Appendix B: South Africa Indicators Testing Report

Report of the NCAVES Project

United Nations | System of Environmental Economic Accounting

Testing and refining global and national SEEA-EEA related indicators

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PREFACE AND ACKNOWLEDGEMENTS

This work forms part of the Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES) project, which was launched in 2017 by the United Nations Statistics Division (UNSD) and United Nations Environment Programme (UN Environment) with funding from the European Union (EU). The NCAVES project aims to assist five participating partner countries, including South Africa, to advance the knowledge agenda on environmental and ecosystem accounting and initiate pilot testing of System of Environmental-Economic Accounting (SEEA) Experimental Ecosystem Accounting (EEA).

In South Africa, the NCAVES project was led jointly by Statistics South Africa (Stats SA) and the South African National Biodiversity Institute (SANBI), working closely with a range of national and sub-national stakeholders, to further develop ecosystem accounts for South Africa. SANBI commissioned Anchor Environmental Consultants (Pty) Ltd, in partnership with GEOTERRAIMAGE (Pty) Ltd (GTI), to assist Stats SA and SANBI with the compilation of the land and terrestrial ecosystem accounts. This report is one of a set of reports which are the outcome of this collaborative effort.

This report on the testing and refining of global and national SEEA-EEA related indicators was compiled by Jane Turpie and Joshua Weiss of Anchor with inputs from Amanda Driver, Aimee Ginsburg, Andrew Skowno and Nancy Job of SANBI.

The EU is acknowledged for funding the NCAVES project and the Delegation of the European Union to South Africa for supporting its implementation in South Africa. The UNSD and UN Environment are acknowledged for leading the NCAVES project globally and supporting its management and implementation in South Africa. The contents of the report do not necessarily reflect the views of the EU or the United Nations (UN).

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ACRONYMS

BioNet	City of Cape Town Terrestrial Biodiversity Network
BSU	Basic Spatial Unit
DEFF	Department of Environmental, Forestry and Fisheries
DWS	Department of Water and Sanitation (now Human Settlements, Water and Sanitation)
EI4WS	Ecological Integrity for Water Security
ECJRO	European Commission Joint Research Commission
EEA	Experiment Ecosystem Accounting
FAO	Food and Agricultural Organization of the United Nations
GTI	GeoTerra Image
KBA	Key Biodiversity Area
NBA	National Biodiversity Assessment
NCA	Natural Capital Accounting
NCAVES	Natural Capital Accounting and Valuation of Ecosystem Services
NDVI	Normalised Difference Vegetation Index
NLC	National Land Cover
NPAES	National Protected Area Expansion Strategy
RAMSAR	Ramsar Convention on Wetlands of International Importance
SANBI	South African National Biodiversity Institute
SDG	Sustainable Development Goals
SEEA	System of Environmental-Economic Accounting
SEEA EA	System of Environmental-Economic Accounting Ecosystem Accounting (adopted 2021)
SEEA EEA	System of Environmental-Economic Accounting Experimental Ecosystem Accounting (published 2014)
SNA	System of National Accounting
Stats SA	Statistics South Africa
SWSA	Strategic Water Source Area
UN	United Nations
UNEP-WCMC	United Nations Environment Programme World Conservation Monitoring Centre
USGS	United States Geological Survey
WDPA	World Database on Protected Areas

1 INTRODUCTION

1.1 Sustainable Development Goal Indicators

In 2015, 193 countries adopted the 2030 Agenda for Sustainable Development as a framework to guide global peace and prosperity. At the core of the Agenda are 17 ambitious Sustainable Development Goals (SDGs). The SDGs were originally conceptualized at the UN Conference on Sustainable Development held in Rio de Janeiro, Brazil (Rio+20) in 2012. The conference's key outcomes captured in the report titled, "The Future We Want", proposed a set of SDGs that would mainstream and mobilise the global sustainability agenda. In 2015, the UN General Assembly commenced negotiating the post-2015 development agenda, this resulting in the Agenda for Sustainable Development and its associated goals.

The SDGs are built on what is commonly referred to as the five P's (UN 2015):

- People: 'We are determined to end poverty and hunger, in all their forms and dimensions, and to ensure that all human beings can fulfil their potential in dignity and equality and in a healthy environment.'
- Planet: 'We are determined to protect the planet from degradation, including through sustainable consumption and production, sustainably managing its natural resources and taking urgent action on climate change, so that it can support the needs of the present and future generations.'
- Prosperity: 'We are determined to ensure that all human beings can enjoy prosperous and fulfilling lives and that economic, social and technological progress occurs in harmony with nature.'
- Peace: 'We are determined to foster peaceful, just and inclusive societies that are free from fear and violence. There can be no sustainable development without peace and no peace without sustainable development.'
- Partnership: 'We are determined to mobilize the means required to implement this Agenda through a revitalized Global Partnership for Sustainable Development, based on a spirit of strengthened global solidarity, focused in particular on the needs of the poorest and most vulnerable and with the participation of all countries, all stakeholders and all people.'

The 17 goals are focused on global health, education, poverty alleviation, equity and equality, clean energy and water, economic growth, peace and justice and environmental preservation and sustainability. Nested within the goals are 169 targets and 232 indicators, which nations can work towards, and which when combined, help meet the broader targets and goals? (UN 2018). The indicators within each goal are split into three tiers based on the methodology for their computation and assessment.

- Tier I: Indicator is conceptually clear, has an internationally established methodology, and established standards for its evaluation, and data are regularly produced by at least 50% of countries in regions where the indicator is relevant.
- Tier II: Indicator is conceptually clear, has an internationally established methodology and standards are available, but data are not regularly produced by countries.
- Tier III: No internationally established methodology or standards are yet available for the indicator, but methodology/standards are being (or will be) developed or tested.

Ideally, the global indicators should be calculated using internationally-standardised methods for consistent reporting. This has been the focus of the UN in preparing detailed guidelines for the calculation of each indicator. There are also global metadata for Tier I and Tier II indicators that countries can draw upon in reporting on their SDGs[1]. These are data and statistics provided by the UN System and other international organizations. They are not yet available for Tier III indicators which are still under methodological development.

Nevertheless, it has been recognised that local circumstances may necessitate some degree of "domestication" of the indicators, for example, in cases where the indicator in its existing form does not pertain to the local context or in the cases of data limitations (see Stats SA 2019 for examples). Different countries have therefore developed national indicators and their own guidelines for indicators for SDG reporting.

1.2 Potential role of Natural Capital Accounting in producing indicators

Natural Capital Accounting (NCA) refers to the use of an accounting framework to provide a systematic way to measure and report on stocks and flows of natural capital, analogous to accounts for other forms of capital. It 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. NCA is being constantly refined globally as more countries pilot incorporating ecosystem accounts into the national accounting frameworks, with lessons learnt in different places informing developments in the accounting framework and process.

The System of Environmental-Economic Accounts (SEEA) has been developed by the UN/UNSD to integrate economic and environmental data in a way which highlights the links between economic activities and the environment and to elucidate the importance of stocks and flows of environmental assets which are often neglected in standard national statistical computation. The framework uses consistent and standardised concepts, definitions and classifications which allow for internationally comparable statistics to track the contribution of ecosystems and natural resources to social and economic goals, such as water security, food security and job creation. The process can provide a wealth of information that can improve planning and decision-making related to the management of natural resources and in so doing, can enable the assessment of progress towards sustainable development which is made measurable by the SDG indicators and the various indices required to report on.

The United Nations Environment Programme World Conservation Monitoring Centre and United Nations Statistics Division (UNSD, 2019) have 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 Experimental Ecosystem Accounting (EEA) framework (see UN 2014; 2017). Of these 17 indicators, four were selected as 'full possibilities' for alignment with the SEEA, and all four have covered multiple reporting commitments. These four priority indicators are:

- SDG 6.6.1: Change in the extent of water-related ecosystems over time;
- 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;
- SDG 15.1.1: Forest area as a proportion of total land area; and
- SDG 15.3.1: Proportion of land that is degraded over total land area.

[1] https://unstats.un.org/sdgs/metadata/

1.3 The South African context

South Africa was one of the first supporters of the 2030 Agenda for Sustainable Development. South Africa has developed national plans and strategies with the aim of meeting international SDGs within the local socio-economic and environmental context of South Africa and its policy environment (Stats SA 2019). Stats SA coordinates the reporting on SDG indicators for South Africa, in collaboration with a range of institutions. To guide national reporting on SDGs, Stats SA prepared the **Sustainable Development Goals: Indicator Baseline report 2017** (Stats SA 2017), which covers 98 (out of the 156) indicators for which the necessary data to report progress on currently exists within the country or elsewhere. This was devised with the help of working groups for each goal or group of goals. The report provided values for these indicators for a base year 2016 (or as close as possible). Following this, Stats SA produced the **Sustainable Development Goals: Country report 2019**, which was the "first full-scale report" on progress towards the SDGs and expanded on the list of indicators included (Stats SA 2019). Of the four indicators discussed above, one was included in the Baseline Report, and three were included in the Country Report (Table 1).

Table 1. Inclusion of the four indicators in the 2017 and 2019 South African SDG reports.

