 532.71**
Non-wood products	18.11	866.56	175.23	537.16	49.95	0.54			**1 647.54**
Livestock production	2.9906	984.9509	95.0889	384.2992	5.0088	0.5349			**1 472.87**
Crop production							7 535.43		**7 535.43**
Experiential value	21.1	326.0	193.9	297.4	80.9	36.3	161.9	1 009.1	**2 126.60**
Carbon storage	133.26	13 261.20	1 421.88	9 010.02	909.21	4.40	9 839.37		**34 579.34**
Pollination	0.06	11.09	5.03	29.73	1.77	0.00			**47.69**
Flow regulation	23.29	2 014.08	22.61	1 020.55	85.19	1.06			**3 166.78**
Flood attenuation								23.50	**23.50**
Sediment retention	5.99	167.75	22.28	94.58	39.50	0.30			**330.40**
Water quality amelioration	-	12.89	0.08	2.65	0.41	-			**16.03**
Total R millions	**208.04**	**18 165.17**	**2 115.85**	**11 989.10**	**1 388.14**	**43.29**	**17 536.70**	**1 032.61**	**52 478.90**
Value R/ha	**3 789.37**	**5 414.55**	**5 829.68**	**5 230.13**	**7 643.78**	**1 098.11**	**7 425.83**	**1 512.15**	**5 624.43**

Table 22: Total use per economic user (2005) in monetary values. R millions

	Economic Users							
Ecosystem Service	**Agric, Forestry and Fisheries**	**Water supply**	**Trade, catering & accommodation**	**Other sectors**	**Households**	**Government**	**Rest of world**	**Total**
Wood products					1 714.69			**1 714.69**
Non-wood products					2 007.47			**2 007.47**
Livestock production	849.35				823.63			**1 672.98**
Crop production	5 855.99				600.71			**6 456.70**
Experiential value			532.83	1 164.97				**1 697.80**
Carbon storage							29 922.56	**29 922.56**
Pollination					51.26			**51.26**
Flow regulation	3 247.87							**3 247.87**
Flood attenuation					31.02			**31.02**
Sediment retention		435.79						**435.79**
Water quality amelioration		20.40						**20.40**
Total	**9 953.21**	**456.19**	**532.83**	**1 164.97**	**5 228.78**	**-**	**29 922.56**	**47 258.52**

Table 23: Total use per economic user (2011) in monetary values. R millions

	Economic Users							
Ecosystem Service	**Agric, Forestry and Fisheries**	**Water supply**	**Trade, catering & accommodation**	**Other sectors**	**Households**	**Government**	**Rest of world**	**Total**
Wood products					1 532.71			**1 532.71**
Non-wood products					1 647.54			**1 647.54**
Livestock production	815.45				657.43			**1 472.88**
Crop production	5 954.69				1 580.74			**7 535.43**
Experiential value			798.83	1 327.78				**2 126.60**
Carbon storage							34 579.34	**34 579.34**
Pollination					47.69			**47.69**
Flow regulation	3 166.78							**3 166.78**
Flood attenuation					23.50			**23.50**
Sediment retention		330.40						**330.40**
Water quality amelioration		16.03						**16.03**
Total	**9 936.91**	**346.43**	**798.83**	**1 327.78**	**5 489.61**	**-**	**34 579.34**	**52 478.90**

Source: Turpie et al (2021)

Section 7:
Thematic Accounts

7.1 Species Accounts

SEEA EA guidelines identify three high-level species accounting concerns: species important for ecosystem services; species of conservation concern; and species important for ecosystem condition.

The accounts developed in South Africa focused on two groups of species of special concern, namely black and white rhinoceros (hereafter referred to as rhinos), and cycad plant group. These three categories are obviously not always mutually exclusive. Rhinos for instance are of conservation concern; they are also important to ecosystem functioning as megaherbivores, have enormous cultural significance and are a massive drawcard in South Africa's tourism sector.

The selection of these two groups of species was made in consultation with SANBI's Threatened Species Programme and the national Scientific Authority for the Convention for International Trade in Endangered Species (CITES). The decision was to trial species accounts in for both fauna and flora, and the options were narrowed down on the basis of conservation importance and availability of time series population data (i.e. direct observation data) to develop national-level accounts. It was agreed that accounts would not present any geospatial information in order to protect sensitive location information.

These types of accounts could provide evidence to either include species in CITES Appendix or transfer them from one list to another. Drafts have already been presented to the Scientific Authority, which is convened by SANBI to assist with regulating trade in species, including CITES-listed species.

Although the accounts were completed as part of the NCAVES project, they have yet to be published by Stats SA. It has thus not been possible to include the results of the accounts in this country report; instead we have shown the structure of the accounting tables. The accounts will be published in the course of 2021 in Stats SA's Natural Capital series.

7.1.1 Cycads

Cycads are long-lived, ancient species that are a symbol of South Africa's natural and cultural heritage and represent an important evolutionary indicator. The country is home to over a tenth of the world's cycad species, of which 29 are endemic to South Africa (DEA, n.d.), occurring nowhere else on earth.

Cycads are highly prized as ornamental plants and have suffered from intensive poaching from the wild as a result; worse than almost any other taxa in the country and by far the most poached plant group (DEA, 2017), with losses worth R11-billion worth being poached between 1995 and 2015 (Seid, 2015). If the whole plant is not removed, the seeds, which are vital for longevity of the species' survival, are harvested for export (and domestic use) where they are propagated in gardens worldwide (DEA, 2017). This group of plants was chosen as a charismatic plant group species of conservation concern.

Cycads occur on all land ownership types as well as within and outside of protected areas. While only one protected area is dedicated specifically to protected cycads (Modjadji Nature Reserve, Limpopo), several other protected areas, both existing and proposed, have been designated as key sites for conservation of cycads in South Africa with species-specific management plans (DEA, 2017).

The main intention of the cycad species accounts is to highlight the changes in cycad populations over the last few decades at a species level and track their threat status changes according to IUCN red list categories.

7.1.1.1 Cycad threat status account

The threat status account captures the changes in threat status for all 38 of South Africa's cycad species, according the IUCN Red List categories between two assessments in 1996 and 2009 (Hilton-Taylor, 1996; Raimondo et al., 2009) (using data explained in Section 2.2.6).

The account table (Table 4) shows changes in the number of species that are Extinct or Extinct in the Wild, the number that are Critically Endangered/Endangered etc. As explained earlier, the results have yet to be published so are not provided here.

Table 24: Structure of the cycad species threat status account, 1996 to 2009, showing changes as additions and reductions in number of species falling into four groups of IUCN Red List categories (the results are not shown here as accounts are still to be published by Stats SA)

Cycad Threat Status	Extinct /Extinct in the Wild	Critically Endangered /Endangered	Vulnerable	Not threatened /Rare / Least Concern	Total Species
Opening stock 1996					
Re-evaluations of threat status					
Threat status improved					
Threat status worsened					
Closing stock 2009					
Net change since 1996					

Source: Stats SA (2021c)

7.1.1.2 Cycad population account

In-depth information on cycad populations is only available for a sub-set of the group, namely for 12 critically endangered species with non-detriment findings (NDFs) (explained in Section 2.2.6). Data were summarized into a single population estimate per decade (from the 1970s to the 2010s) as explained in Section 2.2.6. Population accounts for the 12 Critically Endangered cycad species were compiled.

Table 25 shows the structure of the accounting table for four of the 12 species. The population data were rather sparse and were therefore compiled into a single population estimate for each decade from the 1970s until the 2010s. Some species had not yet been described in the earliest time periods (e.g. Lowveld or Lillie cycad), and for others the populations had not been counted and so population estimates were incomplete. Occasionally, population estimates were given as a range. The data are more regular and reliable for more recent decades, allowing for more robust comparisons. Despite not having consistent estimates for each species, the cycad accounts still yield a great deal of information on the status of these Critically Endangered species.

Table 25: Structure of the cycad species accounts for Critically Endangered species 5-8 (the results are not shown here as accounts are still to be published by Stats SA).

	Encephalartos dyerianus	Encephalartos heenanii	Encephalartos hirsutus	Encephalartos inopinus
	Lowveld cycad / Lillie cycad	Woolly cycad	Venda cycad	Lydenburg cycad
Reference (benchmark)				
Opening stock 1970s				
Closing stock 1980s				
Change (number)				
Change (%)				
Closing stock 1990s				
Change (number)				
Change (%)				
Closing stock 2000s				
Change (number)				
Change (%)				
Closing stock 2010s				
Change (number)				
Change (%)				
Net change since opening/ earliest full estimate (number)				
Net change as % since opening/ earliest full estimate				
Population remaining since opening/earliest count (%)				

Source: Stats SA (2021c)

As to be expected with any data not specifically collected for the purpose of populating species accounts, there were limitations with the data compiled including data gaps, inconsistent survey periods and differences in the way of recording population data. Even without perfect data, the accounts provide accessible metrics for consideration in future policy decisions and population management. The process of compiling the accounts can highlight data gaps meaning that recommendations for data improvements can be made.

Regular accounts are useful for monitoring the effectiveness of conservation effort. The intention is for information from these accounts to be useful for decision makers and those directly involved in cycad conservation nationally. The intended users of these accounts are policymakers making decisions regarding biodiversity and management of natural ecosystems across South Africa, particularly those involved in conserving and collecting data on cycads. These are primarily government departments at all levels. The data is also of interest to conservation and anti-poaching Non-governmental organisations (NGOs) as well as private landowners.

7.1.2 Rhinos

Rhino have been legally and illegally hunted in SA for decades, to the point where they were on the brink of extinction in the 1960s. Their recovery is well documented and one of the world's conservation success stories. Following massive efforts to curb poaching, along with monumental translocation efforts and important trading restrictions, South Africa's rhino populations increased exponentially to a point where South Africa, by 2014, was home to 90 per cent of the world's southern white rhinos and 36 per cent of the world's black rhino population. Today, legal off-take[38] has been permitted under special circumstances, however, more recently, poaching has become an enormous conservation concern, with a large-scale increase in poaching activity, which especially targets rhinos. This poaching increase is mainly owing to the demand of rhino horn in a number of Asian countries, in particular China and Vietnam, where the horns are either crushed into a powder for use in traditional medicines or are put on display as a symbol of wealth (Milliken and Shaw, 2012; Ayling, 2013; Dang Vu and Nielsen, 2018). The increase in poaching began in 2008, surging in 2012 and peaking in 2015, with the majority of this activity occurring in South Africa owing to its greater rhino numbers (DEA, 2019a).

Given the depth of different types of information available for rhinos, the accounts were expanded to incorporate some of the threats (e.g. poaching) as well as the distribution of the populations across private and state owned land. These elements create easily accessible metrics for consideration in future policy decisions and population management.

7.1.2.1 Rhino population account

The rhino population account was compiled for national populations for the period 1970 to 2017. The accounting table summarizes the total change in black and white rhinoceros' populations between 1970 and 2017, with the changes in population numbers over time presented at 10-year time steps, 5-year time steps, and annual time steps. It provides a breakdown of reductions due to hunting, exporting and poaching.

Table 26: Structure of the overall rhinoceros population account 1970 to 2017 (the results are not shown here as accounts are still to be published by Stats SA).

