# DEVELOPMENT OF WATER-ENERGY-FOOD NEXUS INDEX AND ITS APPLICATION TO SOUTH AFRICA AND THE SOUTHERN AFRICAN DEVELOPMENT COMMUNITY

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by

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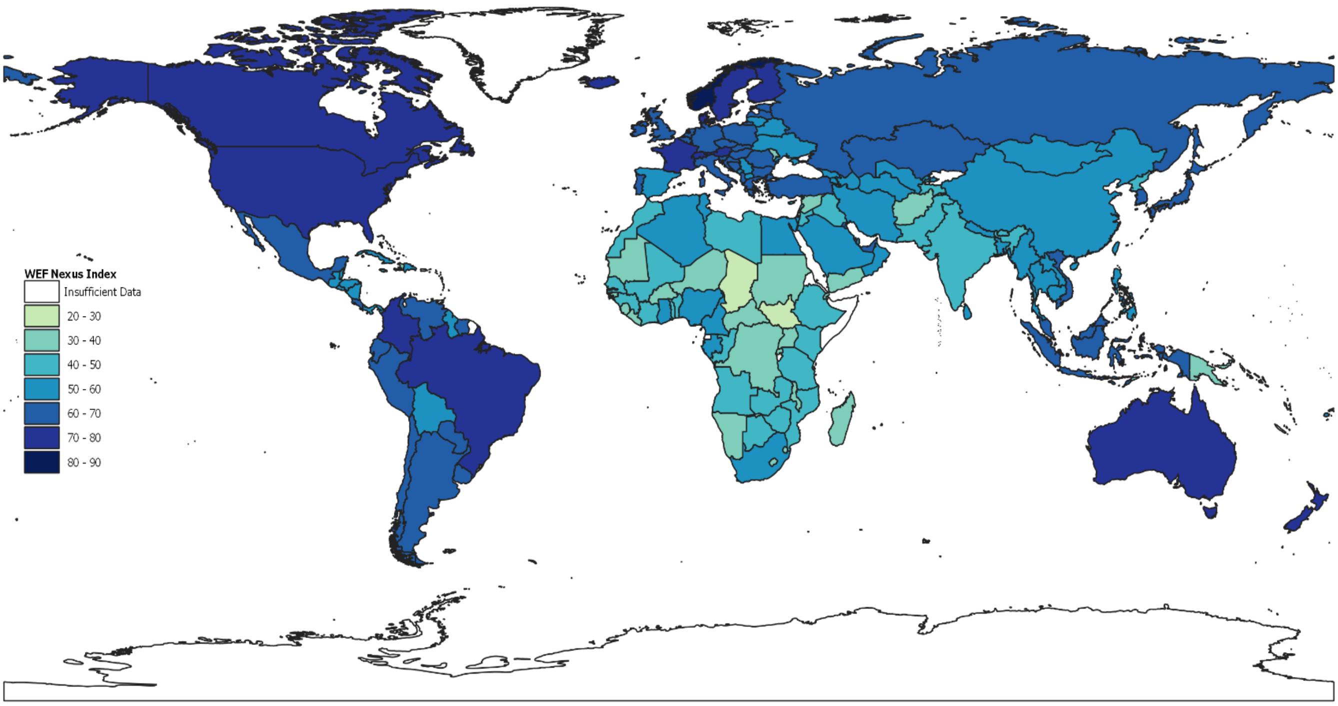
# EXECUTIVE SUMMARY

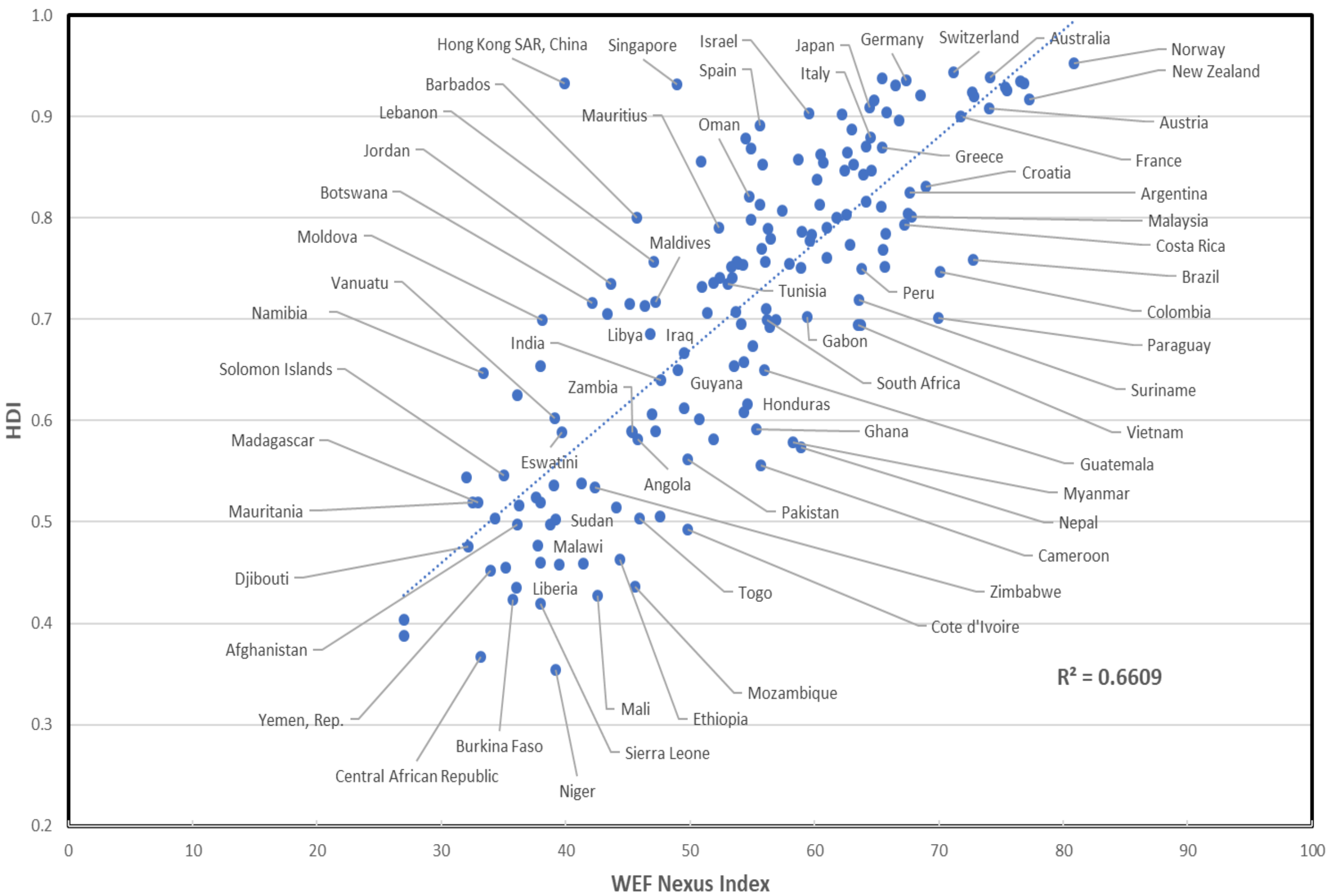
Due to the exponential growth in the global population and economic development since the industrial revolution, increasing pressure has been placed on natural resources, with various publications warning that vital planetary boundaries are being exceeded. Following the 2008 financial crisis, concerns have been raised that if finite resources such as water are not effectively managed then the environment, livelihoods and economic development will be detrimentally impacted. The interdependency of water, energy and food security has also been highlighted, and since 2011 significant attention has been given to the water-energy-food (WEF) nexus in academic, policy, regulatory and development fraternities. The WEF nexus is a multi-centric lens through which to assess sustainable development and integrated resource management. This approach has direct links to the Sustainable Development Goals (SDG), principally SDGs 2, 6 and 7.

Because the WEF nexus has constituents that are measured in different units, and at different spatial and temporal scales, there is a need to normalise indicators from each of these sectors before integrating them. One such method is the development of a composite indicator (or index), and this report presents the development of an index with the WEF nexus as its guiding framework. The methodology that has been employed in constructing the proposed composite indicator is that of the Joint Research Centre's *Competence Centre on Composite Indicators and Scoreboards* (JRC-COIN).

In the development of the proposed WEF Nexus Index, a total of 87 indicators relevant to an anthropocentric WEF nexus framework (that was developed as part of this project) were reviewed to ascertain their relevance and data availability. Following an iterative process, a total of 21 indicators were selected for inclusion in the proposed composite indicator, with adequate data being available for 170 countries. The WEF Nexus Index values per country are plotted on the following world map:



Once the results of the WEF Nexus Index were determined, these results were plotted on two separate graphs against the SDG Index and the Human Development Index (HDI). The R-squared values for the two plots are 0.72 and 0.66 respectively. If these R-squared values were too high, i.e. approaching unity, then the WEF Nexus Index would be rendered redundant. These graphs, however, yield interesting insights. In the plot of HDI versus the WEF Nexus Index, presented below, countries that plot above the regression line typically have living standards (or human development) that exceed their available domestic resource base, e.g. Singapore and Hong Kong. The corollary is true of nations that plot below the regression line.




The top twenty ranking nations based on the WEF Nexus Index calculation are dominated by first-world countries, with Norway, New Zealand and Sweden ranking highest. Five South American countries feature in the top twenty, with Brazil being the highest placed of these. One Asian nation (Malaysia) features in the top twenty, while no African nations make this list. Three-quarters of the bottom twenty ranking nations are from Africa.

South Africa ranks 72$^{nd}$ of the 170 nations assessed. While South Africa ranked relatively well in terms of its "Water-access" and "Food-access" sub-pillars, it performs comparatively poorly in the two associated "Availability" sub-pillars. Similarly, although the proportion of South Africans with access to electricity is relatively high, much of this energy is generated by burning fossil fuels. Because of this, the country has a high level of $CO_2$ emissions. Because the "Energy-Access" sub-pillar is linked to SDG 7 (access to clean, modern, affordable energy), the relatively high level of access to electricity in this country is to a large degree nullified in this sub-pillar by the high emissions and low level of renewable energy adoption.

The ranking of SADC countries[1] according to their respective WEF Nexus Index values has South Africa ranking highest, while Madagascar is lowest at 165th, as presented in the following table. Also shown in this table are the SDG Index and HDI values for the fifteen SADC countries listed.

| Country | WEF Nexus Index Rank | WEF Nexus Index | SDG Index | HDI |
|---|---|---|---|---|
| Angola | 124 | 45.8 | 49.3 | 0.581 |
| Botswana | 136 | 42.1 | 61.6 | 0.717 |
| Comoros | 161 | 34.3 | 47.6 | 0.503 |
| Congo, Dem. Rep. | 141 | 39.5 | 41.6 | 0.457 |
| Eswatini | 140 | 39.7 | 52.4 | 0.588 |
| Lesotho | 151 | 37.9 | 50.9 | 0.520 |
| Madagascar | 165 | 32.9 | 45.6 | 0.519 |
| Malawi | 152 | 37.7 | 52.3 | 0.477 |
| Mauritius | 100 | 52.3 | 66.2 | 0.790 |
| Mozambique | 126 | 45.6 | 51.4 | 0.437 |
| Namibia | 163 | 33.4 | 57.1 | 0.647 |
| South Africa | 72 | 56.1 | 60.4 | 0.699 |
| Tanzania | 138 | 41.3 | 55.9 | 0.538 |
| Zambia | 127 | 45.3 | 53.0 | 0.588 |
| Zimbabwe | 135 | 42.4 | 54.8 | 0.535 |

With much of the developed world having built their nations on the foundation of fossil-fuel-based energy generation, it is evident that the dearth of coal in Africa outside of South Africa has crippled its development and contributed to a poverty trap. Ironically, much of the world is moving away from coal-fired power generation, but they can do so because they have reached the point where they can afford to do so. Access to energy is indeed a pivotal enabler of economic development. In reviewing the constituent indicators of the WEF Nexus Index it is evident that most SADC nations are not utilising their available freshwater. If they could gain significantly broader access to affordable, modern, renewable energy, then a great benefit could result in terms of food production and economic development. The "Food-availability" sub-pillar is generally the poorest performing sub-pillar within the WEF Nexus Index for SADC countries.

By following the JRC-COIN process, the proposed composite indicator has been developed sensibly and transparently. If the WEF Nexus Index results are utilised responsibly they can contribute to the sustainable development and integrated resource management discourse.

[1] Excluding Seychelles, since there was insufficient data to ascertain the WEF Nexus Index for this country

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| | |
|---|---|
| AFG | Afghanistan |
| AGO | Angola |
| ALB | Albania |
| AMD | Acid Mine Drainage |
| ARE | United Arab Emirates |
| ARG | Argentina |
| ARM | Armenia |
| AUS | Australia |
| AUT | Austria |
| AZE | Azerbaijan |
| BEL | Belgium |
| BEN | Benin |
| BFA | Burkina Faso |
| BFAP | Bureau for Food and Agricultural Policy |
| BGD | Bangladesh |
| BGR | Bulgaria |
| BIH | Bosnia and Herzegovina |
| BLR | Belarus |
| BLZ | Belize |
| BOL | Bolivia |
| BRA | Brazil |
| BRB | Barbados |
| BRN | Brunei Darussalam |
| BTN | Bhutan |
| BWA | Botswana |
| CAF | Central African Republic |
| CAN | Canada |
| CER | Centre for Environmental Rights |
| CHE | Switzerland |
| CHL | Chile |
| CHN | China |
| CIV | Cote d'Ivoire |
| CMR | Cameroon |
| COD | Democratic Republic of Congo |
| COG | Republic of Congo |
| COIN | Competence Centre on Composite Indicators and Scoreboards |
| COL | Colombia |
| COM | Comoros |
| CPV | Cabo Verde |
| CRI | Costa Rica |
| CRSES | Centre for Renewable and Sustainable Energy Studies |
| CSIR | Council for Scientific and Industrial Research |
| CUB | Cuba |
| CYP | Cyprus |

| | |
|---|---|
| CZE | Czech Republic |
| DAFF | Department of Agriculture, Forestry and Fisheries |
| DEA | Department of Environmental Affairs |
| DEU | Germany |
| DJI | Djibouti |
| DMA | Dominica |
| DME | Department of Minerals and Energy |
| DNK | Denmark |
| DoE | Department of Energy |
| DOM | Dominican Republic |
| DWAF | Department of Water Affairs and Forestry |
| DWS | Department of Water and Sanitation |
| DZA | Algeria |
| ECU | Ecuador |
| EGY | Egypt |
| ESI | Environmental Sustainability Index |
| ESP | Spain |
| EST | Estonia |
| ETH | Ethiopia |
| FAO | Food and Agriculture Organisation of the United Nations |
| FIN | Finland |
| FJI | Fiji |
| FRA | France |
| GAB | Gabon |
| GBR | United Kingdom |
| GDP | Gross Domestic Product |
| GEO | Georgia |
| GHA | Ghana |
| GHG | Greenhouse gas |
| GHI | Global Horizontal Irradiance |
| GIN | Guinea |
| GMB | Gambia, The |
| GNB | Guinea-Bissau |
| GNI | Gross National Income |
| GNP | Gross National Product |
| GRC | Greece |
| GTM | Guatemala |
| GUY | Guyana |
| GW | Gigawatt |
| HDI | Human Development Index |
| HDR | Human Development Report |
| HKG | Hong Kong SAR, China |
| HND | Honduras |
| HRV | Croatia |
| HTI | Haiti |

| | |
|---|---|
| HUN | Hungary |
| IDN | Indonesia |
| IEA | International Energy Agency |
| IHE | IHE Delft Institute for Water Education |
| ILI | Infrastructure Leakage Index |
| ind. | Indicator |
| IND | India |
| IRENA | International Renewable Energy Agency |
| IRL | Ireland |
| IRN | Islamic Republic of Iran |
| IRP | Integrated Resource Plan |
| IRQ | Iraq |
| ISL | Iceland |
| ISR | Israel |
| ITA | Italy |
| IWRM | Integrated Water Resources Management |
| JAM | Jamaica |
| JOR | Jordan |
| JPN | Japan |
| JRC | Joint Research Centre |
| KAZ | Kazakhstan |
| KEN | Kenya |
| KHM | Cambodia |
| KOR | Republic of Korea |
| Kt | Kilo-ton |
| KWT | Kuwait |
| LAO | Lao PDR |
| LBN | Lebanon |
| LBR | Liberia |
| LBY | Libya |
| LKA | Sri Lanka |
| LSO | Lesotho |
| LTU | Lithuania |
| LUX | Luxembourg |
| LVA | Latvia |
| MAR | Morocco |
| MDA | Moldova |
| MDG | Madagascar |
| MDGs | Millennium Development Goals |
| MDV | Maldives |
| MENA | Middle East and North Africa |
| MEX | Mexico |
| MKD | Macedonia, FYR |
| MLI | Mali |
| MLT | Malta |

