

Safe and Just Operating Space for South Africa: National and Provincial Doughnuts



A Research Study Done By The Green Connection



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Introduction

South Africa faces multiple challenges across the social and ecological spectrum. On the human development front, there is a lot of work remaining to be done to lift millions of people out of poverty, improve health, education, reduce inequality, and many other basic services. By the time the Sustainable Development Goals (SDGs) were signed by more than 190 nations in 2015, South Africa was still struggling to meet the Millennium Development Goals (first signed 15 years earlier in 2000). At the time, the country failed to reach 62% of the targets expressed in the MDGs, including some critical targets (Statistics South Africa, 2019). For example, none of the six targets under MDG 5 targets to improve maternal health were met, and neither were the three targets under MDG 4 to reduce child mortality. These examples and other statistics on the status of unemployment, obscene inequality, and other development indicators, paint a difficult current and future picture for South Africa. This requires a concerted effort to address and earlier efforts such as the National Development Plan have still not redressed these concerns.

On the environmental front, and despite some gains such as an increase in the extent of protected areas in the past decade (Skowno et al., 2019), there is extensive work to be done to protect, restore, and prevent degradation of ecosystems which are critical for the economy and society, to curb pollution, and to reduce greenhouse gas emissions which contribute to climate change. The National Biodiversity Assessment report show that all ecosystems and species are experiencing some level of threat, driven by climate change, habitat loss, overuse of rangelands, biological invasions, and disrupted fire regimes (Skowno et al 2019). At the same time, many critical ecosystems such as rivers and wetlands remain poorly protected. Other issues such as air pollution, evidenced by the recent ‘deadly air’ campaign signal both environmental and health challenges for the country. These trends in South Africa mirror global trends in the state and trends of nature and its vital contributions to people, which are observed to be declining the world over (IPBES, 2019), while greenhouse gas emissions and pollution are simultaneously increasing.

Whereas in the past it seemed reasonable to think about separate social and environmental agendas – for example the human development and the environmental agendas have largely been separated from one another – we now have a better idea on the intertwined social and ecological challenges. Human activity impacts on the environment, and the environment impacts human development. These impacts can be negative (e.g., clearing pristine biodiversity, or natural disasters causing harm and death), or positive (e.g., restoration of degraded landscape or contribution of nature through supply of water, food, and energy). For this reason, its it critical to design holistic development strategies that account for both social and ecological dimensions, instead of pitting one against the other, in a false dichotomy.

The Doughnut Economics Model which defines the **Safe and Just Operating Space** (SJOS, **Figure 1**) for humanity, presents a lens for combining social and environmental issues under one umbrella that recognises both the shortcomings of societal development, as well as the pressure society exerts on the environment (Raworth, 2012). The ‘**safe**’ in the framework speaks to the planetary boundaries (Rockström et al., 2009; Steffen et al., 2015) which define

critical thresholds beyond which there is a lot of uncertainty about the stability of the Earth System. Here one can imagine guardrails on either side of the highway, which indicate the edge of the road, and which serve as markers for a *safe* space within which to drive. These guardrails are defined by nine planetary boundaries including (1) climate change, (2) ocean acidification, (3) biosphere integrity (functional and genetic diversity), (4) stratospheric ozone depletion, (5) novel entities, (6) atmospheric aerosol loading, (7) freshwater use, (8) biochemical flows (nitrogen and phosphorus), and land-system change (Rockstrom et al 2009; Steffen et al 2015). This framing recognizes the “ecological limits” which, if transgressed, could lead to undesirable tipping points and disaster for humanity.

In her articulation of the **safe and just** operating space, Raworth (2012) added the notion of **justice** to the planetary boundary framework. This was primarily to highlight the needs of those most vulnerable in our society and identify several dimensions of these needs which must be met to lift people from falling further behind. The ‘**just**’ in the model refers to ‘the avoidance of unacceptable human deprivation and extreme global inequality in the context of human rights’ (Cole et al., 2014; Raworth, 2012). These are not unlike the usual development challenges such as improving: (1) Food security, (2) Health, (3) Education, (4) Income and work, (5) Water and sanitation, (6) Energy, (7) Networks, (8) Housing, (9) Gender Equality, (10) Social Equity, (11) Political Voice and, (12) Peace and security. Both the social and environmental dimensions highlighted in the SJOS framework align with some of the many challenges facing South Africa today – from poverty and inequality to biodiversity loss and pollution.

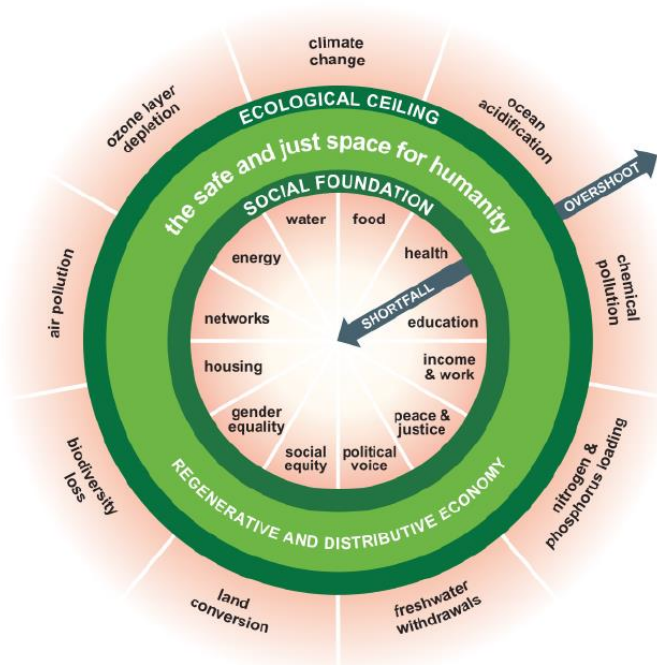


Figure 1 Safe and Just Operating Space for Humanity. The planetary boundaries (safe space) are defined by the outer green ring. The nine dimensions on the outside must be kept from *overshooting* the green outer boundary. The just space is defined by the inner green ring, and the 12 elements must be pushed into the inside of the green rings, to prevent *shortfall*, similar to how poverty lines are defined. Source: Doughnut Economics Lab <https://doughnuteconomics.org/>

South Africa's Safe and Just Operating Space

Two previous efforts to calculate South Africa's safe and just operating space (SJOS) exist at the national and provincial levels (Cole et al., 2017, 2014). In addition, efforts to determine the country's ability to attain 'good life for all within planetary boundaries' at the University of Leeds (Fanning et al., 2022) also calculates SJOS dimensions for South Africa. These analyses and others elsewhere in the world aim to downscale this global level framework (**Figure 1**) by looking at social and environmental limits at regional, national, and subnational levels (Dearing et al., 2014; Fang et al., 2021; Hossain et al., 2017). In all these sub-global applications, various modifications are made to the indicators or domains to contextualize the model to the needs and interest of the context in which they are applied. For example, Cole and colleagues (2014) substituted ocean acidification with marine harvesting and dropped social equity metrics for the South African analysis. This is in part because of the criteria they used, which strictly required availability of data, and in another part because they determined that fisheries were more important consideration about the ocean.