	White Rhinoceros (Ceratotherium simum simum)	Black Rhinoceros (Diceros bicornis)	All Rhinoceros
Reference (pre-1900)	No estimate	No estimate	No estimate
Earliest Historical Reference (~1900)			
Opening Stock (1970)			
Additions			
Number of live imports (for re-introduction)			
Births			
Reductions			
Natural mortality			
Number legally hunted (1970-2004)			
Number legally hunted (2004-2017)			
Number poached			
Number of live exports from wild			
Closing Stock (2017)			
Net Change (from earliest historical reference)			
Net Change (from opening)			
Change (% of earliest historical reference)			
Change (% of opening)			

Source: Stats SA (2021d)

[38] Off-take is essentially the number of animals that are removed from a location at some scale for primarily but not limited to management purposes. This may be through culling, selling, legal and illegal hunting, poaching, consumption, auction or translocation. This is often expressed as a rate relative to a location's population at some time.

An additional accounting table provides information on the numbers of rhino on state and private land respectively, which is useful for highlighting the increasing importance of private landowners in the conservation of rhinos in South Africa.

Table 27: Structure of rhinoceros ownership account 2017-1987 in 10 yearly increments (the results are not shown here as accounts are still to be published by Stats SA).

	Rhinoceros on Private land	Rhinoceros on State land	All Rhinoceros
Earliest Historical Reference (~1900)			
Opening Stock (1987)			
Closing Stock (1997)			
Net Change (from earliest historical reference)			
Net Change (from opening)			
Change (% of earliest historical reference)			
Change (% of opening)			
% of national herd			
Closing Stock (2008)			
Net Change (from earliest historical reference)			
Net Change (from opening)			
Change (% of earliest historical reference)			
Change (% of opening)			
% of national herd			
Closing Stock (2017)			
Net Change (from earliest historical reference)			
Net Change (from opening)			
Change (% of earliest historical reference)			
Change (% of opening)			
% of national herd			

Source: Stats SA (2021d)

The compiled numbers from South Africa can also be compared to the African continental numbers to gain an understanding of the relative importance of the South African rhinoceros populations in the global conservation of both the black and white rhinoceros species.

7.1.3 Recommendations emanating from species accounts

These pilot accounts for cycads and rhinos have shown that it is possible to compile useful species population accounts and threat status accounts, even with incomplete data, and also show that the process of compiling the accounts can help to highlight data gaps. In particular, it has drawn attention to the fact that monitoring of species populations currently often relies on volunteers and NGOs with limited funding to do more than is already being done. Recommendations in relation to monitoring and data gathering are an important output of the accounting process.

Species accounts are time consuming and resource intensive to compile, and should be approached selectively with a clear rationale for the species selected. Further discussion is needed in South Africa to determine regularity of accounts for species and which additional species would be priorities for developing accounts.

7.2 Accounts for protected areas, 1900 to 2020

Protected areas form a central part of national biodiversity conservation strategies. The protected area network as a whole aims to protect ecologically viable areas that represent South Africa's biodiversity and its natural landscapes and seascapes. Collectively, protected areas should conserve representative samples of all ecosystem types as well as critical habitats for species and the ecological and evolutionary processes that allow biodiversity to persist over time.

Protected areas are vital not only for conserving biodiversity but also for ecological sustainability more broadly and for climate change adaptation. Protected areas are national assets that serve as nodes in South Africa's ecological infrastructure network, protecting ecosystems that deliver important services to people, such as the production of clean water, flood moderation, prevention of erosion, carbon storage, and the aesthetic value of the landscape. They also provide a home for some of the country's most iconic species, recreational spaces for South Africans and global visitors, and can play an important role in rural economies. Protected areas are thus social and economic assets as well as conservation assets.

South Africa has developed spatial biodiversity plans that identify priority areas for consolidating and expanding the protected area estate (referring to the collective set of South Africa's protected areas, which are formalised in the National Protected Area Expansion Strategy (NPAES). For more about this and on the role and importance of protected areas, see the NPAES 2016 (DEA, 2016) and the National Biodiversity Assessment (NBA) 2018 (SANBI, 2019).

The accounts track the expansion of the land-based protected area estate at regular time intervals over the period 1900 to 2020. They are compiled at the national level, and for provinces and for biomes, disaggregated by types of protected areas. The period 1900 to 2020 was divided into 11 accounting periods, with 20-year intervals from 1900 to 1960, ten-year intervals from 1960 to 2000, and five-year intervals from 2000 to 2020.

Several types of protected area are recognized by South African law, with different degrees of restriction on land use and activities and different management and governance arrangements. National Parks, Nature Reserves and Protected Environments are declared in terms of the Protected Areas Act, while Forest Nature Reserves, Forest Wilderness Areas, Mountain Catchment Areas and World Heritage Sites are declared in terms of other legislation and recognised by the Protected Areas Act. All have formal status as protected areas and are included in these accounts. The changes in the extent of different types of protected areas reflect the evolving strategies for conservation, allowing for a range of different governance and management arrangements.

The accounts presented here deal only with protected areas on South Africa's mainland. The accounts do not include Marine Protected Areas in South Africa's territorial waters or Exclusive Economic Zone (EEZ), or protected areas in South Africa's Sub-Antarctic territory. Future iterations of these accounts will include Marine Protected Areas. For simplicity, the rest of the discussion refers just to "protected areas" rather than specifying land-based protected areas.

7.2.1 National and provincial protected area extent accounts

The key findings show the historical growth of the extent of protected areas in South Africa, from 1900 until 2020.

The national protected area estate at the end of 2020 occupies 11 280 684 ha or 9,2 per cent of the terrestrial mainland surface area (Table 28) (Figure 26). The protected area types that contribute most to this overall figure are Nature Reserves, National Parks, and Protected Environments. Nature Reserves account for 4,1% of the mainland area and make up 44,5% of the protected area estate. National Parks make up 3,5% of the mainland area and contribute 37,4% to the protected area estate. Protected Environments, despite being a relatively recent type of protected area, make the third largest contribution to the protected area estate (7,1% of the protected area estate). The provinces in which their contribution is proportionally large based on extent at the end of 2020 are the Eastern Cape (where they make up 38,0% of the province's protected area estate), and North West (where they make up 10,3% of the province's protected area estate).

The growth of the protected area estate is also expressed as percentage change in the size of the protected area estate for a given period. What is notable about the expansion of protected land in the 2015–2020 period is the rapid increase of Protected Environments, which increased by 171,0% (or by 507 116 ha). Protected Environments incorporate land that is used for activities other than conservation, often under private ownership, and they frequently act as buffers around other protected areas. Many Protected Environments are examples of contract protected areas established through biodiversity stewardship programmes, in which private or communal landowners enter into formal partnerships with conservation authorities.

Table 28: Extent account for land-based protected areas on South Africa's mainland, 1900–2020, in hectares, based on declaration dates in the South African Protected Areas Database [39]

	National Park	Nature Reserve	Protected Environment	Forest Nature Reserve	Forest Wilderness Area	Mountain Catchment Area	World Heritage Site*	Not protected	Total	Total protected (ha)	Total protected (%)
Opening stock 1900	**-**	**-**						**121 966 453**	**121 966 453**	**-**	**0,0%**
Additions to stock		126 561						-	126 561		
Reductions in stock		-						-126 561	-126 561		
Net change in stock		**126 561**						**-126 561**	**-**	**126 561**	
Net change as % of opening								*-0,1%*	*0,0%*		
Closing stock 1920	**-**	**126 561**						**121 839 892**	**121 966 453**	**126 561**	**0,1%**

	National Park	Nature Reserve	Protected Environment	Forest Nature Reserve	Forest Wilderness Area	Mountain Catchment Area	World Heritage Site*	Not protected	Total	Total protected (ha)	Total protected (%)
Opening stock 1920	**-**	**126 561**						**121 839 892**	**121 966 453**	**126 561**	**0,1%**
Additions to stock	3 032 143	75 208						-	3 107 351		
Reductions in stock	-	-						-3 107 351	-3 107 351		
Net change in stock	**3 032 143**	**75 208**						**-3 107 351**	**-**	**3 107 351**	
Net change as % of opening		59,4%						-2,6%	0,0%	2 455,2%	
Closing stock 1940	**3 032 143**	**201 769**						**118 732 541**	**121 966 453**	**3 233 912**	**2,7%**

	National Park	Nature Reserve	Protected Environment	Forest Nature Reserve	Forest Wilderness Area	Mountain Catchment Area	World Heritage Site*	Not protected	Total	Total protected (ha)	Total protected (%)
Opening stock 1940	**3 032 143**	**201 769**						**118 732 541**	**121 966 453**	**3 233 912**	**2,7%**
Additions to stock	-	464 152						-	464 152		
Reductions in stock	-	-						-464 152	-464 152		
Net change in extent	**-**	**464 152**						**-464 152**	**-**	**464 152**	
Net change as % of opening	0,0%	230,0%						-0,4%	0,0%	14,4%	
Closing stock 1960	**3 032 143**	**665 921**						**118 268 389**	**121 966 453**	**3 698 064**	**3,0%**

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[39] There are many cases in which portions of a World Heritage Site have also been declared as another type of protected area, leading to spatial overlaps between World Heritage Sites and other types of protected area. For instance, the Cape Floristic Region Protected Area World Heritage Site overlaps with sites also declared as National Parks or Nature Reserves or Forest Wilderness Areas or Mountain Catchment Areas. To avoid double-counting, the account tables reflect only those portions of the World Heritage Site that are not also declared as another type of protected area.

	National Park	Nature Reserve	Protected Environment	Forest Nature Reserve	Forest Wilderness Area	Mountain Catchment Area	World Heritage Site*	Not protected	Total	Total protected (ha)	Total protected (%)
Opening stock 1960	**3 032 143**	**665 921**						**118 268 389**	**121 966 453**	**3 698 064**	**3,0%**
Additions to stock	190 373	801 158						-	991 531		
Reductions in stock	-5	-						-991 526	-991 531		
Net change in extent	**190 368**	**801 158**						**-991 526**	**-**	**991 526**	
Net change as % of opening	*6,3%*	*120,3%*						*-0,8%*	*0,0%*	*26,8%*	
Closing stock 1970	**3 222 511**	**1 467 079**						**117 276 863**	**121 966 453**	**4 689 590**	**3,8%**

	National Park	Nature Reserve	Protected Environment	Forest Nature Reserve	Forest Wilderness Area	Mountain Catchment Area	World Heritage Site*	Not protected	Total	Total protected (ha)	Total protected (%)
Opening stock 1970	**3 222 511**	**1 467 079**		**-**	**-**	**-**		**117 276 863**	**121 966 453**	**4 689 590**	**3,8%**
Additions to stock	192 253	1 055 710		59 867	229 432	363 661		6	1 900 929		
Reductions in stock	-	-3		-	-	-		-1 900 926	-1 900 929		
Net change in extent	**192 253**	**1 055 707**		**59 867**	**229 432**	**363 661**		**-1 900 920**	**-**	**1 900 920**	
Net change as % of opening	*6,0%*	*72,0%*						*-1,6%*	*0,0%*	*40,5%*	
Closing stock 1980	**3 414 764**	**2 522 786**		**59 867**	**229 432**	**363 661**		**115 375 943**	**121 966 453**	**6 590 510**	**5,4%**