| | |
|---|---|
| MMR | Myanmar |
| MNE | Montenegro |
| MNG | Mongolia |
| MOZ | Mozambique |
| MRT | Mauritania |
| Mt | Mega-tons |
| MUS | Mauritius |
| MW | Megawatt |
| MWI | Malawi |
| MYS | Malaysia |
| NAM | Namibia |
| NER | Niger |
| NGA | Nigeria |
| NIC | Nicaragua |
| NLD | Netherlands |
| NOR | Norway |
| NPL | Nepal |
| NZL | New Zealand |
| OECD | Organisation for Economic Co-operation and Development |
| OMN | Oman |
| PAK | Pakistan |
| PAN | Panama |
| PER | Peru |
| PHL | Philippines |
| PISA | Programme for International Student Assessment |
| PNG | Papua New Guinea |
| POL | Poland |
| PRK | Democratic People's Republic of Korea, |
| PRT | Portugal |
| PRY | Paraguay |
| PV | Photovoltaic |
| QAT | Qatar |
| ROU | Romania |
| RUS | Russian Federation |
| RWA | Rwanda |
| SABMiller | South African Breweries Miller |
| SADC | Southern African Development Community |
| SADCC | Southern African Development Co-ordination Conference |
| SAPP | Southern African Power Pool |
| SAU | Saudi Arabia |
| SDG | Sustainable Development Goals |
| SDN | Sudan |
| SDP | Spatial Development Plan |
| SEI | Stockholm Environmental Institute |
| SEN | Senegal |

| | |
|---|---|
| SGP | Singapore |
| SLB | Solomon Islands |
| SLE | Sierra Leone |
| SLV | El Salvador |
| SRB | Serbia |
| SSD | South Sudan |
| SSEG | small-scale embedded generation |
| STP | Sao Tome and Principe |
| SUR | Suriname |
| SVK | Slovak Republic |
| SVN | Slovenia |
| SWE | Sweden |
| SWSA | Strategic Water Source Area |
| SWZ | Swaziland/Eswatini |
| SYR | Syrian Arab Republic |
| TCD | Chad |
| TGO | Togo |
| THA | Thailand |
| TJK | Tajikistan |
| TKM | Turkmenistan |
| TLS | Timor-Leste |
| TTO | Trinidad and Tobago |
| TUN | Tunisia |
| TUR | Turkey |
| TZA | Tanzania |
| UAW | Unaccounted for water |
| UGA | Uganda |
| UK | United Kingdom |
| UKR | Ukraine |
| UN | United Nations |
| UNDP | United Nations Development Programme |
| UNICEF | United Nations International Children's Emergency Fund |
| URY | Uruguay |
| USA | United States of America |
| UZB | Uzbekistan |
| VEN | Venezuela, RB |
| VIP | ventilated improved pit |
| VNM | Vietnam |
| VUT | Vanuatu |
| WASH | Water, Sanitation and Hygiene |
| WCEP | Water consumption for electricity production |
| WEF | Water-Energy-Food |
| WEForum | World Economic Forum |
| WHO | World Health Organisation |
| WMA | Water Management Area |

| | |
|---|---|
| WSM | Samoa |
| WWF | World Wide Fund |
| WWF-SA | World Wide Fund South Africa |
| YEM | Republic of Yemen |
| ZAF | South Africa |
| ZMB | Zambia |
| ZWE | Zimbabwe |

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# 1 INTRODUCTION

Before the industrial revolution, the world's population was largely rural and stable in terms of numbers, estimated to be 470 million in 1650 (UN, 1951). Following the industrial revolution, the world's population grew to over one billion by 1850, approximately 1.5 billion by 1900, and exceeded 2.4 billion in 1950 (UN, 1951). By 2005 the global population reached 6.5 billion (Bongaarts, 2009) and in 2019 it exceeds 7.7 billion people. By the middle of the current century, it is estimated it will extend to 9.7 billion (Gerland et al., 2014). Together with this exponential growth in the population, demand for resources such as metals, building materials, energy, agricultural products, and water also snowballed.

Despite there being a stark disparity in the distribution of wealth as nations developed, researchers started to realise that there are limits to anthropogenic increase (Meadows et al., 1972). People recognised that resources such as agricultural land, minerals and water are finite. Various indicators were developed to monitor aspects related to economics, development, the environment and sustainability. The required data was, and is, collected by national statistical offices, development organisations and research institutions. One of the first indicators that were widely used was the Gross Domestic Product (GDP), or GDP/capita.

Later, composite indicators were developed to understand systems. A composite indicator is formed "when individual indicators are compiled into a single index on the basis of an underlying model" (OECD, 2008). In 1990, for example, the Human Development Index (HDI) was developed by Pakistani economist Mahbub ul Haq to provide a more comprehensive representation of wellbeing than the GDP. He included indicators of health and education with the natural logarithm of the Gross National Income (GNI) per capita. The creation of the HDI was based on the premise that human development should focus on the three essential elements of human life, namely longevity, knowledge and decent living standards (UNDP, 1990). Although the method of calculating the HDI has changed with time, it has served as a valuable tool for the United Nations Development Programme (UNDP) and other organisations in evaluating the many countries and regions under their jurisdiction.

Some composite indicators, in contrast to the HDI, are relatively complex. The Environmental Sustainability Index (ESI), for example, integrates 76 datasets into 21 indicators, which are subsequently condensed into a single index (Esty et al., 2005). The ESI serves as a policy tool for identifying issues that deserve greater attention within national environmental protection programs and across societies more generally (ibid.).

Many composite indicators, or indices, have been developed in the last three decades. Some groupings, e.g. advocacy groups, view composite indicators as a valuable tool to further their cause. Others, such as some professional statisticians, are cautious of composite indicators due to the potentially subjective nature of the selection of the constituent indicators, the method of aggregation, and the weighting of the indicators. Because composite indicators are not universally accepted, they must be developed in a sensible and transparent manner and used responsibly. To this end, this report has been developed using the revised ten steps[2] set out by the Joint Research Centre's (JRC) *Competence Centre on Composite Indicators and Scoreboards (COIN)* (Saisana et al., 2018).

## 1.1 Scope and Purpose

The purpose of this report is to present the development of a Water-Energy-Food (WEF) nexus-based indicator framework, dashboard and composite index, and apply it to South Africa and the Southern African Development Community (SADC) region:

- For assessing national progress towards the constituent Sustainable Development Goals (SDGs), i.e. SDGs 2, 6 and 7, and
- To facilitate integrated sustainability planning and policy development at both national and regional levels.

The visualisation of the indicator data making up the composite index will provide a representation of both country- and regional-level progress towards integrated resource security and livelihood vulnerability associated with the system under assessment (i.e. the WEF nexus), while also highlighting actual or potential trade-offs, and synergies, that exist between the resource sectors. Two policy briefs, one for each of South Africa and SADC, will form part of this study.

## 1.2 Background

The word *nexus* means to "connect" (De Laurentiis et al., 2016). The view that water resources, energy generation and food production are interdependent is not novel (Allouche et al., 2015, Muller, 2015, Wichelns, 2017). Sušnik (2018) argues that the earliest global study on a nexus was the publication *The Limits of Growth*. In this book, Meadows et al. (1972) state that "If the present growth trends in world population, industrialisation, pollution, food production and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next one hundred years." The study, compiled during the 'Great Acceleration'[3], assessed the exponential growth in the global population and the demand for resources since the onset of the industrial revolution. Many researchers at that time were concerned about the full cost of development. Schaeffer (1970), for example, stated that "if man is not able to solve his ecological problems, then man's resources are going to die."

Various approaches, such as Integrated Water Resources Management (IWRM), were developed in order to manage resources within the broader context of sustainable development. Following the 2008 financial crisis, various nexus concepts were considered in order to promote integrated resource management (Mohtar and Daher, 2012). The WEF nexus approach gained prominence following the Bonn2011 Conference (Hoff, 2011) and the

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[2] The ten steps are: Developing the framework; Selection of indicators; Data treatment; Normalisation; Weighting; Aggregation; Statistical coherence; Robustness and sensitivity; Back to the data; and Visualisation and communication.

[3] The 'Great Acceleration' refers to the second half of the twentieth century during which the rate of impact of human activity upon the Earth increased significantly.

World Economic Forum's publication of *Water Security: The Water-Food-Energy-Climate Nexus* (World Economic Forum, 2011).

The study of a nexus – such as the WEF nexus – assesses the individual components of the system, their interactions and linkages, as well as synergies and trade-offs that exist between them. The interactions include water for food (e.g. irrigation) and water for energy (e.g. cooling in a power plant), energy for water (e.g. pumping and treating water) and energy for food (e.g. ploughing of land or transporting agricultural produce), and food for energy (e.g. bioenergy). The UN World Water Assessment Programme (2014) explains that "A nexus approach to sectoral management, through enhanced dialogue, collaboration and coordination, is needed to ensure that co-benefits and trade-offs are considered and that appropriate safeguards are put in place."

The process that led to the compilation of the SDGs originated at the Rio+20 conference in Brazil in 2012 (Griggs et al., 2013). At this meeting, it was concluded that the Millennium Development Goals (MDG) were outdated and that the SDGs would build upon the original goals but would be more comprehensive and would involve a more inclusive participatory process. The SDGs were adopted by 193 countries in September 2015 at the UN Sustainable Development Summit, where 17 goals, 169 targets and 232 indicators were outlined in the 2030 Development Agenda titled "Transforming our world: the 2030 Agenda for Sustainable Development" (Schmidt-Traub et al., 2017). The most noticeable difference between the MDGs and SDGs is that the latter's aim favours collective action with universal goals as opposed to the MDGs that focused on donor-recipient relationships where richer countries would aid poorer countries (Melamed and Scott, 2011). Unlike the MDGs, the SDGs include an SDG that specifically addresses energy (SDG 7). Along with SDG 7, SDGs 2 (zero hunger) and 6 (clean water and sanitation) directly relate to the WEF nexus, with SDGs 12 (responsible consumption and production), 13 (climate action) 14 (life below water) and 15 (life on land) being indirectly related to the nexus.

### 1.3 Motivation for assessing the WEF Nexus

A principal reason for utilising the WEF nexus as a lens for assessing sustainable development and integrated resource management is the linkages within the WEF nexus. In this regard, the following bulleted percentages present global estimates of the proportion that each WEF nexus sector supplies/obtains from the adjacent sector (in selected cases a resource may be reused, e.g. water runoff from agricultural lands may be utilised downstream for power generation or domestic consumption, or vice versa):

- 71% of the available freshwater and 30% of the energy produced globally are utilised within the agricultural sector (Mohtar and Daher, 2012, FAO, 2014).
- One-third of all food produced globally is either lost or wasted (IRENA, 2015a).
- 15% of the globally available freshwater is utilised in energy production (Olsson, 2013, Yuan et al., 2016) while 14% of water is utilised for domestic purposes (World Economic Forum, 2011).
- 1% of all food produced is utilised within the bioenergy sector (Garcia and You, 2016).

- In 2011 only 13% of the energy generated globally originated from renewable sources (Hoff, 2011).
- 8% of all energy generated is utilised for the pumping and treatment of water (Hoff, 2011), while total industrial withdrawals account for 16% of today's global water demand (World Economic Forum, 2011).

These percentages indicate the profound interdependence of the constituent sectors within this nexus configuration. Approximately 86% of the globally available freshwater is used either for food production or energy generation. That a third of food is wasted or lost indicates a significant loss of 'virtual'[4] water and energy, used in agricultural production. Water shortages as a result of climate change, which are predicted for regions such as southern Africa (Conway et al., 2015, Scholes et al., 2015) will threaten both food production (and prices) and energy generation (particularly in countries that are highly dependent on hydropower generation). The use of food to generate energy can lead to an ethical dilemma, particularly in countries that experience appreciable levels of undernourishment, stunting and wasting.

Not only are there deep-rooted interdependencies between the three resource sectors within the WEF nexus, but the demand for each one of these is projected to continue to increase in the impending decades. The National Intelligence Council (2012) predicted that the global demand for water, energy and food in 2030 will grow by approximately 40, 50 and 35% respectively. Similar increases in demand for these resources were projected by Beddington (2009). These noteworthy increases are due to the persistent increase in the world's population, as well as a marked increase in urbanisation, and the size of the middle class with its associated consumption patterns. Salam et al. (2017) argue that "The gap between future availability and demand can be closed not through the discovery of more water supplies but through effective demand-side management, which will definitely need effective policy interventions."

Another reason for utilising the WEF nexus approach is that it is multicentric, with each sector being treated with equal importance (Benson et al., 2015, Abdullaev and Rakhmatullaev, 2016, Gallagher et al., 2016, Liu et al., 2017). This approach is often contrasted with concepts such as IWRM, which is viewed as being water-centric. It has met with varying levels of success (de Loe and Patterson, 2017), with some arguing that it is not sufficient as a stand-alone tool (Bogardi et al., 2012). The goal of nexus approaches is that the trade-offs resulting from policy development in institutional 'silos' will be reduced (Belinskij, 2015). Further, it is hoped that by pursuing an integrated approach, synergies between the sectors will be exploited.

A further reason for pursuing the WEF nexus is that it is regarded as a mechanism for achieving the relevant sector-related SDGs, i.e. SDGs 2 (Zero Hunger), 6 (Clean Water and Sanitation), and 7 (Affordable and Clean Energy). In the *SDG Index and Dashboard Report 2018*, it is astutely noted that "no country is on track to achieve all the goals by 2030" (Sachs

[4] Virtual water circulates in the international economic system as an embedded ingredient of food and other globally traded products. It is the equivalent volume of water that was utilised in the production of that food or product, that is in essence 'virtually' exported with the food or product.

et al., 2018). In this report, it is highlighted that while Sweden, Denmark and Finland have the best SDG Index ratings, these nations must more purposefully pursue goals such as SDG 12 (Sustainable Consumption and Production) and SDG 13 (Climate Action) if they are to achieve them within the prescribed target timeframe (ibid.).

The motivation for developing the proposed composite indicator related to the WEF nexus was birthed by a question that was repeatedly asked during the workshop “Water-Energy-Food Nexus and its linkages to the implementation of the SDGs” held in Hilton, South Africa in November 2016. The question raised was “How do we measure the nexus?” This question relates to the desire to understand a system that has components measured in different units (e.g. $m^3$, kWh and calories) that occur at different spatial and temporal scales. This is why the development of a composite indicator requires that the constituent indicators be normalised such that they can be integrated (OECD, 2008).

It could be argued that the development of the SDG Index (Sachs et al., 2016), which incorporates SDGs 2, 6 and 7, renders the WEF Nexus Index redundant. El Costa (2015) however suggests that since the SDGs seek to incorporate multiple development goals, identifying targets *at the nexus* of various sectors will be instrumental in yielding a less complex SDG framework. There is, therefore, a compelling argument in favour of developing an indicator framework for a *subsystem* within the SDGs, such as the WEF nexus. Boas et al. (2016) agree, arguing that “novel ways of cross-sectoral institutionalisation” are required if the 2030 Agenda for Sustainable Development is to be implemented. The relationship between the SDG Index and the WEF Nexus Index will be described later in this report, together with the resultant R-squared value.

### 1.4 Criticisms of the WEF Nexus

Various criticisms have been levelled at the WEF nexus during the last decade. Some have called the WEF nexus a ‘buzzword’ (Cairns and Krzywoszynska, 2016). Its novelty has been questioned, although novelty is not a prerequisite for relevance (Simpson and Jewitt, 2019a). The constituent sectors within this nexus have also been probed, with some viewing them as being arbitrary (Wichelns, 2017). This is because the nexus could also include sectors such as land, climate, waste, livelihoods, governance or the environment (Ringler et al., 2013, Leck et al., 2015, Machell et al., 2015, Larcom and van Gevelt, 2017). Some authors have questioned whether the quest for global resource security has resulted in the neglect of livelihoods and the environment in WEF nexus studies (Biggs et al., 2013, Ringler et al., 2013, Leese and Meisch, 2015). Allouche et al. (2015) explain that it is simplistic to assume that “increased food supply will automatically reduce hunger or that increased supply of water will improve general access to water.”