	Baseline Report 2017	**Country Report 2019**
SDG 6.6.1: Change in the extent of water-related ecosystems over time;	-	Included
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;	-	-
SDG 15.1.1: Forest area as a proportion of total land area; and	Included	Included
SDG 15.3.1: Proportion of land that is degraded over total land area.	-	Included

South Africa has begun a process of embarking on NCA in line with the SEEA EA methodology and guidelines. Land and terrestrial ecosystem accounts, accounts for protected areas, land accounts for metropolitan municipalities, and species accounts for rhinoceros and cycads have been produced (Stats SA 2020a, 2020b, 2021a, 2021b). This report investigates the potential usefulness in informing the indicators in Table 1.

1.4 Aim of this study

The aim of this study was to assess the usefulness of NCA in informing four indicators identified by UNSD (2019) as priorities for testing. To this end, the study aimed to identify how well South Africa's ecosystem accounts are aligned with the indicators in terms of data requirements and calculation as well as conveying the intended purpose and meaning of the indicators.

Following UNSD (2019), for each indicator, the assessment aims to identify whether ecosystem accounting:

- Is essential to and ideal for calculating the target indicator;
- provides additional information that supports reporting on the indicator; or
- is irrelevant in its calculation.

Based on our findings we make recommendations 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 (along with other countries carrying out similar evaluations).

1.5 Structure of this report

The next four sections deal with each of the SDG indicators to be tested as identified above. For each of these indicators, we provide:

- A brief description and rationale for the indicator;
- An overview of the UN's guidelines for its computation and where relevant, an overview of the global datasets that can inform its calculation;
- How South Africa has computed this indicator (if at all) in SDG reporting to date;
- A brief account of the relevant data in the ecosystem accounts being compiled by South Africa following SEEA guidelines;
- A discussion on whether and how ecosystem accounting will be able to improve on SDG reporting in South Africa, how South Africa might domesticate indicators, and how the SDG indicators might be improved and/or aligned with the SEEA.

The report is concluded with a brief summary of the findings and recommendations, focusing on the role of ecosystem accounting in SDG reporting.

2 INDICATOR 6.6.1: SPATIAL EXTENT OF WATER-RELATED ECOSYSTEMS

2.1 Description and rationale

"Spatial extent of water-related ecosystems" is an element (sub-indicator) of Indicator 6.6.1, an indicator for Target 6.6 which falls under SDG 6:

- **SDG 6**: Ensure availability and sustainable management of water and sanitation for all.
- **Target 6.6**: By 2030 protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.
- **Indicator 6.6.1**: Change in the extent of water-related ecosystems over time.
- Sub-indicator 1: Spatial extent of water-related ecosystems.

Target 6.6 focuses on the protection and restoration of water-related ecosystems in order to secure the delivery of essential ecosystem services. In the context of SDG 6, this specifically relates to the supply of freshwater to society. While other indicators cover the contribution of other types of ecosystems to water supply, Indicator 6.6.1 focuses on waterbodies and wetlands (UNSD, 2018d).

Indicator 6.6.1 tracks the **change in the extent of water-related ecosystems over time**. The indicator includes five categories: 1) vegetated wetlands, 2) rivers and estuaries, 3) lakes, 4) aquifers, and 5) artificial waterbodies. Importantly, UN guidelines explain that the term "extent" goes beyond spatial extent to capture additional basic parameters needed for the protection and restoration of water-related ecosystems. Importantly, "extent" therefore includes three components: the spatial extent or surface area, the quality, and the quantity of water-related ecosystems. To address its complexity, Indicator 6.6.1 has been divided into 5 Sub-Indicators to capture the various data sources and methodologies required for monitoring components of the Indicator. Data sources come from a combination of ground sampling and earth observations. Depending on the type of ecosystem and the type of extent being measured, the data collection methodology can also differ greatly. A progressive monitoring approach with two levels is proposed by the UN:

- Level 1: 2 Sub-Indicators based on globally available data from earth observations which will be validated by countries against their own methodologies and datasets:
  - Sub-Indicator 1 – spatial extent of water-related ecosystems
  - Sub-Indicator 2 – water quality of lakes and artificial water bodies
- Level 2: Data collected by countries through 3 Sub-Indicators:
  - Sub-Indicator 3 – quantity of water (discharge) in rivers and estuaries
  - Sub-Indicator 4 – water quality imported from SDG Indicator 6.3.2
  - Sub-Indicator 5 – quantity of groundwater within aquifers

Since sub-indicator 1 is the element of Indicator 6.6.1 that deals with spatial extent, this could potentially be informed by ecosystem extent accounts. The others could be informed by condition accounts in future, but are not discussed here.

2.2 UN guidelines and international data sources

It is anticipated that this sub-indicator will be measured using satellite data on the spatial extent of open water over a long period of time, taking seasonal changes into account. To distinguish one water-related ecosystem type from another, further processing of this open water data is required in conjunction with other datasets. Thus, open water has to be categorised into lakes, rivers and estuaries versus artificial waterbodies (such as dams). In addition, vegetated wetlands are to be discerned through more complex processing of Earth observation data such as soil moisture and vegetation water content combined with other geospatial datasets related to the topography, the hydrography and the soil types. The resulting datasets obtained from earth observations on the spatial extent of vegetated wetlands and artificial waterbodies are excluded from the calculation of spatial extent values for lakes, rivers and estuaries, to prevent duplication of spatial extent estimations.

Three global datasets are generated through this methodology annually: spatial extent of lakes, rivers, and estuaries; spatial extent of artificial waterbodies; and spatial extent of vegetated wetlands. These spatial extent datasets are provided to countries to validate. Once validated, the annual datasets are used to calculate percentage change of spatial extent over time, using a 2001-2005 baseline period. Subsequent five-year averages are compared to this baseline. The three global datasets are as described below, giving their outputs for South Africa:

- The European Commission's Joint Research Centre (ECJRC) has produced a GIS dataset of the location and spatial distribution of surface water, from 1984 to 2015, at 30 m resolution, with over 95% accuracy, for the entire planet (Pekel *et al.* 2016). This dataset has been derived from Landsat satellite imagery, specifically to inform this sub-indicator. Based on this dataset, the total surface water extent for South Africa was 526 096 ha (0.43% of total land area) in 1990 and 571 551 ha(0.47% of total land area) in 2014 (Figure 1). This is appropriate in principle to inform the sub-indicator, but may not be accurate at this scale.

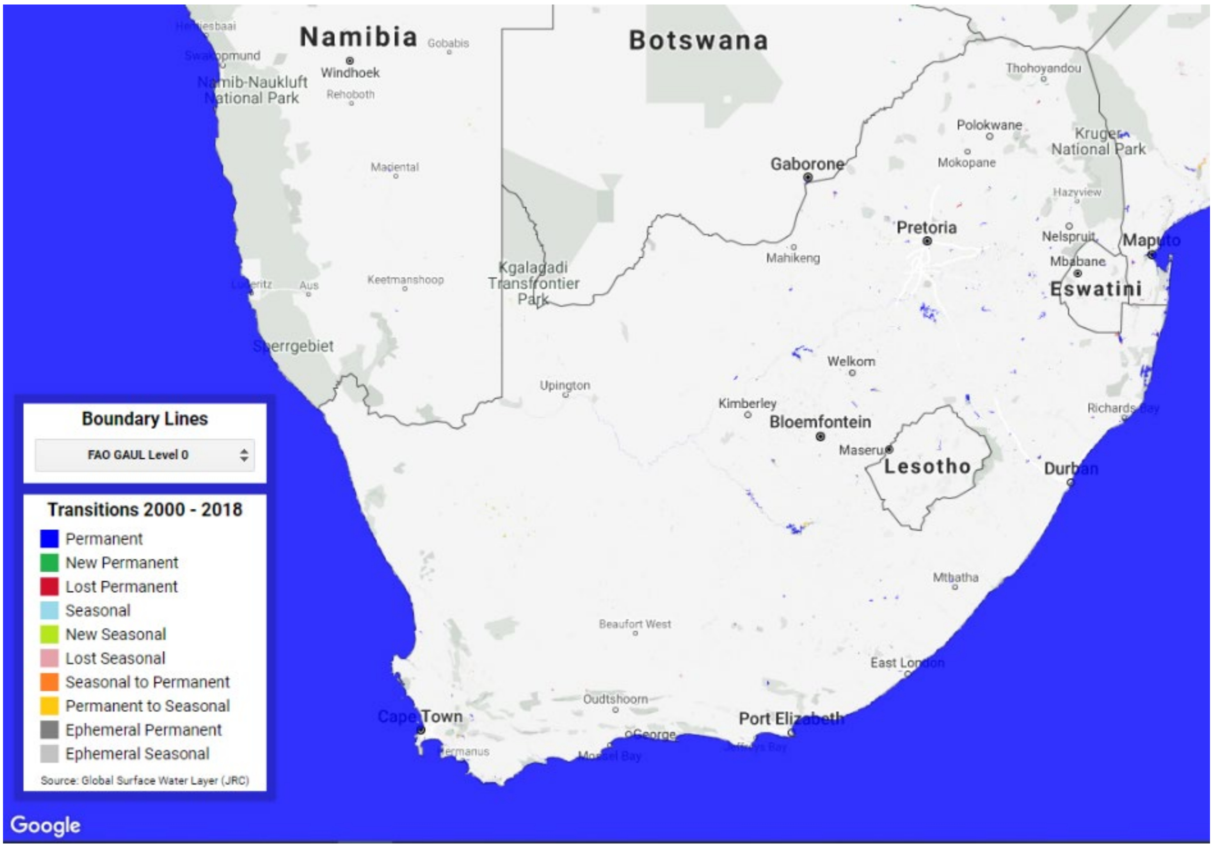

Figure 1. The extent and changes of water-related ecosystems in South Africa between 2000 and 2018 on the ECJRC (Pekel et al. 2016) online tool aimed at reporting towards SDG 6.6.1.