	National Park	Nature Reserve	Protected Environment	Forest Nature Reserve	Forest Wilderness Area	Mountain Catchment Area	World Heritage Site*	Not protected	Total	Total protected (ha)	Total protected (%)
Opening stock 1980	**3 414 764**	**2 522 786**	**-**	**59 867**	**229 432**	**363 661**		**115 375 943**	**121 966 453**	**6 590 510**	**5,4%**
Additions to stock	189 929	566 602	12 022	62 129	48 003	195 762		4	1 074 451		
Reductions in stock	-	-2	-	-	- 2	- 2		-1 074 445	-1 074 451		
Net change in extent	**189 929**	**566 600**	**12 022**	**62 129**	**48 001**	**195 760**		**-1 074 441**	**-**	**1 074 441**	
Net change as % of opening	*5,6%*	*22,5%*		*103,8%*	*20,9%*	*53,8%*		*-0,9%*	*0,0%*	*16,3%*	
Closing stock 1990	**3 604 693**	**3 089 386**	**12 022**	**121 996**	**277 433**	**559 421**		**114 301 502**	**121 966 453**	**7 664 951**	**6,3%**

	National Park	Nature Reserve	Protected Environment	Forest Nature Reserve	Forest Wilderness Area	Mountain Catchment Area	World Heritage Site*	Not protected	Total	Total protected (ha)	Total protected (%)
Opening stock 1990	**3 604 693**	**3 089 386**	**12 022**	**121 996**	**277 433**	**559 421**	**-**	**114 301 502**	**121 966 453**	**7 664 951**	**6,3%**
Additions to stock	279 398	905 194	63 785	6 172	-	2	766	1	1 255 318		
Reductions in stock	-	-3	-	- 1	-	-	-	-1 255 314	-1 255 318		
Net change in extent	**279 398**	**905 191**	**63 785**	**6 171**	**-**	**2**	**766**	**-1 255 313**	**-**	**1 255 313**	
Net change as % of opening	*7,8%*	*29,3%*	*530,6%*	*5,1%*	*0,0%*	*0,0%*		*-1,1%*	*0,0%*	*16,4%*	
Closing stock 2000	**3 884 091**	**3 994 577**	**75 807**	**128 167**	**277 433**	**559 423**	**766**	**113 046 189**	**121 966 453**	**8 920 264**	**7,3%**

	National Park	Nature Reserve	Protected Environment	Forest Nature Reserve	Forest Wilderness Area	Mountain Catchment Area	World Heritage Site*	Not protected	Total	Total protected (ha)	Total protected (%)
Opening stock 2000	**3 884 091**	**3 994 577**	**75 807**	**128 167**	**277 433**	**559 423**	**766**	**113 046 189**	**121 966 453**	**8 920 264**	**7,3%**
Additions to stock	173 036	152 838	-	-	-	-	-	1	325 875		
Reductions in stock	-	-1	-	-	-	- 1	-	-325 873	-325 875		
Net change in extent	**173 036**	**152 837**	**-**	**-**	**-**	**- 1**	**-**	**-325 872**	**-**	**325 872**	
Net change as % of opening	*4,5%*	*3,8%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*-0,3%*	*0,0%*	*3,7%*	
Closing stock 2005	*4 057 127*	*4 147 414*	*75 807*	*128 167*	*277 433*	*559 422*	*766*	*112 720 317*	*121 966 453*	*9 246 136*	*7,6%*

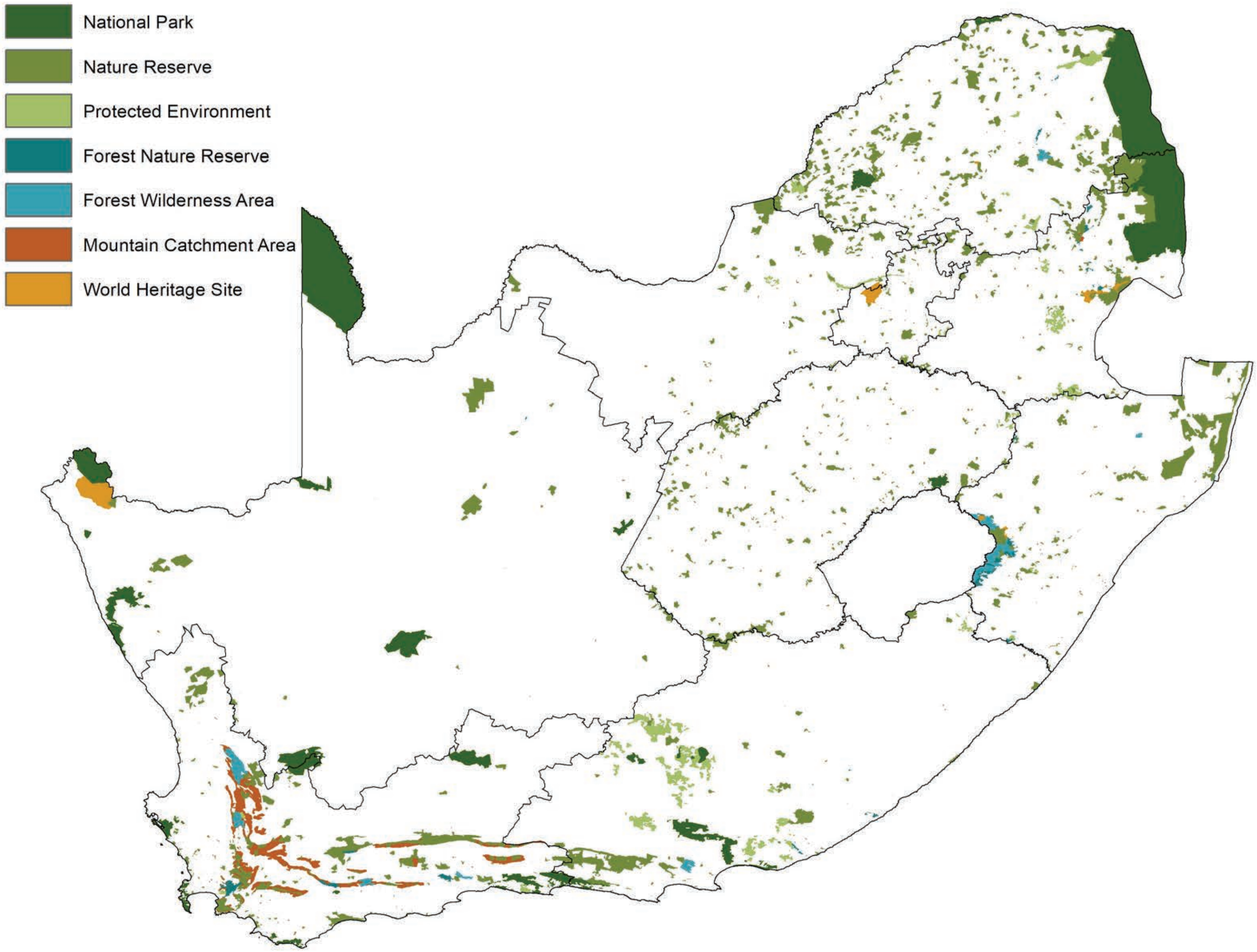
	National Park	Nature Reserve	Protected Environment	Forest Nature Reserve	Forest Wilderness Area	Mountain Catchment Area	World Heritage Site*	Not protected	Total	Total protected (ha)	Total protected (%)
Opening stock 2005	**4 057 127**	**4 147 414**	**75 807**	**128 167**	**277 433**	**559 422**	**766**	**112 720 317**	**121 966 453**	**9 246 136**	**7,6%**
Additions to stock	26 817	91 469	26 053	-	-	-	213 470	1	357 810		
Reductions in stock	-2	-2	-	-	-	-	-	-357 806	-357 810		
Net change in extent	**26 815**	**91 467**	**26 053**	**-**	**-**	**-**	**213 470**	**-357 805**	**-**	**357 805**	
Net change as % of opening	*0,7%*	*2,2%*	*34,4%*	*0,0%*	*0,0%*	*0,0%*	*27 868,1%*	*-0,3%*	*0,0%*	*3,9%*	
Closing stock 2010	**4 083 942**	**4 238 881**	**101 860**	**128 167**	**277 433**	**559 422**	**214 236**	**112 362 512**	**121 966 453**	**9 603 941**	**7,9%**

	National Park	Nature Reserve	Protected Environment	Forest Nature Reserve	Forest Wilderness Area	Mountain Catchment Area	World Heritage Site*	Not protected	Total	Total protected (ha)	Total protected (%)
Opening stock 2010	**4 083 942**	**4 238 881**	**101 860**	**128 167**	**277 433**	**559 422**	**214 236**	**112 362 512**	**121 966 453**	**9 603 941**	**7,9%**
Additions to stock	-	284 947	194 042	15 298	-	3	-	-	494 290		
Reductions in stock	-	-3	-	-	-	-	-	-494 287	-494 290		
Net change in extent	**-**	**284 944**	**194 042**	**15 298**	**-**	**3**	**-**	**-494 287**	**-**	**494 287**	
Net change as % of opening	*0,0%*	*6,7%*	*190,5%*	*11,9%*	*0,0%*	*0,0%*	*0,0%*	*-0,4%*	*0,0%*	*5,1%*	
Closing stock 2015	**4 083 942**	**4 523 825**	**295 902**	**143 465**	**277 433**	**559 425**	**214 236**	**111 868 225**	**121 966 453**	**10 098 228**	**8,3%**

	National Park	Nature Reserve	Protected Environment	Forest Nature Reserve	Forest Wilderness Area	Mountain Catchment Area	World Heritage Site*	Not protected	Total	Total protected (ha)	Total protected (%)
Opening stock 2015	**4 083 942**	**4 523 825**	**295 902**	**143 465**	**277 433**	**559 425**	**214 236**	**111 868 225**	**121 966 453**	**10 098 228**	**8,3%**
Additions to stock	134 965	499 086	507 116	2 326	1	3	38 959	-	1 182 456		
Reductions in stock	-	-	-	-	-	-	-	-1 182 456	-1 182 456		
Net change in extent	**134 965**	**499 086**	**507 116**	**2 326**	**1**	**3**	**38 959**	**-1 182 456**	**-**	**1 182 456**	
Net change as % of opening	*3,3%*	*11,0%*	*171,4%*	*1,6%*	*0,0%*	*0,0%*	*18,2%*	*-1,1%*	*0,0%*	*11,7%*	
Closing stock 2020	**4 218 907**	**5 022 911**	**803 018**	**145 791**	**277 434**	**559 428**	**253 195**	**110 685 769**	**121 966 453**	**11 280 684**	**9,2%**

Source: Stats SA (2021b)