Another criticism of the nexus approach is the complexity of integrating and optimising the three constituent resource sectors, while also taking into account adjacent components (de Loe and Patterson, 2017). Leck et al. (2015) note that although the nexus concept is attractive, it will be an appreciable challenge to implement it. The Stockholm Environmental Institute, who were prominent in creating the momentum behind the WEF nexus approach, have assessed that the process has not yet yielded a systematic toolkit, nor has it yet proven itself in enhancing the integrated governance of resources (Galaitsi et al., 2018). Albrecht et al.

(2018), following a systematic review of relevant literature, state that many nexus methods are (ironically) confined to disciplinary silos. They also note that the adoption of social science methods in WEF nexus analyses is limited (ibid.).

The FAO (2018) explains that to date, there are limited examples of the mainstreaming of the WEF nexus approach in national policies, programmes and institutions, although they do note that it has been introduced to some extent in Austria, Germany, Mauritius and Qatar. There is a general call in the current literature for the WEF nexus to move from being conceptual in nature to being operationalised (McGrane et al., 2018). There is also a call for the publishing of case studies where WEF nexus thinking has been applied (Hoff et al., 2019). In implementing the WEF nexus, Allouche et al. (2019) emphasise that this approach must not be viewed as being technical and apolitical in nature. They note that power, politics and justice are key barriers and entry points for governing the nexus and that WEF nexus assessments must move "towards a clear and articulated political choice about allocation and trade-offs between resources" (ibid.).

# 2 PROPOSED FRAMEWORK

The first of the revised ten steps for developing a composite indicator set out by the JRC-COIN (Saisana et al., 2018) is the development of a framework for the system being assessed. In this section selected existing WEF nexus frameworks will initially be outlined, whereafter the framework that has been designed as part of the WEF Nexus Index's development is presented.

## 2.1 Existing WEF Nexus Frameworks

Numerous frameworks have been developed in an attempt to present the interdependencies and trade-offs between water, energy, and food (Mabhaudhi et al., 2018). There have been many deliberations on which element – water, energy or food – should be at the centre of these frameworks. This may appear to be a trivial matter, but it has monumental implications for policy development and implementation (since policies would be set up to ensure that the central sector attains the highest level of security, with the secondary sectors experiencing the negative outcome of any trade-off with the core sector). Various conceptual WEF nexus frameworks are offered in academic and grey literature, with several emphasising the interlinkages between the three resource sectors (Gulati et al., 2013, Smajgl et al., 2016, Liu et al., 2017).

The original WEF nexus framework, shown in **Figure 2-1**, was presented at the Bonn2011 Conference (Hoff 2011). In this framework "Available water resources" was placed at the centre of this framework because it functions as a control variable of change.

This framework formed the basis of many subsequent WEF nexus configurations, one of which focused specifically on Southern Africa. Conway et al. (2015) modified Hoff's nexus framework to examine the interactions between water, energy and food in Southern Africa, as depicted in **Figure 2-2**. A distinct difference between this framework and the former one is that water is no longer in the centre of the nexus. Rather, available resources are central to managing the three sectors. Where Hoff (2011) highlighted ecosystem services as being an important driver for the nexus, Conway et al. (2015) elaborated on the environmental drivers by including various influences such as climate change and variability.

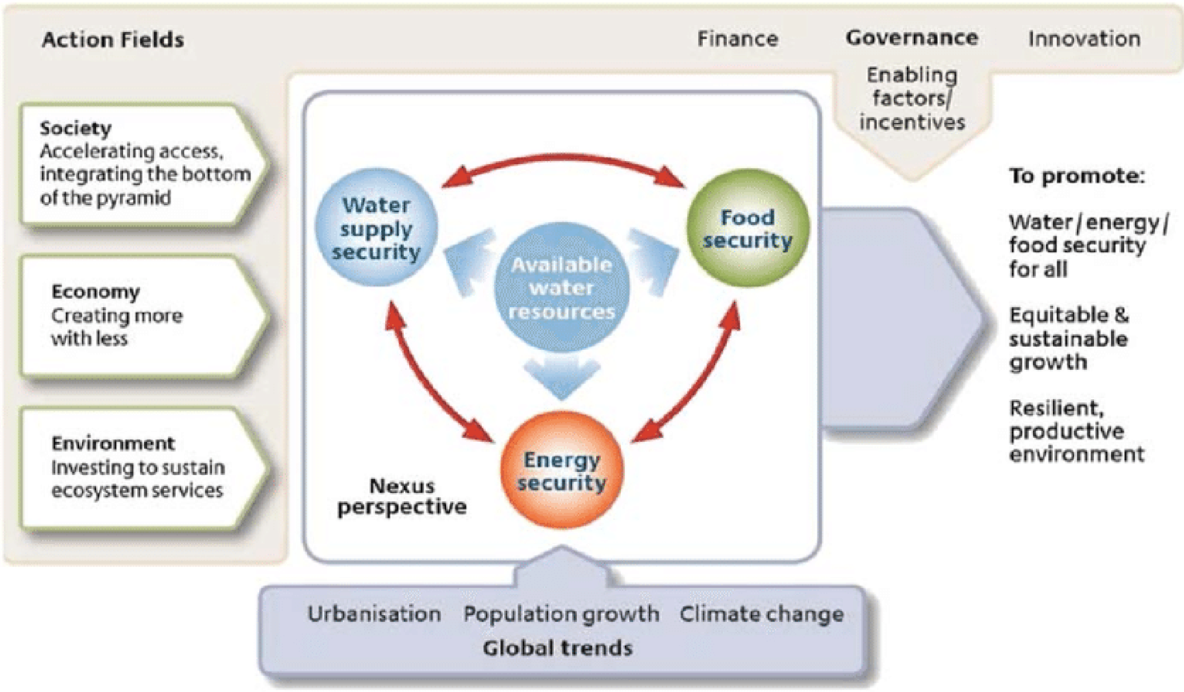


**Figure 2-1: WEF nexus framework presented at the Bonn Conference (Hoff 2011)**

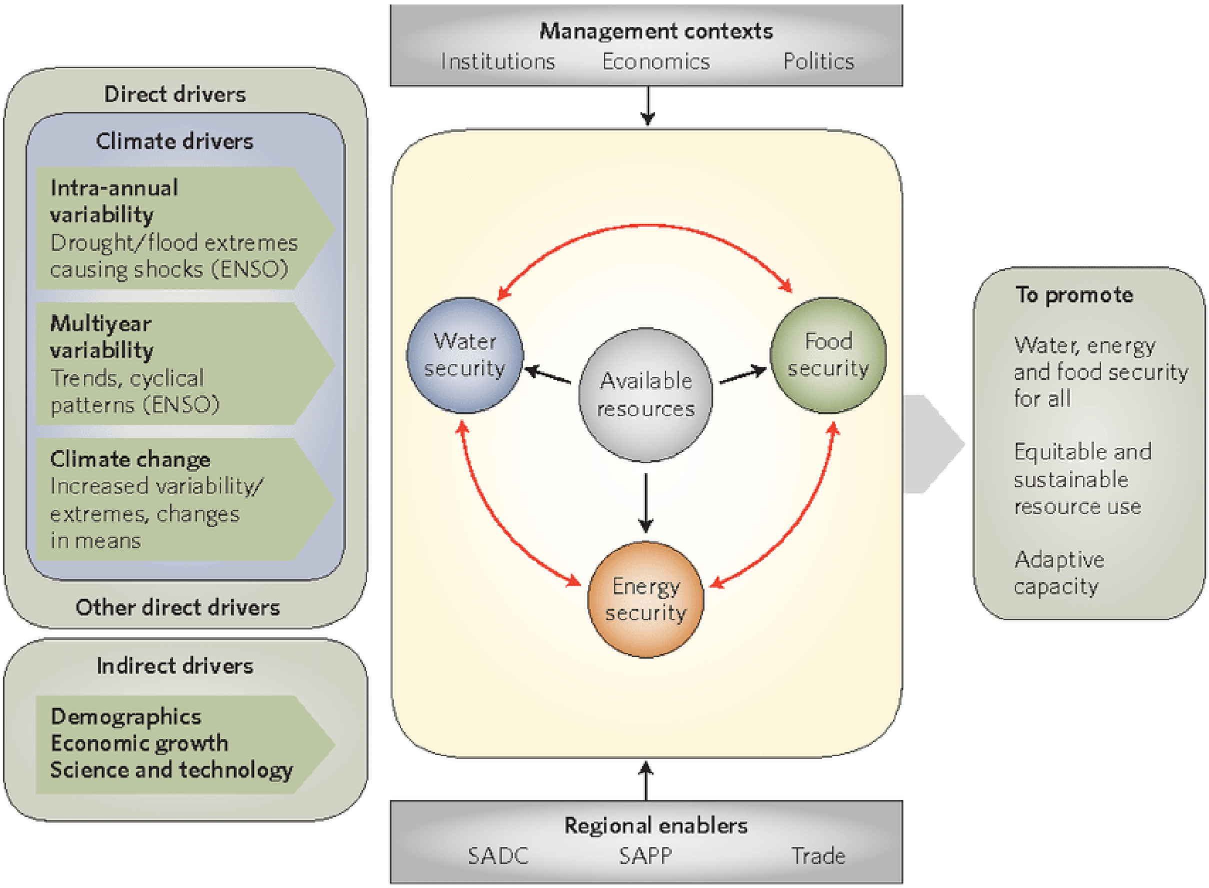


**Figure 2-2: The WEF nexus framework proposed by Conway et al. (2015)**

Some WEF nexus frameworks are more complex and consider other aspects, such as climate change, ecosystem services, and land, to be equally important to water, energy, and food. Karabulut et al. (2016) designed an interesting framework which is presented in **Figure 2-3**. In this framework, the drivers are connected to the key components via gears 'driving' human well-being and economic growth. In this framework, "ecosystem services" is viewed as being the central component in resource management since it incorporates all features that support water, energy, land and food availability and production.

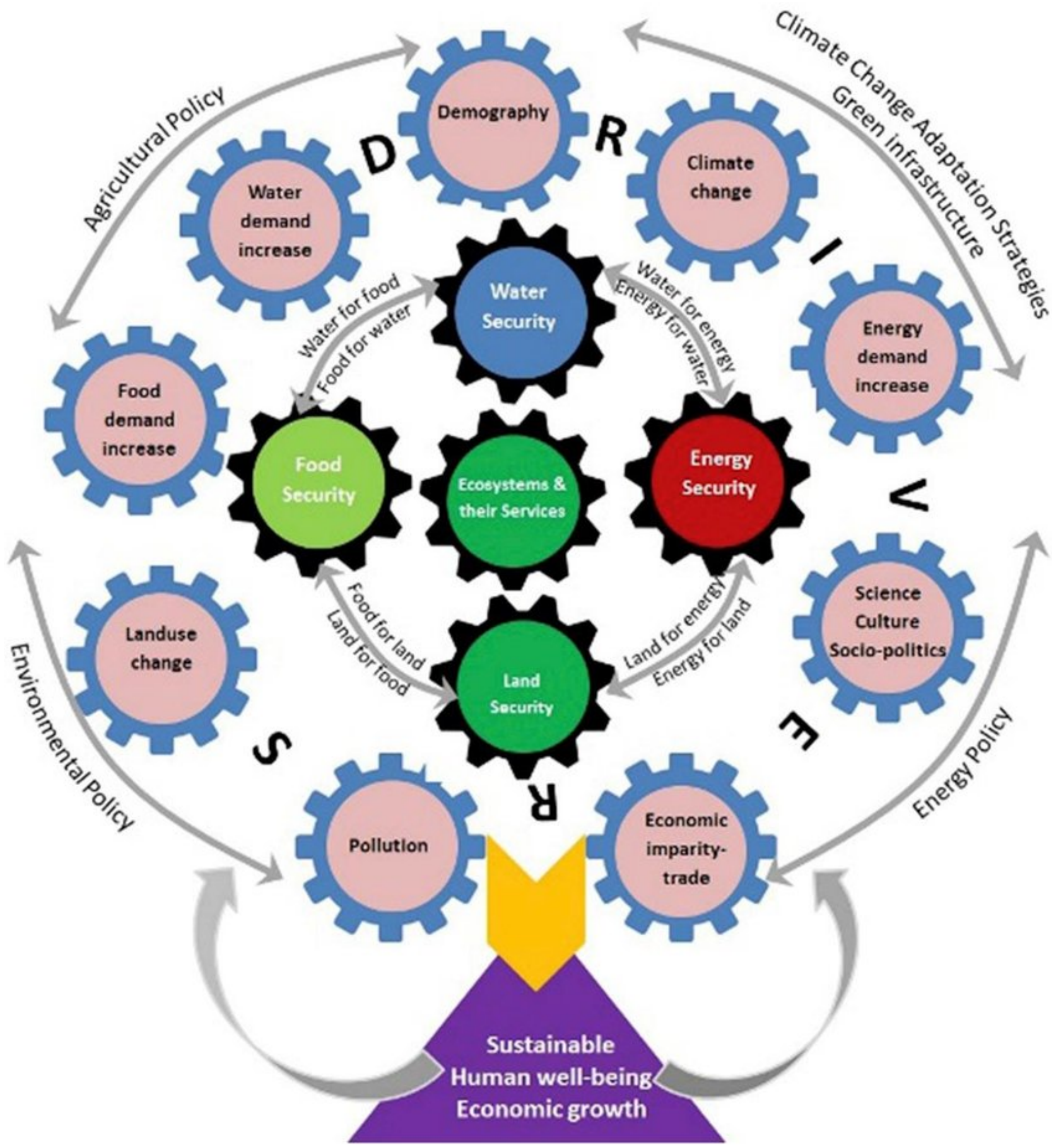


**Figure 2-3: Karabulut et al. (2016)'s ecosystem-water-food-land-energy (RIFLE) nexus**

Smajgl et al. (2016)’s framework provides three distinct entry points that relate to resource security. These are subsequently subdivided into resource demand and access. In contrast to Conway et al. (2015)’s framework, the drivers that were identified in their framework are in the centre of Smajgl et al. (2016)’s framework as the variables that connect water, energy and food security. No reference is made to governance or financial aspects relating to the implementation of the WEF nexus.

