



Calculating the environmental sustainability gap in South Africa

Authors of the report

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Version: 1.1

Date: 17/09/2025

Abstract

The ESGAP framework provides a strong sustainability perspective on the environment through metrics that measure performance against science-based environmental standards (SBES) intended to depict the conditions under which the functions of natural capital are not threatened. The framework has been showcased in European countries and in a few countries in Africa, Latin America and the Asia-Pacific region.

This study computes the Strong Environmental Sustainability Index (SESI) and the Strong Environmental Sustainability Progress Index (SESPI) for South Africa. The former provides information on how the country performs against SBES, while the latter reports on the progress made towards meeting these SBES in 2030. The results show that several environmental functions are threatened in South Africa, with areas such as water scarcity, CO₂ emissions, the status of estuaries and inland wetlands, and ambient air pollution being particularly worrying. Furthermore, 12 of the 21 indicators used to compute SESI and SESPI describe are moving in the wrong direction, which sheds a cautionary message around current progress.

The format under used by the annual State of the Environment Report in South Africa offers an opportunity to trial the ESGAP approach and report on strong sustainability, as this is a perspective not adequately captured by the Sustainable Development Goals.

1. Introduction

Human activity is accelerating environmental degradation, with many of the key metrics to measure sustainability showing worsening trends (IPBES, 2019; Richardson et al., 2023). This makes the monitoring of sustainability increasingly critical to assess progress towards or away to desired outcomes for people and planet. Despite consensus at the international level on the urgency of environmental action (IPBES, 2019; IPCC, 2021; UNEP, 2019), there remains a persistent gap between scientific knowledge and policy implementation. This gap is exacerbated by the lack of adequate indicators to monitor environmental sustainability at the national level (Usubiaga-Liaño & Ekins, 2021b). The ability to measure sustainable development is among six capacities identified as critical to guide interventions for development towards sustainability (Clark & Harley, 2020). Metrics serve not only to describe conditions but also to shape perceptions, guide allocation of resources, and could also trigger responses. As such, the absence of robust and policy-relevant metrics represents a major obstacle in translating science into meaningful environmental governance (Esty, 2018; Radermacher, 2019).

A critical debate in economics and sustainability science is the distinction between weak and strong sustainability. Weak sustainability allows for substitutability between natural and other forms of capital – for example, metrics such as Inclusive Wealth (UNEP, 2023) assume natural capital to be substitutable for other capitals (such as human or manufactured capital) which can compromise the integrity of nature and its function. Strong sustainability on the other hand contends on the irreplaceability of critical natural capital due to its foundational role in ecosystem resilience and human survival (Neumayer, 2025). The Planetary Boundaries framework exemplifies this approach by identifying reference values in Earth System processes that, if transgressed, could lead to irreversible environmental change (Rockström et al., 2009). These global reference values have prompted a rethinking of sustainability indicators, encouraging focus on ‘threshold-based’, biophysically grounded standards that safeguard ecological integrity (Comte et al., 2023; Fischer et al., 2007).

The Environmental Sustainability Gap (ESGAP) framework emerges from the strong sustainability perspective discussed above (Usubiaga-Liaño & Ekins, 2021b). The framework proposes a dual-index approach that comprises the Strong Environmental Sustainability Index (SESI) and the Strong Environmental Sustainability Progress Index (SESPI), to evaluate a country’s proximity to and progress toward science-based environmental standards (SBES) intended to represent ‘good environmental condition’ (Usubiaga-Liaño & Ekins, 2021a, 2022). These indices are built around four broad functions of nature, namely *life support function* which focuses on the health of biodiversity and ecosystems, *sink function* which focuses on Earth System and pollution processes, *source function* which focuses on the supply of renewable and non-renewable resources, and lastly, the *health and welfare function*, which focuses on human wellbeing outcomes (Ekins et al., 2003). The indices assess whether national performance respects SBES of good environmental functioning across these four functions.

The ESGAP framework is unique in its normative clarity, scientific grounding, and policy relevance, offering a more comprehensive and actionable assessment than

conventional indices like the Environmental Performance Index or the SDG indicators which do not provide information about proximity to a desired sustainable state (Usubiaga-Liaño et al., 2024; Usubiaga-Liaño & Ekins, 2021b). ESGAP has been applied to various context for various objectives depending on context (Table 1). The objective of this article is therefore to add South Africa to this database of applications of the framework, and specifically determine the suitability of data and standards available in South Africa. This is especially important because the application in three of the four countries in the developing context lacked indicators for the life support function (Vietnam, Kenya), or had unreliable data (Senegal). In contrast, South Africa has well developed datasets for biodiversity, and reports relevant indicators in the National Biodiversity Assessments (SANBI, 2019) and the State of the Environment Report (DFFE, 2025b). The relevance of the ESGAP framework to South Africa, especially in terms of policy application, is further explained in the description of the case study in section 2.1.

Table 1: Application of the ESGAP framework across various contexts and scales

Case study	Approach	Main findings	Reference
Europe (28 countries)	SESI & SESPI with the most recent data	Good in health and other welfare, and in source dimensions, poor in sink and life support but disparity among the countries.	(Usubiaga-Liaño & Ekins, 2021a, 2022)
Japan	SESI for the 2011-2017 period	Best scores in human health and welfare, and life support. Worst score in sink.	(Sato et al., 2024)
New Caledonia	SESI with the most recent data	Best scores in source, life support and human health and welfare. Very poor in sink.	(Comte et al., 2023)
Colombia	SESI & SESPI with the most recent data	Low scores in every function, especially sink.	(Garcés et al., 2025)
Colombia	Test ESGAP framework at a subnational level for land and water management.	Identified severe sustainability gaps; demonstrated local adaptability	(Di Stefano, 2025)
Senegal	SESI with the most recent data	Highlighted role of data choice and weighting in index sensitivity as influencing the scores.	(Prudhomme et al., 2023)
Vietnam	SESI with the most recent data	Best score in source, worst in sink. The study lacked indicators for life support functions – highlighting data challenges	(Thang et al., 2022)
Kenya	SESI with the most recent data	Best score in sink, worst in human health and other welfare. The study lacked indicators for life support functions – highlighting data challenges	(Otieno et al., 2022)

2. Methods

2.1. Case study

South Africa faces a dual sustainability challenge: mitigating acute social deprivation (Statistics South Africa, 2014) while addressing environmental degradation (DFFE, 2025b). Despite strides in expanding access to basic services, the country still grapples with persistent inequality, unemployment, and poverty—factors that undermine long-term societal resilience. Simultaneously, previous research has reported that the country has exceeded safe ecological thresholds for biodiversity loss, freshwater use, marine harvesting, and climate change (Cole et al., 2014). These challenges are exacerbated by the spatial heterogeneity of environmental pressures and developmental needs, which complicates top-down policy responses. As such, South Africa urgently requires integrated and functionally relevant sustainability metrics that reflect both environmental sustainability concerns and social justice imperatives. ESGAP, with its strong sustainability orientation and function-based structure, provides a critical lens for this context, enabling the identification of sustainability gaps across policy-relevant environmental topics (Usubiaga-Liaño & Ekins, 2021a).

The ESGAP framework is especially relevant in the South African context because it enables the integration of national biophysical realities with normative sustainability reference values. Unlike weak sustainability models that assume natural capital can be substituted by manufactured capital, ESGAP is grounded in the recognition that certain ecological functions—like climate regulation and biodiversity maintenance—are irreplaceable. This is particularly important for an ecologically megadiverse and climatically vulnerable country such as South Africa, where ecosystem degradation directly threatens food security, water quality, and rural livelihoods (Cole et al., 2014). ESGAP's function-based approach aligns well with South Africa's policy environment, which includes progressive frameworks like the National Development Plan (NPC, 2012), the adoption of the Agenda 2030 on sustainable development (NPC, 2019) or the National Strategy for Sustainable Development set up in 2008 (DEAT, 2008), yet often lacks concrete indicators to measure progress toward strong sustainability. By incorporating biophysical SBES and linking them to environmental functions critical for societal well-being, ESGAP serves as a scientifically rigorous and policy-relevant tool to guide transformative, equity-focused sustainability planning.