The approach in the current report is to identify issues which are considered pressing in the country, even though they may currently not have suitable data, as a call to action to prioritize these in future monitoring efforts. These issues are reported in the section "What is still missing" towards the end of the report. The intention of this document is therefore two-fold. First it aims to update South Africa's Safe and Just Operating Space using alternative existing data sources and alternative indicators, which can be repeatable with limited technical requirement. These indicators are reported at national and provincial level where applicable. Secondly, the document highlights key indicators which might currently not have suitable data but are nevertheless important in the South African context.

Methodology

The overall approach includes reviewing the indicators and data available to quantify the social and environmental indicators proposed in the global SJOS framework, as well as identifying additional indicators which may or may not have data but are important for the South African context. It also involves defining or identifying new boundaries for the 'new' indicators included in this report, which were not in the previous reports. Data sources and boundaries sources are summarized in **Table 1 & Table 2**).

Social foundation, indicators, and data

South Africa's National Development Plan sets out as it aims to 'eliminate poverty and reduce inequality in 2030' ([NDP 2012](#)). This aim needs further unpacking as the understanding of poverty as a unidimensional measure (mostly using an income metric) has since shifted to recognize poverty as a multidimensional phenomenon. The South African Multidimensional

Poverty Index defines four key dimensions and their indicators: (1) Health (indicators: Child Mortality), (2) Education (indicators: Years of Schooling & School Attendance), (3) Standard of Living (indicators: Fuel for lighting, heating & cooking, water access, sanitation type, dwelling type, and asset ownership), (4) Economic activity (indicator: Unemployment) (Statistics South Africa, [2014](#)). The indicators chosen for this index reflect the deep challenges facing the country, including excessive youth unemployment and challenges with the provision of basic services. These indicators continue to persist in various iterations of development plans and targeting mechanisms such as the SDGs, reflecting a slow and sometimes stagnant process towards achieving them.

Table 1 Development indicators used to determine the ‘just’ of the safe and just operating space (SJOS).

HWB component	Indicator name	2019 (%)	Boundary	Source
Energy	Households with access to electricity	85.0	100	GHS 2019
Water	Households with access to piped or tap water in their dwellings, off or onsite	88.2	100	GHS 2019
Sanitation	Households with a toilet or ventilated pit latrine	82.1	100	GHS 2019
Housing	Households with formal dwellings	81.9	100	GHS 2019
Education	Adults (≥20y old) with more than 7y of schooling (adult illiteracy)	75.6	100	GHS 2019
Health	Infant (<1y) immunisation coverage	81.9	100	DHB 2019 & 2010
Voice	National voter turnout as a proportion of voting age population (VAP)	49.0	100	Collette Schulz-Herzenberg 2020
Employment	Labour force participation rate	59.8	100	QLFS 2019
Food security	Households with adequate food	82.2	100	GHS 2019
Safety	Individuals feeling safe walking alone in their area at night	41.8	100	GPSJS 2020
Poverty	Upper bound poverty line (UPBL)	55.5	100	Stats SA 2017
Livelihood	Percent of people in need receiving social grants	77.3	100	SASSA 2021
Connectivity	Household with cellular telephone in their dwelling	87.8	100	GHS 2019
Governance	Corruption perception Index	44.0	100	Transparency International

Most of the social data and indicators proposed in the SJOS can be easily found in Statistics South Africa’s various databases including the Census, General Household Surveys, Quarterly Labour Statistics, Victims of Crime Survey, and several others. Where data were missing in national databases, international databases provide additional information. Due to the large number of indicators in these datasets, it was relatively easy to expand the indicator base used in previous iterations of calculating the safe and just operating space (from 11 to 14), although other critical issues such as inequality and gender-based violence still lack sufficient data to represent here (see Section 5 on missing indicators). These issues are particularly important to

incorporate given that South Africa is among the most unequal countries on Earth, and gender-based violence continues to increase and is under-reported (SAPS, 2019).

Setting social thresholds and boundaries

Because most of the social indicators aim to achieve a specific goal *for all*, such as ending poverty, or improving health, there are specific targets that are defined in policy documents, which makes the process of determining boundaries easier. Countries typically strive to provide 100% of their population with such services, or to protect 100% of their citizens from a particular misfortune. For example, South Africa aims to provide access to energy, clean water, and improved sanitation for all. Similar sentiments are also expressed in global policy documents such as the United Nation's Agenda 2030, which aims to 'leave no one behind'. Progress for these variables is assessed based on how far from 100% the variable is, with percentages closer to 100% being desirable, and vice versa. As such, the reported values on **Figure 2** for the social foundation highlight distance to 100%, represented as a shortfall.

Environmental ceiling, indicators, and data

South Africa has multiple policies and targets, both locally and globally which highlights the country's commitments to achieving environmental sustainability. These range from the National Protected Area Expansion Strategy (DEA, 2016), to the commitments to contribute to the Paris Agreement expressed in the country's National determined Contribution (NDC) (DFFE, 2021). The country is also committed to reducing or banning the use of Ozone Depleting Substances (DEFF, 2018). South Africa also has a dedicated publication on the [State of the Environment Report](#) which aggregates information about wide-ranging environmental issues such as air pollution, ecological degradation, biodiversity, climate and oceans and coasts.

Environmental indicators are trickier because data are scarce. The 'common' issues such as climate change have better data, which also goes back in time, giving some historical perspectives which are usually more difficult in environmental accounting. Even so, South Africa still has good data about some key domains such as biodiversity (Skowno et al 2019), Department of Water Affairs' State of the Rivers which uses monitoring sites spread across the country to classify the health of major rivers ([DWS 2018](#)), and the State of the Environment Reports. Again, here where data cannot be sourced locally, international sources such as 'Our World in Data', the World Bank or the United Nations Environmental Programme were used.

Setting environmental thresholds and boundaries

Like social indicators, some of the environmental indicators have a simpler boundary, mainly about staying as close to zero as possible. Indicators such as endangered ecosystems or species, aim to keep the proportion of ecosystems and species to zero, and any percentage above this is undesirable. Similarly, indicators such as 'Protected Area Extent' are measured against the goals expressed in policy document to increase this extent. Developing a boundary for this indicator was based on the expressed growth of terrestrial protected areas as expressed in the National Protected Area Expansion Strategy (NPAES 2016), i.e., the number of square

kilometres expressed in this document determines the boundary towards which protected area extent is growing and the value is determined by dividing the current extent with this future extent.