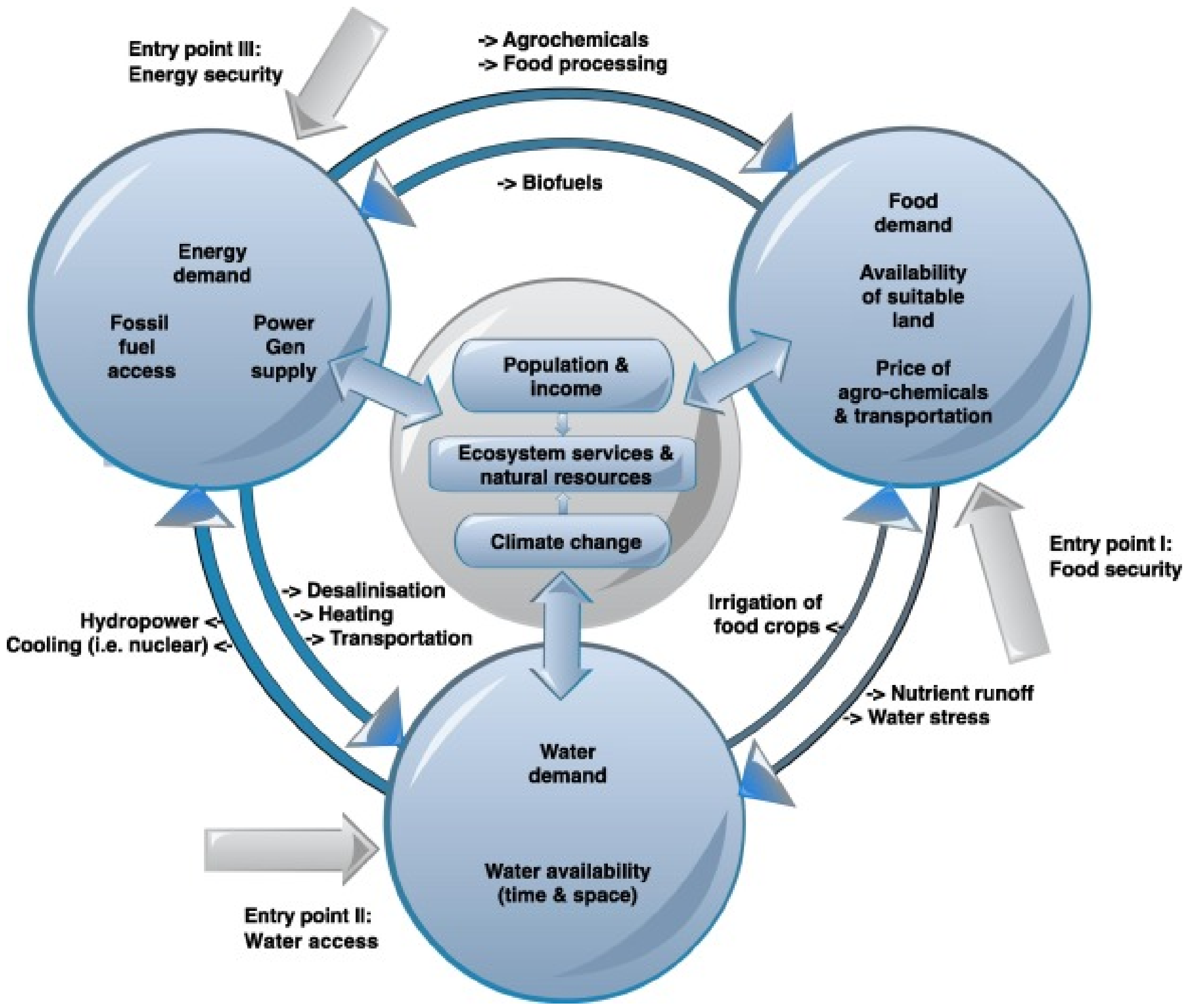


**Figure 2-4: The WEF nexus framework as proposed by Smajgl et al. (2016)**

The rapid growth of interest in the WEF nexus has resulted in the evolution of many framework configurations that can be altered to be more applicable to a specific country, region or area (Mabhaudhi et al., 2018). In order for the development of new WEF nexus frameworks to be sustainable and universally applicable, the incorporation of social drivers could be considered, i.e. waste management, policy implementation and system resilience.

## 2.2 Proposed Anthropocentric WEF Nexus Framework

The WEF nexus approach requires a system perspective (Pahl-Wostl, 2017). In seeking to develop a framework for the development of a composite indicator associated with the WEF nexus, the pivotal question is "What is driving the entire WEF system?" Schaeffer (1970) stated almost a half-century ago that mistreatment of our environment "involves the negligence of a small businessman on the Kalamazoo River, the irresponsibility of a large co-operation on Lake Erie, the impatient use of insecticides by a farmer in California, [and] the stripping of land by Kentucky mine operators." The answer to the question is therefore that humanity, with our insatiable demand for a myriad of products and services, is the principal driver within the WEF system. *Anthropos*' exponential development demands that that more and more food, energy and water be produced, generated and delivered. Ironically, humanity also influences the governance and policies that determine how the environment and resources are managed (or *mismanaged*). People's profound influence on planet Earth has resulted in some authors proposing that a new Epoch be inaugurated, i.e. the Anthropocene (Crutzen and Stoermer, 2000, Crutzen, 2002). It is therefore proposed that the framework utilised in the development of the WEF Nexus Index be anthropocentric in nature. The framework is presented in **Figure 2-5**.

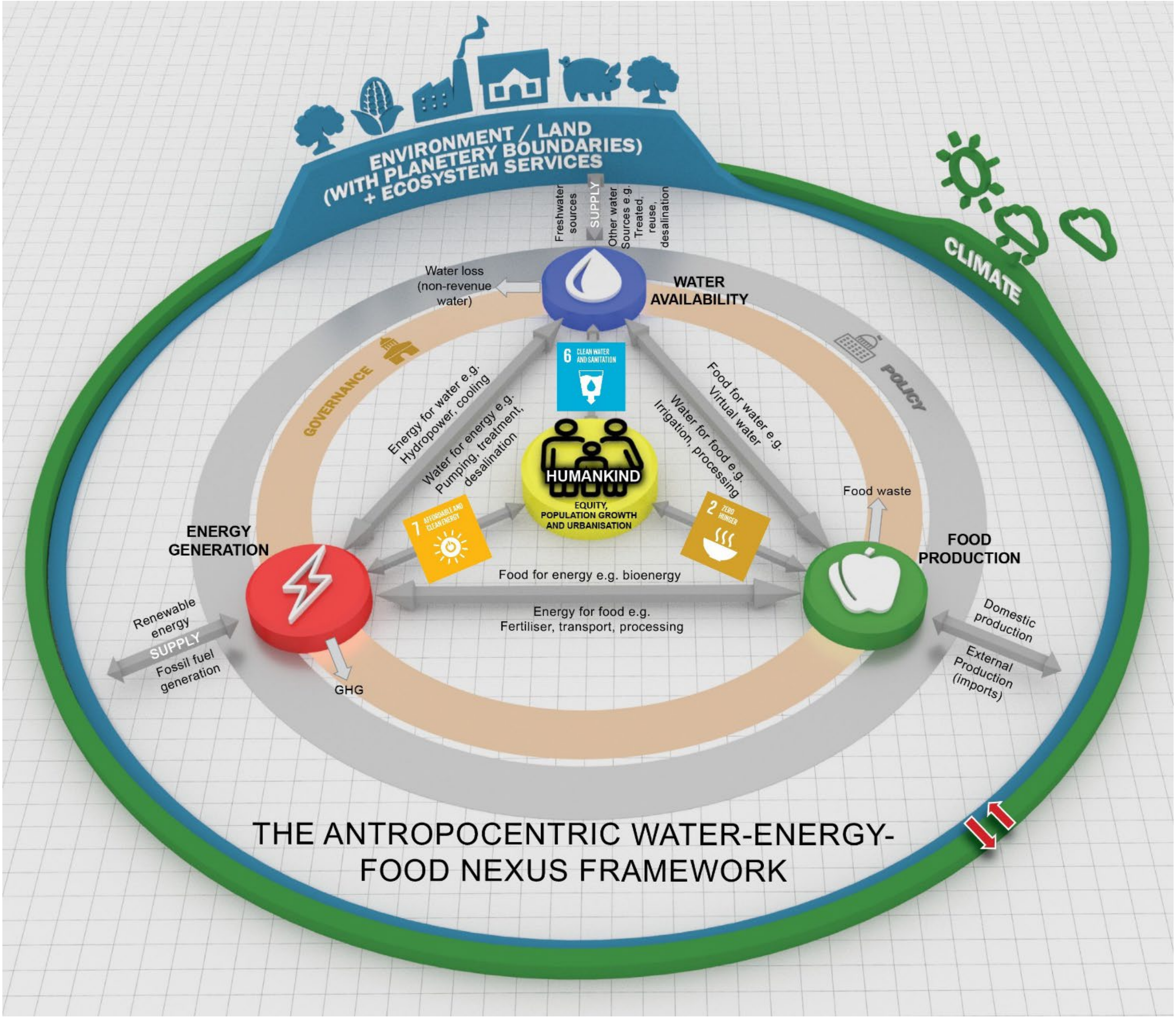


**Figure 2-5: The Anthropocentric WEF Nexus Framework**

Humankind, with the associated drivers of change, namely population growth and urbanisation, are at the centre of this proposed framework. People receive water, energy and food in order to sustain their livelihoods. The link between each of these resources and the core of the framework is however not limited to the supply of water, energy and food. Equitable access, represented by SDGs 2, 6 and 7, form the second component of the link between the respective resources and people. The interdependencies between the three sectors are represented by the direct links between water availability, energy generation and food production. Noteworthy by-products associated with the three sectors are water loss (e.g. pipe leaks), greenhouse gases and food wastage, respectively. The supply of water, energy and food are ultimately obtained from the natural realm. The climate influences the environment which is in turn influenced by how these resources are 'procured.' This supply can be either renewable or non-renewable. In the case of food, it could be domestic production thereof or imported food. All levels of the system, including the environment and/or land use, are influenced by policies and governance, which are determined by people. Humanity, therefore, drives the global supply chain system from the centre of this framework, while yielding momentous influence throughout the framework. If people are to obtain all that they demand from Earth in the long-term then they must, in turn, govern wisely and develop appropriate, integrated policies. Resource demand management, sustainable supply, and the reduction of greenhouse gases and food waste are also imperative (Simpson and Jewitt, 2019b).

# 3 SELECTION OF INDICATORS

An indicator "is the operational representation of an attribute (quality, characteristic, property) of a given system, by a quantitative or qualitative variable (for example numbers, graphics, colours, symbols) (or function of variables), including its value, related to a reference value" (Waas et al., 2014). Several indicators currently exist for each of the three individual resources within the WEF nexus. Many of these sector-specific indicators are reported upon by the World Bank, the United Nations (including their Food and Agricultural Organisation, or FAO), and individual countries through their national statistical departments. These indicators, however, often describe isolated components of sector-specific information, and thereby neglect the interconnections or dependencies between the resource sectors.

There are however exceptions, such as the *Percent of arable land equipped for irrigation* which links agriculture, water and energy (since the irrigated water must generally be pumped from either a surface or groundwater source to enhance crop production). Notwithstanding the fact that many indicators are sector-specific, Owen et al. (2018) note that consumption-based indicators have substantial potential for measuring progress in terms of the WEF nexus. Yuan et al. (2016) argue that in order to achieve robust WEF nexus quantifications, future research must include, amongst others, the identification of crucial indicators and the development of an integrated and flexible analytical framework.

Five indicator classes include informative, predictive, problem-oriented, program-evaluation and target-delineation indicators (MacGregor and Fenton, 1999). Indicators are developed from data, which leads to information, knowledge, decision-making and ultimately policy (with the possible inclusion of the development of a composite indicator, or index, as an intermediary step), as shown in **Figure 3-1**. This relationship has also been represented as an "information pyramid", with the successive layers of the pyramid being primary data, analysed data, indicators, with indices at the pinnacle of the pyramid (Segnestam, 2002).

The JRC-COIN specify that ideally two-thirds of the time spent in building a composite indicator should be expended on developing the framework and selecting the indicators, i.e. the first two steps in the ten-step process of developing a composite indicator (Saisana et al., 2018). Once a suitable framework, or context, is established (refer to **Section 2.2**), indicators associated with the various components of the framework must be selected and evaluated for inclusion in the index. The selected indicators must be relevant to the components of the framework, *and* they must have adequate data at both country and indicator levels:

- At a country level, at least 65% of indicators should have valid data, and
- At the indicator level, at least 65% of countries should have valid data (Saisana et al., 2018).

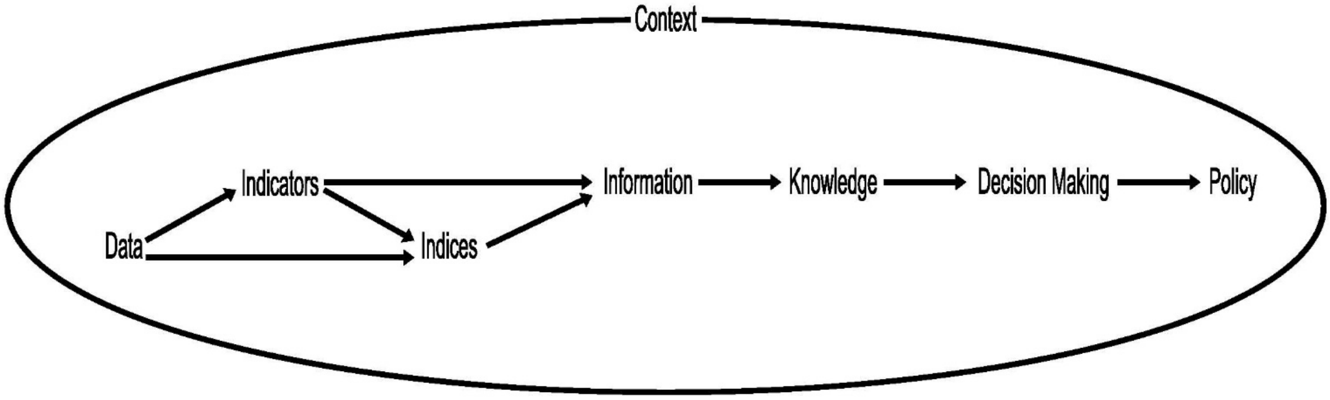


**Figure 3-1: From data to knowledge; modified from Segnestam (2002) and Waas et al. (2014)**

The proposed WEF Nexus Index will be based on indicators representing the three interdependent resource sectors. A rule-of-thumb in this regard is that between 15 to 40 indicators should make up the composite indicator (ibid.). There are exceptions to this rule, such as the HDI, which has only four indicators, and the ESI which has more than forty indicators. It is essential that any proposed index be determined from indicators that are universally available, at least at a national level, since any missing, unconsolidated, conflicting, unclear or inaccessible data will severely limit the composite indicator's relevance and application (Hussey and Pittock, 2012).

Both the proposed anthropocentric framework and the selection of indicators to make up the WEF Nexus Index were presented at various forums during this project in order to facilitate stakeholder engagement. These interactions proved to be immensely beneficial in obtaining expert opinions on both the interpretation of the framework and the final selection of indicators. The forums that the framework and indicators were presented at include:

- A *Research on Tap Seminar* entitled "Towards a Water-Energy-Food Nexus Index" at the University of KwaZulu-Natal's *Centre for Water Resources Research* on 25 April 2019, in Pietermaritzburg, South Africa (see **Appendix F** for Minutes and attendance register)
- A workshop entitled the "Development of the Water-Energy-Food Nexus Index and its application to South Africa and SADC: From Theory to Practise" at the Water Research Commission in Pretoria, South Africa, on 10 May 2019 (see **Appendix F** for attendance register)
- A presentation at the 2019 European Climate Change Adaptation Conference in Lisbon, Portugal, on 30 May 2019, entitled the "Development of the Water-Energy-Food Nexus Index and its application to South Africa and SADC"

- A lunchtime seminar at IHE Delft Institute for Water Education, Delft, The Netherlands on 5 June 2019, entitled the "Development of the Water-Energy-Food Nexus Index and its application to South Africa and SADC"
- A COIN Open Day at the JRC in Ispra, Italy, on 7 June 2019, entitled the "Development of the Water-Energy-Food nexus index and its application to South Africa and SADC"

In the following three subsections, indicators associated with each of the three sectors within the WEF nexus are reviewed in turn. A more detailed table of the 87 indicators reviewed is included in **Appendix A**. Indicators for the development of a WEF Nexus Index have been selected based on their relevance regarding "access to" and "availability of" water, energy and food at a national level. In this regard, it was found that adequate data is available for several relevant indicators for 170 countries[5]. Many indicators, including some SDG indicators, lack adequate datasets and have thus been excluded from the WEF Nexus Index. However, these have still been listed in **Appendix A** to ensure that all relevant indicators have been considered and that the process of developing the index is as transparent as possible. The statistical coherence of the indicators within each pillar is also reviewed in the following three subsections. This aids in the selection of indicators, which is an iterative process.

## 3.1 Water Indicators

Water security is defined as:

> "The capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability" (UN Water, 2013).

Unpolluted freshwater accounts for only 0.025% of the total water accessible globally (Fenner, 2016). Of the total volume of freshwater withdrawals globally, about 71% is used for agricultural production (Mohtar and Daher, 2012). The National Intelligence Council (2012) predicted that by 2030 nearly half of the world's population will live in areas experiencing severe water stress. The Falkenmark indicator is perhaps the most widely used measure of water stress (Brown and Matlock, 2011). This indicator represents the fraction of total annual runoff available for human use. Based on the 'per capita' usage, the water conditions in an area can be categorised as: "no stress", "stress", "scarcity" or "absolute scarcity". The values of 1700 $m^3$ and 1000 $m^3$ per capita per year are used as thresholds for the water-stressed and water-scarce areas respectively, as presented in **Table 3-1**.