2.2. Indicator selection

Our approach follows Usubiaga-Liaño & Ekins (2021) in terms of in the process for indicator selection, but focused on two aspects: availability of environmental standards and data. The indicators are clustered across 15 topics, which are nested within eight principles, which themselves below to one of the four functions. Overall, we selected 21 indicators which are described in detail in the supplementary material and are listed in Table 2. Selection of time period were purely based on data availability rather than a time period of particular relevance. The year for represented in each indicator is also included in the supplementary material. Equal weights were assigned to all functions and to all indicators within each function, and the indicators were aggregated using a geometric mean.

Table 2: List of selected indicators

Function	Principle	Topic	Indicator
Source	Renew renewable resources	Biomass resources	Fish stocks considered 'not of concern'
		Water resources	Freshwater withdrawal as a proportion of available freshwater resources
			Groundwaters in normal status or better
	Use non-renewable resources prudently	Soil resources	Area with tolerable soil erosion
Sink	Prevent the disruption of Earth System processes	Climate change	Per capita CO2 emissions
		Ozone layer	Consumption of ozone depleting substances
	Respect critical loads for ecosystems	Ecosystem critical loads	Dams in oligotrophic status
Life Support	Maintain ecosystem health	Terrestrial ecosystems	Terrestrial ecosystems not threatened
		Freshwater ecosystems	River ecosystems not threatened
			Inland wetlands not threatened
		Marine & Coastal Ecosystems	Marine ecosystems not threatened
			Coastal ecosystems not threatened
			Estuarine ecosystems not threatened
	Maintain biodiversity	Terrestrial ecosystems	Species in terrestrial ecosystems not threatened
		Freshwater ecosystems	Species in freshwater ecosystems not threatened
		Marine & Coastal Ecosystems	Species in marine ecosystems not threatened
			Species in estuarine ecosystems not threatened
Human health and welfare	Respect standards for human health	Air pollution	Population exposed to safe PM2.5 levels
			Population using clean fuels and technology for cooking
		Drinking water pollution	Water supply systems with (almost) full compliance with microbiological criteria
	Conserve other welfare	Recreation	Recreational sites that comply with microbiological criteria

As expected, the indicators used differ from those used in previous cases studies, as they often rely on national datasets, thereby limiting the comparability of the results. All in all, SESI comprises four indicators for the source function, three for the sink function, ten for the life support function and four for the human health and other welfare function. There are notable differences with the other countries (Table 3), especially in the life support function where South Africa consistently reports on both ecosystem health and biodiversity. This is a major novelty compared to other case studies, especially those in which it was not possible to compute a score for this function. Nonetheless, the number of life support indicators in this case study should be interpreted with care, as because of the data format, the life support indicators distinguish between six types of ecosystems when it comes to ecosystem health and four types of ecosystems when it comes to biodiversity. In other cases, similar data was more aggregated.

Table 3: Number of indicators per environmental function

Case study	Source	Sink	Life support	Human health and welfare	Reference
South Africa	4	3	10	4	This study
Europe (28 countries)	5	7	3	6	(Usubiaga-Liaño & Ekins, 2021a, 2022)
Japan	4	7	1	6	(Sato et al., 2024)
New Caledonia	4	3	2	4	(Comte et al., 2023)
Colombia	4	4	4	5	(Garcés et al., 2025)
Senegal (*)	18	6	6	2	(Prudhomme et al., 2023)
Vietnam	4	6	0	4	(Thang et al., 2022)
Kenya	4	4	0	4	(Otieno et al., 2022)

(*): The goal of this study is to test the uncertainty associated with the selection of different indicators, so in practice, there are very similar indicators sourced from different databases or indicators that are not that conceptually relevant.

2.3. Strong Environmental Sustainability Index (SESI)

SESI is constructed by aggregating the normalised scores of the indicators listed above. The normalisation is done through the goalpost method, where the maximum and minimum goalposts (gp_{max} and gp_{min} respectively) represent full and null compliance with the SBES.

$$NI = 100 \frac{I - gp_{min}}{gp_{max} - gp_{min}}$$

The normalised values are then aggregated to topics, sustainability principles, environmental functions following the structure described in Table 2. The environmental functions scores are then aggregated into a single index, SESI. All the aggregation steps use equal weights and the geometric mean. When aggregating from indicators to topics, a minimum of score of five is assigned to avoid the geometric mean collapsing to zero in the cases in which normalised scores are zero.

The overall index score gives a notion of the extent to which the functions of natural capital in a country are threatened. Thus, very high scores show that almost all the indicators meet or are close to meeting the SBES, while very low scores show that the natural capital base of the country is threatened.

2.4. Strong Environmental Sustainability Progress Index (SESPI)

The goal of SESPI is to provide insights on trends towards or away environmental sustainability. To that end, normalised scores are generated based on the ratio between current and desired trends (Usubiaga-Liaño and Ekins, 2021a). The latter

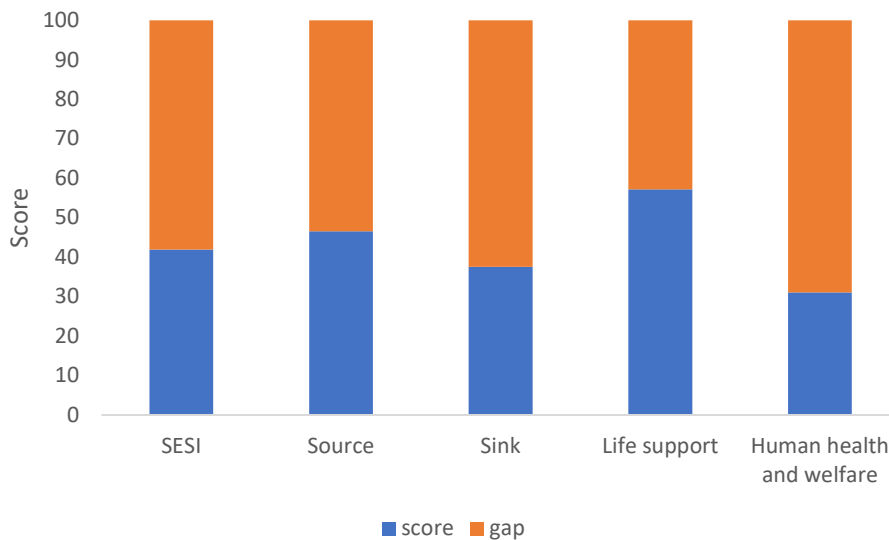
represents the trend needed to reach SBES by 2030. Calculating SESPI uses the same data used in the calculation of SESI, but considers more than one time slice. This is applied differently according to the type of indicator. The formula to calculate the ratio between the observed and desired trajectories is as follows:

$$R_{o-d} = \frac{trend_{obs}}{trend_{des}}$$

3. Results

South Africa obtained a SESI score of 42, which shows that the country is far from meeting environmental sustainability conditions reflected by SBES (Figure 1). The country performs best in the life support function (score of 57), followed by source (47 points) and sink (38 points). At the bottom, the human health and welfare function obtained a score of 31 points. This seems to be the opposite effect seen in European countries, which consistently perform the best in this function (Usubiaga-Liaño & Ekins, 2021a).