Several other indicators have data but no clearly defined boundaries. For example, national accounting for land determines changes in stocks of natural and semi-natural land, water bodies, cultivated land and urban land. Because there is no ideal mix, what is defined beforehand about how much each share of land use should be in South Africa (or any country), it is difficult to determine a boundary here. Even for natural areas, one can be tempted to use total land area as the boundary to work towards, but realistically land has always been used, and it was never all natural.

Table 2 Development indicators used to determine the 'safe' of the safe and just operating space (SJOS).

Domain	Indicator(s)	Value	Boundary	Unit	Year	Proximity (%)	Source
Climate change	<i>Annual CO2 emission (excl. forestry)</i>	487	440	MT CO2e	2020	110.7	Climate Tracker
Ozone depletion	Annual HCFC consumption	110.86	370	ODPt	2019	30.0	NEDLAC (2012)
Freshwater Quantity	Registered water use	20.2	14.7	billion m3/a	2019	137.4	WRC 2018
Freshwater Quantity	<i>Blue drop score</i>	79.6	100	%	2014	79.6	DWS 2014
Biodiversity loss	Endangered and critically endangered ecosystems	50%	0	%	2018	50.0	NBA 2019
Air pollution	Annual average PM2.5 concentration	21.6	5	µg/m3	2017	432.0	DEA 2018 World Air Quality
Land Use Change	Natural or semi-natural area extent	83.2	100	ha	2014	83.2	Stats SA 2020
Nitrogen loading	Nitrogen consumption per capita	72,8	41	kg			DAFF 2018
Marine harvesting	Marine stocks of concern	39%	0	%	2020	39.0	DEFF 2020

Safe and Just Operating Space for South Africa Today

Social foundations

Every one of the 14 social foundation indicators had a shortfall with four notable shortfalls involving more than 50% of the relevant population. Nearly 60% of people do not feel safe walking alone in their area at night, 56% perceive the country's public sector to be corrupt, 55% live under the poverty line, and just over half of the voting age population doesn't vote. At the same time, 40% of the labour force is unemployed, and this has recently seen further declines

since the COVID-19 pandemic, which decimated labour markets across the world. The latest reports from Statistics South Africa show that the country lost 648 000 non-agriculture formal sector jobs in the second quarter of 2020 during the COVID-19 lockdown (Stats SA, [2022](#)). With poverty still very high in the country, one would expect this to have worsened in the years since 2015, as unemployment has continued to increase, with little prospect for the economy to provide alternatives. This is also evidenced by the increasing number of people dependent on social grants.

The basic services such as energy, water, sanitation, and housing were first ramped up as part of the two policies: RDP in 1994 (Reconstruction and Development Programme) and ASGISA in 2005 (Accelerated and Shared Growth Initiative for South Africa). While progress has been made in terms of housing, education, health, sanitation, and food security, currently between 18 – 24% of people still lack these basic services. And in some cases, the reported improvement such as increase in piped water access does not represent actual access – a [newspaper article](#) reported that “It’s important to note that even when communities have access to water through infrastructure, this doesn’t guarantee the delivery of basic water supply services”. This is a similar story to energy access, which has seen recent increases in blackouts, which have [increased in intensity](#) since the first significant reports in 2015.

Ecological ceilings

Of the nine indicators representing nine planetary boundaries, four have exceeded the boundaries in South Africa, with air pollution being the most significant transgressor. A caveat for air pollution however is that it is currently only monitored at a few stations around mainly metros and does not necessarily represent countrywide outcomes. Even with this consideration, the areas being monitored are showing pollution outcomes orders of magnitude above the World Health Organisation (WHO) standards. Nitrogen consumption per capita exceeds the boundary recommended by Steffen et al 2015, registered freshwater demand exceeds available supply, and the country’s greenhouse gas emissions exceeds the climate action tracker’s [fair share](#) value (**Figure 2**). Registered water use exceeds the available supply by 37%, representing overallocation of available water resources, which is a significant challenge given the water-scare nature of the country.

South Africa has made progress on reducing the consumption of ozone depleting substances as part of the Montreal Protocol and has managed to keep marine stocks of concern to below 40%. While land use change and biodiversity loss have been calculated, it is worth noting that boundaries for land use change and biodiversity loss are difficult to determine as there are no scientific baselines on which to base the boundaries (i.e., how much land should be allocated to what use and based on which date?). Besides, just because an indicator has not passed the boundary (however arbitrary), this does not mean it is following a sustainable trajectory.