[5] The countries with insufficient data, i.e. at less than 65% at either the indicator or country level included Andorra, Aruba, Antigo and Barbados, The Bahamas, Bahrain, Bermuda, Cayman Islands, Chanel Islands, Curacao, Equatorial Guinea, Faroe Islands, French Polynesia, Gibraltar, Greenland, Grenada, Isle of Man, Kiribati, Kosovo, Kyrgyz Republic, Liechtenstein, Macao SAR China, Marshal Islands, Micronesia Fed States, Monaco, Nauru, New Caledonia, Northern Mariana Islands, Palau, Puerto Rico, San Marino, Saint Maarten (Dutch part), Seychelles, Somalia, Tonga, St Kits and Nevis, St Lucia, St Martin (French part), St Vincent and the Grenadines, Turks and the Caicos Islands, Tuvalu, Virgin Islands, West Bank and Gaza.

**Table 3-1: Water stress/scarcity differentiation proposed by Falkenmark (Brown and Matlock, 2011)**

| Index ($m^3$ per capita per annum) | Category / Condition |
|---|---|
| >1700 | No stress |
| 1000-1700 | Stress |
| 500-1000 | Scarcity |
| <500 | Absolute scarcity |

The Organisation for Economic Cooperation and Development (OECD) have however stated that “the current water ‘crisis’ is not a crisis of scarcity but a crisis of mismanagement, with strong public governance features” (OECD, 2011). They continue, stating that “whether in developed or developing countries, and whether water is scarce or plentiful, *water governance* remains in a state of confusion” (ibid.). Demand management is, therefore, one of the dominant challenges faced by policymakers (Sullivan, 2002).

It is estimated that global water system losses exceed 45 million Mℓ/day, which equates to approximately 20 to 50% of the total freshwater produced (Fenner, 2016). The world average Non-Revenue Water[6] figure is estimated to be 36.6% (Mckenzie et al., 2012), while the international best practice has real losses in conveyance systems at 15% (Bruinette and Claasens, 2016). The water crisis is compounded because many people do not have access to safe drinking water, and still more lack adequate sanitation services. The World Bank (2018a) reports that about 71% of people in the world have water that is considered to be safely managed. Further, they state that “Globally, 6 in 10 people use sanitation facilities that are not safely managed and may contribute to the spread of disease” (ibid.). The planetary boundary of the availability of freshwater will pose a major challenge for many regions in the world in approaching decades.

In selecting water-related indicators to develop the WEF Nexus Index, a total of 36 water-related indicators were reviewed (refer to **Appendix A**). Some indicators, such as the Infrastructure Leakage Index (ILI), would be a valuable indicator of water losses and municipal governance. On an international level, however, uniformity in measuring, interpreting and reporting of the ILI does not exist (Mckenzie et al., 2012). Other indicators such as the *Desalinated water product*, *Treated municipal water* and *Change in the extent of water-related ecosystems over time* do not have sufficient data. The last of these indicators is an SDG indicator (6.6.1), and because of this, its data availability will probably improve with time since the measurement of this indicator is now a focus-point for the United Nations and national statistical offices.

[6] Non-Revenue Water is becoming the standard term replacing unaccounted-for water (UFW) in many water balance calculations and is the term recommended by the International Water Association in preference to UFW. It is a term that can be clearly defined, unlike the unaccounted-for water term which often represents different components to the various water suppliers. Non-Revenue Water incorporates the following items: Unbilled authorised consumption; Commercial Losses; and Physical Leakage (Mckenzie et al., 2012).

In terms of access to freshwater resources, the following indicators are both relevant to SDG 6 and have sufficient data:

- *Population using at least basic drinking water services*, and
- *Population using safely managed sanitation services*.

As presented in **Table 3-2**, these two indicators are well correlated (0.89), but not too high such that one would have to be excluded because of double accounting. Of the 170 countries with adequate data at both an indicator and country-level, several countries have 100% coverage in terms of providing a minimum of basic drinking water services. Other countries such as Ethiopia, Papua New Guinea and Uganda are below 40% in attaining this level of service delivery. There are a total of 33 nations (of the 170 countries) who do not attain at least 40% for this indicator.

The indicator *Degree of Integrated Water Resources Management (IWRM) Implementation* is defined as:

> "the degree to which IWRM is implemented, by assessing the four components of policies, institutions, management tools and financing. It takes into account the various users and uses of water, with the aim of promoting positive social, economic and environmental impacts at all levels, including the transboundary level, where appropriate" (UN Water, 2016).

This indicator has a positive correlation (0.42 and 0.48 respectively) with both the *Percentage of people using at least basic drinking water services*, and the *Percentage of People using safely managed sanitation services*, as presented in **Table 3-2**. These three indicators together constitute the "Water-access" sub-pillar of the "Water pillar", which is one of the three equal limbs of the WEF Nexus Index.[7]

**Table 3-2: Correlations within the "Water-access" sub-pillar**

| **Name** | **Indicator** | ind.01 | ind.02 | ind.03 |
|---|---|---|---|---|
| The percentage of people using at least basic drinking water services | ind.01 | 1.00 | **0.89** | **0.42** |
| Percentage of people using safely managed sanitation services. | ind.02 | **0.89** | 1.00 | **0.48** |
| Degree of IWRM implementation (1-100) | ind.03 | **0.42** | **0.48** | 1.00 |

In terms of the indicator *Total annual freshwater withdrawals* (as a percentage of internal resources), the Republic of Congo withdraws only 0.02% of its available freshwater resources, which includes the immense Congo River – the second largest river in the world by discharge. Almost 10% of the nations included in the index calculation (15 of the 170), by contrast,

[7] An index is made up of sub-indices, pillars, sub-pillars and indicators, in succeeding levels of a hierarchical structure. For the WEF Nexus Index the index and sub-index are equivalent, with the equal pillars representing water, energy and food. Two sub-pillars are located below each pillar, one representing "Access" and one "Availability" of the specific resource sector. Refer to **Table 3-9** and **Table 4-4** for a representation of the relationships.

withdraw over 100% of their available internal freshwater resources. Many of these nations are in the Middle East and as a result, rely on desalination for their water supply. Voulvoulis (2012) noted that Saudi Arabia (17.4%), the United Arab Emirates (14.7%) and Kuwait (5.8%) account for almost 38% of the world's seawater desalination capacity between them. Countries such as the United Arab Emirates and Turkmenistan each utilise almost 2000% of their available internal freshwater resources. In many countries water scarcity is associated with overuse of groundwater resources for agriculture, resulting in a decline in both water quality and food productivity (Linke, 2014).

The indicator, *Renewable internal freshwater resources,* is defined as the:

> "internal renewable resources (internal river flows and groundwater from rainfall) in the country. Renewable internal freshwater resources per capita are calculated using the World Bank's population estimates" (World Bank, 2018b).

Iceland has the highest volume of renewable internal freshwater resources per capita, at over 500 000 $m^3$/capita (ibid.). The environment provides ecosystem services such as the purifying and attenuating of water. The indicator, *Environmental flow requirements,* is defined as "the quantity and timing of freshwater flows and levels necessary to sustain aquatic ecosystems which, in turn, support human cultures, economies, sustainable livelihoods, and wellbeing" (Arthington, 2012). Brazil, with its vast Amazon River, has the highest *Environmental flow requirement* of the 170 countries assessed, at $6.5 \times 10^9$ $m^3$/annum. Regarding the availability of freshwater, the full list of indicators reviewed are presented in **Appendix A**.

The following indicators were ultimately selected to constitute the "Water-availability" sub-pillar of the "Water pillar":

- *Total annual freshwater withdrawals as a percentage of internal resources,*
- *Renewable internal freshwater resources per capita,*
- *Environmental flow requirements per annum, and*
- *Average annual precipitation*.

As presented in **Table 3-3**, these four indicators all have positive correlations with one another. They provide a broad overview of freshwater usage, availability and the volume that the environment requires.

**Table 3-3: Correlations within the "Water-availability" sub-pillar**

| **Name** | **Indicator** | ind.04 | ind.05 | ind.06 | ind.07 |
|---|---|---|---|---|---|
| Annual freshwater withdrawals, total (% of internal resources) | ind.04 | 1.00 | **0.66** | **0.38** | **0.48** |
| Renewable internal freshwater resources per capita (cubic meters) | ind.05 | **0.66** | 1.00 | **0.58** | **0.60** |
| Environmental flow requirements ($10^6$ $m^3$/annum) | ind.06 | **0.38** | **0.58** | 1.00 | **0.44** |
| Average precipitation in depth (mm per year) | ind.07 | **0.48** | **0.60** | **0.44** | 1.00 |

## 3.2 Energy Indicators

Energy security is defined as "the uninterrupted availability of energy sources at an affordable price" (IRENA, 2015a). Jeffrey Sachs states that "Of all the problems of reconciling growth with planetary boundaries, probably none is more urgent and yet more complicated than the challenge of the world's energy system" (Sachs, 2015). This statement is largely motivated by the world's dependence on fossil fuels since the industrial revolution, combined with the resultant emission of greenhouse gases (GHG), principally carbon dioxide.

SDG 7 and SDG 13 calls for a deliberate move towards affordable and *clean* energy, and a radical decarbonisation of the global energy system. In 2016, the International Energy Agency (IEA) reported that the world's capacity to generate electricity from renewable sources had overtaken that of coal (Walker, 2016). It is important to note that it was the *capacity* to generate electricity that has overtaken coal, rather than the *amount* of electricity produced. With reference to the component of SDG 7 that calls for energy to be both accessible and affordable, Professor Sachs laments that "one billion people or more do not have access to electricity in the twenty-first century, a technology that was developed and adopted by the technological leaders at the end of the nineteenth century" (Sachs, 2015). The World Bank (2018a) report that in Sub-Saharan Africa population growth has outpaced energy infrastructure development to such a degree that more people in this region now live without electricity than in 1990.

Power stations around the world require water for, amongst other uses, their cooling technologies. These systems use different water quantities, with a closed-loop (wet) cooling system generally consuming the most water. Similarly, water is required in the generation of hydropower and nuclear power. Although the water use of hydropower plants is high, the water consumption is much lower than fossil fuel-generated power and nuclear power since the water is returned to the water resource. Although hydropower is a renewable source of energy it can have indirect negative impacts on, for example, water availability downstream or biodiversity, e.g. fish migration, especially in large systems like the Mekong basin (Smajgl et al., 2016).

A total of fifteen energy-related indicators were reviewed in the construction of the WEF Nexus Index. In evaluating access to energy, SDG 7 calls for access to affordable, reliable, sustainable and modern energy. Utilising the indicator *Access to electricity (percentage of population)* would therefore not suffice, on its own, in representing SDG 7. The access portion of the energy sub-index must therefore also address the extent to which the energy source is renewable, or not. To this end, good data is available for the following indicators:

- *Renewable energy consumption (percentage of total final energy consumption),*
- *Renewable electricity output (percentage of total electricity output), and*
- *$CO_2$ emissions (metric tons per capita)*[8].

These three indicators representing the degree of implementation of clean energy are negatively correlated to the indicator *Access to electricity (percentage of population)*, as

[8] Within the index this indicator has a negative direction, i.e. a lower $CO_2$ emission value will result in an increased index value, with all other indicator's values being held constant.

presented in **Table 3-4**. This is to be expected since much of the energy supply and security in the world is currently still derived from fossil-fuel based supply.

**Table 3-4: Correlations within the "Energy-access" sub-pillar**

| **Name** | **Indicator** | ind.08 | ind.09 | ind.10 | ind.11 |
|---|---|---|---|---|---|
| Access to electricity (% of population) | ind.08 | 1.00 | -0.72 | -0.27 | -0.48 |
| Renewable energy consumption (% of total final energy consumption) | ind.09 | -0.72 | 1.00 | **0.62** | **0.57** |
| Renewable electricity output (% of total electricity output) | ind.10 | -0.27 | **0.62** | 1.00 | **0.35** |
| $CO_2$ emissions (metric tons per capita) | ind.11 | -0.48 | **0.57** | **0.35** | 1.00 |

In 24 of the 170 countries that have sufficient data for inclusion in the WEF Nexus Index, less than 40% of their respective populations have access to electricity (World Bank, 2018b). The vast majority of these countries are in Africa. A paramount reason for this, as well as much of the lag in Africa's development, is that most of the continent does not have coal reserves. Access to coal has driven exponential development in many other corners of the globe following the industrial revolution. South Africa, the ninth largest of the 54 countries in Africa, has 95% of the continent's proven coal reserves (Agora, 2017). Many countries that have relatively low access to electricity as a proportion of their population have relatively high *Renewable energy consumption* levels. This is because these countries are almost entirely reliant on renewable energy sources, such as hydropower, yet their generation capacity and distribution are relatively low. Some examples in this regard are the Democratic Republic of Congo, Lesotho, Malawi and Zambia, which are states that derive almost 100% of their electricity production by means of hydropower generation (Conway et al., 2015).

In terms of $CO_2$ emissions, fifteen countries are responsible for more than two-thirds of the worldwide $CO_2$ emissions, as shown in **Table 3-5**. Interestingly, if the $CO_2$ emissions for each country are ranked *per capita*, China does not rank in the top twenty. The "per capita" highest emitter is Qatar (Linke, 2014), with the Gulf States constituting three of the top four. The United States of America is ranked eighth, behind Australia at seventh (Fleming, 2019a). In the development of the WEF Nexus Index it was decided to include the indicator *$CO_2$ emissions (metric tons per capita)* rather than *Total greenhouse gas emissions (kt of $CO_2$ equivalent)* or *$CO_2$ emissions* (kt) since the measure of $CO_2$ emissions alone (as opposed to the total greenhouse gases) is more representative of the energy industry, while the "per capita" denominator normalises the emissions for the nation's population size.

In terms of the availability of energy, the World Bank (2018b) presents sufficient data for *Electric power consumption (kWh per capita)*. An indicator that was considered in the development of the "Energy-availability" sub-pillar was *Energy use (kg of oil equivalent per capita)*. This indicator has very good data availability but is highly correlated (0.94) to *Electric power consumption (kWh per capita)* and, therefore, has been excluded to avoid double accounting within the proposed index.

The indicator *Energy imports, net (% of energy use)* was considered since it provides an indication of a nation's independence (and therefore security) in terms of energy supply. Because several nations generate surplus energy, and export that additional capacity, more than a few countries have negative values for this indicator (refer to **Appendix C**). The indicator, therefore, measures both imports and exports of energy. In order to limit this indicator to imports only, the indicator values were truncated at zero. This resultant indicator, *Energy imports, net*, however, has a low, yet negative correlation (-0.07) with *Electric power consumption (kWh per capita)*, as presented in **Table 3-6**. Becker (2019) notes that the negative correlation is not significant and that it would be expected that these two indicators would not correlate strongly. He further notes that it makes sense conceptually to include this indicator in this sub-pillar.

**Table 3-5: Top $CO_2$ emitting countries, modified from Fleming (2019a)**

| Rank | Country | Emissions in 2017 ($MtCO_2$) | % of Global Emissions |
|---|---|---|---|
| 1 | China | 9 839 | 27.2% |
| 2 | United States of America | 5 269 | 14.6% |
| 3 | India | 2 467 | 6.8% |
| 4 | Russia | 1 693 | 4.7% |
| 5 | Japan | 1 205 | 3.3% |
| 6 | Germany | 799 | 2.2% |
| 7 | Iran | 672 | 1.9% |
| 8 | Saudi Arabia | 635 | 1.8% |
| 9 | South Korea | 616 | 1.7% |
| 10 | Canada | 576 | 1.6% |
| 11 | Mexico | 490 | 1.4% |
| 12 | Indonesia | 487 | 1.3% |
| 13 | Brazil | 476 | 1.3% |
| 14 | South Africa | 456 | 1.3% |
| 15 | Turkey | 448 | 1.2% |
| | **Top 15** | **26 125** | **72.2%** |
| | **Rest of world** | **10 028** | **27.7%** |

The indicator *International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems* was also considered for the “Energy-availability” sub-pillar. This indicator also experienced a low correlation with other indicators, probably because it does not consider domestic expenditure on renewable energy projects, and therefore penalises many of the donor countries who are themselves progressive in terms of transitioning to a low-carbon economy. It was therefore decided to exclude this indicator from the “Energy-availability” sub-pillar.