- The Ramsar International Convention on Wetlands (RAMSAR) provides a database of Ramsar sites (although this includes terrestrial land surrounding surface water). This dataset shows that South Africa's 26 sites cover just over 563 000 ha (RAMSAR 2020). This dataset is not sufficient or appropriate for informing the sub-indicator, however, as Ramsar sites make up only a small proportion of water-related ecosystems in South Africa.

- A Global Lakes and Wetlands (GLW) database is also available, but is at a very coarse resolution and excludes most small wetlands and rivers. It suggests that 1 536 066 ha or just under 1.3% of South Africa's land surface is classed at waterbodies (Lehner and Döll 2004). This database is not considered to be sufficiently reliable for reporting on this indicator at national scale.

In addition, a Wetland Extent Trends (WET) Index has been developed to track the status of wetlands globally (Darrah et al. 2019). This is based on time series data collated from a large number of countries, but is not a systematised source of information to draw on at national level. Rather, it might benefit from more rigorous national-level accounting.

2.3 South Africa's approach to date

Spatial extent of water-related ecosystems was not included in South Africa's SDG Baseline Report (Stats SA 2017), but was included in the SDG Country Report for 2019 (Stats SA 2019). This was based on data provided by SANBI and the Department of Water and Sanitation (DWS)[2]. Spatial extent (in km^2) was reported at a national scale for a slightly different set of ecosystem types to the five suggested by the UN (see above), namely: wetlands (vegetated and ephemeral), inland lakes, estuaries and artificial waterbodies (dams). Rivers were excluded from the analysis as the extent of rivers had not changed noticeably, but it was noted that rivers are critical ecosystem types under serious threat (SANBI 2019) and need to be included in the future. According to the SDG Country Report for 2019 (Stats SA 2019), dams, estuaries, wetlands and lakes accounted for 0.17%, 0.23%, 2.70% and 0.10% of the country's total surface area, respectively. This was based on the HYDSTRA Database produced by SANBI and CSIR (Stats SA 2019). These figures were acknowledged to be based on a rapid assessment that did not fully assess the total extent and condition of waterbodies in South Africa.

Meanwhile, SANBI has embarked on the development of a South African Inventory of Inland Aquatic Ecosystems (SAIIAE; van Deventer *et al.* 2018). While this has not been used in SDG reporting to date, it has been used in the latest National Biodiversity Assessment (NBA) of 2018, and is intended to be used in future editions of the NBA. The SAIIAE draws on a number of datasets on the extent and state of the country's aquatic resources that have mostly been developed by SANBI, who are the custodians of river, wetland and estuary data in South Africa. The SAIIAE includes comprehensive data on rivers (both spatial data and ecological condition), natural wetlands, artificial (man-made) wetlands, peatlands, aquaculture sites, thermal springs, wastewater treatment works and estuaries, all of which underpinned the inland aquatic and estuarine components of the NBA (SANBI 2019). It includes a National Wetland Map. Based on SAIIAE, the combined area of aquatic ecosystems (excluding narrow rivers[3]) in 2018 was roughly 4 124 798 ha, or 3.4% of the mainland terrestrial area. This is a substantially higher figure than both the Pekel *et al.* (2016).

Thus so far, South Africa has used different datasets for reporting on the extent of water-related ecosystems in the SDGs and the NBA. Going forward, it is expected that the existence of an ecosystem accounting framework will help to define which data are used in which reporting obligations.

[2] Now the Department of Human Settlements, Water and Sanitation (DHSWS)

[3] Which don't appear as polygons in the GIS dataset.

2.4 Relevant data in South Africa's Natural Capital Accounts

The first Land and Terrestrial Ecosystem Accounts (LTEA) have been produced at a national scale for 1990 to 2014 (Stats SA 2020) and include a land cover class for waterbodies. The LTEA was based on the South African National Land Cover data for 1990 and 2014 (GTI 2015, 2016), which are produced at 30 m resolution. The waterbodies class in the LTEA was the combination of three of the 72 land cover classes in the NLC, namely "wetlands", "water seasonal" and "water permanent". The description of these classes is provided in Table 2 below.

Table 2. Description of National Land Cover classes that relate to surface water

National Land Cover classes	Description of land cover class
Wetlands	Wetland areas that are primarily vegetated on a seasonal or permanent basis. Defined on the basis of seasonal image identifiable surface vegetation patterns (not subsurface soil characteristics). The vegetation can be either rooted or floating. Wetlands may be either daily (i.e. coastal), temporarily, seasonal or permanently wet and/or saturated. Vegetation is predominately herbaceous. Includes but not limited to wetlands associated with seeps/springs, marshes, floodplains, lakes / pans, swamps, estuaries, and some riparian areas.
Water permanent	Areas of open, surface water, that are detectable on all image dates used in the Landsat 8 based water modelling processes. Permanent water extent typically refers to the minimum water extent, which occurs throughout the 2013-14 assessment period. Includes both natural and man-made water features.
Water seasonal	Areas of open, surface water, that are detectable on one or more, but not all image dates used in the Landsat 8 based water modelling processes. Seasonal water extent typically refers to the maximum water extent, which may only occur for a limited time within the 2013-14 assessment period. Includes both natural and man-made water features.

The reason that these classes were aggregated in the initial set of LTEA was that South Africa was in the process of developing more comprehensive and accurate sources of data for inland water ecosystems (the SAIIAE, described above), and that these classes are not considered a meaningful reflection of the extent of water-related ecosystems. South Africa will in future develop more comprehensive freshwater ecosystem accounts, using the SAIIAE.

2.5 Discussion and recommendations

South Africa has datasets on aquatic ecosystems of much higher quality than the global datasets on offer. The NLC datasets, from which the LTEA was developed, have a high level of accuracy (88 and 99% for wetlands and water respectively in the 2014 NLC product). Nevertheless, remote sensing has limitations in picking up some types of water-related ecosystems. The SAIIAE combines remote sensing with other data to produce the most comprehensive dataset on water-related ecosystems for South Africa. It includes many small waterbodies that are not picked up in other datasets, and reports the highest area of water-related ecosystems of the available global and national datasets (Table 3).

Nevertheless, none of the South African datasets have the temporal resolution required for accurate reporting on trends, at this stage. For example, in the LTEA, the combined waterbodies class covered 1.7% of the total mainland area in 1990, and 1.2% in 2014. This suggests a 32.2% net decline in extent over this period. However, 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, and in this case the decrease in area is likely to reflect primarily that 1990 was a wetter year than 2014. This highlights the need for a good temporal data either at regular intervals or using a dataset compiled by assessing waterbodies of a long period of time and making adjustments to create an accepted value. The assessments should be derived from far more frequent analysis, and/or a combination of satellite data and on-the-ground monitoring data.

National wetland data in National Wetland Map, which is part of SAIIAE, is spatially and categorically (typologically) more refined and accurate than global estimations based on automated remote sensing algorithms. The development of the National Wetland Map involved a great deal of fine scale, manual digitising of wetland features. But these data are difficult to update regularly (i.e. temporal resolution will always be a challenge). The global regional and national remote sensing products are a blunt tool for delineation of wetlands (though good for waterbodies), but are excellent tools for tracking temporal change. Fusing these somehow is likely the best solution, for example by iteratively training the remote sensing algorithms to focus on the change in the predefined wetlands areas that are part of the National Wetland Map.

Table 3. 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

There could be issues with resolution if the indicator is compiled directly from the ecosystem accounts, rather than from the source data themselves. Because the accounts summarise data at a 100 m resolution, some detail could be lost for small or narrow features. This is an issue for water related ecosystems which often comprise high numbers of very small wetlands. Therefore, the highest quality indicator would be from the SAIIAE data directly, but it may also be possible to generate similar quality data from freshwater ecosystem accounts if a sub-BSU grid is used (e.g. with 20 m divisions). The difference in values using the 100 m BSU compared to a sub-BSU will be tested when freshwater ecosystem accounts are developed. Tracking the extent of water-related ecosystems using global databases is unlikely to be very accurate at this stage, but these will likely improve over time.

A key potential weakness of the indicator if applied too simply, is its inability to distinguish what has been permanently lost versus temporarily lost 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) is important in this regard, and can be delivered by freshwater ecosystem accounts.

It is therefore recommended that South Africa uses the SAIIAE (its highest quality data on aquatic ecosystems) as the basis for freshwater ecosystem accounts and reports on the remaining extent of wetlands based on an estimation of their natural full extent that takes both seasonality and longer period natural variation into account. The Land and Terrestrial Ecosystem Accounts are not considered to provide reliable information about the extent water-related ecosystems, and should not be used to report on this indicator. It will also be necessary to track the longer term (interannual) variation wet and dry cycles and extended droughts in the accounts as this is important for more accurate description of the delivery of ecosystem services. Ideally, the land cover data will need to be better refined to track these interannual variations.