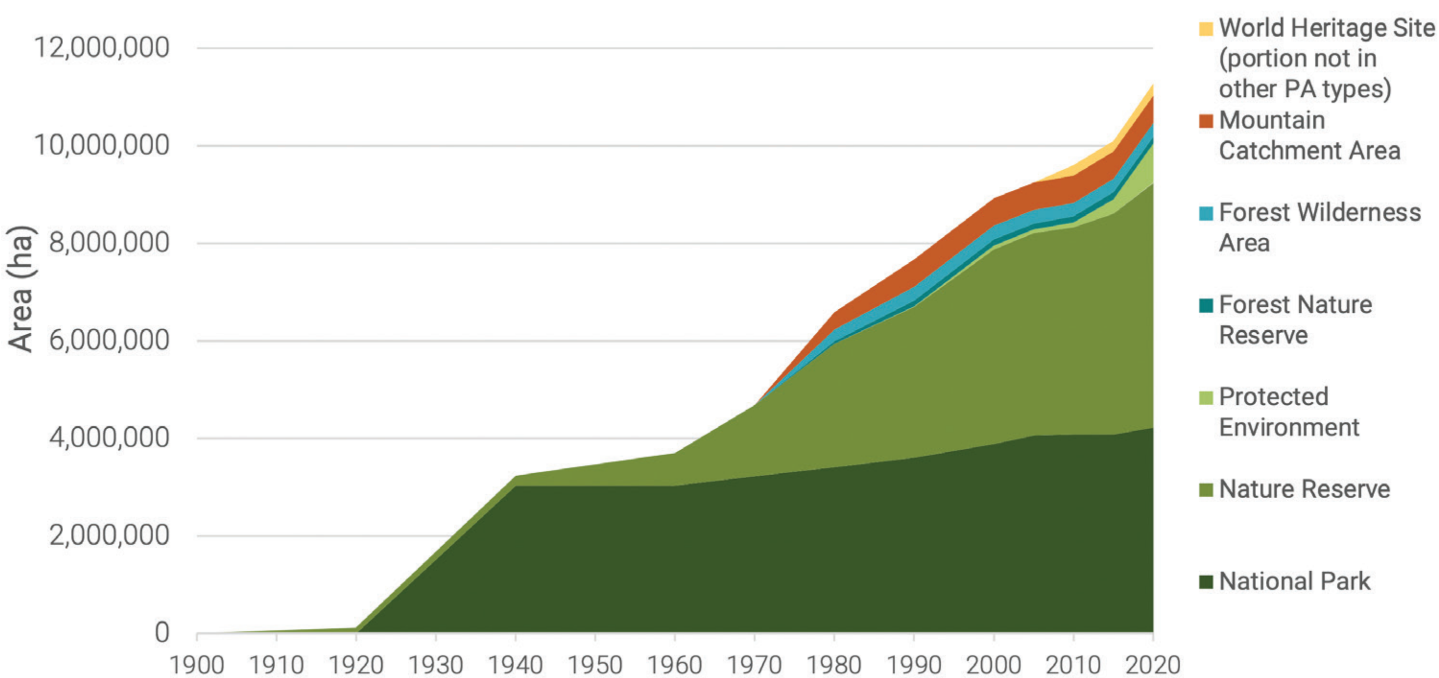
Figure 25: South Africa's mainland land-based protected areas in 2020, based on declaration dates in the South African Protected Areas Database



Source: Stats SA (2021b)

Figure 26 illustrates the increase in the extent of protected area estate from 1900 to 2020. By the end of 2000, the protected area estate was 8 920 264 ha, occupying 7,3% of the South African mainland. From 2005 to 2010, the land-based protected area estate increased by 357 805 ha (3,9% of the opening stock). From 2010 to 2015, the land-based protected area estate increased by 5,1% and just under 500 000 ha. Nearly 60,0% of this were Nature Reserves and just under 40,0% were declaration of Protected Environment. From 2015 to 2020, the land-based protected area estate increased more in this 5-year accounting period than it did in the last 15 years combined. It increased by nearly 1,2 million ha. This represents a 11,7% net increase in the protected area estate and brought the closing stock of protected area at the end of 2020 to 11 280 684 ha, or 9,2% of the South African mainland. The increase in protected areas in this accounting period is attributable to a large net increase in Protected Environment, which accounted for 42,9% of the net increase in this accounting period.

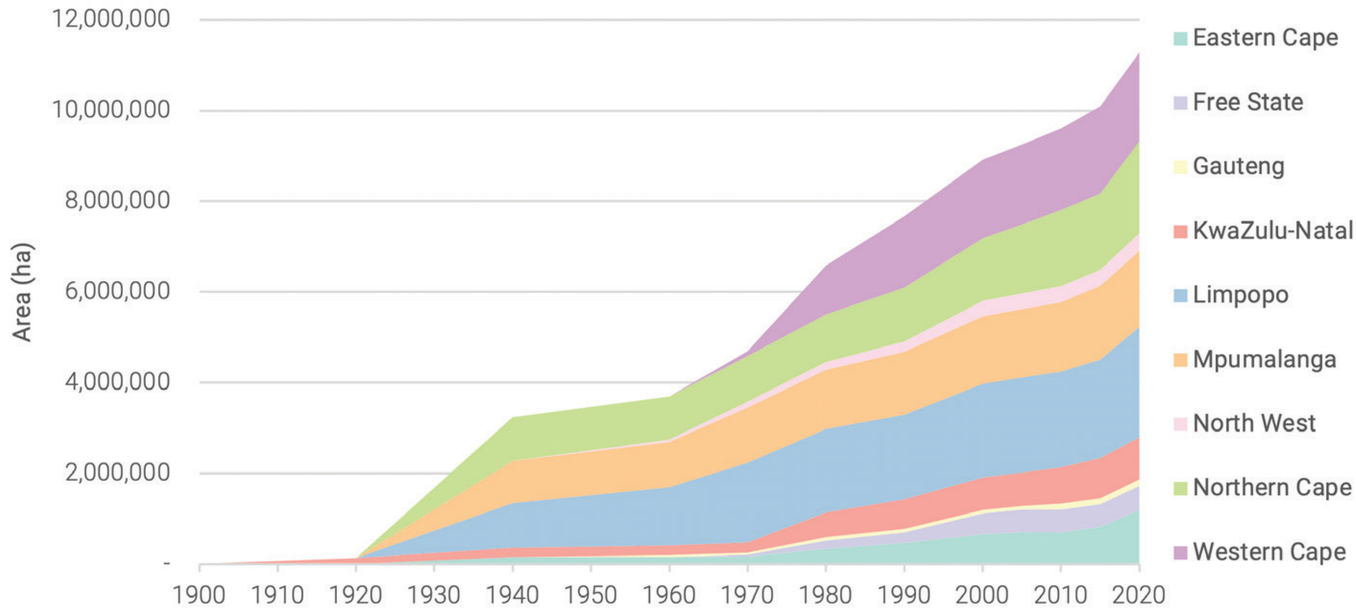
Figure 26: Cumulative extent of the land-based protected area estate by type of protected area, reflecting the 11 accounting periods from 1900 to 2020 and based on declaration dates in the South African Protected Areas Database, in hectares.



Source: Stats SA (2021b)

The accounts also show how the protected area extent has changed in each of South Africa's provinces. The contribution to the protected area estate has differed substantially across provinces and across time periods, as shown in Figure 27.

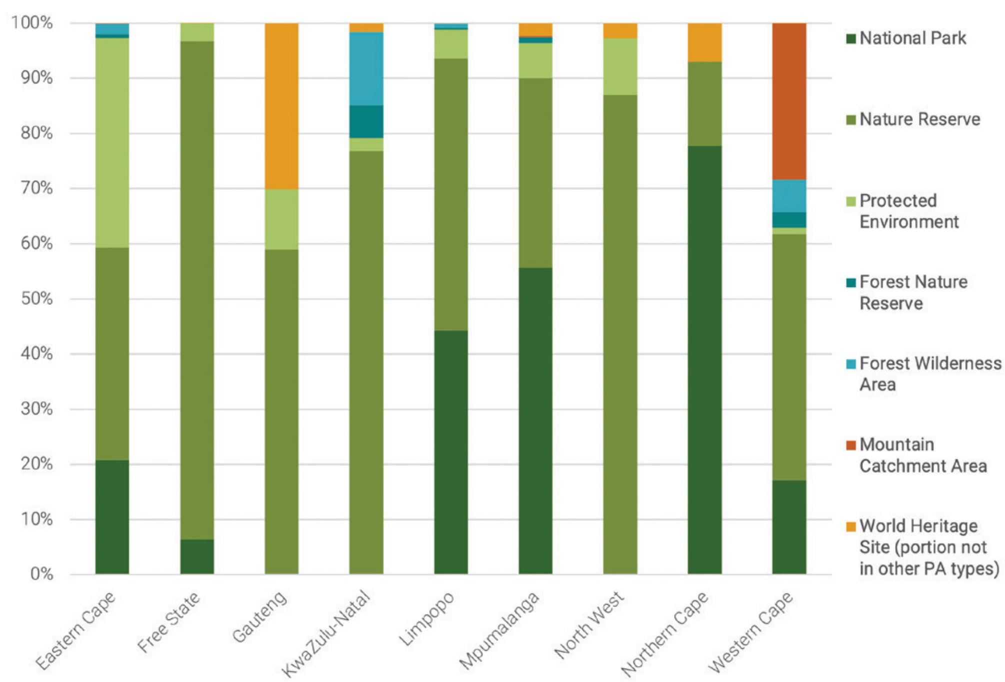
Figure 27: Cumulative extent of the protected area estate by province, reflecting the 11 accounting periods from 1900 to 2020 and based on declaration dates in the South African Protected Areas Database, in hectares



Source: Stats SA (2021b)

The accounts also provide information of the proportion of each province protected (refer to Stats SA 2021b) and of the types of protected areas that dominate in each province (Figure 28). At the end of 2020, National Parks make up the majority of the protected area estate in only two provinces, Mpumalanga and Northern Cape, and are not present in Gauteng, KwaZulu-Natal and North West province. Nature Reserves make an important contribution to the protected area estate in all provinces. Mountain Catchment Areas are declared in only three provinces, Eastern Cape, Mpumalanga and Western Cape.

Figure 28: Composition of the protected area estate by protected area type, for each province in 2020, based on the South African Protected Areas Database.

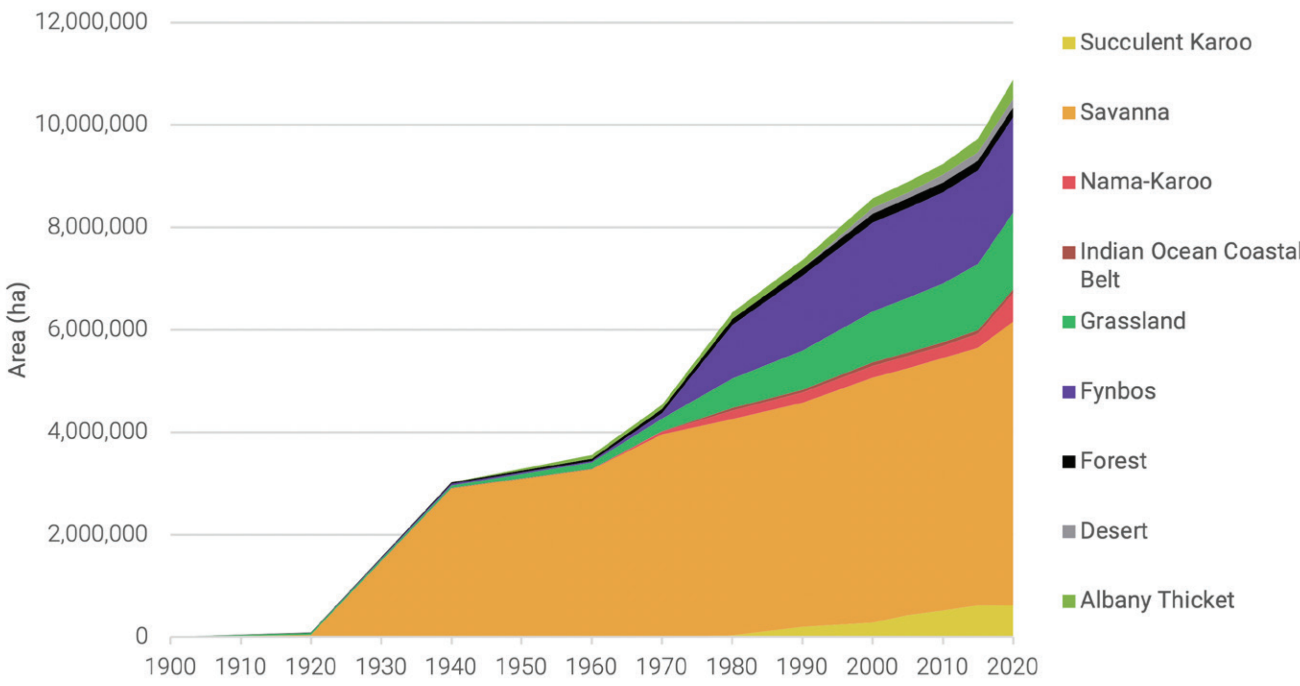


Source: Stats SA (2021b)

7.2.2 Proportion of ecosystems protected at biome level

The key findings from the land-based protected area extent account are also explored in relation to terrestrial ecosystem types grouped into nine biomes that occur in South Africa. The contribution to the protected area estate has differed substantially across biomes and across time periods (Figure 29). Historically, a range of factors influenced where and how protected areas were established and expanded, with the location of protected areas often biased towards land unsuitable for agriculture or other purposes or determined by recreation and tourism considerations. This means that the protected area estate tends to protect some ecosystem types and biomes better than others. The NPAES 2008 was the first time there was comprehensive national science-based guidance to inform the expansion of the protected area estate. The NPAES 2008 and 2016 emphasised the need for expansion and consolidation of the PA network to focus on under-protected ecosystem types as well as to support ecological sustainability more broadly. Progress has been made towards a more fully representative land-based protected area estate that includes ecosystem types from all South Africa's terrestrial biomes, as is shown in these accounts.