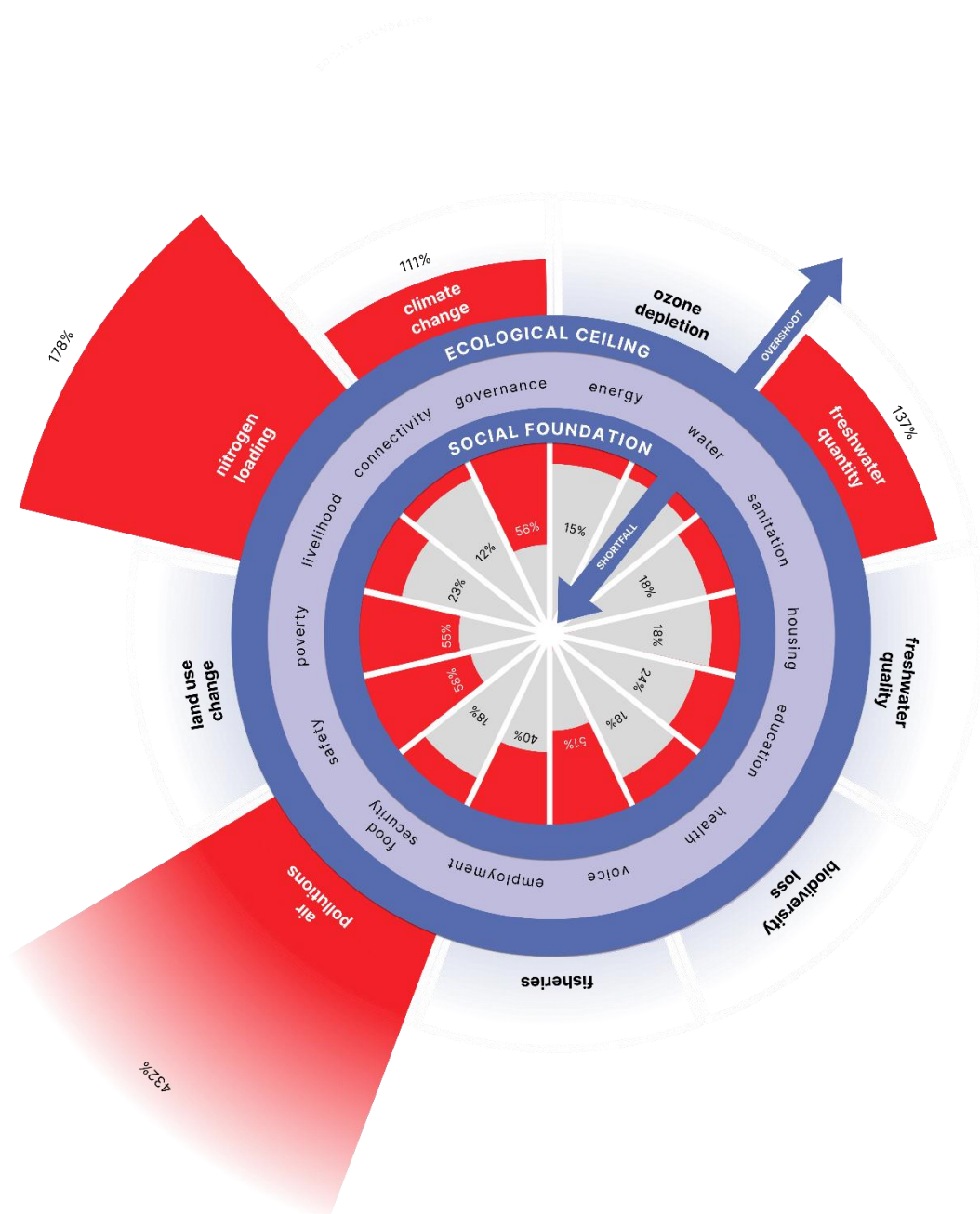


Figure 2 The inner ring of the doughnut representing the minimum developmental needs. Currently all indicators show a shortfall, but of varying degrees, with some significant shortfalls over 50%. The outer ring of the doughnut, or the domesticated 'planetary boundaries also shows four boundaries being transgressed, although with some caveat for air pollution which is only monitored in specific areas in the country.

Provincial doughnuts

Methodology

The provincial doughnuts are only reported for the social foundations data, since environmental boundaries were harder to establish. For example, Cole and colleagues in 2017 determined boundaries for a range of environmental indicators using a combination of share of national value, aggregation across select provinces (based on which province reported), and sometimes they left out indicators based on lack of methods or data to populate these indicators (Cole et al 2017).

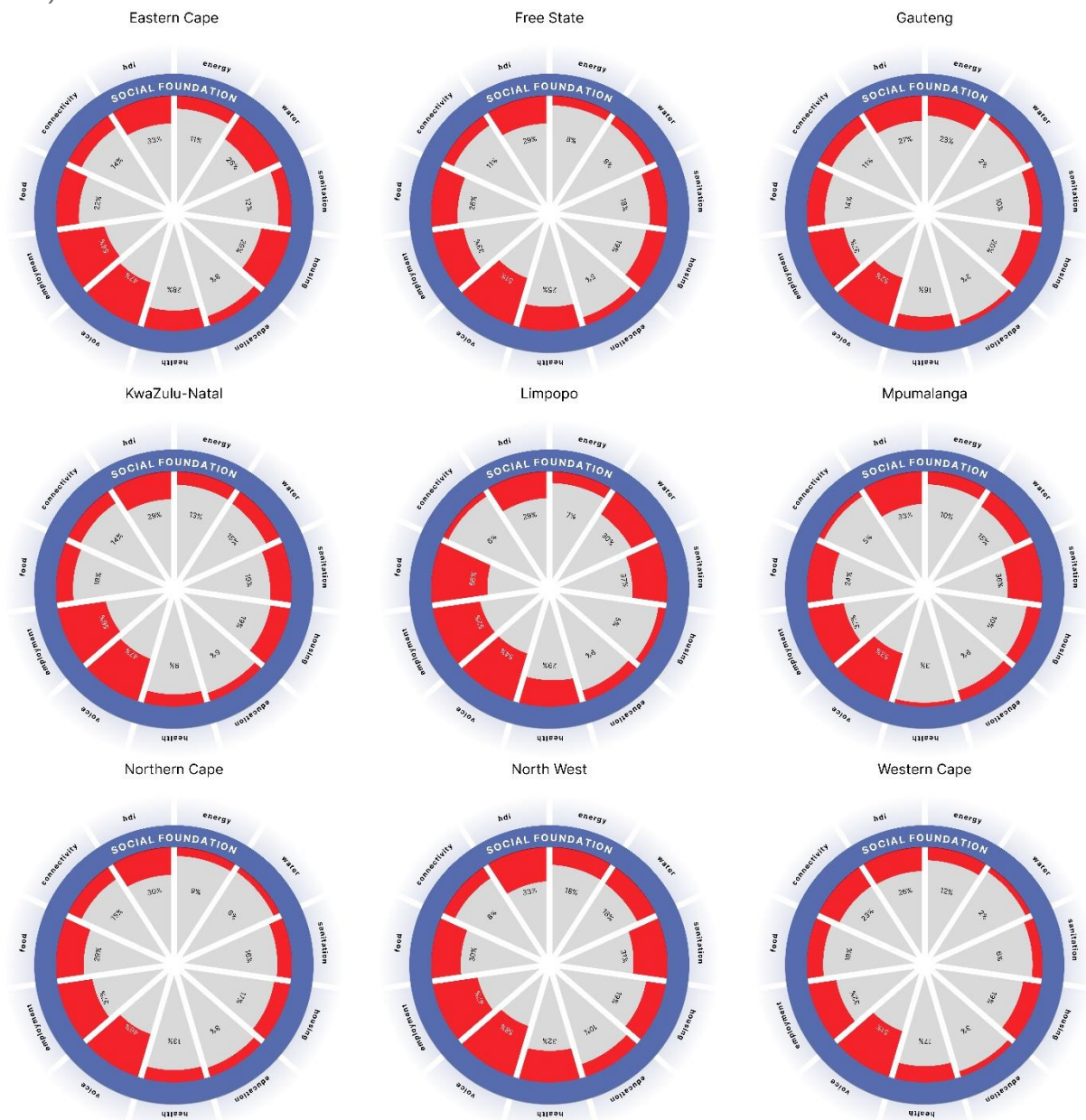


Figure 3 Just Operating Space at the Provincial Level.

Environmental data at the provincial level was difficult to find. Ideally, each province should produce an “Environmental Outlook” report, similar to the national [State of the Environment Report](#). However, of the nine provinces, only five produce these reports – and not all of them pay equal attention to all important dimensions. Table 3 below summarises the key indicators considered in the five reporting provinces.

For these five provinces, there are varying levels of focus on the different indicators. In part this is because they report differently on each dimension (e.g., Gauteng had an explicit indicator for wetlands, whereas the Western Cape aggregates at the ecosystem level), in another part because some indicators such as those concerned with marine resources are not applicable to all provinces. Further, for most indicators – with a few exceptions such as the KwaZulu-Natal’s Protected Area Expansion Strategy’s clearly defined target of increasing protected areas – there are not explicitly stated targets or no quantifiable targets which makes it challenging to set the boundaries. The Western Cape, for example, has clearly defined targets, but these are not quantified.