3 INDICATOR 11.7.1: ACCESS TO URBAN OPEN SPACE

3.1 Description and rationale

Indicator 11.7.1 on access to open space in cities is an indicator for Target 11.7, which falls under SDG 11:

- **SDG 11**: Make cities and human settlements inclusive, safe, resilient and sustainable.
- **Target 11.7**: By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities.
- **Indicator 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.**

This indicator supports baseline data that can be used for long-term planning to achieve sustainable urban development. Open public spaces are important as they contribute significantly to the wellbeing of urban residents (WHO 2016, White et al. 2017). This has often been overlooked or underestimated by planners and policy makers, largely because the use and value of open space is still so poorly understood. In rapidly urbanizing countries, particularly in Africa, cities are experiencing dramatic reductions in the quantity and quality of public open space areas, and evidence suggests that this will have a negative impact on quality of life (White et al. 2017). UN-Habitat has been promoting the concept of urban open space since 2011, and has undertaken initiatives to guide cities in securing open space areas, and to develop consistent methods for defining and reporting on public open space in cities. These spaces are seen to provide a means of humanizing cities and making streets and public areas more communal, so that public and private spaces can enhance one another. To this end, UN-Habitat has developed tools, programmes and guidelines to assist cities in measuring, and accounting for the available public space in cities.

3.2 UN guidelines and international data sources

Following the piloting of methods in over 250 cities, the UN Habitat guidelines for calculating SDG 11.7.1 recommend a three-step process:

a) Spatial analysis to delimit the built-up area of the city;

b) Spatial analysis to identify potential open public spaces, field work to validate data and access the quality of spaces and calculation of the total area occupied by the verified open public spaces;

c) Estimation of the total area allocated to streets;

In the first step, using satellite-derived land cover data, the built-up area is defined by determining the percentage of a 1 km^2 circle around each pixel that is classified as built up. If this is >= 50%, then the pixel is deemed to be urban, or if between 25% and 50%, then it is suburban. If it is <=25%, then the pixel would be classified as rural. Contiguous urban and suburban pixels are combined into urban clusters. We find this approach to defining the urban boundary to be somewhat flawed, and this is discussed further below.

In the second step, open public spaces within the urban boundaries defined above are mapped based on inventories, land use plans and satellite imagery. Field work is required for verification, and can be carried out with the help of a freely available tool developed by UN-Habitat.[4] This step allows the calculation of the area of open spaces.

In the third step, the area of the streets within the urban extent is computed using detailed spatial data, data on lengths and widths of streets, or a sampling approach in which detail on streets is digitized for randomly-selected areas and then extrapolated. It is not clear from the guidelines how verges are dealt with.

According to the guidelines in the metadata description, the indicator is then computed as follows for an urban agglomeration:

$$\%\,Open\ Space = \frac{Open\ public\ space\ area + Street\ area}{Built-up\ area}$$

3.3 South Africa's approach to date

The indicator for urban open space has not been reported in either the Baseline (Stats SA 2017) or Country Report (Stats SA 2019), and there appears to be no existing framework in South Africa for reporting on open space in the urban context. Urban sustainability in South Africa has generally focused on renewable energy, food security, waste and water management, and climate change mitigation and adaptation. However, some South African cities have developed their own systems for open space information management (see discussion below).

3.4 Relevant data in the National Land and Ecosystem Extent Accounts

South Africa has developed a set of Land Accounts for Metropolitan Municipalities (hereafter the metro accounts; Stats SA 2021a). South Africa's mainland terrestrial area is divided into nine provinces and within these, 44 district and eight metropolitan municipalities. Metropolitan municipalities (hereafter referred to as metros) 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. Collectively they cover just over 2 million ha in five provinces.

In addition to summarising changes in land cover classes within an administrative boundary[5] in a formal accounting framework, the metro accounts also describe (a) the proportion of green open space area and (b) the degree of greenness within the urban land cover classes as a supplementary analysis. These are briefly outlined below.

The land accounts for metros describe changes in the extent of built-up land, cultivated land, natural or semi-natural land, and waterbodies, within the boundary of each metropolitan municipality, with built-up and cultivated land cover classes also being subdivided into more detailed classes. The built-up land cover classes include "urban parkland"[6] which includes most managed urban parks. However, it

[4] https://ee.kobotoolbox.org/x/#IGFf6ubq

[5] Municipal boundaries are determined by the Municipal Demarcation Board. There are small adjustments from time to time but the boundaries are relatively stable.

[6] Urban Parkland is defined in the National Land Cover as "Areas containing a low-density mix of buildings, other built-up structures associated with golf courses. The class includes both residential golf estates and non-

is important to note that the account covers the entire metropolitan municipality, including semi-rural and rural areas. The metro accounts are effectively a subset of the national Land and Terrestrial Ecosystem Accounts. They use exactly the same land cover classification and grouping of land cover classes into three tiers as in the LTEA

The metro accounts 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. The results from the metro accounts show that urban parkland as a proportion of the total urban area (as per land cover classes) ranged from 5.8% to 1.3% in 1990 and between 5.8% and 1.4% in 2014 across the eight metros. During this period, only two metros (Buffalo City and the City of Cape Town) showed a decline in this land cover class (urban parkland). Nelson Mandela Bay (Port Elizabeth) had the greatest proportional representation of this land cover class, 5.8% in 2014. If natural land cover and other green spaces not captured well in the metro areas by the urban parkland class in the NLC, were included, the figures are likely to be substantially higher. The expansion of urban green space relative to the growth of the city as a whole is also important. The urban metro account shows that between 1990 and 2014, urban parkland increased by 19.6 ha for every 100-ha increase in all urban land cover area in Nelson Mandela Bay. Ekurhuleni showed an increase of 8.1 ha per 100 ha, while the remaining cities were below 5 ha per 100 ha, or negative whereby urban parkland was lost.

However, the “urban parkland” land cover class in the NLC dataset does not adequately and consistently capture urban green open space. Many open spaces, including waterways, timber plantations and natural vegetation, are not captured in this class, and are classified as other built-up, cultivated or natural classes. The use of a 1-ha basic spatial unit has also proved too coarse to interpret land cover change within urban environments. In future metro accounts, the use of a sub-BSU (e.g. 20 m or 50 m) may be explored.

As a supplementary analysis 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 this 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 derived from the detailed land cover classes that include whether urban residential areas have a backdrop of bare ground, grass, bush or trees, and summarised 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 metros are semi-rural, with open space that may be beneficial to residents, however they are often inaccessible and do not fit the SDG 11.7.1 definition of open spaces (safe, accessible green and public spaces within the *built-up* area of a city). As such it is important to be guided by the methodology in defining an urban extent, after which calculating the indicator can be achieved more accurately.

3.5 Discussion and recommendations

The metro accounts, as they stand, do not provide an overall indication of the share of public open space in its urban areas. This is because:

- The accounts do not cover all urban areas – smaller cities and towns in municipalities other than the metros were not included;

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residential golf courses, and typically represents the border extent of the entire estate or course”. However, the description could be broader as in reality most managed urban parks and managed green open spaces fall into this class.

- The criteria to define a land cover class as urban (i.e. defining urban extent) in the NLC were different to those in the UN-Habitat guidelines;

- The NLC does not distinguish all the types of public open space required by the indicator;

- The NLC urban parkland class is not consistently defined and has not been verified; and

- The basic spatial unit is too coarse to track this indicator with accuracy, and data would need to be analysed at a sub-BSU scale.

These issues are discussed further below.

South Africa's metro accounts describe land cover and land cover changes in the eight metropolitan municipalities (metros) which include the largest urban agglomerations in the country. There are also many urban areas outside of these metros. Indeed, the country's city regions have also been delineated and do not align entirely with municipal boundaries (see van Huyssteen et al 2018; CSIR 2018). In submitting 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 (the latter is not clear from the guidelines). It is likely that urban open space increases in importance with increasing city size (in area or population). Below some threshold, smaller towns would tend to have more connection with their surrounding open space (Turpie *et al.* 2020). Therefore, within the national context, it would be important to identify which urban centres would be included for monitoring progress towards this indicator. It may even be that *every* municipality tracks progress within the primary urban areas, as long as the contiguous urban area meets a certain minimum area threshold. Alternatively, a representative sample could be considered.

The NLC does not follow the UN-Habitat (2018) guidelines on determining urban extent. This would be a very helpful modification. In the UN-guidelines, the primary spatial area in which to calculate the amount of open space, is paradoxically the built-up area. However, as per the definitions in UN-Habitat (2018), it would be more appropriate to use the urban extent. The urban extent is defined 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*" (UN-Habitat 2018). 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 this method be used as the primary determinant of urban extent.

It is important to note that the global indicator refers to public open space rather than *green* public open space, and includes built-open space such as plazas, streets and walking boulevards, as well as public open spaces such as parks (UNEP-WCMC 2018). 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 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 20 or 30 m for land cover data). 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. Particularly good examples are the eThekwini Municipality's Durban Metropolitan Open Space System (DMOSS; eThekwini Municipality date unknown) and the City of Cape Town's BioNet (Holmes and Pugnalin 2016). Other existing data that may be able to be integrated could be open space data from cadastral layers held by Stats SA (although these could be out-of-date) or newly developed urban land cover and open space spatial layers produced by GeoTerraImage. These may be useful in developing standardised open/green space datasets that are consistent across the country which need to be regularly maintained (possibly under a central body such as the South African Cities Network). Such datasets 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 (as per indicator guidelines), none of which has 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. Land and ecosystem accounts are unlikely to be a good source of information for this aspect of the indicator. Furthermore, 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 open space, whether green or built-up. As explained above, as a supplementary analysis to 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 this areas. This measure does not necessarily fulfil the requirements for Goal 11 (i.e. it would not be required as an indicator), but does help to contextualise progress against this goal. 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. The current metro accounts could deliver information on green open spaces. Further work would be required to distinguish if these are publicly accessible. Other, hard covered, public spaces are not distinguished from built-up area, and it would likely require significant effort to identify those. Including streets in the indicator would not be ideal in South Africa given safety concerns. One option would be to exclude streets when adapting SDG 11.7.1 to national circumstances; another could be to include only certain streets, for example those with high greenness indicator values.