Figure 29: Cumulative extent of the protected area estate by biome, reflecting the 11 accounting periods from 1900 to 2020 and based on declaration dates in the South African Protected Areas Database, in hectares.



Source: Stats SA (2021b)

The accounts provide information on the cumulative extent of the protected area estate in both absolute area (ha) and relative to the size of the biomes, as these vary substantially. For instance, the Forest and Dessert biomes are the smallest in South Africa and so while their contribution to the protected area estate shown in Figure 29 looks small relative to other biomes, Figure 30 illustrates that they in fact have the highest proportion of area protected (40,1 per cent and 22,4 per cent respectively). The Savanna biome is the largest biome in

South Africa and has been well represented in the protected area estate for a long time with well-known protected areas such as Kruger National Park and Pilanesberg Game Reserve. The proportion of the Grassland biome protected increased from 3,0% at the end of 2000 to 4,6% at the end of 2020. In spite of having the second largest absolute increase in area protected, with 503 103 ha protected since 2000, the biome still had the second lowest proportion of biome protected at the end of 2020 (second to Nama-Karoo biome).

Figure 30: Cumulative extent of the land-based protected area estate in each biome, reflecting the 11 accounting periods from 1900 to 2020 and based on declaration dates in the South African Protected Areas Database, as a percentage of the total biome area, all shown on the same scale.

Source: Stats SA (2021b)

7.2.3 Directions for future work

Protected area extent accounts are useful for tracking progress in expanding the protected area estate, including against national and global protected area targets, and should be compiled and published regularly.

Directions for future work that would further enhance and add richness to the work undertaken include:

- Investing in improvements to the protected area dataset to for instance include land ownership information, protected areas or portions of protected areas that have been withdrawn, and conservation area[40].
- Expanding the accounts to include Marine Protected Areas in South Africa's mainland marine territory, and ideally also South

....

[40] Protected areas are complemented by conservation areas, which are areas not formally protected by law but informally protected by the current owners and users, and managed at least partly for biodiversity conservation. These areas include botanical gardens, conservation zoned areas of UN Educational, Scientific and Cultural Organization (UNESCO) Biosphere Reserves, buffer zones around World Heritage Sites, areas protected by spatial planning laws (e.g. zoning for conservation use) and areas protected by conservation servitudes. A process is underway globally and in South Africa to develop criteria and standards for these "other effective area-based conservation measures" (OECMs)..

Africa's Sub-Antarctic territory, which consists of the Prince Edward Islands and their marine territory.

- Explore linking accounts for protected areas to land accounts and other socio-economic data, which could provide information of value to: managers of individual protected areas; understanding patterns at the provincial and national level; and to broader analyses of the contribution of protected areas to people and the economy.
- Building on the accounts presented here with additional accounts for protected areas, such as expenditure accounts on protected areas, accounts for flows of ecosystem services from protected areas and analyses of jobs related to protected areas.

7.3 Land accounts for metropolitan municipalities, 1990 to 2014

South Africa's mainland terrestrial area is divided into nine provinces and within these, 44 district and eight metropolitan municipalities. Metropolitan municipalities (hereafter shortened to metros) have exclusive municipal executive and legislative authority in its area (unlike district municipalities, which share authority with local municipalities). They encompass major cities or urban conurbations that are predominantly urban but also include areas between urban nodes or around development nodes, that are more rural in nature, but benefit from nearby access to urban facilities and a functional settlement within the metro boundaries. A metro therefore comprises a mixture of interacting high-density urban settlements, low-density settlements as well as natural and semi-natural areas. In 1995, six metros were demarcated, and a further two were demarcated subsequently. Collectively they cover just over 2 million ha in five provinces. The land accounts for metropolitan municipalities were compiled for these eight metros (using the 2011 boundaries as determined by the Municipal Demarcation Board), looking at change in land cover between 1990 and 2014.

Land accounts provide detailed information that captures the changing dynamics of land cover. There are a wide range of uses and applications for this information and data associated with strategic urban development strategies such as the South Africa's Integrated Urban Development Framework (IUDF; COGTA 2016). They can be used to improve policy, spatial planning and decision-making related to land use, natural assets and resources, and ecosystem services that flow from landscapes and ecosystems at municipal scales.

The accounts also explore the changes in urban green space at a broad level using information from the land accounts. Both functional and publicly accessible green spaces (such as botanical gardens, playgrounds, community parks, vacant plots, golf courses, riparian areas and cemeteries) are important to the well-being of urban citizens and represent natural capital assets. The intended users of these accounts are policy and decision makers influencing spatial planning at a municipal level.

As explained earlier, the land accounts for metros will not yet have been published by Stats SA when this report is released, so the results and key findings of the accounts have not been included here (see table) Table 29, however the structure of the accounting tables is shown.

Table 29: Structure of the South African Metropolitan Municipality land accounts (main land-cover classes) for two Metropolitan Municipalities for the period 1990-2014, in hectares (the results are not shown here as accounts are still to be published by Stats SA)

Metropolitan Municipality	Broad land cover classes (tier 1)	Natural or semi-natural	Cultivated				Built-up		Waterbodies	TOTAL
	Main land cover classes (tier 2)		Commercial crops	Subsistence crops	Orchards and vines	Plantations	Urban	Mines		
Buffalo City	**Opening Stock**									
	Additions to stock									
	Reductions in stock									
	Net change in stock									
	Net change as % of opening stock									
	Extent of stable opening stock									
	Stability as % of opening stock									
	Total turnover of opening stock									
	Turnover as % of opening stock									
	Closing stock									

Metropolitan Municipality	Broad land cover classes (tier 1)	Natural or semi-natural	Cultivated				Built-up		Waterbodies	TOTAL
	Main land cover classes (tier 2)	Natural or semi-natural	Commercial crops	Subsistence crops	Orchards and vines	Plantations	Urban	Mines		
City of Cape Town	**Opening Stock**									
	Additions to stock									
	Reductions in stock									
	Net change in stock									
	Net change as % of opening stock									
	Extent of stable opening stock									
	Stability as % of opening stock									
	Total turnover of opening stock									
	Turnover as % of opening stock									
	Closing stock									

Source: Stats SA (2022)

7.3.1 Greenness and green spaces

The land accounts for metros also present a pilot analysis of greenness and green spaces in metropolitan municipalities. This supplementary analysis provided an indication of the proportion of green open space area in relation to the urban area within each metro. This relied on the land-cover classification to determine urban extent. This was possible since the urban classification included parks and open space areas.

However, the "urban parkland" land-cover class in the National Land Cover data set does not adequately and consistently capture urban green open space. Many open spaces including waterways, golf courses, forestry plantations and natural vegetation are not captured in this class, and are classified as other built or natural classes. The use of a 1-ha basic spatial unit also proved too coarse to interpret land-cover change within urban environments, so the analysis should ideally be done at sub-BSU scale.

The greenness indicator was derived from the detailed land-cover classes that include whether urban residential areas have a backdrop of bare ground, grass, bush or trees, and summarized changes in the extent and proportion of the urban area falling into each of these categories.

While open space, in the form of natural or semi-natural land cover, should be incorporated into urban open space calculations, in certain contexts they are misleading, particularly in certain South African contexts. In South Africa, large areas of the metropolitan municipalities or other municipalities with fast growing towns, are semi-rural, with open space that may be beneficial to residents, however they are often inaccessible.

As noted in the discussion on indicators in Section 8:the greenness indicator developed as part of the metro accounts may provide a useful proxy for SDG Indictor 11.7.1 on access to urban open space in the absence of comprehensive data to calculate that indicator.

Section 8: Indicators and Analysis

8.1 Introduction

Accounts can be relevant for deriving indicators (either national or international indictors) for monitoring and reporting on policy at national and global level.

The United Nations Statistics Division (UNSD) has determined that 17 of the 232 indicators within the SDG framework can be fully calculated by compiling natural capital accounts using the UN's SEEA Ecosystem Accounting (EA) framework (UN, 2014; UN, 2017). Of these 17 indicators, four were selected as "full possibilities" for alignment with the SEEA, and all four have covered multiple reporting commitments (UNSD, 2020a). These four priority indicators are:

1. **SDG 6.6.1:** Change in the extent of water-related ecosystems over time;
2. **SDG 11.7.1:** Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities;
3. **SDG 15.1.1:** Forest area as a proportion of total land area; and
4. **SDG 15.3.1:** Proportion of land that is degraded over total land area.

South Africa has developed national plans and strategies with the aim of meeting international 2030 SDGs within the socioeconomic and environmental context of South Africa and its policy environment. Stats SA coordinates the reporting on SDG indicators for South Africa, with the help of a range of institutions.

South Africa undertook a study to assess the usefulness of the accounts compiled thus far in informing four indicators identified by UNSD (2019) as priorities for testing. The study considered data requirements and calculation as well as the intended purpose and meaning of the indicators. Based on the findings, recommendations are made as to how South Africa might adjust the calculation of the indicators to better suit the national context, i.e. "domestication" of the indicators. The study aims to inform both national and international decision-making on SDG indicator reporting.

8.2 Results

8.2.1 Indicator 6.6.1: Spatial extent of water-related ecosystems

South Africa has data sets on aquatic ecosystems of much higher quality than the available global data sets (Table 29). The NLC data sets, from which the LTEA was developed, have a high level of accuracy (88 and 99 per cent for wetlands and water respectively in the 2014 NLC product). However, remote sensing has limitations in picking up many types of water-related ecosystems. The South African Inventory of Inland Aquatic Ecosystems (SAIIAE) (van Deventer et al., 2018) combines remote sensing with other methods and data to produce the most comprehensive data set on water-related ecosystems for South Africa. It includes the full extent of wetlands, including those that are seasonally or periodically dry, as well as many small waterbodies that are not picked up in other data sets. The SAIIAE thus reports the largest area of water-related ecosystems of the available global and national data sets (Table 30), and is closest to being a comprehensive, accurate value.