There are some encouraging developments in some of the Outlook reports. Gauteng province has a section discussing key environmental vulnerabilities for the province which cover key dimensions of the Planetary boundary framework such as land use, freshwater quality and quantity, air quality and the status of ecological systems. The report also identifies potential *tipping points* (the language of tipping points is the same language used in the Planetary Boundaries framework to denote pushing boundaries beyond reversible levels) and the likelihood of their occurrence. Similar innovative developments include the Western Cape’s section on emerging issues, which highlight issues like drought, shale gas potential, renewable energy development, sand mining, and others. Limpopo Province’s report quantifies the carbon dioxide equivalences of various emissions sources, which is useful for development of country boundaries based on provincial shares.

Overall, the provinces reporting on the Environment Outlook Reports have great potential to provide data needed to develop provincial level doughnut similar to those by Cole et al 2017. It is however worrying that four provinces do not produce these reports, and for North West, key dimensions such as climate change and energy are missing from the report. The four missing provinces, including the Eastern Cape, Mpumalanga, Northern Cape and Free State have unique issues that would be critical to highlight. For example, Mpumalanga has a substantial mining footprint, along with greenhouse gas emissions and air quality concerns. The Eastern Cape has large populations who are highly dependent on local environment for their livelihoods (Hamann et al., 2015) and whose livelihoods are consequently negatively impacted by environmental change.

Table 3 Provincial Environmental Outlooks

	Gauteng (2017)	KwaZulu Natal (2017)	Western Cape (2018)	Limpopo (2016)	North West (2018)
Land	7	11	5	10	6
Biodiversity and Ecosystem Health	12	11	6	13	6
Freshwater	11	13	3	9	7
Climate Change	6	8	3	5	
Energy	7	11	5	3	
Air Quality	4	3	3	6	3
Waste management	7	10	4	5	3
Environmental Governance	6	9		10	
Marine and Coastal Resources		11	6		
Human Settlement	10	13	4	16	3

For this report, environmental indicators are therefore only reported in a table, rather than visualised in the doughnuts in **Figure 3**. To determine the depth of the shortfall, arbitrary values were assigned to each indicator, such that a percentage under 80% was deemed low for most indicators, 45% for voice, 50% for labour participation, and 71% for human development index (based on the national average).

Province SJOS

For the provinces, 11 indicators were used for the social foundations (**Figure 3**). Unsurprisingly, and just like the national doughnut all provinces experienced some level of shortfall across all these indicators. The most common shortfalls were lack of adequate food, and immunisation of infants, which fell under 80% in five provinces (EC, FS & NW for both indicators, and LP for immunisation, and NC for inadequate food). This also makes the Eastern Cape and North West provinces to be the provinces with deeper shortfalls.

For the two indicators for which a boundary can be determined, all provinces exceed the per capita carbon dioxide equivalent emissions of 1.06, with Mpumalanga leading that charge, mainly due to the coal mines and coal-fired power plants. The North West and Northern Cape follow closely behind. In terms of water consumption, surprisingly all but one province exceeds the maximum allowable litres per day of 173 per capita, with five provinces in excess of 200 litres. Freshwater use can also be estimated using the demand and supply per catchment system and reconciling this with the provinces relying on those systems (see **Table 10** for details on these data).

Table 4 The two available boundaries for environmental data

Dimension	Indicator	Unit	WC	EC	NC	FS	KN	NW	GP	MP	LP	Boundary	Year*
Climate change	Per capita consumption of Eskom electricity	CO2e tonnes / yr.	2.8	1.4	4.57	1.32	3.49	5.51	3.61	6.71	3.58	1.06	2022
Freshwater use	Per capita consumption per day	l/c/d	214	178	224	237	170	126	286	201	114	173	2019

Sources: [Statistics South Africa](#) Energy Use for estimating greenhouse gas emissions & [Green Book](#) and [Green Cape](#) for estimating water consumption

What is new compared to previous iterations of the SJOS in South Africa?

Social indicators

The previous efforts on developing the SJOS laid out important foundations for engaging with this framework and developed some methodological innovations which were instrumental in developing the assessment in this report. The current iteration adds several new indicators to the SJOS for South Africa, which hopefully helps to build a more comprehensive picture of the state of societal and environmental issues in the country.

From a social foundations' perspective, indicators for *voice* were yet to be determined in Cole et al 2014's iteration and was also not considered by the University of Leeds's Doughnut. Here we propose two indicators for voice: The first is voter turnout, which is a proxy for voice because it represents a significant avenue for citizens to express their (dis) satisfaction with government policies and implementation. Data for voter participation are available and have been included as part of the social foundation indicators. Another indicator (which is not currently included in this iteration), is 'Voice and Accountability' found in the World Governance Indicators database collated by the World Bank (Kaufmann et al 2020). This indicator captures perceptions of the extent to which a country's citizens can participate in selecting their government (similar to voter participation), as well as freedom of expression, freedom of association, and a free media.

Three other indicators are included, which also represent important dimensions of social participation, connectivity and safety nets. The first of these is connectivity represented by whether or not a household has access to a mobile phone. Since fixed telephone line usage has been bypassed by many households, and computers are still not widely available for many households in the country, mobile phones are a critical technology for connecting with the outside world, substituting for physical banking, and providing a source of internet. As such, they form one of the basic needs of operating in a society today. The second is the perception of corruption in the country. South Africa has experienced very publicised forms of corruption in the recent "State Capture" and other corruption cases involving the private sector such as the loss Steinhoff and VBS Bank. These are the more famous of many corruption scandals plaguing the country, and an indicator on the perception of state corruption is important to gauge public opinion. Third and lastly, dependence on social grants was included because it highlights two

sides of the problem. On the one hand, it shows the commitment by government to provide safety nets for many citizens in the country, and on the other hand, signifies the lack of jobs and development which is necessary to provide the means for people to earn a decent living.

Ecological indicators

From an ecological ceiling perspective, a few additions were made to this iteration. First, water quality was included, which is often missing from these types of analyses. Monitoring water quality in South Africa is critical for various reasons including that water is scarce, wasted, and poor water quality adds to the challenge of providing clean available water and reports from many municipalities are highlighting the challenges with sanitation infrastructure ([Blue Drop Report 2022](#)). With registered use exceeding available supply, monitoring supply has the potential to also help allocate water of quality below drinkable to uses that do not require it, therefore reducing competition for clean drinkable water, among other issues, some of which have important health outcomes. Water quality is measured using *blue drop score*, which address water quality from the perspective of infrastructure capacity to deliver and treat waste water ([DWS 2015](#); [DWA 2009](#)).