Figure 1: Index and function scores



The results for South Africa point towards some areas in need of urgent improvement (Figure 2). This is particularly relevant for the human health and other welfare function, in which South Africa obtains its lowest score at the function level. In the last 20 years, South Africa has increased the percentage of the population using clean fuels from 63% in 2003 to almost 90% in 2023, thereby avoiding exposure to very high levels of indoor air pollution. Nonetheless, progress in outdoor air pollution remains a major problem in the country with virtually every citizen being exposed to PM2.5 levels above those recommended by the World Health Organisation in 2021. The low score in this indicator contrasts with the data on days of 'good air' reported in the SOER (DFFE, 2025b). The latter are defined based on the national Air Quality Index (DFFE, 2025a), which uses much more lenient reference values than those recommended by the World Health Organisation. There are also problems related to microbiological pollution in recreational and drinking water. In the first case, only

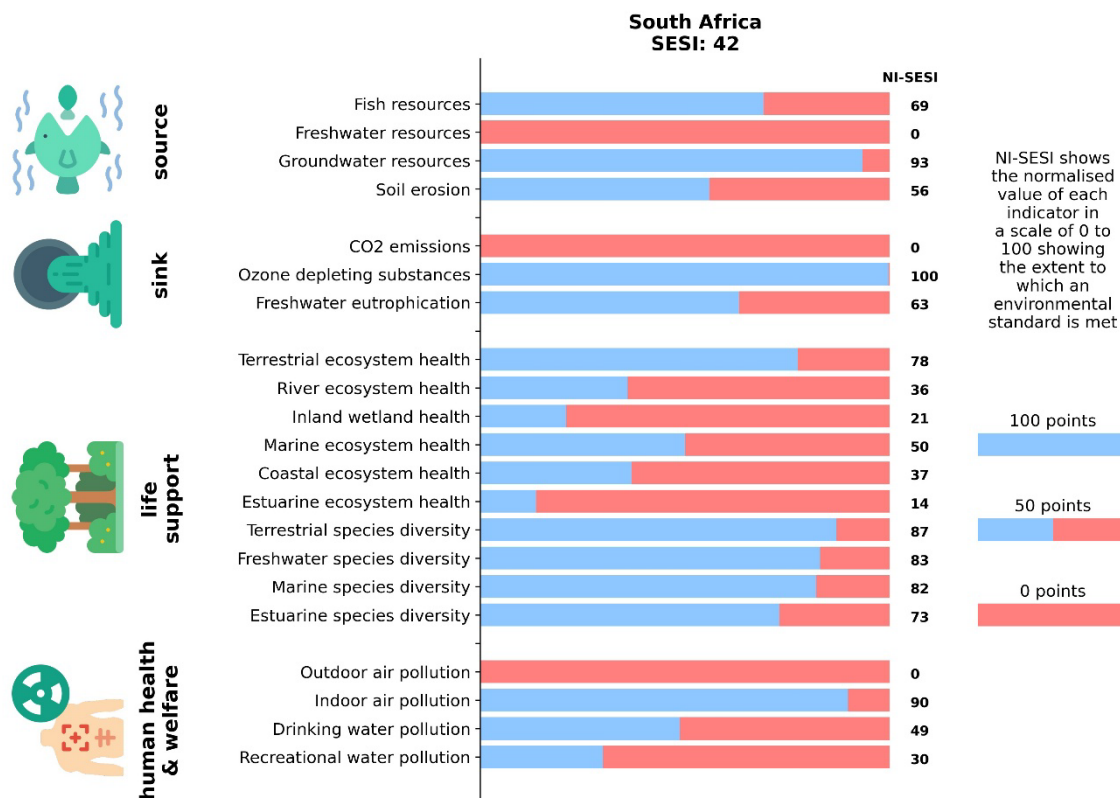
30% of the sampled sites were considered not to pose a high risk of infection to individuals being in full contact with those waters (DWS, 2023). In the second, only 49% of the sampled water supply systems had (almost) full compliance with the microbiological pollution criteria defined in the South African legislation (DWS, 2023). A similar percentage is reported for chemical pollution criteria. The percentage of water supply systems that obtain a Blue Drop Certificate is much lower (3% in 2023), but this not only requires (almost) full compliance with microbiological and chemical criteria, but also other management and operational criteria.

In the sink function, the same pattern as in most previous case studies emerges when it comes to the disruption of Earth System processes. In this line, South Africa meets the SBES set for the consumption of ozone depleting substances, but obtains the lowest possible score in terms of CO₂ emissions. In other words, the current CO₂ emission levels are well above than those required to meet the goals of the Paris Agreement. For regional pollution processes, South Africa only has a single indicator focused on the eutrophication of rivers, which has a normalised score of 63. This means that 63% of the rivers have a low nutrient concentration and are therefore not subject to any kind of eutrophication.

As for the supply of renewable and non-renewable resources, South Africa performs best in the management of groundwater and fish resources, as opposed to surface water and soil resources. In the case of groundwater, 93% of the 64 hydrogeological regions report average groundwater level status classified as normal or better. In this case, normal refers to historical averages (Fourie, 2022). For fish resources, 69% of stocks are considered not of concern (DFFE, 2025c). The scores of surface water and soil resources are more worrying. In this case, the withdrawal of freshwater resources is well above to the levels considered to lead to scarcity (FAO, 2025), while soil erosion exceeds the tolerable soil erosion rates in around half of the territory (Borrelli et al., 2017).

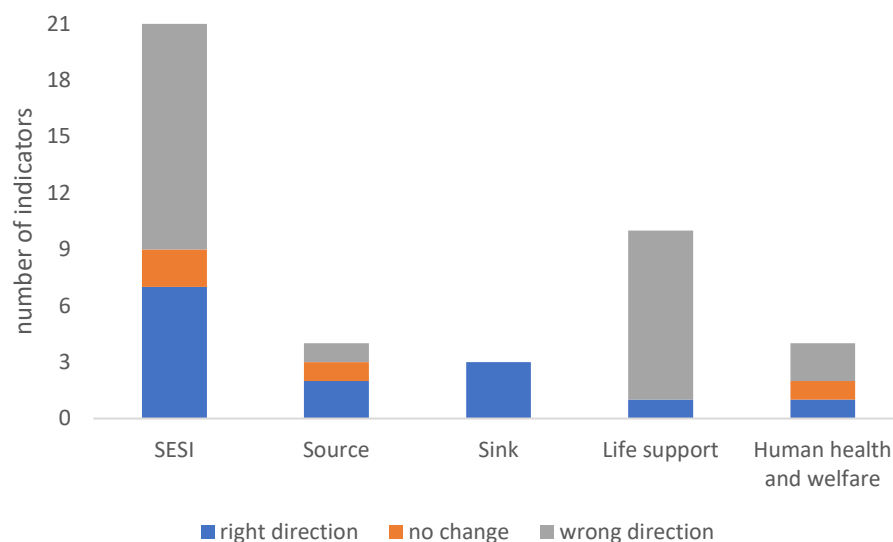
Lastly, South Africa scores the best in the life support function, although there are some relevant caveats. Ecosystem health indicators show that, depending on the type, 14-78% of the ecosystems are considered to be of 'least concern' according to the criteria proposed by the Red List of Ecosystems (SANBI, 2019). For species, the range increases to 73-87%.

Figure 2: Country fiche with normalised scores



SESPI also shows that the overall situation is not improving (Figure 3). With a score of 23 points, 12 of the 21 indicators (57%) describe negative trends. Additionally, two indicators (10%) show no signs of improvement, while seven indicators (33%) are moving in the right direction.

Figure 3: Number of indicators classified by direction of change



4. Discussion

4.1. Environmental sustainability in South Africa

The results provided by SESI and SESPI show that South Africa is far from being environmentally sustainable. This is not a surprise, as none of the countries assessed in previous case studies is. Nonetheless, it is difficult to draw relevant comparisons between countries, as each of the previous assessments has used a different set of indicators in line with existing country data. Nevertheless, one of the main strengths of SESI and SESPI is that cross-country comparisons are not needed, as these metrics monitor absolute environmental sustainability against SBES rather than relative environmental performance against other countries. In this paper, the results showcase the potential of SESI and SESPI as headline indicators of strong sustainability.

The normalised scores of the underlying indicators highlight several areas that demand policy attention. Water scarcity, CO₂ emissions, the status of estuaries and inland wetlands, and ambient air pollution obtained very low scores, which indicates the need for additional measures to reverse the situation. On the other side, South Africa obtains scores above 90 for indoor air pollution, the exploitation of groundwater resources and for the consumption of ozone depleting substances. Existing trends are not favourable either, which suggest that considerable efforts will be needed in South Africa to achieve most SBESs, which intend to represent an environmentally sustainable future.