At this stage, none of the South African data sets have the temporal resolution required for accurate reporting on trends in the extent of water-related ecosystems. It is more difficult to judge the accuracy of such a change for waterbodies than for other land-cover classes because of the seasonal and interannual variability of aquatic ecosystems. For example, a decrease in the extent of waterbodies over a particular period can reflect simply that the opening year was a wetter year with more rainfall than the closing year. This was the case with the extent of waterbodies in the Land and Terrestrial Ecosystem Accounts, which decreased by 32.2 per cent between 1990 and 2014, from 1.7 per cent of the mainland area to 1.2 per cent. This decrease reflects mainly that 1990 was a wetter year than 2014, and cannot be used to draw conclusions about actual change in the extent of water-related ecosystems. This highlights the need for assessments of the extent of waterbodies to be derived from a combination of satellite data, modelling of wetland probability and on-the-ground mapping of wetlands, ideally at regular intervals.

Table 30: Table of the different computations of extent of water-related ecosystems, highlighting the vast differences in values and the complexity of determining an accurate value

		SAIIE (van Deventer et al. 2018)	SDG Country report. (Stats SA 2019)	Pekel et al. (2016) 2014 data*	GLW (Lehner and Döll 2004) *	LTEA 2014
Ca. 1990	Extent of water-related ecosystems (ha) (approximate)	N/A	N/A	526 096	N/A	2 096 528
	Extent of water-related ecosystems (% of total land area) (approximate)	N/A	N/A	0.4	N/A	1.7
Ca. 2014	Extent of water-related ecosystems (ha) (approximate)	4 123 798	3 902 926	571 551	1 536 066	1 420 676
	Extent of water-related ecosystems (% of total land area) (approximate)	3.4	3.2	0.5	1.3	1.2

Source: SANBI (2021)

A key weakness of this indicator if applied too simply is its inability to distinguish what has been permanently lost versus temporarily reduced through natural fluctuations, for example due to seasonal or longer term variation in rainfall or major drought. Understanding the full extent of wetlands from data during wet periods (as will be provided by SAIIAE) in relation to land cover is important in this regard.

Consideration should be given to the impact of the resolution of analysis using the BSU (100m resolution) as some detail could be lost for small or narrow features, such as very small wetlands. The impact on measurement of the extent of waterbodies of using the BSU relative to, for example, a 30m resolution, should be further tested.

Owing to the limitations described above, a key conclusion that can be made is that tracking the extent of water-related ecosystems using available global databases is unlikely to be accurate or meaningful at this stage, either in South Africa or globally. It is recommended that South Africa incorporates the SAIIAE (its highest quality data on aquatic ecosystems) into ecosystem accounting, and reports on the remaining extent of wetlands based on an estimation of their full natural extent that takes both seasonality and natural variation over longer periods into account. A reduction in the extent of wetlands and other waterbodies should be reported only when there has been outright loss of area (for example, as a result of conversion of wetlands to intensive land uses such as cultivation or mining) and not when the reduction in extent is the result of natural seasonal or longer-term fluctuations. It will also be useful to track the longer-term (interannual) variation of wet and dry cycles and extended droughts in the accounts, as this is important for more accurate description of the delivery of ecosystem services.

8.2.2 Indicator 11.7.1: Access to urban open space

This indicator has not yet been reported on in South Africa's SDG country reports to date. South Africa has prepared accounts for metropolitan municipalities (metros), as a subset of the national land accounts, as discussed in Section 7.3. The administrative boundaries of metros were used rather than the urban extent of city regions, partly because of the challenge of the changing urban extent from one accounting period to another.

South Africa's metro accounts describe land cover and land-cover changes in the eight metros, which include the largest urban agglomerations in the country. There are also many urban areas in towns outside of these metros. For calculating an indicator of urban open space extent at national scale, it would be necessary to decide which urban areas are included, and how the overall scores are aggregated across all the urban agglomerations. Therefore, within the national context, it will be important to identify which urban centres would be included for monitoring progress towards this indicator. It is recommended that focusing on major cities (those within metropolitan municipalities) is a workable option at this stage.

The NLC does not follow the UN-Habitat (2018) guidelines on determining urban extent. This would be a helpful modification. UN-Habitat defines the urban extent as: "the total area occupied by the built-up area and the urbanized open space. It consists of all the buildings and small open spaces (< 200ha) that are surrounded by buildings plus the open space fringe within 100m of urban and suburban areas". The method of delineating the boundary is documented by UN-Habitat (2018) and has been employed for several cities across the globe, in a systematic way by Angel et al. (2016). It is recommended that in future this method be used as the primary determinant of urban extent.

It is important to note that the global indicator refers to open space rather than green space, and includes built open space such as plazas, streets and walking boulevards, as well as public open spaces such as parks (UNSD, 2019). In the NLC, paved open spaces and roads are all classified as built areas and not distinguished as public areas, so these are not distinguished in the metro accounts.

Satellite-derived NLC data alone are limited in terms of classification of different types of open space. Far more detailed and accurate data are available for several of the larger municipalities, some with a very fine resolution of about 2.5 metres (compared with 30m for the NLC). These data have been developed based on a combination of satellite data, planning information and on-the-ground verification, in order to support monitoring and management efforts. To include all elements of Indicator 11.7.1, such data sets will also need to include information on the accessibility, safety and usability of the open space areas, particularly for women, children and people with disabilities, none of which have been collated in South Africa at this stage.

Indicator 11.7.1 also requires data on the total area allocated to streets, which could be obtained in various ways, not necessarily from satellite data. It is questionable whether this aspect of the indicator is appropriate in general. While streets are functionally important, they do not always represent safe or necessarily accessible space and they do not have the same benefits as other public open space. What is missing from the indicator is the extent to which streets are enhanced, for example with trees, verges and walkways. This is important, not only from an aesthetic point of view but also influences levels of comfort in the city, relating to temperature and air quality effects. It is recommended that the streets aspect of the open space indicator is modified to reflect their amenity value.

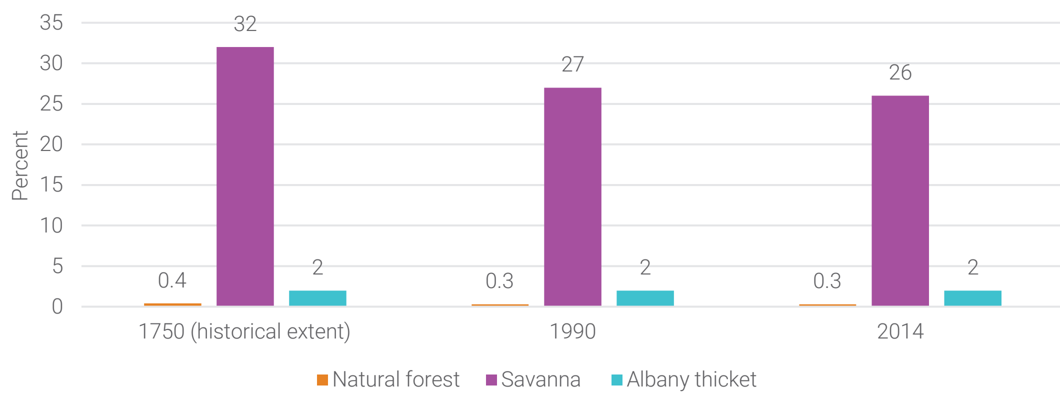
Indicator 11.7.1 is about public space. In the metro accounts, a greenness indicator was derived that describes the degree of vegetation and trees in residential areas, in other words, within private space as well as the streets in these areas. This indicator is also relevant to understanding the quality of people's environment within cities, and is important because there is a degree of substitutability between private gardens and public green space, especially in higher income areas; conversely, urban areas, whose residential areas are less green, may be expected to have a higher need for public green open space. The greenness indicator was made possible by a very detailed land-cover classification in urban areas. This measure does not necessarily fulfil the requirements for Goal 11, but does help to contextualise progress against this goal. The greenness indicator could be used as a proxy for Indicator 11.7.1. Other countries may also benefit from this approach.

In summary, Indicator 11.7.1 is thought to be a good indicator, with the proviso that the streets part of the indicator is modified to account for features such as street trees. Natural capital accounting may help to provide some of the information required for the indicator, but is not likely to be a perfect match, since the indicator requires more tailored, detailed data. At present natural capital accounts, at least in South Africa, do not meet these requirements.

8.2.3 Indicator 15.1.1: Forest area as a proportion of total land area

In its SDG country reports to date, South Africa has used a domesticated version of Indicator 15.1.1 that reports on the area of South Africa's three forest and woodland biomes – Forest, Savanna and Albany Thicket – as a proportion of the total mainland area of the country (Figure 31).

Figure 31: Domesticated version of Indicator 15.1.1, as reported in South Africa's SDG Country Report 2019: Natural forest and woodland area as a percentage of total land area



Source: Stats SA (2019)

Although both the global indicator for 15.1.1 and the domesticated indicator measure forest area as a proportion of total land area, the method of computation used by the Food and Agriculture Organization (FAO) uses a definition of forest that includes commercial plantations of exotic trees, and the South African definition excludes these. The broad definitions of forest used by FAO include all wooded vegetation types with over 10 per cent canopy cover. This gauge of forest cover does not align with the definition of forest in South Africa's National Vegetation Map, which separates wooded vegetation into (true) forest (tall and with a closed canopy), savanna (grassy landscape with trees) and thicket (low dense woody vegetation). Additionally, using the FAO definition, stands of invasive alien trees (which are a major pressure on ecosystems, biodiversity and water security in South Africa) are likely to be included in the measurement of Indicator 15.1.1, which would be counter to the intention of Goal 15.

Forests, as a total proportion of total land area, depend on a range of factors in the South African context, where indigenous forests are naturally a small biome that makes up a small proportion of the country and expansion of exotic invasive trees is a major challenge. Reporting on the proportion of forest area as defined by the FAO is not a meaningful indicator of progress towards achieving Goal 15.

The domesticated version of Indicator 15.1.1 is well supported by the terrestrial ecosystem extent accounts discussed in Section 3.3.2. The current global version of the indicator would not be supported by these ecosystem extent accounts.

It is recommended that:

- The global metadata for Indicator 15.1.1 be amended to exclude exotic tree plantations and the FAO definition of forests be replaced with the definition of forests from the Global Ecosystem Typology, which better reflects the intention of Goal 15;
- Indicator 15.1.1 is re-crafted to report on all biomes in the Global Ecosystem Typology, not just forests. It is not clear why forests are the sole focus of the indicator. In its current form, the indicator is focused on vegetative structure (seen through a forestry lens) rather than on conveying a sense of the state of ecosystem health and biodiversity. The focus on forests is a common northern hemisphere perspective, and is not particularly appropriate for the tropical and south temperate regions, where terrestrial ecosystems are often far more diverse and where other biomes commonly dominate.

In addition, there is a concern that the indicators for Goal 15 do not take ecosystem condition into consideration. Ecosystem condition accounts could supply such information.

8.2.4 Indicator 15.3.1: Proportion of land that is degraded

While South Africa has not yet incorporated condition and ecosystem services into its accounts, the intention is that ecosystem accounts will track changes in land cover, ecosystem condition and carbon storage. As they exist or are envisaged, these do not directly inform the three sub-indicators for Indicator 15.3.1 – land cover, net primary productivity (NPP) and soil organic carbon (SOC) – but could improve on two of them.

With respect to the first sub-indicator (land cover), land accounts provide information on the extent to which natural or semi-natural areas have been converted to intensively modified land uses, such as cultivation, mining and urban areas. However, it is not clear that such changes should be classified as degradation, as habitat loss should not be conflated with degradation. Rather degradation should be assessed in relation to a natural reference condition or to a reference condition for the type of anthropogenic land use. Clear guidance is provided on this in the SEEA, which could be used to improve global guidance on the calculation of the Indicator.