**Table 3-6: Correlations within the "Energy-availability" sub-pillar**

| Name | Indicator | ind.12 | ind.13 |
|---|---|---|---|
| Electric power consumption (kWh per capita) | ind.12 | 1.00 | -0.07 |
| Energy imports, net (% of energy use) | ind.13 | -0.07 | 1.00 |

## 3.3 Food Indicators

The FAO (2014) defines food security as the state in which "all people at all times have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active, healthy life." Agriculture is viewed as having a comparable and in some cases a greater, impact on the environment to energy generation (Sachs, 2015). Continuing population and consumption growth will result in the increase in global demand for food for at least another 40 years, by 70 to 100% more than the production level in 2010, whereafter predictions indicate that the world's population will plateau at about nine billion people (Godfray et al., 2010). While demand is going to increase, it is estimated that there are currently 805 million chronically undernourished people in the world (FAO, 2015b).

Much of the available arable land globally has been developed, and there is significant competition for the additional land from other sectors, e.g. urban growth, forestry, mining, biofuels or game farming (Simpson et al., 2019). Further, climate change impacts threaten food security both directly and indirectly, i.e. in crop yields and food prices respectively. This, in turn, places at risk the availability, stability, utilisation and access to food, which is predicted to increase the number of people at risk of hunger by up to 170 million (Schmidhuber and Tubiello, 2007).

A total of 36 food-related indicators, relevant to the construction of the WEF Nexus Index, have been reviewed (refer to **Appendix A**). Salam et al. (2017) state that the most used indicator for measuring and monitoring the world food status is *Food consumption* in kcal/person/day. The FAO monitors and reports on various food security indicators (FAO, 2016).

Young children and infants are most vulnerable to the effects of malnutrition. Globally, over 95 million fewer children were stunted in 2016 than in 1990, yet in Sub-Saharan Africa, the number of stunted[9] children has increased mainly because of the region's increasing population (World Bank, 2018a). Wasting[10] affects one in thirteen children globally (ibid.). These fifty million children weigh less than expected/average for their height. Half of them live in South Asia, and a quarter lives in Sub-Saharan Africa, with boys being more often affected

[9] "Stunting refers to a child who is too short for his or her age. These children can suffer severe irreversible physical and cognitive damage that accompanies stunted growth. The devastating effects of stunting can last a lifetime and even affect the next generation" (UNICEF/WHO/World Bank, 2019).

[10] "Wasting refers to a child who is too thin for his or her height. Wasting is the result of recent rapid weight loss or the failure to gain weight. A child who is moderately or severely wasted has an increased risk of death, but treatment is possible" (UNICEF/WHO/World Bank, 2019).

than girls. Globally, ten percent of people are undernourished, i.e. they do not have enough food to meet their dietary needs. (ibid.).

The indicator *Depth of food deficit* has good data availability but has a very high correlation with the *Prevalence of undernourishment* and has thus been excluded from the final list of indicators selected to constitute the WEF Nexus Index to prevent double accounting. The reason for including the *Prevalence of undernourishment* rather than the *Depth of food deficit* is that it is one of the two official indicators for monitoring the state of food insecurity in the world. The other is the *Proportion of underweight children under five years of age* (FAO, 2015b). These indicators are both aligned with SDG 2, which has "Zero hunger" as its monumental goal.

It is believed by some that the FAO indicator of undernourishment has a number of advantages over other indicators for quantifying the overall status and distribution of global hunger (Schmidhuber and Tubiello, 2007). These advantages include the fact that (i) it covers two dimensions of food security, namely availability and access; (ii) the underlying methodology is straightforward and transparent; and (iii) the parameters and data needed for the FAO indicator are readily available for past estimates and can be derived without major difficulties in the future (ibid.).

Indicators relating to access to food that have been selected for inclusion in the "Food-access" sub-pillar of the "Food pillar" include the:

- *Prevalence of undernourishment (percentage of population)*
- *Prevalence of severe wasting, weight for height (percentage of children under 5)*
- *Prevalence of stunting, height for age (percentage of children under 5)*
- *Prevalence of obesity in the adult population (18 years and older)*

There is a good correlation between the *Prevalence of undernourishment* and the levels of wasting and stunting in children under five years of age (0.41 and 0.73 respectively), as presented in **Table 3-7**. There is however a negative correlation of these three indicators with the *Prevalence of obesity in the adult population*. This negative association is not unexpected since generally, undernourishment is a challenge in developing nations while obesity occurs in more developed nations. Neves (2019) suggests that by combining the undernourishment and obesity indicators a combined indicator can be created, with the negative correlation being removed. In this first iteration of the WEF Nexus Index, it has however been decided to retain all the constituent indicators in their basic form, with any negative correlations, in order to promote transparency. Although there is a negative correlation between the prevalence of undernourishment (and stunting and wasting) and obesity, it is important to include both components of access to food in the WEF Nexus Index. This is because they represent different nutritional challenges for different portions of the global population, i.e. children under five years of age versus adults, eighteen years and older, and Third World challenges against First World problems.

During the "Research on Tap Seminar" at the University of KwaZulu-Natal, it was proposed that a 'nexus-indicator' such as the *Percent of arable land equipped for irrigation* be included in the proposed index. It is termed a nexus-indicator since irrigation is a technology that generally uses energy to convey water in order to produce food. The challenge is that this indicator correlated very poorly with all the other food-related indicators, both in terms of "access" and "availability".

**Table 3-7: Correlations within the "Food-access" sub-pillar**

| **Name** | **Indicator** | ind.14 | ind.15 | ind.16 | ind.17 |
|---|---|---|---|---|---|
| Prevalence of undernourishment (%) | ind.14 | 1.00 | **0.41** | **0.73** | -0.60 |
| Percentage of children under 5 years of age affected by wasting (%) | ind.15 | **0.41** | 1.00 | **0.68** | -0.52 |
| Percentage of children under 5 years of age who are stunted (%) | ind.16 | **0.73** | **0.68** | 1.00 | -0.75 |
| Prevalence of obesity in the adult population (18 years and older) | ind.17 | -0.60 | -0.52 | -0.75 | 1.00 |

The *Cereal import dependency ratio* communicates how much of the available domestic food supply of cereals has been imported and what proportion emanates from the country's own production. Negative values indicate that the country is a nett exporter of cereals. This indicator provides a measure of the independence of a country or region in terms of cereal imports. Countries limited in available freshwater and land resources rely on imported food in order to compensate for their lack of production ability (Brown and Matlock, 2011). Qatar, for example, imports 90% of its food products from other countries (Wicaksono et al., 2017). In their assessment of Southern Africa, Conway et al. (2015) note that the *Cereal import dependency ratio* is very high for the relatively small nations of Swaziland (79%) and Lesotho (85%). They also highlight that the ratio is excessive for some of the larger countries in this region, e.g. Botswana (90%), Namibia (65%) and Angola (55%). The *Cereal import dependency ratio* is, therefore, an indirect indicator of water scarcity. This indicator, even after being truncated at zero to remove exports, was found to have a very poor level of correlation with all the other food availability-related indicators and has consequently been excluded from the WEF Nexus Index. The indicators *Agriculture, forestry and fishing, value added (% GDP)* and *Value of food imports over total merchandise exports* also have low correlations with the other food availability-related indicators and have also been excluded. In terms of the availability of food on a national basis, the following indicators have been selected for incorporation in the food sub-index of the WEF Nexus Index:

- *Average protein supply*
- *Cereal yield*
- *Average dietary energy supply adequacy*
- *Average value of food production*

As presented in **Table 3-8**, these four indicators selected for inclusion in the "Food-availability" sub-pillar of the "Food pillar" have strong, positive correlations. The fact that together they represent protein supply, cereal yield, dietary energy supply adequacy and the value of food production, with a strong correlation, indicates that this is a strong sub-pillar within the proposed index.

**Table 3-8: Correlations within the "Water-availability" sub-pillar**

| **Name** | **Indicator** | ind.18 | ind.19 | ind.20 | ind.21 |
|---|---|---|---|---|---|
| Average protein supply (gr/caput/day) | ind.18 | 1.00 | **0.57** | **0.70** | **0.54** |
| Cereal yield (kg per hectare) | ind.19 | **0.57** | 1.00 | **0.44** | **0.48** |
| Average Dietary Energy Supply Adequacy (ADESA) (%) | ind.20 | **0.70** | **0.44** | 1.00 | **0.42** |
| Average value of food production (I$ per caput)[11] | ind.21 | **0.54** | **0.48** | **0.42** | 1.00 |

## 3.4 Indicators selected to constitute WEF Nexus Index

Following an in-depth review of available water-, energy- and food-related indicators in the preceding three sections (and **Appendix A**), the indicators selected for inclusion in the WEF Nexus Index are presented in **Table 3-9**. The index is therefore made up of three pillars, six sub-pillars and 21 indicators: seven water-related, six energy-related and eight food-related indicators.

[11] *International dollars per capita*: An international dollar could purchase, in the cited country, a comparable amount of goods and services that a US$ would acquire in the United States of America. This term is generally utilised in conjunction with Purchasing Power Parity (PPP) data.

**Table 3-9: Indicators selected to constitute the WEF Nexus Index**

| | | | | | |
|---|---|---|---|---|---|
| p.01 Water Sub-Index | sp.01 | Access | ind.01 | People using at least basic drinking water services (% of population) |
| | | | ind.02 | Percentage of people using safely managed sanitation services (% of population) |
| | | | ind.03 | Degree of integrated water resources management implementation (0-100) |
| | sp.02 | Availability | ind.04 | Annual freshwater withdrawals, total (% of internal resources) |
| | | | ind.05 | Renewable internal freshwater resources per capita ($m^3$ per capita) |
| | | | ind.06 | Environmental flow requirements ($10^6$ $m^3$/annum) |
| | | | ind.07 | Average precipitation in depth (mm per year) |
| p.02 Energy Sub-Index | sp.03 | Access | ind.08 | Access to electricity (% of population) |
| | | | ind.09 | Renewable energy consumption (% of total final energy consumption) |
| | | | ind.10 | Renewable electricity output (% of total electricity output) |
| | | | ind.11 | $CO_2$ emissions (metric tons per capita) |
| | sp.04 | Availability | ind.12 | Electric power consumption (kWh per capita) |
| | | | ind.13 | Energy imports, net (% of energy use) |
| p.03 Food Sub-Index | sp.05 | Access | ind.14 | Prevalence of undernourishment (% of population) |
| | | | ind.15 | Prevalence of severe wasting, weight for height (% of children under 5) |
| | | | ind.16 | Percentage of children under 5 years of age who are stunted |
| | | | ind.17 | Prevalence of obesity in the adult population (18 years and older) |
| | sp.06 | Availability | ind.18 | Average protein supply (g/caput/day) |
| | | | ind.19 | Cereal yield (kg per hectare) |
| | | | ind.20 | Average dietary energy supply adequacy (%) |
| | | | ind.21 | Average value of food production (I$ per caput) |

# 4 DEVELOPMENT OF COMPOSITE INDICATOR

Composite indicators have some enthusiastic supporters, such as advocacy groups who develop indices to advance a cause. There are others, such as some economists and official statisticians who are concerned about the potentially subjective nature of the selection of variables, weights and aggregation. Their concerns are well-founded since a poorly constructed index could send misleading policy messages, be misused or result in political disputes. The JRC-COIN, therefore, issued a twofold call, namely that composite indicators must be developed sensibly and used responsibly (Saisana et al., 2018). The 'sensible development' of a composite indicator "implies a quality control process based on both conceptual and statistical considerations" (ibid.). 'Responsible use' calls for "care in drawing conclusions and recommendations without taking into account the conceptual context in which composite indicators were developed" (ibid.).

## 4.1 Challenges in measuring the WEF Nexus

The challenges in measuring the WEF nexus are legion. Indeed, this difficulty led to the initial concept of a WEF Nexus Index being documented (Simpson and Berchner, 2017). The three resource sectors have different units of measurement. Water is generally measured in cubic metres, energy is recorded in kilowatt-hours, while food is measured in various ways, i.e. calories, obesity, malnourishment, value, etc. Another obstacle is the spatial extent of the assessment, which can vary from a household level to a city, catchment, province, country or regional scale.

How the data are obtained is also important. Questions that must be considered when collecting data include:

- Is the methodology utilised in obtaining the data universal?
- Are the people undertaking the monitoring, census or research equally competent across regions?
- How does one consider the temporal variability of data? e.g. hydrological flows.
- Are the required monitoring tools and equipment easily accessible and reliable? For example, are the weirs and monitoring equipment designed, installed and calibrated to measure extreme events, e.g. the 1 in 200-year return-period events?

Other challenges involve the incorporation of virtual water (Bogardi et al., 2012) and large scale land acquisitions (Siciliano et al., 2017) in WEF nexus assessments. These concepts blur national boundaries since water, energy and even land become 'embedded' in products that countries import and export. Transboundary water catchments also add complexity to WEF nexus assessments.

Even when reliable, representative, recent data have been obtained, there remains the challenge of integrating data in order to inform policy and governance. The managing of one resource (e.g. as in IWRM) has proved to be difficult enough (Wichelns, 2017), and integrated resource management will be even more testing (de Loe and Patterson, 2017).

## 4.2 What is a Composite Indicator?

If two or more indicators, or several data, are combined, an index (or composite indicator) is formed (Segnestam, 2002). The common interpretation of an index is a single value that captures the information from several variables into one composite measure, typically taking the following form:

$$\text{Index} = A_1X_1 + A_2X_2 + A_3X_3 + \ldots + A_pX_p$$

Where the $A_i$ are weights to be determined from the data and the $X_i$ are an appropriate subset of "p" variables (Abeyasekera, 2003). Other methods of aggregation are also possible, e.g. multiplication.

Most indices are devised for their use at a national level in order to facilitate decision making and policy development (Gallopín, 1997). However, if the index can be applied at a subnational level it will be of additional assistance to sector experts and policymakers. For example, the river basin is a very appropriate spatial extent for assessing how terrestrial hydrological processes exert their influence on human activities (Lawford et al., 2013). The construction of an index is an evolving process and periodic evaluation of its composition (indicators, weighting and aggregation) is essential (Jha and Murthy, 2003).

The allure of an index is that one value can represent a complex, integrated system in a condensed manner. The indicator for a country/region can then be compared to a reference value, or to other countries/regions, or to values for the same nation at different time scales (either historic or future) in order to ascertain performance and/or trends. Indicators and the knowledge that they provide are, however, only as good as the data from which they are derived.

Before developing a composite index, it is essential to review various key considerations. These include:

- The purpose of the index,
- How the index is constructed,
- What scale the index is relevant to, and
- How universally available is the data required to calculate the index.

The development of a composite indicator is a quantitative method for reporting on a system such as the WEF nexus (Endo et al., 2015). Any effort towards the development of an indicator relating to sustainability or resource security must proceed with caution. This is because much effort in this regard has led to an "indicator zoo", characterised by a multitude of approaches that are limited in their impact on policy and outcomes that are the actual goals of sustainable development (Pintér et al., 2012).

### 4.3 Pros and Cons of Composite Indicators

Saltelli (2007) explains that "the use of composite indicators is very much the subject of controversy, pitting aggregators against non-aggregators." Nardo et al. (2005) present selected pros and cons related to composite indicators in **Table 4-1**.

**Table 4-1: Pros and cons of composite indicators (Nardo et al., 2005)**

| Pros of composite indicators | Cons of composite indicators |
|---|---|
| • Summarise complex or multi-dimensional issues, in view of supporting decision-makers.<br>• Are easier to interpret than trying to find a trend in many separate indicators.<br>• Facilitate the task of ranking countries on complex issues in a benchmarking exercise.<br>• Assess the progress of countries over time on complex issues.<br>• Reduce the size of a set of indicators or include more information within the existing size limit. | • May send misleading policy messages if they are poorly constructed or misinterpreted.<br>• May invite drawing simplistic policy conclusions if not used in combination with the indicators.<br>• May lend themselves to instrumental use (e.g. be built to support the desired policy) if the various stages (e.g. selection of indicators, choice of model, weights) are not transparent and based on sound statistical or conceptual principles.<br>• The selection of indicators and weights could be the target of political challenge. |

| Pros of composite indicators | Cons of composite indicators |
|---|---|
| • Place issues of countries' performance and progress at the centre of the policy arena.<br>• Facilitate communication with ordinary citizens and promote accountability. | • May disguise serious failings in some dimensions of the phenomenon, and thus increase the difficulty in identifying the proper remedial action.<br>• May lead to wrong policies if dimensions of performance that are difficult to measure are ignored. |

## 4.4 Existing Composite Indicators

In this section, descriptions are given of the two indices against which the WEF Nexus Index is compared (refer to **Figures 4-1** and **4-2**).