Two indicators build on Cole et al 2014's indicators for land use change and nutrient loading, but they are expanded beyond change in arable land to change in extent of natural land, and from nitrogen application in maize, to nitrogen consumption on aggregate to capture the fuller scope of use beyond one crop. Finally, air pollution here is measured using smaller particulate matter (PM 2.5), instead of the coarser particulate matter (PM10). Other variation include the indicators under marine harvesting, where an indicator for 'marine stocks of concern' from the Department of Environment, Forestry and Fisheries report on the status of the South African Marine Fishery Resources ([DEFF 2010](#)) was used. This is slightly different from the 'depleted marine fisheries stocks' used by Cole and colleagues.

What is still missing

The indicators presented here, while they cover the various dimensions of the safe and just operating space, do not necessarily represent the most pressing issues in the country, but merely reflect the biases in data availability. In the duration of this exercise, several other indicators were identified, which lack data, but have clearly defined methodologies. Table 3 below summarizes some of these indicators.

The first speaks to gender violence: crime against women 18 years and older. This indicator is reported in the South African Police Service annual crime reports, and the value was defined by first dividing the number of women 18 years and older experiencing crime by the total number of women 18 years and older, to get the proportion of women affected multiplied by 100. This gives a new indicator of 'Percentage of women 18 years and older experiencing crime'. The boundary for this is 0%, and any value above this is an overshoot and undesirable. The second indicator calculates the number of people in need, who receive social grants. Determining who is in need was based on the lower bound poverty line poverty line of South Africa (R647 per person per month in 2015). The value is determined by dividing all people who receive social

grants with all people falling below this poverty line. The boundary is 100% such that all people in need (i.e., below the poverty line), should receive a form of safety net. Here values closer to 100% are desirable, and vice versa.

Three indicators of gender-based violence are also reported. The first records incidence where women are subjected to physical violence, the second reports on sexual violence and reports on crimes committed against women who are 18 years or older. This last indicator includes information from the other two indicators too as it reports on all, and any crimes committed towards adult women. These figures are likely very underestimated as reporting of crimes, especially sexual violence, is often met with more harassment rather than help from those in charge of handling such cases.

Table 5 Potential new indicators to include in the next iterations of the SJOS assessment

Domain	Indicator	Description/Justification
Safety	Gender Based Violence	GBV is an urgent issue in South Africa, and reports in the media and elsewhere have highlighted how critical it is. Several indicators exist such as: Experience of violence by partner Women feeling unsafe to walk alone at night
Inequality	Income percentile shares Gini Coefficient	South Africa is among the most unequal countries in the world, and this inequality will take deliberate effort, or to use Raworth's words, efforts that "design to distribute".
Biodiversity loss	Invasive Species	The impacts of invasive species are well documented across the country, including negatively on biodiversity and on a range of benefits for society (SANBI 2019).
Land use	Land use change Water Bodies Cultivated land Urban settlements	Statistics South Africa's natural resources accounting team has been releasing reports on water accounts, land accounts, and other resources. There is potential to use these accounts to develop indicators of land conversions from natural and semi-natural areas, to other uses. The same can be done about changes in water bodies, which are often cultivated, settled, and encroached The land account has two other variables of cultivated land and water bodies. It is currently difficult to determine the boundaries to use because this requires agreed upon allocated shares of each land use
Chemical Pollution	Chemical application in Agriculture and Industry Sewage deposits in rivers	United Nations Environmental Programme (UNEP) reports that "The third national waste baseline shows that South Africa generated approximately 108 million tonnes of waste in 2011, of which 98 million tonnes was disposed of at landfill. In the order of 59 million tonnes is general waste, 43 million tonnes is currently unclassified waste and the remaining 6 million tonnes hazardous waste. In the order of 10 of all waste generated in South Africa was recycled in 2011". This points to a significant increasing challenge.
Ocean Health	Ocean PH	Ocean PH is an important indicator of potential ocean acidification.
	Aragonite concentration in seawater	Aragonite is a common, naturally occurring crystal form of calcium carbonate, CaCO_3 , whose concentration in seawater is used to track ocean acidification (DFFE 2014; 2020)
	Dissolved Oxygen Levels	Dissolved oxygen in seawater is essential for survival of most marine organisms, but its concentrations have been decreasing globally over the last few decades (DFFE 2014; 2020). Currently two thresholds exist which were observed to have consequences for marine life (e.g., causing 'dead zones')
	Ocean Acidification Indicator	ACID-I defined as the aragonite saturation state, $\Omega_{\text{aragonite}}$. An ACID-I values above 1.0 indicate seawater that is saturated with respect to aragonite (and therefore also calcite); values below 1.0 indicate seawater conditions favourable to aragonite dissolution.

Conclusion

The Doughnut Economics framework is a useful tool for both assessing the status of various social and environmental issues facing countries from national to local levels. It has been used widely across the world, with varying degrees of success. Our application reveals a few key issues. The first is that the framework provides a quick overview of data gaps. Although the intention of this exercise was not to identify data gaps per se, looking for representative indicator for each of the key dimensions quickly reveals important gaps. These gaps are both in terms of missing indicators and data, as well as missing targets and boundaries. Secondly, the framework is a useful tool for communication. Based on a series of workshops accompanying this report, it was evident that people can relate to most of the issues discussed in the key dimensions, and if they couldn't relate to all, they are still able to participate by bringing issues that are important to them, and which can be included as part of the analysis. Third, despite challenges with boundaries, we were still able to plot a limited number of indicators, and from here we are able to see areas of concern for the country. Although some of the boundaries crossed are not particularly surprising (e.g., climate change and air pollution), others such as nitrogen loading, and freshwater use were less obvious. Especially nitrogen use, which is not something that is often discussed in the South African policy landscape. The other many gaps of key issues such as gender-based violence data, reflect a deep challenge in South Africa and elsewhere of underreporting, mainly perpetuated by the lack of seriousness with which such cases are handled. Overall, the method has a lot to offer, and there is still a lot of scope to both use is to convene dialogues as well as to highlight key challenges and opportunities at the scale of interest.