South Africa's future ecosystem accounts will likely improve on the second sub-indicator (SOC). Currently countries are expected to report on SOC as a proxy for total ecosystem carbon until the means for reporting on the latter are improved. Carbon sequestration and storage will be quantified in ecosystem service accounts. This will include the full suite (including above and below ground biomass), so is more aligned to the envisaged evolvement of the sub-indicator to its full form.

With respect to the third sub-indicator (NPP), terrestrial ecosystem condition accounts are likely to produce a more reliable assessment of degradation than one based simply on positive or negative change in NPP, since they will evaluate where positive changes in NPP actually signify degradation, among other things. However, as discussed in Section 4.2, these methods are still under discussion and development. The potential use of the normalised vegetation index (NDVI), a proxy for NPP to assess condition, has been explored. The conclusion is that NDVI trends alone cannot reliably be used to indicate degradation in terrestrial ecosystems, let alone present condition.

Substantial discussion and work needs to be undertaken to develop a reliable and consistent methodology to assess terrestrial ecosystem condition in South Africa. Once these methods are in place, then ecosystem condition accounts will be able to provide estimates of degradation to inform the sub-indicator. South Africa will likely choose to domesticate the sub-indicator in this regard, but it is also recommended that the indicator itself is modified to accommodate a more reliable estimate of degradation where feasible.

Indicator 15.3.1 only reports land area that has degraded since 2000, not all degraded areas. This is pragmatic, allowing use of satellite data, and also suited to the purpose of achieving land degradation neutrality targets relative to 2015. However, unless communicated clearly, this indicator could signal that things are better than they are. This is particularly pertinent for countries such as South Africa that are dominated by rangelands.

Assuming that condition and changes will be heavily reliant on NPP measures going forward, it is important that degradation is viewed in terms of long-term trends. The indicator is required to be assessed every four years, which may be construed as a comparison of two points in time (present and previous assessment). It should be made clear that the time series analysis being updated every four years should include earlier years with a periodicity appropriate to the type of ecosystem. The four-yearly update of the indicator should be based on a long-term trend analysis and not on a comparison of two periods (present and previous assessments).

8.3 Main conclusions

The following main conclusions are made in respect of each indicator, from a South African perspective:

- **For Indicator 6.6.1 (extent of water-related ecosystems),** the global data sets, as they stand, are inadequate. South Africa has developed accurate, high-resolution data that combine land-cover information with other data sources and verification in the form of the SAIIAE. The development of ecosystem extent accounts for inland wetlands, using the SAIIAE to provide the baseline extent for wetlands and tracking actual wetland extent against that baseline, will provide the most rigorous and consistent information for this indicator. The waterbodies class in the land accounts should not be used for reporting on this indicator as it does not provide meaningful information on the total extent of water-related ecosystems or changes in their extent.

- **For Indicator 11.7.1 (access to urban open space),** land accounts may help to provide some of the information required for the indicator, but are not likely to be sufficient, since the indicator requires more tailored, detailed data. South Africa largely has the information to compile the indicator, which could be done as an adjunct to the accounts for metros. However, it would require substantial work to gather and analyse the data, which means that it will probably not be feasible to report on this indicator in the short to medium term. The greenness indicator developed in South Africa's land accounts for metros, discussed in Section 7.3, could provide a useful proxy for Indicator 11.7.1. Other countries may also benefit from this approach.

- **For Indicator 15.1.1 (forest area),** South Africa has domesticated the indicator to report on the extent of its three natural woody biomes (indigenous forest, savannah and thicket). This avoids the inclusion of invasive alien trees and exotic forest plantations, which have negative impacts on ecosystems in South Africa and would thus make the indicator meaningless for tracking progress towards achieving Goal 15. It is suggested that globally this indicator be changed from being forestry- to ecosystem-focused, and that all major biomes in the Global Ecosystem Typology are included rather than just forests. Ecosystem extent accounts will be very well suited to deliver that information.

- **For Indicator 15.3.1 (area of degraded land),** once ecosystem accounts are further developed, they should be considered essential for informing this indicator, and indeed for improving upon its three sub-indicators. The ecosystem service accounts will not only inform but also improve on the carbon indicator in that it will be more aligned to the envisaged evolvement of the sub-indicator to its full form rather than its proxy (SOC). Terrestrial ecosystem condition accounts are likely to make an important contribution to measuring the degradation sub-indicator, as they are likely to produce a more reliable assessment of degradation than one based simply on change in NPP. These methods are still under development, however.

Section 9: Conclusions and Way Forward

9.1 Applications of accounts

NCA is a means to provide decision makers with the data and information needed for evidence-based policymaking. Standardized information on national economic activity is available through measures such as GDP, and statistics and indicators on demographic variables, such as population, health and education, are also prevalent. However, information on the environment is often disparate and lacking agreement on collection, harmonization and headline indicators. SEEA seeks to fill this gap, by providing a common framework for measuring and tracking over time the contribution of ecosystems to social and economic goals, such as water security, food security and job creation, and provides a wealth of information that can improve planning and decision-making related to the management of natural resources.

Engaging widely and creating links between the developers and users of accounts is crucial to their successful mainstreaming and policy uptake, thereby matching the supply of and demand for the accounts. This is central to South Africa's National NCA Strategy, discussed in Section 9.2 below. Demonstration effects are also important. By providing examples of how policies could be enhanced with the benefit of accounts, policymakers are more likely to demand accounts to be produced on a more regular basis.

Examples of national policies in South Africa for which the accounts produced through this project could provide valuable information and indicators for include:

- The Land and Terrestrial Ecosystem Accounts provide indicators such as net change in stock and EEI that could be useful for reporting on SDGs, support monitoring of the NSDF 2050 (which introduces the concept of National Ecological Infrastructure System as a national spatial development lever to support spatial transformation). Together with the Land Accounts for Metropolitan Municipalities, these accounts could provide the information relevant for district municipalities in the context of the accelerated roll-out of the District Development Model to 23 districts by the end of 2020.

- Protected area extent accounts are useful for tracking progress in consolidating and expanding the protected area estate, including against national and global protected area targets, such as those in the NPAES, NBSAP and SDG targets. Combining the protected area extent account, the ecosystem extent account and the land account can provide a wealth of information about the protection of particular ecosystem types and also about the socioeconomic context of individual protected areas. This can support management planning and decision-making for individual protected areas as well as broader analyses of the contribution of protected areas to people and the economy.

- The species accounts for rhinos and for cycads developed are an example of accounts that can support the sustainable use of biodiversity. The species accounts for rhino adds to the richness of evidence available to decision-makers. The draft accounts have been presented to, and well received by, the South Africa national Scientific Authority for CITES, convened by SANBI, to assist with regulating trade in species, including CITES-listed species such as black and white rhino. Such species accounts could also be explored for providing information for reporting on targets being developed in the Post-2020 Global Biodiversity Framework.

The policy scenario analysis undertaken as part of the NCAVES project is a further example of the potential applications of natural capital accounts. Policy scenario analysis is an exercise that aims at informing decision-making and makes use of scenarios to assess the outcomes and effectiveness of various policy intervention options. Ecosystem accounts are by nature backward-looking: they describe the state of affairs at some point in the past, which may be relevant for a whole range of policies. Policymaking is, by contrast, forward-looking: it seeks to influence future states of affairs based on decisions taken today. The challenge, then, is how to marry the two. The use of backward-looking data in forward-looking policy scenario analysis allows policymakers, therefore, to assess the possible impacts of their choices.

In South Africa, as part the NCAVES project, a policy scenario analysis has been undertaken on land restoration programmes in the Thukela river basin in KZN based on the accounts developed for the KZN pilot study of ecosystem service accounts. This study aimed to use a scenario-based approach to explore an issue relating to existing targets, programmes and interventions and of particular relevance to government stakeholders. Following consultation with DFFE and KZN conservation authority (Ezemvelo KZN Wildlife), among others, and exploration of spatial data, the focus of the study was narrowed down to that of land degradation, specifically in relation to South Africa's land degradation neutrality (LDN) commitments under the United Nations Convention to Combat Desertification (UNCCD). In the KwaZulu-Natal, land degradation mainly takes the form of (a) loss of biomass cover leading to bare areas and erosion, (b) increased indigenous woody biomass ("bush encroachment") and (c) encroachment of invasive alien plants (IAPs). The main aim of the study was to provide insights into the consequences of land degradation and the costs and benefits of investing in measures to address this problem in KwaZulu-Natal.

9.2 Future outlook: National NCA Strategy

As part of the NCAVES project, South Africa developed the *National NCA Strategy: A ten-year strategy for advancing Natural Capital Accounting (NCA) in South Africa* (hereafter referred to as 'the National NCA Strategy') (Stats SA 2021e). The National NCA Strategy has a ten-year timeframe, but it is envisaged that it will be reviewed and revised after five years. The process of developing the strategy was highly consultative and involved a wide range of stakeholders, as discussed further below.

9.2.1 What is the purpose of the strategy?

Natural capital accounts for South Africa to date have been produced on an ad hoc basis, and most often through donor-funded projects. In order to build and strengthen the statistical and institutional mechanisms as well as the systems and production processes required to consistently and regularly produce natural capital accounts, an integrated and more holistic approach is needed to advance NCA in South Africa.

The purpose of the strategy is to respond to the need to focus the efforts of Stats SA and other institutions engaged in NCA on developing priority national-level natural capital accounts and effective statistical systems and institutional mechanisms to inform South Africa's sustainable development policy objectives.

It is intended to support:

- Coordination of an integrated body of NCA work in SA.
- Development of statistics from natural capital accounts within and outside of the national statistical office through agreed standards, delivering reliable and comparable results that are also coordinated with socioeconomic statistics.
- Derivation and use of relevant national indicators for statistical purposes from NCA in measurement of national indicators in South Africa (as called for in the National Development Plan (NDP), MTSF, and continental and international sustainable development agendas), such as those contained in the Stats SA integrated indicator framework (IIF).
- Collaboration between institutions to strengthen investment and commitment to the production of consistent and regular accounts that provide credible evidence for integrated planning, monitoring and decision-making.

9.2.2 How was the strategy developed?

The development of the strategy was led by Stats SA and SANBI and followed a highly consultative and collaborative process over three years involving:

- The completion of an Assessment report towards the development of a national strategy for advancing environmental-economic and ecosystem accounting in South Africa (SANBI & Stats SA, 2018).
- Stakeholder engagement through: the National NCA Stakeholder Workshop in March 2018, the National NCA Forum in June 2019, and the National NCA Strategy Stakeholder Workshop in November 2020.
- Through numerous tri- and multi-lateral engagements organized by Stats SA and SANBI.
- The establishment and convening of the NCA Strategic Advisory Group (SAG) to guide the development of the National NCA Strategy. The following institutions are represented on the NCA SAG (listed in alphabetical order): DFFE, DPME, Department of Science and Innovation (DSI), DWS, National Business Initiative (NBI), National Treasury (NT), SANBI, South African National Parks (SANParks), Stats SA, and the Water Research Commission (WRC).
- Guidance from a Project Reference Group (PRG) for the NCAVES Project.

9.2.3 Who is the strategy for?

NCA is inherently multi-disciplinary, requiring expertise, data and information from various organisations, and NCA information is or could be used by a wide range of organizations. It discourages the traditional "silo approach" to development of statistics and requires that different organizations collaborate to produce statistics beyond their respective thematic areas.