4 INDICATOR 15.1.1: FOREST AREA

4.1 Description and rationale

Indicator 15.1.1 on forest area is an indicator for Target 15.1, which falls under SDG 15:

- **SDG 15**: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

- **Target 15.1**: By 2030, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements.

- **Indicator 15.1.1: Forest area as a proportion of total land area**

The rationale for the indicator is the fact that forests are considered vital for humanity, including through provision of a range of valuable goods and services, and that changes in forest area can indicate unsustainable practices in the forestry and agricultural sectors.

4.2 UN guidelines and international data sources

The indicator is conceptually clear, with an established methodology that has global traction. It is essentially calculated as forest area (in a reference year), divided by the total land area, and expressed as a percentage. Total land area is the total surface area of the country less the area covered by inland waters, such as major rivers and lakes.

The UN has adopted the very broad FAO definition of the term ‘forest’ (UNEP-WCMC 2019): “land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*.” This does not include land under agricultural or urban land use. More specifically:

- Forest is determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 meters.

- It includes areas with young trees that have not yet reached but which are expected to reach a canopy cover of at least 10 percent and tree height of 5 meters or more. It also includes areas that are temporarily unstocked due to clear-cutting as part of a forest management practice or natural disasters, and which are expected to be regenerated within 5 years. Local conditions may, in exceptional cases, justify that a longer time frame is used.

- It includes forest roads, firebreaks and other small open areas; forest in national parks, nature reserves and other protected areas such as those of specific environmental, scientific, historical, cultural or spiritual interest.

- It includes windbreaks, shelterbelts and corridors of trees with an area of more than 0.5 hectares and width of more than 20 meters.

- It includes abandoned shifting cultivation land with a regeneration of trees that have, or are expected to reach, a canopy cover of at least 10 percent and tree height of at least 5 meters.

- It includes areas with mangroves in tidal zones, regardless whether this area is classified as land area or not.

- It includes rubberwood, cork oak and Christmas tree plantations.
- It includes areas with bamboo and palms provided that land use, height and canopy cover criteria are met.
- It excludes tree stands in agricultural production systems, such as fruit tree plantations, oil palm plantations, olive orchards and agroforestry systems when crops are grown under tree cover.
- Note: Some agroforestry systems such as the "Taungya" system where crops are grown only during the first years of the forest rotation should be classified as forest.

The above is ambiguous on how exotic timber plantations such as pines and gums in South Africa should be treated. Here, the above definition is taken to mean that timber plantations of exotic tree species should be included. Indeed, in reference to this indicator, the FAO reports that "Forests cover about 4 billion hectares or 30.7 per cent of the world's land area. Of these, 93 percent (or 3.7 billion ha) are natural forests while 7 percent (291 million ha) are planted. Despite a decrease in forest area over the last decades…"[7] The broadness of the FAO definitions in general suggest that they are focused on forests as a source of wood products (rather than forests as ecosystems), with timber plantations being a key source of wood products.

Data on forest extent has been increasing exponentially over the past couple of decades. The FAO has been monitoring the world's forests since 1946 and produces Global Forest Resources Assessments (FRA) every five years, covering 236 countries. From 2015, data are available on an annual basis. These data are archived in the FAO Statistical Database FAOSTAT.[8] In addition, there are a number of satellite-derived datasets, all of which have open access. These include NASA's MODIS and ESA's CCI land cover datasets, the University of Maryland's Global Forest Change database on tree cover, the World Resources Institute's Global Forest Watch annual data on forest cover and condition, the UNEP-WCMC's Global Mangrove Watch. The Global Forest Watch is one of the best-known tools for tracking forest extent (WRI 2014).

4.3 South Africa's approach to date

In its reporting on this indicator, South Africa has chosen to restrict reporting to indigenous natural forest and natural woodland area. The 2019 country report states "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." This is because the timber plantations are established for commercial purposes and displace natural areas, resulting in outright loss of natural ecosystems and biodiversity. They have also resulted in the establishment and spread of invasive plants, as the exotic tree species that are cultivated in timber plantations are invasive. The expansion of invasive alien trees is a major ecological challenge in South Africa, with substantial negative impacts on water security (the trees use much more water than indigenous vegetation), food security (for example when rangelands are invaded, reducing their suitability for grazing) and biodiversity (invasive trees displace indigenous species). Thus, the inclusion of timber plantations and other stands of invasive alien trees in the definition of "forest" would contradict the essence of the Indicator and associated goal.

In South Africa, indigenous woody vegetation is disaggregated in the National Vegetation Map into three biomes: "true" forest (closed canopy), savanna (grass-tree matrix) and thicket (dense, usually lower woody vegetation) (Figure 2). Natural forests make up a very small proportion of the total land area, but savanna and thicket, which are far more extensive, also fall at least partly into the FAO definition of forests. The indigenous forest biome as defined in the National Vegetation Map includes mangroves. The definitions of these biomes in South Africa aligns with the definitions of similar biomes in the IUCN's Global Ecosystem Typology, and South Africa's biomes can be relatively easily cross-walked to the Global Ecosystem Typology,

[7] http://www.fao.org/sustainable-development-goals/indicators/1511/en/

[8] http://www.fao.org/faostat/en/#home

In the country's Baseline Report, Indicator 15.1.1 was domesticated to be based on biomes (natural forest, savanna and Albany Thicket) rather than the area with more than 10% tree cover (which would include exotic timber plantations and stands of invasive alien trees). Forests as a proportion of total land area depend on a range of factors in the South African context, where natural indigenous forests have historically been a small, naturally fragmented biome. For the indicator, the remaining extent of these biomes is calculated in relation to their historical extent (prior to major human modification of the landscape, circa. 1750). In the 2019 SDG Country Report, the extent of Natural Forest was 0.4% of the total land area historically (c.1750), dropping to 0.3% in 1990 and 2014. Savanna declined from 32% of land area historically (c.1750) to 27% in 1990 and to 26% in 2014. Albany Thicket remained at 2% in all years (Figure 3).

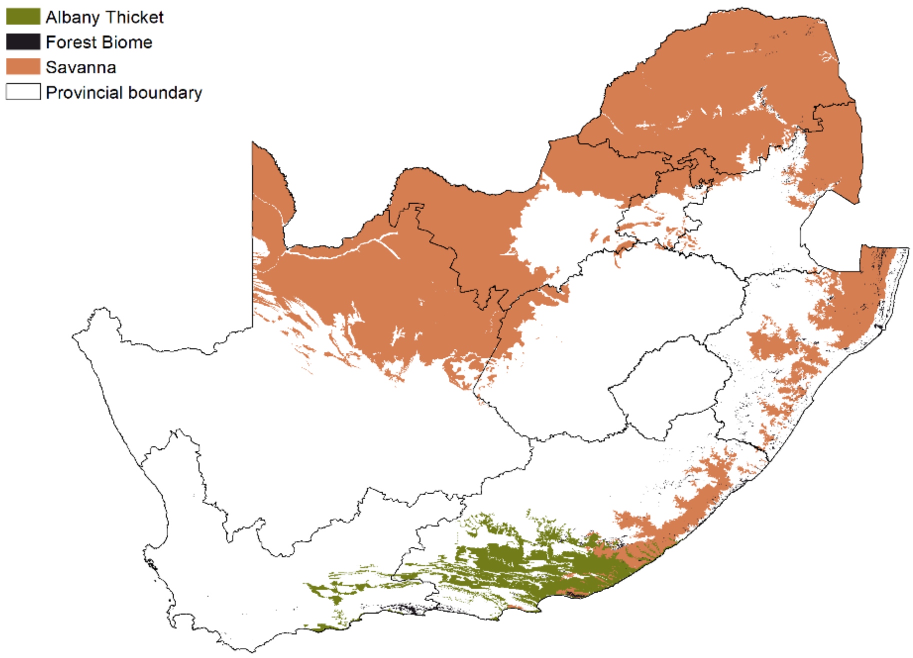

Figure 2. Historical extent (prior to major human modification of the landscape) of the forest, savanna and thicket biomes in South Africa, based on the National Vegetation Map (SANBI 2018)

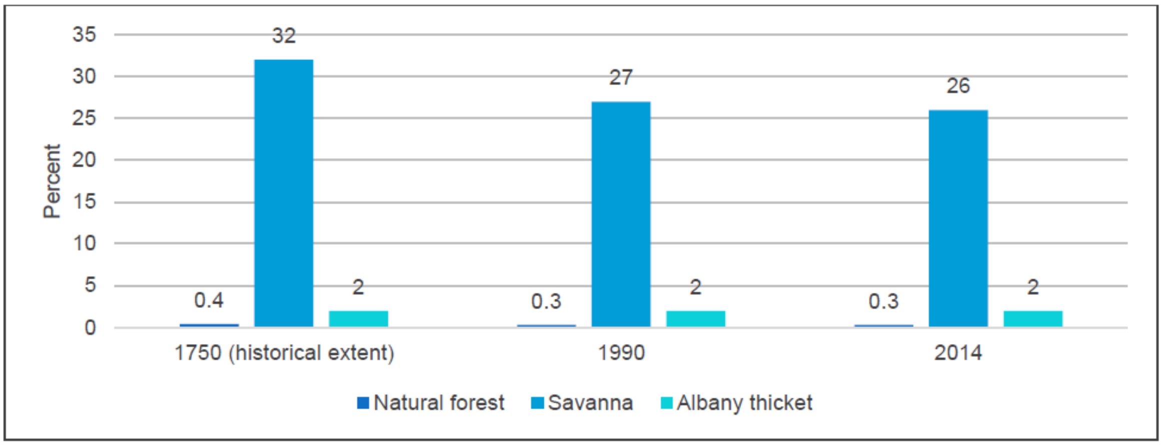

Figure 3: Domesticated version of Indicator 15.1.1, as reported in South Africa's SDG Country Report 2019: Natural forest and woodland area as a percentage of total land