### 4.4.1 Human Development Index

The HDI emerged in the first Human Development Report (HDR), published in 1990. It was birthed out of the belief that development should be measured by more than just economic activity, i.e. Gross Domestic Product per capita. The creation of the HDI was based on the premise that "human development should for the time being focus on the three essential elements of human life – longevity, knowledge and decent living standards" (UNDP, 1990). The GDP per capita and HDI are related but not equivalent (Sachs, 2015). This is because there are countries that are relatively low on income per capita but have relatively high HDIs, with the inverse also being true.

The simplicity of the original HDI was attractive, but it drew criticism from various quarters. Some questioned the choice of variables that made up the index, the normalising of the indicators, the asymmetric treatment of income, and the choice of the weights. An early criticism, based on statistical analysis, concluded: "that the HDI is both flawed in its composition and, like a number of its predecessors, fails to provide insights into intercountry development level comparisons which pre-existing indicators, including GNP per capita, alone cannot" (McGillivray, 1991). A further criticism that was raised was regarding the substitutability of indicators. This factor relates to the fact that the three dimensions are equally weighted. Because of this, a sudden decrease in one factor would affect the HDI, but its impact would be masked by the stability of the other two variables. This could occur, for example, if an epidemic in a nation suddenly reduced mortality rates and therefore life expectancy. It was noted that "This scheme masks trade-offs between various dimensions since it suggests that you can make up in one dimension the deficiency in another" (Sagar & Najam, 1998). A solution proposed to resolve the substitutability relating to the HDI was to calculate the product, and not summation, of the constituent indicators, i.e. to change the method of aggregation. Another criticism of the HDI emphasised that for this index to capture the sustainability dimension of human development, it would need to incorporate some mechanism for accounting for the over-exploitation of natural resources (ibid.).

An irony related to the HDI is that in evaluating countries "there is a strong correlation between the levels of the HDI and per capita income" (Klugman et al., 2011). This is not surprising since it reflects the reality that more developed countries tend to be richer, healthier and more educated than poor countries. There are however exceptions such as Qatar, Kuwait, Equatorial Guinea and Gabon which have significantly higher GDP ranks than HDI ranks (Sachs, 2015).

#### 4.4.2 SDG Index

At the beginning of 2016, the seventeen SDGs of the *2030 Agenda for Sustainable Development* officially came into force. There is a total of 232 individual indicators that have been selected to monitor progress towards the SDGs. When these SDGs were adopted the United Nations stated that:

> "Indicators will be the backbone of monitoring progress towards the SDGs at the local, national, regional, and global levels. A sound indicator framework will turn the SDGs and their targets into a management tool to help countries develop implementation strategies and allocate resources accordingly, as well as a report card to measure progress towards sustainable development and help ensure the accountability of all stakeholders for achieving the SDGs" (UN, 2015).

Because of the large number of indicators associated with the seventeen SDGs, an SDG Index was developed (Sachs et al., 2016, Schmidt-Traub et al., 2017, Sachs et al., 2018). The SDG Index reports on 156 countries' progress towards all seventeen goals and indicates areas where more rapid progress is required. All countries are ranked according to their percentage of achievement on the same group of indicators, and a dashboard has been generated to facilitate comparison between and within countries. Many indicators within the SDG Index are existing composite indicators, such as the:

- Ocean Health Index
- Sustainable Nitrogen Management Index
- Universal Health Coverage Tracer Index
- Logistics performance index
- Climate Change Vulnerability Monitor
- Red List Index of species survival
- Corruption Perception Index
- Financial Secrecy Score
- Global Slavery Index
- PISA (Programme for International Student Assessment) score

The SDG Index and the associated dashboard apply equal weighting to each indicator and for each goal since all SDGs are considered to have equal importance in the 2030 Agenda (Sachs et al., 2019). At an earlier developmental stage of the SDG Index, experts attempted to determine different weightings for some indicators; however, a consensus on assigning higher weights to these indicators could not be reached.

### 4.5 Data Treatment

Some countries do not measure certain indicators because of the low occurrence of what is being measured in that country. For example, in high-income countries, the proportion of children under five years of age who are affected by wasting is typically very low. UNICEF report an average prevalence of wasting in high-income countries of 0.75% (Sachs et al., 2018). This value was imputed to treat data for high-income countries with missing data for this indicator in the calculation of the WEF Nexus Index. Similarly, the prevalence of stunting in children under five years of age in high-income countries has been taken to be 2.58% while the prevalence of undernourishment (% of the population) has been taken to be 1.2% for high-income countries with missing data (ibid.).

As noted in **Sections 3.2** and **3.3** respectively, the negative values for *Energy imports, net (% of energy use)* and the *Cereal import dependency ratio* were removed such that these indicators excluded the export component that they measure. Due to a low correlation with the other indicators in the food sub-pillars (both with and without the export component of its indicator) the *Cereal import dependency ratio* was subsequently removed from the list of indicators that constitute the WEF Nexus Index. The indicator, *Annual freshwater withdrawals,* has been truncated at 100 in order to reduce the absolute values of the skewness and kurtosis within the generally accepted range, i.e. |<2| and |<3.5| respectively, since this coincided with the conceptual framing of this indicator in development of the WEF Nexus Index.

For some indicators, values are not available for the latest year in the database's record, and the latest value for each country had to be utilised. Examples of indicators for which this had to be done included *Energy imports, net (% of energy use)*, *Energy use (kg of oil equivalent per capita)*, *Firms experiencing electrical outages (% of firms)*, *Percentage of children under 5 years of age affected by wasting*, and *The share of food expenditure of the poor*.

It was necessary to standardise the names of countries in the different databases, e.g. in the World Bank and FAO databases. This is because, for example, one may refer to "Viet Nam" while another refers to "Vietnam". Other examples are "Ivory Coast" as opposed to "Cote d'Ivoire", "Republic of Korea" verses "Korea, Rep." and "Swaziland" instead of "Eswatini".

Within the COIN Excel Tool,[12] various statistical properties of each indicator are determined. These include the missing values (%), missing values (#), minimum, maximum, mean, standard deviation, skewness and kurtosis. By analysing the simultaneous 'anomalous' values of skewness and kurtosis (Saisana et al., 2018) it was ascertained that six indicators have outliers that require 'treatment', either by means of Winsorisation or the Box-cox transformation. The reason for treating outliers is that in developing a composite indicator one is interested in descriptive statistics such as the mean, standard deviation and correlation coefficient, which are often spoiled by outliers (ibid.). Not treating outliers may cause misinterpretations of composite indicators. Winsorisation is the JRC-COIN's preferred method of treating data if there are a low number of outliers, i.e. less than five, while the Box-cox transformation is the preferred method of treatment if there are more than five outliers. The number of outliers for the six indicators require treatment are presented in **Table 4-2**.

### 4.6 Normalisation, Weighting and Aggregation

Since many of the indicators are measured in different units and have differing ranges, some form of normalisation of the data is necessary before it can be weighted and subsequently aggregated. Normalisation transforms indicators to a common scale, which renders the variables comparable. Various methods of normalisation exist, such as Ranking, Standardisation (or z-scores), Min-max, Distance to a reference (OECD, 2008), etc. The

[12] Revision: CT2019-07-30, developed by JRC-COIN.

method of normalisation utilised in the development of the WEF Nexus Index is the Min-max method. This method normalises the indicators to all have an identical range (0;100) by subtracting the minimum value and dividing by the range of the indicator values.

**Table 4-2: Indicators with outliers and the method of data treatment employed**

| Indicator | Ind. No. | No. of outliers | Treatment of outliers |
|---|---|---|---|
| Renewable internal freshwater | ind.05 | 18 | Box-cox |
| Environmental flow requirements | ind.06 | 17 | Box-cox |
| $CO_2$ emissions per capita | ind.11 | 4 | Winsorisation |
| Electric power consumption | ind.12 | 3 | Winsorisation |
| Cereal yield | ind.19 | 2 | Winsorisation |
| Average value of food production | ind.21 | 2 | Winsorisation |

As presented in **Table 4-3** the WEF Nexus Index is made up of pillars, sub-pillars and indicators. The final weight that each indicator and aggregation level have in the overall index is also presented in this table. For example, each indicator is weighted by its indicator weight, but also the weight of its sub-pillar, pillar and sub-index. These are combined to give the overall indicator weight at the index level. The same methodology is used for sub-pillars, pillars and sub-indexes.

These elements are repeated in **Table 4-4**, which presents the composition of the framework for the calculation of the WEF Nexus Index. The relationship between each dimension and supra-dimension within the WEF Nexus Index is presented in this table, together with the weighting and aggregation of each element within the composite indicator. The following is highlighted in terms of the direction column in the table:

> "A value of 1 means that higher values of the indicator are associated with higher values of the index/concept (e.g. higher values of the indicator "income" indicate higher values of index "quality of life"). A value of -1 means that higher values of the indicator are associated with lower values of the index/concept (e.g. higher values of indicator "deforestation" are associated with lower values of index "environmental performance")" (JRC-COIN, 2015).

The weighting of the pillars, i.e. the water, energy and food 'sub-indices', must be equal, since this is the essential philosophy of the WEF nexus. Where previous integrated resource methods, such as IWRM, were water-centric, the attraction of the WEF nexus has been that it is multi-centric, with each sector being treated with equal importance (Allouche et al., 2015). Because the WEF nexus is multi-centric there is a greater chance of it being accepted by a broader set of stakeholders, especially those in the energy and agricultural sectors (Cai et al., 2018). By providing equal weighting across the three pillars it is implied that SDGs 2, 6 and 7 are equally important.

Generally, either the geometric or arithmetic means are utilised to aggregate multiple indicators into a composite index. The OECD (2008) state that "an undesirable feature of additive aggregations is the implied full compensability, such that poor performance in some indicators can be compensated for by sufficiently high values in other indicators." In developing the SDG Index, Sachs et al. (2016) provide two reasons why the arithmetic mean was selected, namely that (i) each SDG generally describes complementary policy priorities with a reasonable degree of substitutability; and that (ii) the arithmetic mean is relatively easy to communicate.

**Table 4-3: Contribution of indicators, sub-pillars and pillars to the final index**

| Indicator | Indicator weight in index | Sub-pillar | Sub-pillar weight in index | Pillar | Pillar weight in index | Sub-index | Sub-index weight in index |
|---|---|---|---|---|---|---|---|
| ind.01 | 0.056 | sp.01 | 0.167 | p.01 | 0.333 | si.01 | 1.000 |
| ind.02 | 0.056 | | | | | | |
| ind.03 | 0.056 | | | | | | |
| ind.04 | 0.042 | sp.02 | 0.167 | | | | |
| ind.05 | 0.042 | | | | | | |
| ind.06 | 0.042 | | | | | | |
| ind.07 | 0.042 | | | | | | |
| ind.08 | 0.083 | sp.03 | 0.167 | p.02 | 0.333 | | |
| ind.09 | 0.028 | | | | | | |
| ind.10 | 0.028 | | | | | | |
| ind.11 | 0.028 | | | | | | |
| ind.12 | 0.083 | sp.04 | 0.167 | | | | |
| ind.13 | 0.083 | | | | | | |
| ind.14 | 0.056 | sp.05 | 0.167 | p.03 | 0.333 | | |
| ind.15 | 0.028 | | | | | | |
| ind.16 | 0.028 | | | | | | |
| ind.17 | 0.056 | | | | | | |
| ind.18 | 0.042 | sp.06 | 0.167 | | | | |
| ind.19 | 0.042 | | | | | | |
| ind.20 | 0.042 | | | | | | |
| ind.21 | 0.042 | | | | | | |

**Table 4-4: Composition of the framework for the calculation of the WEF Nexus Index**

| Dimension/indicator | Supra-dimension | Weight | Aggregation | Direction | Name of dimension/indicator |
|---|---|---|---|---|---|
| Index | | 1 | Arithmetic | 1 | Water-Energy-Food Nexus Index |
| si.01 | Index | 1 | Arithmetic | 1 | Water-Energy-Food Nexus Index |
| p.01 | si.01 | 0.333333 | Arithmetic | 1 | Water sub-index |
| p.02 | si.01 | 0.333333 | Arithmetic | 1 | Energy sub-index |
| p.03 | si.01 | 0.333333 | Arithmetic | 1 | Food sub-index |
| sp.01 | p.01 | 0.5 | Arithmetic | 1 | Access |
| sp.02 | p.01 | 0.5 | Arithmetic | 1 | Availability |
| sp.03 | p.02 | 0.5 | Arithmetic | 1 | Access |
| sp.04 | p.02 | 0.5 | Arithmetic | 1 | Availability |
| sp.05 | p.03 | 0.5 | Arithmetic | 1 | Access |
| sp.06 | p.03 | 0.5 | Arithmetic | 1 | Availability |
| ind.01 | sp.01 | 0.333333 | Arithmetic | 1 | The percentage of people using at least basic drinking water services |
| ind.02 | sp.01 | 0.333333 | Arithmetic | 1 | Percentage of people using safely managed sanitation services. |
| ind.03 | sp.01 | 0.333333 | Arithmetic | 1 | Degree of IWRM implementation (1-100) |
| ind.04 | sp.02 | 0.25 | Arithmetic | -1 | Annual freshwater withdrawals, total (% of internal resources) |
| ind.05 | sp.02 | 0.25 | Arithmetic | 1 | Renewable internal freshwater resources per capita (cubic meters) |

| Dimension/indicator | Supra-dimension | Weight | Aggregation | Direction | Name of dimension/indicator |
|---|---|---|---|---|---|
| ind.06 | sp.02 | 0.25 | Arithmetic | 1 | Environmental flow requirements (106 $m^3$/annum) |
| ind.07 | sp.02 | 0.25 | Arithmetic | 1 | Average precipitation in depth (mm per year) |
| ind.08 | sp.03 | 0.5 | Arithmetic | 1 | Access to electricity (% of population) |
| ind.09 | sp.03 | 0.166667 | Arithmetic | 1 | Renewable energy consumption (% of total final energy consumption) |
| ind.10 | sp.03 | 0.166667 | Arithmetic | 1 | Renewable electricity output (% of total electricity output) |
| ind.11 | sp.03 | 0.166667 | Arithmetic | -1 | $CO_2$ emissions (metric tons per capita) |
| ind.12 | sp.04 | 0.5 | Arithmetic | 1 | Electric power consumption (kWh per capita) |
| ind.13 | sp.04 | 0.5 | Arithmetic | -1 | Energy imports, net (% of energy use) |
| ind.14 | sp.05 | 0.333333 | Arithmetic | -1 | Prevalence of undernourishment (%) |
| ind.15 | sp.05 | 0.166667 | Arithmetic | -1 | Percentage of children under 5 years of age affected by wasting (%) |
| ind.16 | sp.05 | 0.166667 | Arithmetic | -1 | Percentage of children under 5 years of age who are stunted (%) |
| ind.17 | sp.05 | 0.333333 | Arithmetic | -1 | Prevalence of obesity in the adult population (18 years and older) |
| ind.18 | sp.06 | 0.25 | Arithmetic | 1 | Average protein supply (gr/caput/day) |
| ind.19 | sp.06 | 0.25 | Arithmetic | 1 | Cereal yield (kg per hectare) |
| ind.20 | sp.06 | 0.25 | Arithmetic | 1 | Average Dietary Energy Supply Adequacy (ADESA) (%) |
| ind.21 | sp.06 | 0.25 | Arithmetic | 1 | Average value of food production (I$ per caput) |

## 4.7 Results

The WEF Nexus Index values are plotted on a world map in **Figure 4.1**. The results of the WEF Nexus Index calculation for the top twenty and bottom twenty countries are presented in **Tables 4-5** and **4-6** respectively, while the dashboard for all 170 countries is included in **Appendix B**, together with the treated data values. The untreated data values are presented in **Appendix C**.

The high-ranking countries presented in **Table 4-5** are generally first world countries with several of the "access" indicators being close to 100. These include high levels of access to basic drinking water and safely managed sanitation services, and electricity. These countries also have very low levels of undernourishment, wasting and stunting (the latter two in children less than five years of age). Norway, who ranks number one of the 170 countries, for which there is adequate data at both country and indicator levels, have a very high proportion of their electricity supplied by renewable sources. Not only is their power supply renewable, but the World Economic Forum reports that almost half of all new passenger car sales in Norway during 2018 were electric or hybrid vehicles (Fleming, 2019b). In terms of *Annual freshwater withdrawals*, Norway only utilises 0.79% of their internal resources (hence a high rating of 99.2 for this indicator). In terms of food availability, this country can provide a high level of protein supply per capita. Norway, Sweden and Iceland (ranking first, third and fourth) all have relatively low average values of food production, which can be contrasted with New Zealand (ranking second) who have an extremely high average value of food production.