Stats SA have an important role in ensuring coordination and production of reliable environmental statistics, including: as the National Statistical Authority, designating statistics as official, and liaising with other countries and statistical agencies; and as the National Statistical Coordinator, promoting coordination among producers of statistics, formulating quality criteria, establishing standards, classifications and procedures, providing statistical advice, advancing comparability and optimum use of official statistics.

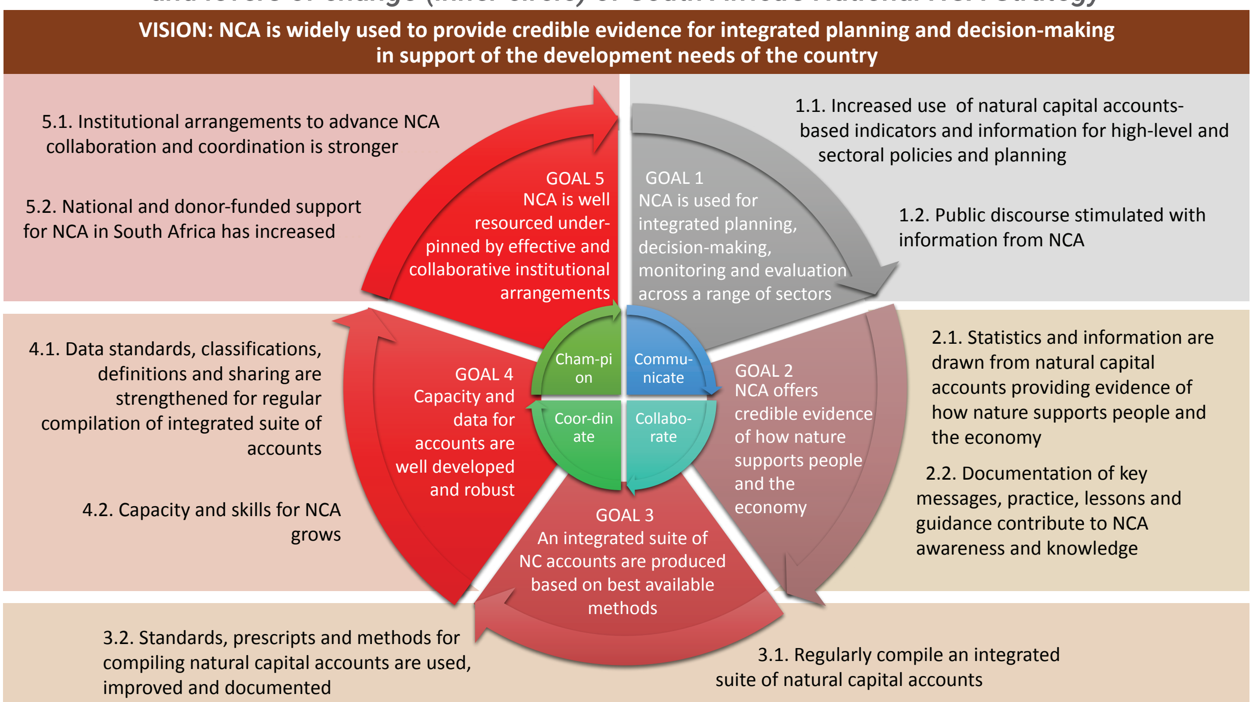
Information that feeds into accounts from a range of sources and information from accounts is or could be used by a wide range of organisations. The strategy thus suggests that if you are feeding data into, producing or using national-level natural capital accounts, you should be able to find yourself and their application in the strategy.

9.2.4 Vision, goals and strategic objectives

The vision that the strategy is working towards is that: Natural capital accounting (NCA) is widely used to provide credible evidence for integrated planning and decision-making in support of the development needs of the country. The vision statement is a summation of many components and concepts, which are further elaborated in the strategy along with principles that guide the strategy's implementation.

The strategy identifies five areas of work that will contribute towards achieving the vision. These are structured into five goals shown in Figure 32, to which more than one strategic objective is linked.

Figure 32: Visual summary of the vision, goals, strategic objectives (around the goals) and levers of change (inner circle) of South Africa's National NCA Strategy



Source: Stats SA (2021e)

Four cross-cutting levers of change are also identified. Coordination, collaboration, communication and the role of champions from a range of sectors are seen as integral to the effective implementation of the strategy. These help to guide how the strategy should be implemented:

- Leadership to champion the use of NCA as a tool and source of evidence is enabled through learning and sharing, building networks and engaging tensions.
- Communication with key stakeholders and partners will be supported by clarifying context and ideas, openly engaging tensions through conversation in communities of practice. There are already a number of CoP operating at a range of scales across the NCA value chain, and communication across these is important.
- Co-create and collaborate in the improvement and development of natural capital accounts provides new opportunities

to harness growing data capabilities and develop beneficial partnerships across private and public sectors. Co-creation and collaboration around accounts, standards, classifications and definitions is crucial to developing outputs of mutual benefit (co-creating value), problem-solving complex transdisciplinary issues, and best ensuring relevance to users and policy.

- Coordinate and manage the change process to effect individual and organization change requires a series of shifts across the NCA value chain (Figure) that will be supported by learning and sharing, and evaluation and adaptive management.

The National NCA Strategy document provides for each Goal, further detail and description of the strategic objectives, outputs and indicative activities towards arriving at those outputs, including information towards the implementation of high-level indicative activities such as:

- Whether the activities are low road activities (can be undertaken with existing human and financial resources) or high road activities (are only possible with additional resources).
- Key role players in the activity.
- An estimation of timeframes.
- An estimation of human or financial resources.

The strategy also provides an overview of institutional mechanisms envisaged to support the strategy's implementation and levers of change. It includes some of the coordination mechanisms to ensure feedback and integration between the five goals (linking to levers of change), including formal and informal structures, NCA Strategic Advisory Group, communities of practice, the like.

Various institutional mechanisms will involve different combinations of technical experts, NCA champions as boundary actors, policy and decision makers interested in engaging with the detail to develop insightful and credible evidence (ensuring users of information are partners in co-creating value). These will share information and make contributions into NCA Community of Practice events, including an annual NCA Forum that Stats SA will convene, with partners, as the main platform for the NCA Community of Practice in South Africa.

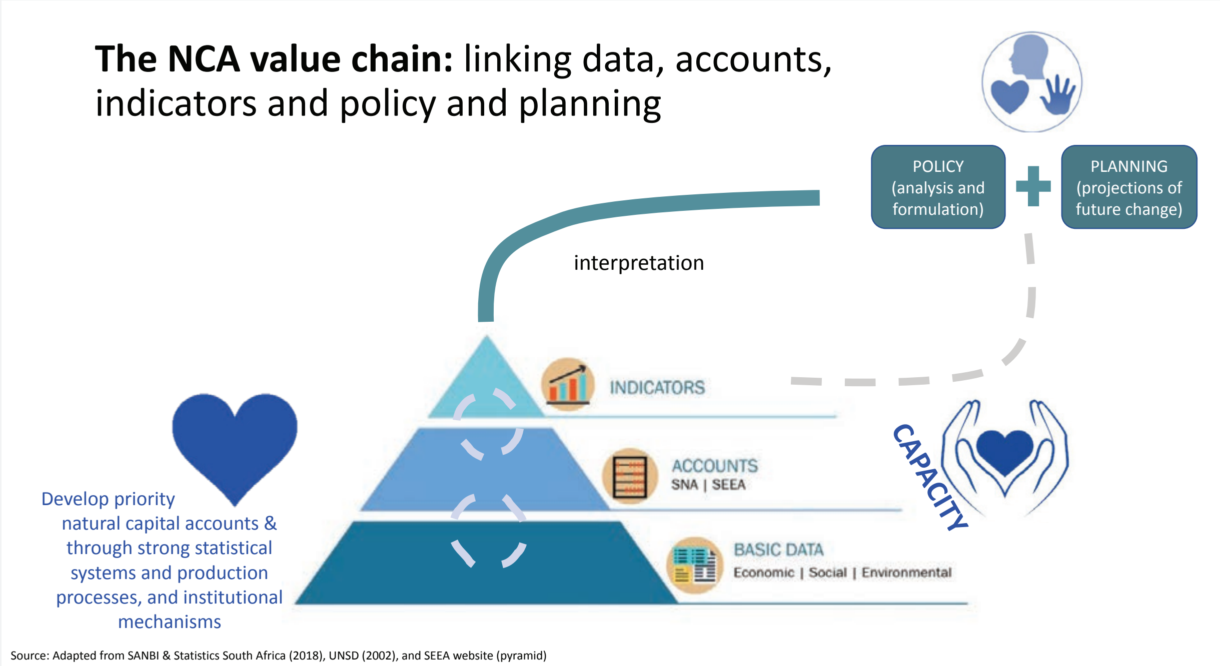
Box 2: NCA value chain

The NCA value chain refers to the processes and activities by which value is built from natural capital accounting, and what the National NCA Strategy must address.

The heart of the NCA focus is on the effort of developing priority natural capital accounts built through strong statistical systems and production processes, and in the right way. However as implied by the pyramid in Figure, accounts are built on data, and apply particular accounting approaches based on internationally accepted methods (base of the pyramid). The types of accounts produced can impact on data requirements, management and information systems (feedback loop). Further, indicators are drawn from accounts (top of the pyramid) and the desired indicators may feedback to inform accounts (feedback loop). Interpretation of these indicators can make links to other environmental, social and economic information and provide information relevant to policy and planning. As illustrated by the feedback arrow to indicators, it is important to consider application and use of information in consideration of indicators and accounts. So we have to spend time asking questions on what information is most useful.

We need the capacity to do all of this - the hands to hold the heart. And we really only realize the value when the heart, hands and head are together.

Figure 33: The NCA value chain linking data, accounts, indicators, policy and planning



Source: Ginsburg (2020)

9.3 Concluding comments

The NCAVES project has been a game-changer for NCA in South Africa, taking NCA from two early pilot accounts to a suite of SEEA accounts that have launched Stats SA's new Natural Capital Series, and generating energy and commitment to NCA across a range of stakeholders.

The project has made a large contribution to demonstrating that ecosystem and related accounts are feasible to produce and that they provide valuable information for a range of users. By providing funding for staff and consultants who have worked closely with officials in Stats SA and SANBI, the project has helped to build crucial technical capacity to compile natural capital accounts in South Africa. This has inspired further work on ecosystem accounts using in-house resources in SANBI and other organisations such as the Council for Scientific and Industrial Research (CSIR).

Through NCAVES project events, a national community of practice on NCA has become well established, with a growing network of NCA champions in government departments and organizations who see themselves as having a key role to play in taking NCA forward in South Africa. The work is helping to unlock collaboration between non-traditional partners.

The project's impact has been amplified through layering of donor investments in NCA, which has meant that the value of the whole is more than the sum of the parts. Sustainability of NCA work in South Africa has been strengthened through layering of current and emerging government- and donor-funded investments in NCA, and is aided further by the development of the National NCA Strategy.

South Africa's rich data foundations, particularly for ecosystems and biodiversity, mean it still has much to offer in terms of compiling further categories of natural capital accounts and exploring an integrated suite of accounts for specific policy- and decision-making purposes. Mobilizing resources, so that South Africa's NCA agenda can continue to produce accounts and develop further capacity, is critical. More capacity is needed, not only to produce a continued and wider range of natural capital accounts, but also to interpret and use this information most effectively.

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