The results need to be interpreted carefully and contextualised based on the detailed assessments produced by South African authorities, which include, but are not limited to, the State of the Environment Report (DFFE, 2025b), the National Water State of Water Report (DWS, 2024), the National Biodiversity Assessment (SANBI, 2019) and the State of Air Report (DFFE, 2024). The reader should bear in mind that the SBES used have different meanings, but they all have a scientific rationale as explained in the supplementary material. For this reason, even the perceived importance of non-compliance might differ for different stakeholders, in all cases SBES act as a warning system of potential problems. Thus, the results provide clear and easy-to-understand messages around environmental sustainability in South Africa, pointing towards the areas that demand additional policy action.

4.2. Integrating strong sustainability in South African indicator initiatives

The vision of the SDGs and of other indicator initiatives South Africa is part of are aligned with strong sustainability thinking (Usubiaga-Liaño et al., 2025). In national policy documents published already more than a decade ago, a stronger focus is set on economic and social development, which is more closely aligned with weak sustainability. This is the case, for instance, of the main development and sustainable development strategies adopted already more than ten years ago (DEAT, 2008; NPC, 2012). Nonetheless, the National Framework for Sustainable Development does refer to “growth that respects the limits of our ecosystems (...)” (DEAT, 2008, p. 15). In this line, research on planetary boundaries (Richardson et al., 2023), tipping points (Armstrong McKay et al., 2022), biodiversity loss (Ceballos et al., 2015), etc. supports a strong sustainability approach to development, and therefore the

integration of this perspective in national policy making. This is a perspective that is not well captured by the SDGs (Usubiaga-Liaño et al., 2024).

The ESGAP framework provides a robust conceptual basis for environmental sustainability assessment at the national level. It requires high-quality environmental data, which sometimes restricts its applicability in countries with limited monitoring capacity (Prudhomme et al., 2023). Nonetheless, this is not the case in South Africa, which although it has room for improvement, it compiles a wealth of information related to natural capital and its functions as reported in outlets such as the State of the Environment Report, the National Water Assessment, the National Biodiversity Assessment and the State of Air Report.

ESGAP could be trialled at the State of the Environmental Report in which every year different headline indicators are selected to develop key messages. The necessary data basis exists already as showcased in this report, but the final list of indicators could be adapted to match existing national data. From a user perspective, the data reported in those reports is not always easily accessible, so the institutions contributing to the State of the Environmental Report are best placed to take the lead in reporting compliance against SBES. In doing so, it would be useful if more emphasis were set on quantitatively reporting progress (or lack thereof) along the current state of the environment. In this work, it has not always been possible to compile detailed time series for various indicators, which required the authors to rely on other sources to assign a normalised score to the trends in some indicators. In this context, it is also unclear if some of the data used to compute SESPI are fully comparable.

The assessment presented here relies on the use of SBES to monitor environmental sustainability. These often differ from existing policy targets in South Africa. That is the case, for instance, for national air pollution targets, which differ considerably from the guideline values proposed by the World Health Organisation. In other cases, comparable quantitative policy targets do not exist. Thus, options exist not only to identify the environmental sustainability gap through the ESGAP framework, but also to identify 'policy gaps' (difference between current situation and policy targets) or 'ambition gaps' (differences between policy targets and SBES).

5. Conclusions

This report implements the ESGAP framework in South Africa. This is the third case study (after Kenya and Senegal) undertaken in an African country. Besides having its own geographic and geopolitical context, the South African case is also unique from a data perspective, as it has a wealth of environmental information that can be used to monitor environmental sustainability from a strong sustainability perspective. This is particularly true when it comes to ecosystem health and biodiversity information, which has been missing in some of the previous case studies.

The approach presented here is intended to showcase the potential of the ESGAP framework for strong sustainability assessment. Our analysis points towards areas in need of further action, but also describes additional applications of the framework. It works with a dual approach in which the index and function level scores can be used to communicate environmental sustainability to high-level policymakers and a non-

technical audience, while the normalised values of the indicators could be used to provide a synthesised and easy-to-understand message to audiences with a more technical background. The format in which the headline indicators of the State of the Environment Report are reported offers an interesting way in to trial the ESGAP framework at the national level.

Acknowledgements

We thank Fanus Fourie (Department of Water and Sanitation) for sending very detailed data on the groundwater indicator.

References

- Armstrong McKay, D. I., Staal, A., Abrams, J. F., Winkelmann, R., Sakschewski, B., Loriani, S., Fetzer, I., Cornell, S. E., Rockström, J., & Lenton, T. M. (2022). Exceeding 1.5°C global warming could trigger multiple climate tipping points. *Science*, 377(6611), eabn7950. <https://doi.org/10.1126/science.abn7950>
- Borrelli, P., Robinson, D. A., Fleischer, L. R., Lugato, E., Ballabio, C., Alewell, C., Meusburger, K., Modugno, S., Schütt, B., Ferro, V., Bagarello, V., Oost, K. V., Montanarella, L., & Panagos, P. (2017). An assessment of the global impact of 21st century land use change on soil erosion. *Nature Communications*, 8(1), 2013. <https://doi.org/10.1038/s41467-017-02142-7>
- Ceballos, G., Ehrlich, P. R., Barnosky, A. D., García, A., Pringle, R. M., & Palmer, T. M. (2015). Accelerated modern human-induced species losses: Entering the sixth mass extinction. *Science Advances*, 1(5). <https://doi.org/10.1126/sciadv.1400253>
- Clark, W. C., & Harley, A. G. (2020). Sustainability Science: Toward a Synthesis. In *Annual Review of Environment and Resources* (Vol. 45, Issue Volume 45, 2020, pp. 331–386). Annual Reviews. <https://doi.org/10.1146/annurev-environ-012420-043621>
- Cole, M. J., Bailey, R. M., & New, M. G. (2014). Tracking sustainable development with a national barometer for South Africa using a downscaled “safe and just space” framework. *Proceedings of the National Academy of Sciences*, 111(42), E4399–E4408. <https://doi.org/10.1073/pnas.1400985111>
- Comte, A., Surun, C., & Levrel, H. (2023). Measuring and managing for environmental sustainability. An application of the Environmental Sustainability Gap (ESGAP) framework in New Caledonia. *Environmental Science & Policy*, 146, 113–122. <https://doi.org/10.1016/j.envsci.2023.05.007>
- DEAT. (2008). *People—Planet—Prosperity: A National Framework for Sustainable Development in South Africa*. Department of Environmental Affairs and Tourism.
- DFFE. (2024). *State of Air Report 2004-2024*. Department of Forestry, Fisheries and the Environment.
- DFFE. (2025a). *Knowing the quality of the air you breathe and how it is reported*. Department of Forestry, Fisheries and the Environment.
- DFFE. (2025b). *South African Environment 2024*. Department of Forestry, Fisheries and the Environment.
- DFFE. (2025c). *Status of the South African Marine Fishery Resources 2025*. Department of Forestry, Fisheries and the Environment.
- Di Stefano, J. (2025). *Environmental Sustainability Gap Framework. The case study of the Chicamocha Canyon, Colombia*.
- DWS. (2023). *Blue Drop Report 2023*. Department of Water and Sanitation.
- DWS. (2024). *National State of Water Report 2023*. Department of Water and Sanitation.
- EEA. (2019). *Production and consumption of ozone-depleting substances in Europe*. European Environment Agency.
- Ekins, P., Simon, S., Deutsch, L., Folke, C., & Groot, R. D. (2003). A framework for the practical application of the concepts of critical natural capital and strong sustainability. *Ecological Economics*, 44(2–3), 165–185. [https://doi.org/10.1016/s0921-8009\(02\)00272-0](https://doi.org/10.1016/s0921-8009(02)00272-0)
- Esty, D. C. (2018). Measurement matters. Toward data-driven environmental policy-making. In *Routledge Handbook of Sustainability Indicators* (1st edn). Routledge.
- FAO. (2025). *SDG Indicators Data Portal: Indicator 6.4.2—Level of water stress: Freshwater withdrawal as a proportion of available freshwater resources*. Food and Agriculture Organization. <https://www.fao.org/sustainable-development-goals-data-portal/data/indicators/642-water-stress/sdg-6-indicators-of-water-use-efficiency-and-water-stress/en>