(Source: Stats SA 2019)

4.4 Relevant data in the National Land and Ecosystem Extent Accounts

The Land and Terrestrial Ecosystem Accounts report on the remaining extent of each terrestrial biome and its constituent vegetation types. This includes the forest, savanna and thicket biomes and their constituent vegetation types. This is based on an overlay of intensively modified land cover classes (such as cultivated areas, urban areas and mines, which have replaced natural or semi-natural land) on the mapped historical extent of the vegetation types, yielding much the same estimates as have been provided in the SDG reports. These areas therefore suffice for the domesticated indicator as defined in South Africa's Baseline SDG report, but do not align to the FAO definition of forests used in the global indicator, as discussed above. The land accounts also report on the area under timber plantations, of relevance to the global indicator. Relevant statistics from the LTEA are provided in Table 4.

Table 4. Percentage land cover of different categories of woody vegetation reported on in South Africa's Land and Terrestrial Ecosystem Accounts, 1990 – 2014

	Exotic timber plantations	**Indigenous forest (closed canopy)**	**Savanna (woodland & treed grasslands)**	**Albany Thicket (lower woody vegetation)**
1990	0.87%	0.4%	32.3%	2.9%
2014	0.88%	0.3%	27.9%	2.7%

4.5 Discussion and recommendations

South Africa has reported on Indicator 15.1.1 using a domesticated version that reports on the remaining extent of woody biomes – forest, savanna and Albany Thicket. This provides a significantly different picture than what would be reported if the UN guidelines were followed, in that:

- Timber plantations are not included;
- The area reported on is defined by woody biomes and is not the same as that defined on the basis of tree cover; and
- Only decreases or increases within the historical extent of the biomes are reported.

South Africa has good data on the extent of timber plantations, which cover a substantial area, but has chosen to exclude it from its domesticated version of Indicator 15.1.1. To include these exotic tree plantations would go against the intention of the indicator, which is to report on performance in respect of protecting, restoring and promoting sustainable use of terrestrial ecosystems, reversing land degradation and halting biodiversity loss. As described above, exotic tree plantations replace natural ecosystems (mainly grasslands) and reduce surface and groundwater flows, hence contributing to ecosystem degradation and loss. They should be seen as a type of cultivated system (silviculture), and indeed are included in the broad land cover class "cultivated" in South Africa's land accounts. It is recommended that the global indicator follows South Africa's lead in this regard, and separates the reporting on indigenous natural forests and exotic timber plantations into two separate indicators, or drops the latter.

South Africa could produce statistics on forests as per the FAO definition, but does not propose to do so because it is not ecologically meaningful, for reasons discussed above. While the NLC 1990 and NLC 2014 datasets used in the compilation of the LTEA were not well aligned to the FAO definition of forests, the latest edition of the NLC (2018) explicitly uses 10% tree cover to delimit natural land cover types (Thompson 2019). Thus, South Africa could now in principle estimate the area of forest as per the FAO definition, on the basis of land cover data (Figure 4). Based on this approach, the area (excluding timber plantations) would be 14.3% (forest 0.3%, dense forest and woodland 1.5%, low forest and thicket 1.5% and open woodland 9.5%). This is considerably less than the area of indigenous woody vegetation types described above (30.9%), mainly because the savanna and thicket biomes includes large areas with tree cover of less than 10%.

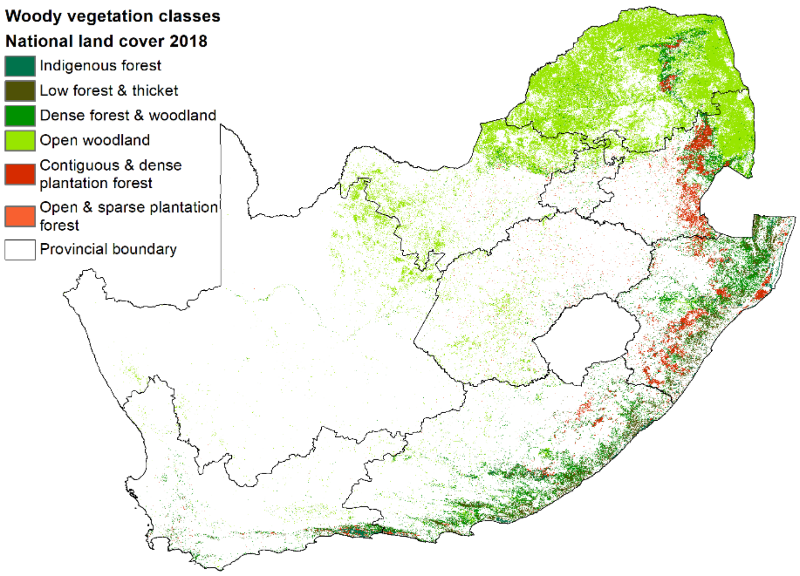

Figure 4. Extent of woody vegetation land cover classes as per the NLC 2018 dataset.

Even without taking timber plantations into account, reporting on areas with greater than 10% tree cover is not well aligned with the sense of the indicator, which is to monitor changes in ecosystems. In this regard, not all trees are equal, and not all trees are "good" from an ecological perspective. Using the land cover/FAO definition approach would mean including increases in tree-covered area as a result of (a) bush encroachment (densification of indigenous woody vegetation in savannas) and (b) the spread of invasive alien trees, as increases in the extent of forests. Areas invaded by invasive alien trees can be indistinguishable from natural woody vegetation on the basis of satellite data (Figure 5). Both bush encroachment and spread of invasive alien trees are a result of poor land management and a form of habitat degradation, having significant negative impacts on ecosystems and their services.

*Figure 5. Alien pine (*Pinus sp.*) invasion of mountain slopes outside Greyton, a biodiversity rich area in the Western Cape province, where naturally very little natural woody vegetation is found. These invasive alien pine trees are in many instances classified as 'natural' woody vegetation in land cover data and would be included in the FAO definition of forests, but they cause substantial ecological damage.*

Rather than reporting on the extent of the area of forest under the FAO definition, South Africa has taken an ecosystem perspective, and has reported on the remaining extent of woody biomes. Thus, only decreases or increases within the historical extent of the vegetation types are reported, as these are considered to provide a better sense of the status of those ecosystems.

Including increases or decreases of any kind of tree-covered area meeting the FAO forest definition would provide a completely different type of information than the domesticated indicator. The global definition of the indicator is focused more on vegetative structure (seen through a forestry lens) than on conveying a sense of the state of ecosystem health and biodiversity. Global indicators that report ecosystem change need to be fit for purpose (Rowland *et al.* 2019). 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 biomes other than forest commonly dominate. In South Africa, terrestrial ecosystem extent accounts report on the remaining extent of all terrestrial biomes, not only woody biomes, by overlaying intensively modified land cover classes (such as cultivated areas, urban areas and mines, which have replaced natural or semi-natural land) on the National Vegetation Map as a historical reference.

In addition, there is a concern that the indicators for Goal 15 do not take ecosystem health (condition) into consideration. This could be done as a composite indicator of remaining functional equivalent area by multiplying percentage remaining extent by percentage resemblance to the reference state. In future, ecosystem accounts will be able to supply this information as well, once ecosystem condition accounts have been developed.

In this regard, it is recommended that for the global SDG 15.1.1:

- Exotic tree plantations are excluded and the FAO definition of forests is abandoned in favour of the definition of forest and other woody biomes in the IUCN's Global Ecosystem Typology;
- The index is recrafted to report on each and every terrestrial biome (or at least to include a wider range of terrestrial biomes), ideally as defined by the IUCN's Global Ecosystem Typology, rather than being focused exclusively on forests;
- That ecosystem condition is taken into account to determine equivalent functional extent.

5 INDICATOR 15.3.1: DEGRADED LAND AREA

5.1 Description and rationale

Indicator 15.3.1 on degraded land area is an indicator for Target 15.3, which also falls under SDG 15:

- **SDG 15**: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
- **Target 15.3**: By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.
- **Indicator 15.3.1: Proportion of land that is degraded over total land area**

Land degradation is defined by the UNCCD as “the reduction or loss of the biological or economic productivity and complexity of rain fed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from a combination of pressures, including land use and management practices.”

The indicator is in response to a number of international initiatives and targets to halt and reverse land degradation and restore degraded land, including the Aichi Biodiversity Targets, which called for the restoration of 15% of degraded ecosystems between 2011 and 2020. It is important to note that the indicator only applies to terrestrial areas.

The intention of this indicator is to draw parallels between land degradation and socio-economic impacts such as unemployment, poverty, and declines in agricultural output at national scales. The definition of land degradation here is focused on the decline in condition and loss of net present value of predicted future ecosystem services of natural ecosystems and degradation of agricultural systems such as rainfed crops, rangeland and pastures (UNEP-WCMC 2019).