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Appendix

Potential national social indicators and data sources

Table 6 Social indicators which can be used to complement or substitute indicators used in this report

HWB component	Indicator name	2019 (%)	Boundary	Proximity (%)	Source
Energy	Households with access to electricity	85	100	85	GHS 2019
Water	Households with access to piped or tap water in their dwellings. off-site or onsite	88.2	100	88.2	GHS 2019
Sanitation	Households with a toilet or ventilated pit latrine	82.1	100	82.1	GHS 2019
Housing	Households with formal dwellings	81.9	100	81.9	GHS 2019
Education	Adult illiteracy (more than 7y of schooling)	75.6	100	75.6	GHS 2019
Health	Infant (<1 y) immunisation coverage	81.9	100	81.9	DHB 2019 & 2010
Health	Household negatively affected by air pollution	17.9	0	17.9	GHS 2019
Health	Household negatively affected by water pollution	16.3	0	16.3	GHS 2019
Health	Infant mortality rate (per 1000 births)	35	0	3.5	SDG report 2019
Voice	National voter turnout as a proportion of VAP	49	100	49	Collette Schulz-Herzenberg 2020
Employment	Population of working age (15-64 yrs.) employed	71.3	100	71.3	QLFS 2010 & 2019
Employment	Labour force participation rate	59.8	100	59.8	QLFS 2019
Refrigerator	Household owns a refrigerator	79.4	100	79.4	GHS 2019
Connectivity	Household owns a vehicle	31.2	100	31.2	GHS 2019
Food security	Households with adequate food	82.2	100	82.2	GHS 2019
Safety	Individuals feel safe walking alone in their area at night	41.8	100	41.8	GPSJS 2020
Poverty	Poverty line (UPBL)	55.5	0	55.5	Stats SA 2017
Safety	GBV: Percent of women subjected to physical violence	7.7	0	7.7	SDG report 2019
Safety	GBV: Percent of women subjected to sexual violence	2.3	0	2.3	SDG report 2019
Equity	Female land ownership	34	100	34	SDG report 2019
Livelihood	Percent of people in need receiving social grants	77.30	100	77.3	SASSA 2021
Safety	GBV: Crimes against women 18 years and older	0.94	0	0.94	SAPS 2010 & 2019
Connectivity	Household with cellular telephone in their dwelling	87.8	100	87.8	GHS 2019
Connectivity	Proportion of population covered by 3G	99.5	100	99.5	SDG report 2019
Connectivity	Proportion of population covered by LTE	85.7	100	85.7	SDG report 2019

Governance	Corruption perception Index	44	100	44	Transparency International
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Potential national environmental indicators and data sources

Table 7 List of environmental data with additional indicators

Domain	Indicator(s)	Value	Boundary	Unit	Year	Source
Climate change	Annual CO ₂ emission	487	440	MT CO ₂ e	2020	https://climateactiontracker.org/countries/south-africa/
Ozone depletion	Annual HCFC consumption	110.86	370	ODPt	2019	NEDLAC. 2012. Hydrochlorofluorocarbons (HCFC) Phase Out Plan for South Africa. National Economic Development and Labour Council, Ferndale, South Africa
Freshwater Quantity	Registered water use	20.2	14.7	billion m ³ /a	2019	WRC. 2018. National Water Accounts for South Africa Systems, Methods and Initial Results. Water Research Commission. Report No. TT 774/18. Pretoria, South Africa
Freshwater Quality	<i>River Ecological Condition Index</i>	72.2	100	%	2011	Nel, J.L. & Driver, A. 2015. National River Ecosystem Accounts for South Africa. Discussion document for Advancing SEEA Experimental Ecosystem Accounting Project, October 2015. South African National Biodiversity Institute, Pretoria.
	<i>Blue drop score</i>	79.6	100	%	2014	DWS. 2014. Blue Drop Report. Department of Water and Sanitation. Pretoria, South Africa
Biodiversity loss	Endangered and critically endangered ecosystems	50%	0	%	2018	Skowno, A.L., Poole, C.J., Raimondo, D.C., Sink, K.J., Van Deventer, H., Van Niekerk, L., Harris, L.R., Smith-Adao, L.B., Tolley, K.A., Zengeya, T.A., Foden, W.B., Midgley, G.F. & Driver, A. 2019. National Biodiversity Assessment 2018: The status of South Africa's ecosystems and biodiversity. Synthesis Report. South African National Biodiversity Institute, an entity of the Department of Environment, Forestry and Fisheries, Pretoria. pp. 1–214
	<i>Endangered and critically endangered species: plants</i>	14%	0	%	2018	
	<i>Endangered and critically endangered species: animals</i>	12%	0	%	2018	
	<i>Protected Area Extent</i>	108000	254814		2018	Department of Environmental Affairs (2018) National Protected AREas Expansion Strategy for South Africa 2018. Department of Environmental Affairs, Pretoria, South Africa
Marine harvesting	Marine stocks of concern	39%	0	%	2020	DEFF (Department of Environment, Forestry and Fisheries) 2020. Status of the South African marine fishery resources 2020. Cape Town: DEFF
Air pollution	Annual average PM ₁₀ concentration	52	15	µg/m ³	2009	Department of Environmental Affairs. 2017. National Framework for Air Quality Management in the Republic of South Africa. Pretoria
	Annual average PM _{2.5} concentration	21.6	5	µg/m ³	2017	Department of Environmental Affairs. 2017. National Framework for Air Quality Management in the Republic of South Africa. Pretoria https://www.iqair.com/world-most-polluted-countries
Chemical pollution	Hazardous waste in landfills	93%	0	%	2017	Department of Environmental Affairs. 2018. South Africa State of Waste. A report on the state of the environment. Final draft report. Department of Environmental Affairs, Pretoria. 112 pp

Land Use Change	Natural or semi-natural area extent	83.2	100	ha	2014	Statistics South Africa. 2020. Natural Capital 1: Land and Terrestrial Ecosystem Accounts, 1990 to 2014. Discussion document D0401.1. Produced in collaboration with the South African National Biodiversity Institute and the Department of Environment, Forestry and Fisheries. Statistics South Africa, Pretoria
	Water bodies extent	1420676		ha	2014	Statistics South Africa. 2020. Natural Capital 1: Land and Terrestrial Ecosystem Accounts, 1990 to 2014. Discussion document D0401.1. Produced in collaboration with the South African National Biodiversity Institute and the Department of Environment, Forestry and Fisheries. Statistics South Africa, Pretoria
	Cultivated land extent	15808759		ha		Statistics South Africa. 2020. Natural Capital 1: Land and Terrestrial Ecosystem Accounts, 1990 to 2014. Discussion document D0401.1. Produced in collaboration with the South African National Biodiversity Institute and the Department of Environment, Forestry and Fisheries. Statistics South Africa, Pretoria
Nitrogen loading	Nitrogen consumption per capita	72,8	41	kg		DAFF. 2018. South African Fertilizers Market Analysis Report. Department of Agriculture, Forestry & Fisheries. Pretoria