- Fischer, J., Manning, A. D., Steffen, W., Rose, D. B., Daniell, K., Felton, A., Garnett, S., Gilna, B., Heinsohn, R., Lindenmayer, D. B., MacDonald, B., Mills, F., Newell, B., Reid, J., Robin, L., Sherren, K., & Wade, A. (2007). Mind the sustainability gap. *Trends in Ecology & Evolution*, 22(12), 621–624. <https://doi.org/10.1016/j.tree.2007.08.016>
- Fourie, S. A. (Fanus). (2022). Approach to view groundwater level fluctuations on an aquifer to national scale. *Groundwater for Sustainable Development*, 16, 100701. <https://doi.org/10.1016/j.gsd.2021.100701>
- Garcés, E., Franco, C. J., Usubiaga-Liaño, A., Ruíz, C. A., & Fairbrass, A. (2025). Assessing Environmental Sustainability in Colombia: Metrics and Policy Recommendations. *Environmental and Sustainability Indicators*, 27, 100812.
- Gütschow, J., Busch, D., & Pflüger, M. (2025). *The PRIMAP-hist national historical emissions time series (1750-2023)* (Version v2.6.1) [Data set]. Zenodo. <https://doi.org/10.5281/zenodo.15016289>
- Huber, S., Prokop, G., Arrouays, D., Banko, G., Bispo, A., Jones, R. J. A., Kibblewhite, M. G., Lexer, W., Möller, A., Rickson, R. J., Shishkov, T., Stephens, M., Toth, G., Akker, J. J. H. V. den, Varallyay, G., Verheijen, F. G. A., & Jones, A. R. (2008). *Environmental Assessment of Soil for Monitoring. Volume I: Indicators & Criteria*. Joint Research Centre.
- IAEG-SDGs. (2021). *Indicator 6.4.2: Level of water stress: Freshwater withdrawal as a proportion of available freshwater resources—Metadata*. Inter-agency Expert Group on SDG Indicators.
- IPBES. (2019). *Global assessment report on biodiversity and ecosystem services*. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.
- IPCC. (2018). *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change*, (V. Masson-Delmotte, P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, & T. Waterfield, Eds). Intergovernmental Panel on Climate Change,.
- IPCC. (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen,]. Intergovernmental Panel on Climate Change.
- IUCN. (2012). *IUCN Red List Categories and Criteria* (Second edi). International Union for the Conservation of Nature.
- Jones, R. J. A., Le Bissonnais, Y., Bazzoffi, P., Sánchez Díaz, J., Düwel, O., Loj, G., Øygarden, L., Prasuhn, V., Rydell, B., Strauss, P., Berényi Üveges, J., Vandekerckhove, L., & Yordanov, Y. (2004). Soil erosion. In *Reports of the Technical Working Groups Established under the Thematic Strategy for Soil Protection. Volume II: Erosion*. Joint Research Centre.
- Keith, D. A., Ferrer-Paris, J. R., Ghoraba, S. M. M., Henriksen, M., Monyeke, M., Murray, N. J., Nicholson, E., Rowland, J., Skowno, A., Slingsby, J. A., Storeng, A. B., Valderrábano, M., & Zager, I. (2024). *Guidelines for the application of IUCN Red List of Ecosystems Categories and Criteria*. International Union for Conservation of Nature.
- Neumayer, E. (2025). *Weak versus Strong Sustainability Exploring the Limits of Two Opposing Paradigms* (5th edn). Edward Elgar Publishing.
- NPC. (2012). *National Development Plan 2030. Our Future-make it work*. National Planning Commission.
- NPC. (2019). *South Africa's Voluntary National Review (VNR) Report 2019. Empowering People and Ensuring Inclusiveness and Equality*. National Planning Commission.
- Otieno, M. N., Mbaisi, C., Nguru, P., Mungai, O., Inganga, F., Busenei, W., Omambia, A., Ooko, E., Maithya, S., Lamutete, A., Soto-Navarro, C., Fairbrass, A., & Usubiaga-Liaño, A.

- (2022). *Strong Environmental Sustainability in Kenya. A case study in the Environmental Sustainability Gap Framework (ESGAP) and Strong Environmental Sustainability Index (SESI)*. Agence française de développement.
- Ozone Secretariat United Nations Environment Programme. (2025). *Consumption of controlled substances*. Secretariat for The Vienna Convention for the Protection of the Ozone Layer & The Montreal Protocol on Substances that Deplete the Ozone Layer.
- Prudhomme, R., Comte, A., Sedel, K., & Levrel, H. (2023). *Influence of nature values on environmental assessments in the ESGAP framework* (Nos 2023–93; CIRED Working Paper). Centre international de recherche sur l'environnement et le développement.
- Radermacher, W. J. (2019). Governing-by-the-numbers/Statistical governance: Reflections on the future of official statistics in a digital and globalised society. *Statistical Journal of the IAOS*, 35, 519–537. <https://doi.org/10.3233/SJI-190562>
- Richardson, K., Steffen, W., Lucht, W., Bendtsen, J., Cornell, S. E., Donges, J. F., Drüke, M., Fetzer, I., Bala, G., Bloh, W. von, Feulner, G., Fiedler, S., Gerten, D., Gleeson, T., Hofmann, M., Huiskamp, W., Kummu, M., Mohan, C., Nogués-Bravo, D., ... Rockström, J. (2023). Earth beyond six of nine planetary boundaries. *Science Advances*, 9(37), eadh2458. <https://doi.org/10.1126/sciadv.adh2458>
- Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, I. I. F. S., Lambin, E., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H., Nykvist, B., Wit, C. A. D., Hughes, T., Leeuw, S. van der, Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U., ... Foley, J. (2009). Planetary boundaries:exploring the safe operating space for humanity. *Ecology and Society*, 14(2).
- SABS. (2015). *SANS 241-1:2015, Drinking water—Part 1: Microbiological, physical, aesthetic and chemical determinands*. South African Bureau of Standards.
- SANBI. (2019). *National Biodiversity Assessment 2018. Synthesis Report*. South African National Biodiversity Institute.
- Sato, M., Usubiaga-Liaño, A., Fairbrass, A., Ekins, P., & Asuka, J. (2024). Monitoring environmental sustainability in Japan: An ESGAP assessment. *Sustainability Science*, 19(2), 539–553. <https://doi.org/10.1007/s11625-023-01441-x>
- Shen, S., Li, C., van Donkelaar, A., Jacobs, N., Wang, C., & Martin, R. V. (2024). Enhancing Global Estimation of Fine Particulate Matter Concentrations by Including Geophysical a Priori Information in Deep Learning. *ACS ES&T Air*, 1(5), 332–345. <https://doi.org/10.1021/acsestair.3c00054>
- Solomon, S., Ivy, D. J., Kinnison, D., Mills, M. J., Neely, R. R., & Schmidt, A. (2016). Emergence of healing in the Antarctic ozone layer. *Science*. <https://doi.org/10.1126/science.aae0061>
- Statistics South Africa. (2014). *The South African MPI Creating a multidimensional poverty index using census data*. Statistics South Africa.
- Thang, N. T., Soto-Navarro, C., Hanh, H. H., Anh, D. T. P., Nga, V. T. T., Thong, N. T., Trung, T. Q., Fairbrass, A., & Usubiaga-Liaño, A. (2022). *Strong Environmental Sustainability in Vietnam. Piloting the Environmental Sustainability Gap Framework (ESGAP) and Strong Environmental Sustainability Index (SESI)*. Agence française de développement.
- UN. (1987). *Montreal Protocol on Substances that Deplete the Ozone Layer*. United Nations.
- UNDESA. (2022). *World Population Prospects 2022*. United Nations Department of Economic and Social Affairs.
- UNDESA. (2025). *SDG Indicators Database*. United Nations Department of Economic and Social Affairs. <https://unstats.un.org/sdgs/dataportal/database>
- UNEP. (2019). *Global Environment Outlook – GEO-6: Healthy Planet, Healthy People*. United Nations Environment Programme.
- UNEP. (2023). *Inclusive Wealth Report 2023: Measuring Sustainability and Equity*. United Nations Environment Programme.