5.2 UN guidelines and international data sources

SDG indicator 15.3.1 is a binary - degraded/not degraded - quantification based on the analysis of available data for three sub-indicators to be validated and reported by national authorities:

- Trends in Land Cover;
- Land Productivity; and
- Carbon Stocks.

If any one of these sub-indicators is negative or declining for a land unit, or stable relative to an earlier negative trend, then the land unit would be considered degraded (following the One Out, All Out principle). The methodology for computing these indicators, detailed in the UN metadata for this index, has been very thoroughly developed and was endorsed by the UNCCD’s governing body in 2017. The baseline year for the indicator has been set as 2015, and its value at 2015 is derived from an assessment for the period 2000 to 2015. It has to be reported on every four years beginning 2018. The computation of the index is summarised in Figure 6. There are a number of global datasets that can be used in compiling degradation statistics, discussed below.

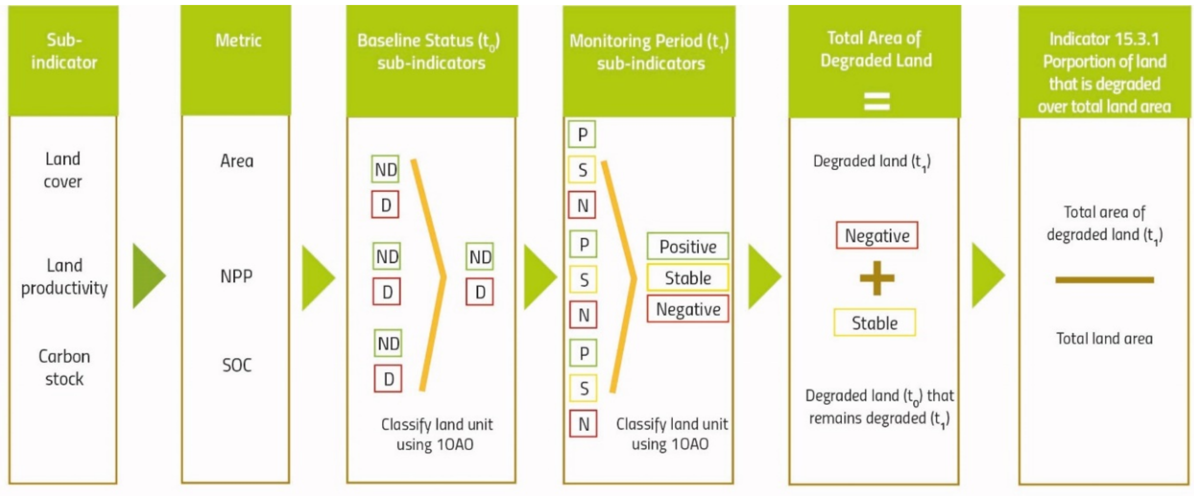

Figure 6 Steps to derive the indicator from the sub-indicators, where ND is not degraded and D is degraded (UN metadata sheet for Indicator 15.3.1).

Land cover changes are used to estimate habitat loss. In addition to any national land cover datasets that a country may have, the following global datasets are available for use:

- ESA-CCI-LC containing annual land cover area data for the period 1992-2015, produced by the Catholic University of Louvain Geomatics as part of the Climate Change Initiative of the European Space Agency; and
- SEEA-MODIS containing annual land cover area data for the period 2001-2012, derived from the International Geosphere-Biosphere Programme type of the MODIS land cover dataset.

Land productivity is the above ground net primary production (NPP) that translates into biomass accumulation, and is estimated in terms of gC/m²/day from remote sensing data. The most accurate and reliable global datasets are considered to be:

- MODIS data products, averaged at 1 km pixel resolution, integrated over each calendar year since 2000; and
- Copernicus Global Land Service products, averaged at 1 km pixel resolution and integrated over each calendar year since 1998.

Carbon stocks comprise above- and below-ground biomass, dead organic matter and soil organic carbon. According to the UNCCD, soil organic carbon (SOC) stock will be used as the proxy metric until there is reliable information on total terrestrial system carbon stocks. In addition to possible national datasets, the following global soil organic carbon stock data are available:

- Harmonized World Soil Database (HWSD), Version 1.2 the latest update being the current *de facto* standard soil grid with a spatial resolution of about 1 km;
- SoilGrids250m, a global 3D soil information system at 250m resolution containing spatial predictions for a selection of soil properties (at six standard depths) including SOC stock (t/ha^{-1}); and
- Global SOC Map, Version 1.0,33.

A sophisticated online tool, Trends.Earth, has been developed to generate this indicator at large spatial scales on the basis of some of the above datasets. This generates the 2015 baseline as well as allowing very up-to-date comparison with the baseline, using sophisticated statistical approaches to control for rainfall variation. The output is a raster grid indicating positive, stable or negative change.

5.3 South Africa's approach to date

Land degradation was not reported on in South Africa's Baseline Report in 2017, but the Country Report (Stats SA 2019) included Indicator 15.3.1, citing earlier work as follows: "According to South Africa's seventh report to the United Nations Convention to Combat Desertification Performance Review and Assessment of Implementation System, presented in 2014, 10.71% of South Africa's land area is classified as degraded." The same figure is provided in South Africa's most recent (2018) report to the UNCCD. [9]

In South Africa, the average value across the baseline period (t0) was assessed for each of the three global indicators of land degradation using the global default data provided by the UNCCD Secretariat for the period 2000-2015 (DEA 2018). According to this report, this was because the national data sources that were available did not assess the three LDN indicators concurrently per given land cover type. The three indicators were analysed separately, but land cover was also used to stratify the other two indicators. Land degradation was considered to occur when: (a) land productivity showed a significant negative trend, or (b) SOC showed a significant negative trend, or (c) negative land cover change occurred, and or a negative change occurred in another nationally relevant indicator. Changes in land cover were considered to be negative in the case of (a) change from natural or semi-natural land cover classes to cropland or settlements, (b) change from forest land to other land cover classes (i.e., deforestation), and (c) change from natural or semi-natural land cover classes and cropland to settlements. This follows the global guidelines that include loss of habitat in the definition of degradation. According to this analysis (DEA 2018), between 2000 and 2010, 16.2% of forest, 35.9% of shrubs, grasslands and sparsely vegetated areas and 33.4% of wetlands showed declining or stressed land productivity dynamics (LPD). For cropland, 17.0% showed declining or stressed net LPD. The conversion of forest to cropland resulted in a loss of 1.4 million tons of SOC between 2000 and 2010. The loss of SOC was 0.03% nationally during the same period.

5.4 Relevant data in the National Land and Ecosystem Extent Accounts

After consideration of the information requirements and potential approaches to the development of condition accounts for terrestrial ecosystems (Turpie *et al*. 2019), condition accounts have not been included in the land and terrestrial ecosystem accounts at this stage, as considerable further work is required (see discussion below). Once this has been completed, the accounts will have a measure of condition for all ecosystems, following SEEA guidelines, using methods still to be developed. This measure will be relative to a reference condition (ideally the condition before major anthropogenic influence in the case of natural ecosystem types), rather than a recent baseline.

5.5 Discussion and recommendations

Key points in this discussion are:

- While South Africa has not yet incorporated condition and ecosystem services into its ecosystem accounts, the intention is that in future the accounts will track changes in land cover, ecosystem

[9] This figure comes from UNCCD online reporting. The reporting template is poorly transcribed to pdf, and its template format does not allow for proper description of the methods, assumptions and interpretation. This needs to be addressed, as it makes critical evaluation of the assessment difficult.

condition and carbon storage. As they exist or are envisaged, these accounts could directly inform the first sub-indicator and could improve on the second and third.

- Carbon sequestration and storage will be included in ecosystem service accounts when these accounts are developed in future. 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.
- Ecosystem condition accounts 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, as discussed further below.
- Indicator 15.3.1 only reports land area that has degraded since 2000, not all degraded area. 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 rangeland.
- Because ecosystem accounts aim to assign a measure of condition relative to reference condition, they can also provide an estimate of the total degraded area (including lands that were already degraded by 2000). Where feasible, this should be reported in an SDG indicator alongside that of 15.3.1.
- 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 assessment).

These issues are explored further below.

In South Africa, changes between natural land cover types were evaluated individually, while some were taken as clear signs of degradation, including from forest to other land cover types, and from natural to cultivation or urban. The latter approach needs further consideration, as habitat loss should not be conflated with degradation. Rather degradation should be measured or assessed in relation to a natural reference condition or to a reference condition for the type of anthropogenic land use concerned. Clear guidance is provided on this in the SEEA, which could be used to improve 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 as ecosystem services in future ecosystem accounts. Carbon accounts will ideally include the full suite of carbon (including above and below ground biomass), so are aligned to the envisaged evolvement of the sub-indicator to its full form.

With respect to the third sub-indicator (NPP), 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, and will include additional indictors of ecosystem condition. These methods are still under discussion and development, however.