Potential provincial social indicators

Table 8 List of possible social indicators, most of which have data

HWB component	Indicator name	WC	EC	NC	FS	KN	NW	GP	MP	LP	Year	Boundary	Source
Basic need	Households with access to electricity	88.4	89.3	91.2	91.6	86.7	81.6	76.6	90.1	93.4	2019	100	GHS 2019
Basic need	Households with access to piped or tap water in their dwellings. off-site or onsite	98.5	73.9	94	91.9	85.4	82.1	97.6	85.2	70	2019	100	GHS 2019
Basic need	Households with access to improved sanitation	94.5	87.6	83.9	82.3	80.9	68.8	90	63.7	63.4	2019	100	GHS 2019
Basic need	Households with formal dwellings	81	71.2	83.3	80.6	81.3	81	80.5	89.6	95.2	2019	100	GHS 2019
Education	Adult illiteracy (reading or writing in at least one language)	97.5	92.2	91.6	94.6	93.7	90	97.9	91.4	90.6	2019	100	GHS 2019
Health	Infant (<1 y) immunisation coverage	82.7	71.9	87.5	74.8	90.8	68.4	84.4	96.8	71	2019	100	DHB 2019
Health	Household experiencing air pollution											0	GHS 2019
Health	Household experiencing water pollution											0	General Household Survey 2019
Health	Infant mortality rate (per 1000 births)	28.3	50.3		52.6	40.3	55	41.7	53.5	23.7	2016	0	WHO 2016

Voice	Voter turnout as a proportion of registered voters	68.2	61	66.6	62.9	67.3	59.5	71.8	66.1	58.7	2019	100	Collette Schulz-Herzenberg 2020
Voice	Voter turnout as a proportion of voting age population (VAP)	48.8	53.2	53.6	48.9	52.8	42.1	48.2	47.4	46.1	2019	100	Collette Schulz-Herzenberg 2021
Livelihood	Population of working age (15-64 yrs) employed	53.7	26.1	41.1	46.6	31.4	37.9	44.5	41.9	36.8	2019	100	QLFS 2010 & 2019
Livelihood	Labour force participation rate	67.9	46.5	63.2	66.8	43.6	53.2	62.6	63.1	47.9	2019	100	QLFS 2019
Refrigerator	Household owns a refrigerator											100	GHS 2019
Connectivity	Households using public transportation (Train, Bus & Taxi*)	27.4	26.1	17.4	22.2	32.5	25.7	37.2	32.1	29.7	2020*	100	NHTS 2020
Connectivity	Travel by public transportation (Train & Bus)	6.8	3.0	4.1	3.5	5.6	4.5	5.2	8.9	4.4	2020*		NHTS 2021
Basic need	Households with adequate access to food	82.2	78.1	71.5	73.9	82.5	70.4	86.1	76	94.5	2019	100	GHS 2019
Safety	Individuals feel safe walking alone in their area at night											100	GPSJS 2020
Equity	Gini Coefficient											0	SDG report 2019
Poverty	Poverty line (UPBL)											0	National Poverty Lines 2019
Safety	GBV: Percent of women subjected to physical violence											0	SDG report 2019
Safety	GBV: Percent of women subjected to sexual violence											0	SDG report 2019
Equity	Female land ownership											100	SDG report 2019
Livelihood	Percent of people in need receiving social grants											100	SASSA 2021
Safety	GBV: Crimes against women 18 years and older											0	SAPS 2010 & 2019
Connectivity	Household with cellular telephone in their dwelling	76.7	86	85.1	88.9	85.8	91.9	88.9	95.3	94.4	2019	100	GHS 2019
Connectivity	Proportion of population covered by 3G											100	SDG report 2019
Connectivity	Proportion of population covered by LTE											100	SDG report 2019
Governance	Corruption perception Index											100	Transparency International

Development	Human Development Index	0.745	0.671	0.697	0.708	0.706	0.672	0.73	0.675	0.71	2019	1	GlobalDataLab Smits & Permanyer
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Potential provincial environmental indicators

Table 9 Environmental indicators with no clear boundaries

Dimension	Indicator	Unit	WC	EC	NC	FS	KN	NW	GP	MP	LP	Year	Source
Land cover change	Percent change in natural or semi-natural area	%	0.4	0.6	0.4	3.3	-2.8	3.9	0.8	1.8	0.6	2014	Stats SA Ecosystem Accounts
Land cover change	Percent change in water bodies	%	20.4	28.4	61.6	40.7	16.7	54.3	13.4	11.2	32.9	2014	
Land cover change	Percent change in cultivated areas	%	-1.1	0.9	8.5	-1.9	14.9	10.9	-6.2	-5.7	-9.5	2014	
Protected Area	Protected Area extent ('000)	ha	1950	1195	2043	526	929	382	143	1680	2429	2020	
Protected Area	Protected are % of total province land	%	15.1	7.1	5.5	4.1	10	3.6	7.9	22	19.3	2020	
Protected Area	Change in percentage of province protected	%	1.7	3.2	1.8	0.9	2.3	0.3	3.4	2.6	2.9	2020	StatsSA 2020
Climate change	Per capita consumption of Eskom electricity	CO2e tonnes/yr.	2.8	1.4	4.57	1.32	3.49	5.51	3.61	6.71	3.58	2022	
Freshwater use	Per capita consumption per day	l/c/d	214	178	224	237	170	126	286	201	114	2019	

Table 10 Water by catchment system

			Current In Mm3 /Year, base year 2021			Future in Mm3 / Year, projected for 2040				
System	Prov	2021 Total Storage capacity in Mm3	Availability (system/ scheme yield)	Demands (estimated requirements)	Deficit (-) / Surplus (+)	Availability (system/ scheme yield)	Demands (estimated requirements)	Deficit (-) / Surplus (+)	Boundary based on capacity	Boundary based on availability in 2021
Western Cape WSS	WC	895	545	585	-40	585	830	-245	107.3	65.4
Outeniqua WSS (Mossel Bay)	WC	49	62	68	-6	62	90	-28	109.7	138.8
Algoa WSS	EC	281	135	167	-32	355	355	0	123.7	59.4
Amathole WSS	EC	241	109	102	7	124	130	-6	93.6	42.3
Crocodile West WSS	LP, NW	495	1200	1170	30	1460	1365	95	97.5	236.4
Polokwane WSS	LP	254	268	261	7	433	408	25	97.4	102.8
Letaba & Levubu WSS	LP	472	243	215	28	276	277	-1	88.5	45.6
Olifants WSS	LP	1859	425	458	-33	442	566	-124	107.8	24.6
Crocodile East	MP	340	67	350	-283	154	375	-221	522.4	102.9

Integrated Vaal River System	MP, NW, GP, FS	10,566	2877	3130	-253	3640	3680	-40	108.8	29.6
Orange River System	NC, FS, EC	7,996	3323	2545	778	3679	3141	538	76.6	31.8
System	KZN	978	405	452	-47	736	552	184	111.6	46.2
Mhlatuze WSS Richards Bay	KZN	413	243	252	-9	290	325	-35	103.7	61.0
Caledon Modder (Bloemfontein)	FS	84	105	104	1	162	191	-29	99.0	123.8
TOTAL		24923	10007	9859	148	12398	12285	113	98.5	39.6