- Usubiaga-Liaño, A., & Ekins, P. (2021a). Monitoring the environmental sustainability of countries through the strong environmental sustainability index. *Ecological Indicators*, 132, 108281. <https://doi.org/10.1016/j.ecolind.2021.108281>
- Usubiaga-Liaño, A., & Ekins, P. (2021b). Time for science-based national targets for environmental sustainability: An assessment of existing metrics and the ESGAP framework. *Frontiers in Environmental Science*, 9(524).
- Usubiaga-Liaño, A., & Ekins, P. (2022). Are we on the right path? Measuring progress towards environmental sustainability in European countries. *Sustainability Science*. <https://doi.org/10.1007/s11625-022-01167-2>
- Usubiaga-Liaño, A., Fairbrass, A., & Ekins, P. (2024). Strong sustainability and the environmental dimension of the Sustainable Development Goals. *Global Sustainability*, 7, e52.
- Usubiaga-Liaño, A., Selomane, O., & Comte, A. (2025). Strong sustainability in the SEEA and the wider indicator landscape. *One Ecosystem*, 10, e141086. <https://doi.org/10.3897/oneeco.10.e141086>
- Verheijen, F. G. A., Jones, R. J. A., Rickson, R. J., & Smith, C. J. (2009). Tolerable versus actual soil erosion rates in Europe. *Earth-Science Reviews*, 94(1–4), 23–38. <http://dx.doi.org/10.1016/j.earscirev.2009.02.003>
- WHO. (2018). *Burden of disease from household air pollution for 2016. Description of method*. World Health Organization.
- WHO. (2021). *WHO global air quality guidelines: Particulate matter (PM_{2.5} and PM₁₀), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. World Health Organization.
- WHO. (2024). *Guidelines for drinking-water quality*. World Health Organization.

Supplementary Material

Fish resources

General information

Indicator code	SO_FISH
Function	Source
Principle	Renew renewable resources
Topic	Biomass resources

SES indicator

Indicator	Fish stocks considered 'not of concern'
Range	0 – 100
Unit	%
Description	The indicator shows the % of fish stocks that are classified as 'not of concern'.
Data provider	Department of Agriculture, Forestry and Fisheries
Data source	(DFFE, 2025c)
Time	2025 (*)
Normalisation bounds	$gp_{min} = 0$, $gp_{max} = 100$
Notes	(*) Only the data of the report is given

Science-based environmental standard(s)

Indicator	Exploitation status
Value / Range	Not of concern
Unit	-
Scale	Fish stock
Description	'Not of concern' covers fish stocks being of unknown, abundant, or optimal status. In general, stock assessment outputs are described relative to two predefined reference points: Target and Limit. Target reference points describe the optimal stock status while Limit reference points define the undesirable low biomass threshold that, if exceeded, would require urgent management intervention. Examples of Target reference points are maximum sustainable yield, or roughly 40% of pre-exploitation (pristine) biomass. Biomass can refer to that part of the population susceptible to capture (exploitable biomass), or a particular part of the population such as mature fish only (spawner biomass), or female fish. Limit reference points are generally formulated as a percentage of pre-exploitation biomass (i.e. biomass <25% of pristine biomass). A comprehensive stock assessment typically requires several streams of data, i.e. a time-series of catch, fishing effort and biological information, including sizes of the fish caught. This information is generally only available for industrial fisheries. Stock status for smaller, artisanal fisheries can still be derived from changes in relative abundance or size composition.
Reference	(DFFE, 2025c)
Notes	-

Freshwater resources

General information

Indicator code	SO_S WATER
Function	Source
Principle	Renew renewable resources
Topic	Water resources

SES indicator

Indicator	Freshwater withdrawal as a proportion of available freshwater resources
Range	0- ∞
Unit	%
Description	The indicator represents the % of freshwater that is withdrawn compared to total renewable freshwater resources, after taking into account environmental flow requirements
Data provider	Food and Agriculture Organization of the United Nations
Data source	(FAO, 2025)
Time	2021
Normalisation bounds	$g_{p_{min}} = 25$, $g_{p_{max}} = 0$
Notes	-

Science-based environmental standard(s)

Indicator	Freshwater withdrawal as a proportion of available freshwater resources
Value / Range	0
Unit	%
Scale	0- ∞
Description	The threshold of 25% is considered to represent full and unconditional safety of water stress. Thus, values below 25% are considered safe (no stress), while values above 25% are considered potentially and increasingly problematic.
Reference	(IAEG-SDGs, 2021)
Notes	-

Groundwater resources

General information

Indicator code	SO_SWATER
Function	Source
Principle	Renew renewable resources
Topic	Water resources

SES indicator

Indicator	Hydrogeological regions without water scarcity
Range	0-100
Unit	%
Description	The indicator represents the % of hydrogeological regions in which the average groundwater level status is categorised as average or better. (*)
Data provider	Department of Water and Sanitation
Data source	(DWS, 2024)
Time	2024
Normalisation bounds	$g_{p_{min}} = 0$, $g_{p_{max}} = 100$
Notes	Groundwater level status is averaged over each of the 64 hydrogeological regions in order to correct for sampling bias.

Science-based environmental standard(s)

Indicator	Groundwater level status
Value / Range	40
Unit	%
Scale	Borehole
Description	Groundwater level status represents the % of the current level between the shallowest (Sgw) and deepest (Dgw) groundwater levels measured in the monitoring history of the borehole (Fourie, 2022). An alert system exists depending on the percentage. Thus, the band 40-60% is considered normal, while values below 40% are considered to be below normal (DWS, 2024).
Reference	(DWS, 2024)
Notes	-

Soil resources

General information

Indicator code	SO_SOIL
Function	Source
Principle	Use non-renewables prudently
Topic	Soil resources

SES indicator

Indicator	Area with tolerable soil erosion
Range	0-100
Unit	%
Description	The indicator shows the % of terrestrial area that is not subject to excessive water soil erosion.
Data provider	European Commission Joint Research Centre
Data source	(Borrelli et al., 2017)
Time	2012
Normalisation bounds	$gp_{min} = 0$, $gp_{max} = 100$
Notes	-

Science-based environmental standard(s)

Indicator	Soil erosion rate
Value / Range	1
Unit	$t\ ha^{-1}\ yr^{-1}$
Scale	Local
Description	Rates higher than the reference value lead to loss of agricultural productivity and decrease in water quality.
Reference	(Huber et al., 2008; Jones et al., 2004; Verheijen et al., 2009)
Notes	-

CO2 emissions

General information

Indicator code	SI_CLIMATE
Function	Sink
Principle	Prevent the disruption of Earth System processes
Topic	Climate change

SES indicator

Indicator	Net per-capita CO ₂ emissions (*)
Range	0-∞
Unit	t per capita
Description	This indicator shows the net per-capita CO ₂ emissions of countries (**)
Data provider	PRIMAP
Data source	(Gütschow et al., 2025)
Time	2023
Normalisation bounds	gp _{min} = 2.5, gp _{max} = 0.5
	(*) It does not consider international bunkers, which are reported as memo items in emission inventories.
Notes	(**) The carbon emission budgets of the Intergovernmental Panel on Climate Change (IPCC 2018) show the 33%, 50% and 67% chances of meeting the 1.5°C and 2°C targets only for CO ₂ emissions.