The potential use of the normalised difference vegetation index (NDVI, an indicator of NPP) to assess condition has been explored in the development of the Land and Terrestrial Ecosystem Accounts (Turpie *et al.* 2019) and elsewhere (Venter & Desmet 2019), including the use of outputs from Trends.Earth and direct analysis of NDVI data. The binary output of Trends.Earth (Figure 7) is an unreliable measure of degradation because degradation is not consistently indicted by declining NPP in South Africa. A change in NDVI in a particular direction cannot be reliably labelled as degradation or improvement in condition. This is because much land degradation in South Africa involves an increase in NPP (e.g. bush encroachment, spread and densification of invasive alien trees), and some forms of degradation would not be expected to be reflected in terms of a change in NPP (e.g. invasion of thicket by alien cactus). In an analysis of NDVI trends over 30 years, Venter & Desmet (2019) interpreted areas of moderate and high increases in biomass as bush encroachment or spread of invasive alien plants (Figure 8). However, this approach also has limitations, in that not all increases in NDVI are a result of degradation. The conclusion is that NDVI trends alone cannot reliably be used to indicate degradation in terrestrial ecosystems, let alone present condition (Turpie et al. 2019).

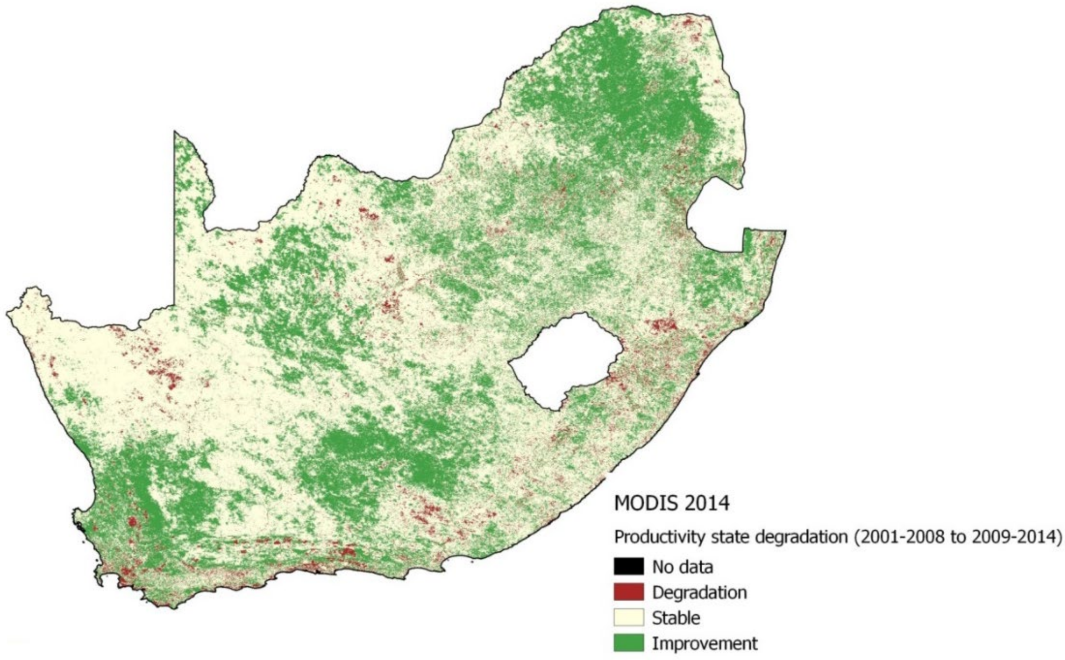

Figure 7. Productivity 'state' 2014 using MODIS NDVI data comparing 2001-2008 with 2009-2014, based on Trends.Earth (Turpie et al. 2019).

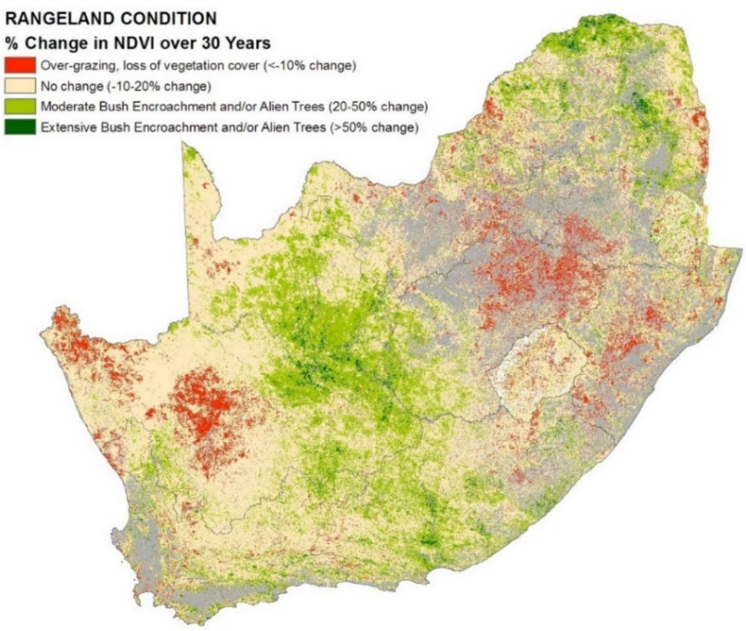

Figure 8. Estimated vegetative condition based on percentage change in NDVI over 30 years, giving the authors' initial interpretations of the cause of change. Areas under built or agricultural land cover are shown in grey. Venter & Desmet (2019).

A key issue relating to finding a measure of condition for NCA 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 250 m). A lack of change in NPP over recent decades would not necessarily indicate that an ecosystem is not degraded, since degradation may have occurred earlier. Analysis of recent NDVI data provide one layer of information, but need to be combined with additional analysis, e.g. using field data, early aerial photography and machine learning, in order to be properly interpreted in relation to reference condition (Turpie et al. 2019). Substantial discussion and work needs to be undertaken to develop a reliable and consistent methodology to assess terrestrial ecosystem condition in South Africa, but it is considered feasible with a combination of old, new and developing technology. Once these methods are in place, then the NCA will be able to derive 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 assesses degradation relative to a recent baseline (2015), which itself is pegged on changes from 2000 to 2015. This is pragmatic, allowing use of satellite data, and also aligned 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. For example, South Africa reports that "10.4% of land is classified as degraded", but does not specify that this is only over a recent period (2000-2015), something that could be missed by policy makers. In general, the presentation of this indicator globally needs to be very clear about this, as there will be far more land that is degraded relative to an earlier state. Because ecosystem accounts aim to assign a measure of condition relative to a reference condition (ideally the largely natural state before significant anthropogenic influence), they can also provide an estimate of the total degraded area (including lands that were already degraded by 2000). Where feasible, this should be reported in an SDG indicator alongside that of 15.3.1. At the national scale, South Africa aims to achieve LDN by 2030 as compared to 2015 and an additional 5% of the national territory has improved. This will require having a full picture on the area that is degraded as well as understanding the extent of recent degradation.

If NCA is used as the basis of the land degradation indicator, then it is important to consider how the trends will be computed and interpreted. In ecosystem accounts, the condition of natural or semi-natural ecosystems (including rangelands) will be measured in terms of their distance from the reference condition of natural (prior to major human modification), and can be expressed as a percentage, and/or translated to a categorical scale, e.g. from A (natural/near-natural) to F (critically modified)[10]. In contrast, Indicator 15.3.1 assesses degradation, and a unit of land is deemed to be degraded if it has experienced a negative trend of any of three parameters. Based on the current binary computation of the indicator (degraded or not degraded), an ecosystem that changes from an A class to a B class would be deemed degraded, as would an ecosystem that has changed from a B class to an E class, with no distinction in the degree of degradation. Future ecosystem accounts in South Africa may also include condition accounts for intensively modified ecosystem types such as cultivated land. It would be useful to separate the analysis of condition of natural/rangeland and cultivated lands in the indicator, as indicators of condition are likely to be substantially different for these different ecosystem types.

Assuming that measurement of 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 requires that it is 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.

[10] Of potential relevance, in South Africa, water policy suggests that aquatic ecosystems may not be allowed to allowed to degrade beyond some threshold state (D, or 60% below the reference condition, on the above scale).

6 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 datasets as they stand are inadequate. South Africa has developed accurate, high resolution data that combine land cover information with other data sources and verification of the extent of water-related ecosystems, in the form of the South African Inventory of Inland Aquatic Ecosystems. This data will form the basis for future freshwater ecosystem accounts, which will provide the most rigorous and consistent information for this indicator.

- 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 is not likely to be a perfect match, since the indicator requires more tailored, detailed data. South Africa largely already has the information to compile such an indicator, and it could be computed as an adjunct to the accounts, but with considerable effort. The greenness indicator calculated as a supplementary analysis to the land accounts for metropolitan municipalities could provide a partial proxy for this indicator.

- For Indicator 15.1.1 (forest area), South Africa's latest National Land Cover dataset for 2018is set up to report directly on this indicator. However, South Africa has domesticated the indicator to report on the remaining extent of its natural woody biomes relative to their historical extent (prior to major human modification of the landscape). This avoids the inclusion of increases in tree-covered area due to bush encroachment and the spread of invasive alien trees, as well as exotic timber plantations, all of which have substantial negative impacts on ecosystems and biodiversity. It is suggested that the global indicator is changed from being forestry- to ecosystem-focused, that all major biomes from the IUCN's Global Ecosystem Typology are included, and that the indicator is modified to functional extent through inclusion of condition as well as extent. Ecosystem accounts will be very well aligned to deliver the latter.

- For Indicator 15.3.1 (degraded land area), once NCA is fully developed, it should be considered essential for informing this indicator, and indeed for improving upon its three sub-indicators. Land accounts are useful for the first sub-indicator. Ecosystem service accounts for carbon will not only inform but 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). Ecosystem condition accounts are likely to make a critical contribution to improvement of the degradation sub-indicator, as they are likely to produce a more reliable assessment of degradation than one based simply on changes in NPP. These methods are still under development, however.

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