Science-based environmental standard(s)

Indicator	Net per-capita CO ₂ emissions consistent with global climate targets
Value / Range	0.5 – 2.5
Unit	t per capita
Scale	Country
Description	0.5 t per capita are consistent with meeting the 1.5°C target with 67% of possibilities. On the other hand, 2.5 t per capital is consistent with meeting the 2°C target with 33% of possibilities. Emissions have been allocated on an equal-per-capita basis using cumulative population figures.
Reference	(IPCC, 2018; UNDESA, 2022)
Notes	Net per-capita CO ₂ emissions consistent with global climate targets

Ozone depleting substances

General information

Indicator code	SI_OZONE
Function	Sink
Principle	Prevent the disruption of Earth System processes
Topic	Ozone layer

SES indicator

Indicator	Per-capita consumption of ozone depleting substances
Range	$(-)\infty - \infty$
Unit	t ODP (ozone depleting potential) per capita
Description	This indicator shows the deviation of per-capita consumption (production + import – export (including destruction)) of ozone depleting substances (ODSs).
Data provider	Ozone Secretariat United Nations Environment Programme
Data source	(Ozone Secretariat United Nations Environment Programme, 2025)
Time	2023
Normalisation bounds	$gp_{\min} = 0.00032$; $gp_{\max} = 0$
Notes	-

Science-based environmental standard(s)

Indicator	Per-capita consumption of ozone depleting substances
Value / Range	0 – 0.00032
Unit	t ODP (ozone depleting potential) per capita
Scale	National
Description	The Montreal Protocol is regarded as a key factor behind the early signs of recovery in the Antarctica (Solomon et al., 2016). In principle, long-term country commitments in the Montreal Protocol and its subsequent amendments can be broadly considered SBES, but more action is required to decrease the pressure on the ozone layer (EEA, 2019). This is interpreted as the need to reduce ODS consumption to zero (upper bound). We provisionally use the per capita consumption of ODS in 1989 (0.00032 t), which represents the peak of the destruction of the ozone layer, to reflect unsustainable conditions.
Reference	(EEA, 2019; UN, 1987)
Notes	-

Freshwater eutrophication

General information

Indicator code	SI_EUTRO
Function	Sink
Principle	Respect critical loads for ecosystems
Topic	Freshwater eutrophication

SES indicator

Indicator	Dams in oligotrophic status
Range	0 – 100
Unit	%
Description	The indicator shows the % of dams not subject to eutrophication
Data provider	Department of Water and Sanitation
Data source	(DWS, 2024)
Time	2023
Normalisation bounds	$gp_{\min} = 0$; $gp_{\max} = 100$
Notes	-

Science-based environmental standard(s)

Indicator	Trophic state
Value / Range	Oligotrophic
Unit	-
Scale	Site
Description	An oligotrophic state is characterised by low levels of nutrients and for not being productive in terms of aquatic and animal plant life.
Reference	(DWS, 2024)
Notes	-

Terrestrial ecosystem health

General information

Indicator code	LS_TERECO
Function	Life support
Principle	Maintain ecosystem health
Topic	Terrestrial ecosystems

SES indicator

Indicator	Terrestrial ecosystems not threatened
Range	0 – 100
Unit	%
Description	The indicator shows the % of terrestrial ecosystems that are considered of 'least concern' in terms of threat status.
Data provider	South African National Biodiversity Institute
Data source	(SANBI, 2019)
Time	2018
Normalisation bounds	$gp_{min} = 0$; $gp_{max} = 100$
Notes	-

Science-based environmental standard(s)

Indicator	Threat status
Value / Range	Least concern
Unit	-
Scale	Ecosystem
Description	Ecosystem threat is assessed based on A) reduction in geographic distribution, (B) restricted geographic distribution, (C) environmental degradation, (D) disruption of biotic processes or interactions and (E) quantitative analysis that estimates the probability of ecosystem collapse. Ecosystems that unambiguously meet none of the quantitative criteria are considered to be of 'least concern'.
Reference	(Keith et al., 2024)
Notes	-

River ecosystem health

General information

Indicator code	LS_RIVECO
Function	Life support
Principle	Maintain ecosystem health
Topic	Freshwater ecosystems

SES indicator

Indicator	River ecosystems not threatened
Range	0 – 100
Unit	%
Description	The indicator shows the % of river ecosystems that are considered of 'least concern' in terms of threat status.
Data provider	South African National Biodiversity Institute
Data source	(SANBI, 2019)
Time	2018
Normalisation bounds	$gp_{min} = 0$; $gp_{max} = 100$
Notes	-

Science-based environmental standard(s)

Indicator	Threat status
Value / Range	Least concern
Unit	-
Scale	Ecosystem
Description	Ecosystem threat is assessed based on A) reduction in geographic distribution, (B) restricted geographic distribution, (C) environmental degradation, (D) disruption of biotic processes or interactions and (E) quantitative analysis that estimates the probability of ecosystem collapse. Ecosystems that unambiguously meet none of the quantitative criteria are considered to be of 'least concern'.
Reference	(Keith et al., 2024)
Notes	-

Inland wetland ecosystem health

General information

Indicator code	LS_INLECO
Function	Life support
Principle	Maintain ecosystem health
Topic	Freshwater ecosystems

SES indicator

Indicator	Inland wetland ecosystems not threatened
Range	0 – 100
Unit	%
Description	The indicator shows the % of inland wetland ecosystems that are considered of 'least concern' in terms of threat status.
Data provider	South African National Biodiversity Institute
Data source	(SANBI, 2019)
Time	2018
Normalisation bounds	$gp_{min} = 0$; $gp_{max} = 100$
Notes	-

Science-based environmental standard(s)

Indicator	Threat status
Value / Range	Least concern
Unit	-
Scale	Ecosystem
Description	Ecosystem threat is assessed based on A) reduction in geographic distribution, (B) restricted geographic distribution, (C) environmental degradation, (D) disruption of biotic processes or interactions and (E) quantitative analysis that estimates the probability of ecosystem collapse. Ecosystems that unambiguously meet none of the quantitative criteria are considered to be of 'least concern'.
Reference	(Keith et al., 2024)
Notes	-

Marine ecosystem health

General information

Indicator code	LS_MARECO
Function	Life support
Principle	Maintain ecosystem health
Topic	Marine and coastal ecosystems

SES indicator

Indicator	Marine ecosystems not threatened
Range	0 – 100
Unit	%
Description	The indicator shows the % of marine ecosystems that are considered of 'least concern' in terms of threat status.
Data provider	South African National Biodiversity Institute
Data source	(SANBI, 2019)
Time	2018
Normalisation bounds	$gp_{min} = 0$; $gp_{max} = 100$
Notes	-

Science-based environmental standard(s)

Indicator	Threat status
Value / Range	Least concern
Unit	-
Scale	Ecosystem
Description	Ecosystem threat is assessed based on A) reduction in geographic distribution, (B) restricted geographic distribution, (C) environmental degradation, (D) disruption of biotic processes or interactions and (E) quantitative analysis that estimates the probability of ecosystem collapse. Ecosystems that unambiguously meet none of the quantitative criteria are considered to be of 'least concern'.
Reference	(Keith et al., 2024)
Notes	-

Coastal ecosystem health

General information

Indicator code	LS_COAECO
Function	Life support
Principle	Maintain ecosystem health
Topic	Marine and coastal ecosystems

SES indicator

Indicator	Coastal ecosystems not threatened
Range	0 – 100
Unit	%
Description	The indicator shows the % of coastal ecosystems that are considered of 'least concern' in terms of threat status.
Data provider	South African National Biodiversity Institute
Data source	(SANBI, 2019)
Time	2018
Normalisation bounds	$gp_{min} = 0$; $gp_{max} = 100$
Notes	-

Science-based environmental standard(s)

Indicator	Threat status
Value / Range	Least concern
Unit	-
Scale	Ecosystem
Description	Ecosystem threat is assessed based on A) reduction in geographic distribution, (B) restricted geographic distribution, (C) environmental degradation, (D) disruption of biotic processes or interactions and (E) quantitative analysis that estimates the probability of ecosystem collapse. Ecosystems that unambiguously meet none of the quantitative criteria are considered to be of 'least concern'.
Reference	(Keith et al., 2024)
Notes	-

Estuarine ecosystem health

General information

Indicator code	LS_ESTECO
Function	Life support
Principle	Maintain ecosystem health
Topic	Marine and coastal ecosystems

SES indicator

Indicator	Estuarine ecosystems not threatened
Range	0 – 100
Unit	%
Description	The indicator shows the % of estuarine ecosystems that are considered of 'least concern' in terms of threat status.
Data provider	South African National Biodiversity Institute
Data source	(SANBI, 2019)
Time	2018
Normalisation bounds	$gp_{min} = 0$; $gp_{max} = 100$
Notes	-

Science-based environmental standard(s)

Indicator	Threat status
Value / Range	Least concern
Unit	-
Scale	Ecosystem
Description	Ecosystem threat is assessed based on A) reduction in geographic distribution, (B) restricted geographic distribution, (C) environmental degradation, (D) disruption of biotic processes or interactions and (E) quantitative analysis that estimates the probability of ecosystem collapse. Ecosystems that unambiguously meet none of the quantitative criteria are considered to be of 'least concern'.
Reference	(Keith et al., 2024)
Notes	-

Terrestrial species diversity

General information

Indicator code	LS_TERBIO
Function	Life support
Principle	Maintain biodiversity
Topic	Terrestrial ecosystems

SES indicator

Indicator	Species in terrestrial ecosystems not threatened
Range	0 – 100
Unit	%
Description	The indicator shows the % of species in terrestrial ecosystems that are considered of 'least concern' in terms of threat status.
Data provider	South African National Biodiversity Institute
Data source	(SANBI, 2019)
Time	2018
Normalisation bounds	$gp_{min} = 0$; $gp_{max} = 100$
Notes	-

Science-based environmental standard(s)

Indicator	Threat status
Value / Range	Least concern
Unit	-
Scale	Species
Description	Species threat is assessed based on A) population size reduction, (B) geographic range, (C) small population size and decline, (D) very small or restricted population and (E) quantitative analysis. Species that unambiguously meet none of the quantitative criteria are considered to be of 'least concern'.
Reference	(IUCN, 2012)
Notes	-

Freshwater species diversity

General information

Indicator code	LS_INLBIO
Function	Life support
Principle	Maintain biodiversity
Topic	Freshwater ecosystems

SES indicator

Indicator	Species in freshwater ecosystems not threatened
Range	0 – 100
Unit	%
Description	The indicator shows the % of species in freshwater ecosystems that are considered of 'least concern' in terms of threat status.
Data provider	South African National Biodiversity Institute
Data source	(SANBI, 2019)
Time	2018
Normalisation bounds	$gp_{min} = 0$; $gp_{max} = 100$
Notes	-

Science-based environmental standard(s)

Indicator	Threat status
Value / Range	Least concern
Unit	-
Scale	Species
Description	Species threat is assessed based on A) population size reduction, (B) geographic range, (C) small population size and decline, (D) very small or restricted population and (E) quantitative analysis. Species that unambiguously meet none of the quantitative criteria are considered to be of 'least concern'.
Reference	(IUCN, 2012)
Notes	-

Marine species diversity

General information

Indicator code	LS_MARBIO
Function	Life support
Principle	Maintain biodiversity
Topic	Marine and coastal ecosystems

SES indicator

Indicator	Species in marine ecosystems not threatened
Range	0 – 100
Unit	%
Description	The indicator shows the % of species in marine ecosystems that are considered of 'least concern' in terms of threat status.
Data provider	South African National Biodiversity Institute
Data source	(SANBI, 2019)
Time	2018
Normalisation bounds	$gp_{min} = 0$; $gp_{max} = 100$
Notes	-

Science-based environmental standard(s)

Indicator	Threat status
Value / Range	Least concern
Unit	-
Scale	Species
Description	Species threat is assessed based on A) population size reduction, (B) geographic range, (C) small population size and decline, (D) very small or restricted population and (E) quantitative analysis. Species that unambiguously meet none of the quantitative criteria are considered to be of 'least concern'.
Reference	(IUCN, 2012)
Notes	-

Estuarine species diversity

General information

Indicator code	LS_ESTBIO
Function	Life support
Principle	Maintain biodiversity
Topic	Marine and coastal ecosystems

SES indicator

Indicator	Species in estuarine ecosystems not threatened
Range	0 – 100
Unit	%
Description	The indicator shows the % of species in estuarine ecosystems that are considered of 'least concern' in terms of threat status.
Data provider	South African National Biodiversity Institute
Data source	(SANBI, 2019)
Time	2018
Normalisation bounds	$gp_{min} = 0$; $gp_{max} = 100$
Notes	-

Science-based environmental standard(s)

Indicator	Threat status
Value / Range	Least concern
Unit	-
Scale	Species
Description	Species threat is assessed based on A) population size reduction, (B) geographic range, (C) small population size and decline, (D) very small or restricted population and (E) quantitative analysis. Species that unambiguously meet none of the quantitative criteria are considered to be of 'least concern'.
Reference	(IUCN, 2012)
Notes	-

Outdoor air pollution

General information

Indicator code	HW_OAP
Function	Human health and other welfare
Principle	Respect standards for human health
Topic	Air pollution

SES indicator

Indicator	Population exposed to safe PM _{2.5} levels
Range	0 - 100
Unit	%
Description	The indicator shows the % of population exposed to lower PM _{2.5} levels than the WHO guideline values.
Data provider	Washington University
Data source	(Shen et al., 2024)
Time	2023
Normalisation bounds	$gp_{min} = 0$, $gp_{max} = 100$
Notes	-

Science-based environmental standard(s)

Indicator	Average annual PM _{2.5}
Value / Range	5
Unit	$\mu\text{g m}^{-3}$
Scale	Local
Description	The SBES reflects the lowest levels at which adverse health effects could be observed with confidence. In practice, the guidelines were based on the average of the 5 th percentiles of exposure distributions from studies with the lowest levels of exposure.
Reference	(WHO, 2021)
Notes	-

Indoor air pollution

General information

Indicator code	HW_IAP
Function	Human health and other welfare
Principle	Respect standards for human health
Topic	Air pollution

SES indicator

Indicator	Population using clean fuels and technologies for cooking
Range	0-100
Unit	%
Description	The indicator shows the percentage of population using clean fuels for cooking.
Data provider	United Nations Department of Economic and Social Affairs
Data source	(UNDESA, 2025)
Time	2023
Normalisation bounds	$gp_{\min} = 0$, $gp_{\max} = 100$
Notes	-

Science-based environmental standard(s)

Indicator	Population using clean fuels and technologies for cooking
Value / Range	100
Unit	%
Scale	National
Description	The indicator shows the percentage of population using clean fuels for cooking. Members of a household using polluting fuels (e.g. coal, wood, charcoal, dung, crop residues and kerosene) for cooking are considered to be exposed to harmful levels indoor air pollution independent from age and gender that are several times higher than the 24-h exposure guidelines values proposed by WHO (WHO, 2018).
Reference	(WHO, 2018)
Notes	-

Drinking water pollution

General information

Indicator code	HW_DWP
Function	Human health and other welfare
Principle	Respect standards for human health
Topic	Drinking water pollution

SES indicator

Indicator	Water supply systems that comply with microbiological criteria
Range	0-100
Unit	%
Description	The indicator shows the % of water supply systems with an 'excellent' microbiological water quality compliance.
Data provider	Department of Water and Sanitation
Data source	(DWS, 2023)
Time	2023
Normalisation bounds	$gp_{min} = 0$, $gp_{max} = 100$
Notes	-

Science-based environmental standard(s)

Indicator	Degree of compliance
Value / Range	Excellent
Unit	-
Scale	Water supply system
Description	'Excellent' requires 97-99% compliance with microbiological criteria depending on the people the water supply system serves. The microbiological quality criteria covers E.coli or faecal coliforms, protozoan parasites, total coliforms, heterotrophic plate count and somatic coliphages. The standards are defined in the relevant legislation (SABS, 2015) and are based on the drinking water guidelines of the World Health Organisation (WHO, 2024).
Reference	(DWS, 2023)
Notes	-

Recreational water pollution

General information

Indicator code	HW_BWP
Function	Human health and other welfare
Principle	Conserve other welfare
Topic	Recreation

SES indicator

Indicator	Recreational sites with a low risk to human health
Range	0-100
Unit	%
Description	The indicator shows the % of sampled recreational sites classified as having a low risk to human health.
Data provider	Department of Water and Sanitation
Data source	(DWS, 2024)
Time	2023
Normalisation bounds	$gp_{\min} = 0$, $gp_{\max} = 100$
Notes	-

Science-based environmental standard(s)

Indicator	Risk of using raw water
Value / Range	Low
Unit	-
Scale	Sample
Description	Risk is measured as the concentration of E. coli (counts/ 100mL) in water. Low risk requires the concentration to be below 130 counts / 100 mL.
Reference	(DWS, 2024)
Notes	-