There are five South American countries in the top 20, namely Brazil, Columbia, Paraguay, Argentina and Uruguay. These countries, in contrast to several first world countries, have relatively low $CO_2$ emissions levels per capita. Brazil and Columbia rank particularly highly in terms of the water availability indicators. This is due to large river basins such as the Amazon and Orinoco Rivers. Paraguay has a very high level of access to electricity, with the supply being predominantly generated from renewable sources. In term of food availability, Argentina and Uruguay have a very high average value of food production.

Malaysia is the only Asian country in the top twenty, and no African countries feature in this list. Malaysia has a precipitation depth of almost three metres per year, and it withdraws less than 2% of its freshwater annually. Malaysia is self-sufficient in terms of energy production, and its entire population has access to electricity, which strengthens the energy pillar. This nation has a relatively low prevalence of undernourishment at 2.9%.

Three-quarters of the bottom twenty ranking nations are from Africa. These nations are low emitters of $CO_2$, largely due to the general absence of proven coal reserves north of South Africa (Agora, 2017). The "food availability" sub-pillar is particularly low for these countries, with the only strong indicator within the "food access" sub-pillar being low levels of obesity. These countries generally have low levels of *Annual freshwater withdrawals*, although this is often due to low levels of service delivery, energy generation and development.

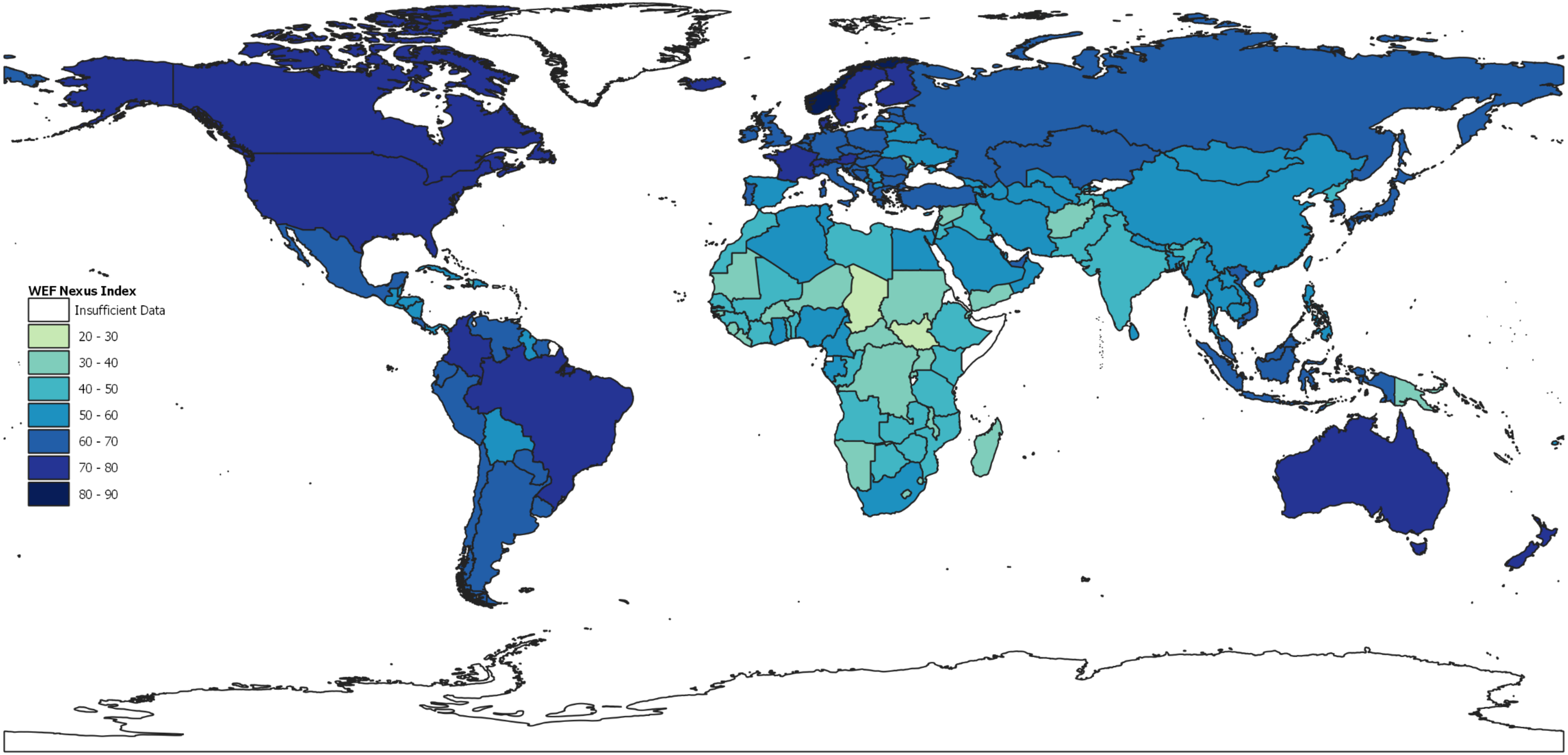


**Figure 4-1: World map indicating the WEF Nexus Index per country**

**Table 4-5: WEF Nexus Index for the twenty top-ranked countries**

| Rank | Country | WEF Nexus Index |
|---|---|---|
| 1 | Norway | 80.88 |
| 2 | New Zealand | 77.29 |
| 3 | Sweden | 76.87 |
| 4 | Iceland | 76.57 |
| 5 | Canada | 75.51 |
| 6 | Denmark | 75.32 |
| 7 | Australia | 74.10 |
| 8 | Austria | 74.06 |
| 9 | Finland | 72.83 |
| 10 | Brazil | 72.75 |
| 11 | United States of America | 72.67 |
| 12 | France | 71.74 |
| 13 | Switzerland | 71.19 |
| 14 | Colombia | 70.12 |
| 15 | Paraguay | 69.99 |
| 16 | Croatia | 68.96 |
| 17 | United Kingdom | 68.53 |
| 18 | Malaysia | 67.79 |
| 19 | Argentina | 67.63 |
| 20 | Uruguay | 67.52 |

Within the bottom twenty ranking countries, Yemen, Mauritania, Djibouti and South Sudan are nations from the Middle East and North Africa (MENA). The MENA region is characterised by extreme water scarcity and a rapid transition toward renewable energy (Hoff et al., 2019). It is, however, the "only region that has seen an increase in the prevalence of hunger and a doubling in the number of hungry people, which now stands at 33 million" (FAO, 2015a).

Nine of the twenty bottom-ranked countries are land-locked nations, which makes economic growth more difficult (Sachs, 2015). Another factor which results in a lower WEF Nexus Index for the nations listed in **Table 4-6** is the absence of data for some indicators. An example of this is that 20 of the 23 bottom-ranked nations do not have data for either of the indicators related to the "energy availability" sub-pillar.

**Table 4-6: WEF Nexus Index for the twenty bottom-ranked countries**

| Rank | Country | WEF Nexus Index |
|---|---|---|
| 151 | Lesotho | 37.93 |
| 152 | Malawi | 37.75 |
| 153 | Rwanda | 37.62 |
| 154 | Uganda | 36.27 |
| 155 | Afghanistan | 36.14 |
| 156 | Timor-Leste | 36.08 |
| 157 | Liberia | 36.03 |
| 158 | Burkina Faso | 35.74 |
| 159 | Guinea-Bissau | 35.18 |
| 160 | Solomon Islands | 35.05 |
| 161 | Comoros | 34.31 |
| 162 | Yemen, Rep. | 33.98 |
| 163 | Namibia | 33.39 |
| 164 | Central African Republic | 33.15 |
| 165 | Madagascar | 32.94 |
| 166 | Mauritania | 32.54 |
| 167 | Djibouti | 32.13 |
| 168 | Papua New Guinea | 32.00 |
| 169 | South Sudan | 26.97 |
| 170 | Chad | 26.96 |

China, the most populous nation on earth, ranks 97$^{th}$ in terms of their WEF Nexus Index. While China is the top $CO_2$ emitter worldwide (refer to **Table 3-5**) it does not rank in the top twenty when the $CO_2$ emissions are expressed per capita (refer to **Section 3.2**). While China has developed significant renewable energy generation capacity, their *renewable energy consumption (as a percentage of final energy consumption)* and *renewable electricity output (as a percentage of total electricity output)* are relatively low. This is because coal still comprises approximately 60% of their installed energy share (Edmond, 2019). In terms of water availability, the mean annual precipitation in China is approximately 645 mm (refer to **Appendix C**), while the average annual precipitation for the 170 countries assessed is 1135 mm. India, who is the third-highest emitter of $CO_2$, similarly rank very low when the value is normalised with this nation's vast population. While their renewable energy development has also been noteworthy, it too is dwarfed by their fossil-fuel-based energy generation. With India having relatively high levels of wasting and stunting amongst their children under five years of age, and the average protein supply per capita being low, they rank 115th in terms of their WEF Nexus Index.

Qatar, who are the highest $CO_2$ emitters per capita at 45.4 metric tons (per capita), rank 105th in terms of the WEF Nexus Index. This nation has a mean annual precipitation of 74 mm resulting in an *Annual freshwater withdrawal* of 387.5% of their internal freshwater resources, i.e. almost four times their available freshwater volume. The low availability of water in Qatar results in the average value of food production being extremely low. Other countries such as Turkmenistan and the United Arab Emirates both have *Annual freshwater withdrawals* approaching 2000% of their internal freshwater resources (refer to **Appendix C**).

In evaluating a composite indicator, it is essential to ascertain if there is any correlation with other related indicators. To this end, the WEF Nexus Index has been plotted on the same set of axes as the SDG Index and the HDI in **Figures 4-2** and **4-3** respectively (refer to **Appendix E** for the SDG Index and HDI values (Sachs et al., 2018; UNDP, 2018)). On each set of axes, the R-squared values have been plotted. R-squared is a statistical measure of how closely the data fit the regression line. The R-squared values for the two plots are 0.72 and 0.66 respectively. If these values were very high, i.e. approaching unity, then the WEF Nexus Index would be rendered redundant, since the existing indices and the WEF Nexus Index would be providing the same result.

Singapore and Hong Kong rank 114th and 139th respectively in terms of the WEF Nexus Index. Both nations have an extremely low average value of food production. This is because these relatively small states rely very heavily on food imports. In the plot of the HDI against the WEF Nexus Index, both Hong Kong and Singapore register as outliers (refer to **Figure 4-3**). This is because their living standards in terms of income, health and education exceed their natural resource base (represented by “Access” and “Availability” in the WEF Nexus Index). The inverse is true of countries such as Brazil, Columbia and Paraguay. These nations have HDI values that are lower relative to their WEF Nexus Index values.

The regression lines in **Figures 4-2** and **4-3** represent a divide between nations that have a resource base that is stronger than their level of development and vice versa. For example, in **Figure 4-2**, those countries above the regression line have higher relative levels of achievement for the SDGs other than SDG 2, 6 and 7, while those below the regression line have a stronger resource base compared to their level of attainment associated with the other SDGs (i.e. not SDGs 2, 6 and 7). Examples of countries that lie above the regression line are Singapore, Namibia, Moldova, Hungary and Malta. Examples of nations that have a stronger resource base relative to their achievement of the other SDGs, and lie below the regression line are Brazil, Nigeria, Canada and Indonesia. Those nations that lie on the regression line, such as India and Austria, have similar levels of attainment for both the SDG Index and the WEF Nexus Index, although Austria ranks significantly higher for both than India.

A similar pattern emerges in **Figure 4-3** where the HDI has been plotted against the WEF Nexus Index. Singapore and Hong Kong register as nations whose living standards (or level of development) are significantly better than their domestic resource base. Other nations that also fall within this category are Qatar, Israel, Oman, Ireland and Malta. Examples of nations whose living standards are lower, relative to their resource base are Brazil, Columbia, Paraguay, Nepal, Cameroon and Mozambique. Interestingly, Norway, Iceland, Canada and New Zealand also plot below the regression line, although these countries have very high

HDIs relative to the majority of nations assessed. Countries that plot on the regression line include France, India, the Russian Federation, the Comoros and Djibouti. Again, although these countries themselves have similar levels of living standards and resource base, there is a significant difference between their levels of attainment of both the HDI and the WEF Nexus Index.

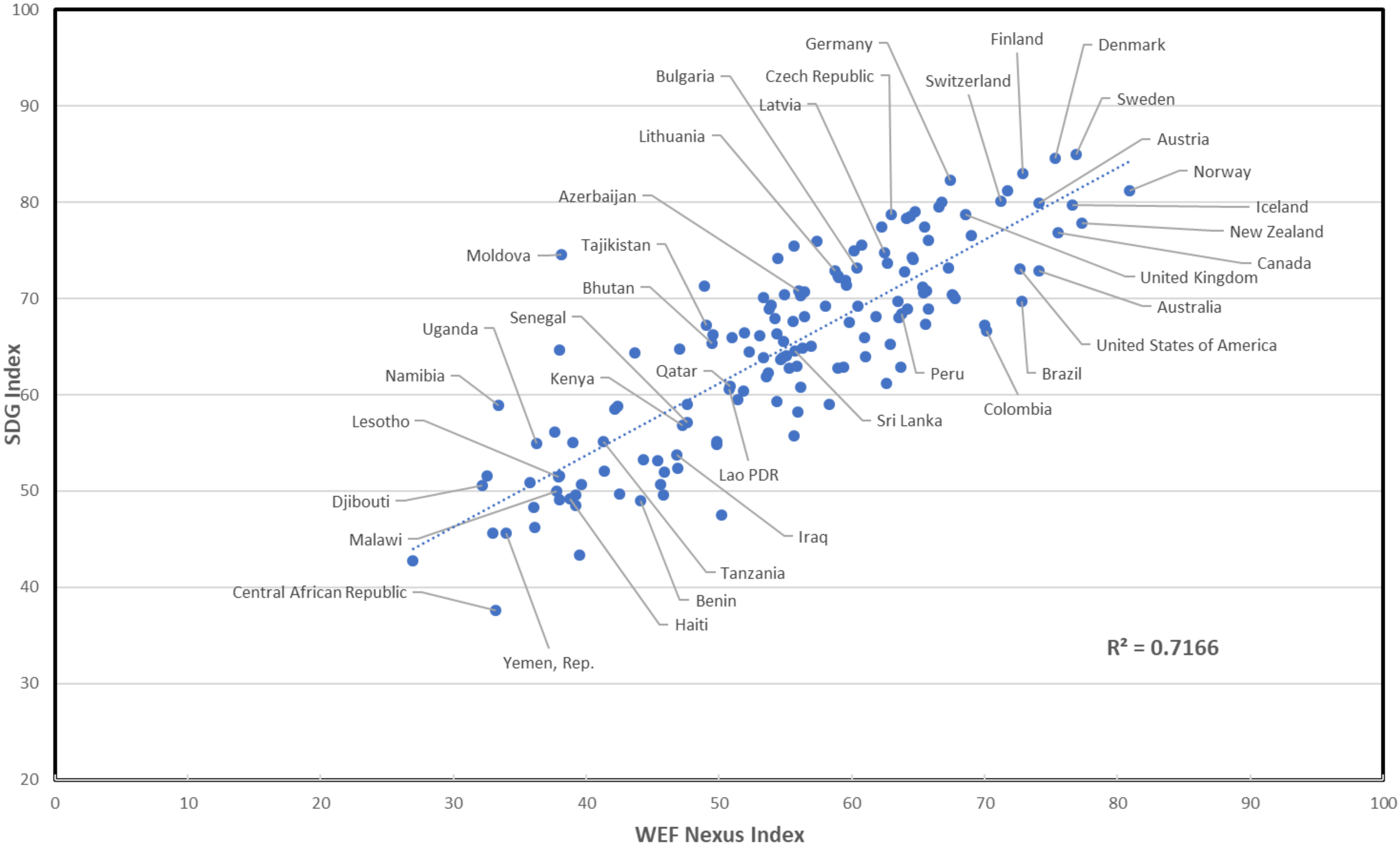


**Figure 4-2: Plot of SDG Index (Sachs et al., 2018) against WEF Nexus Index for selected nations**

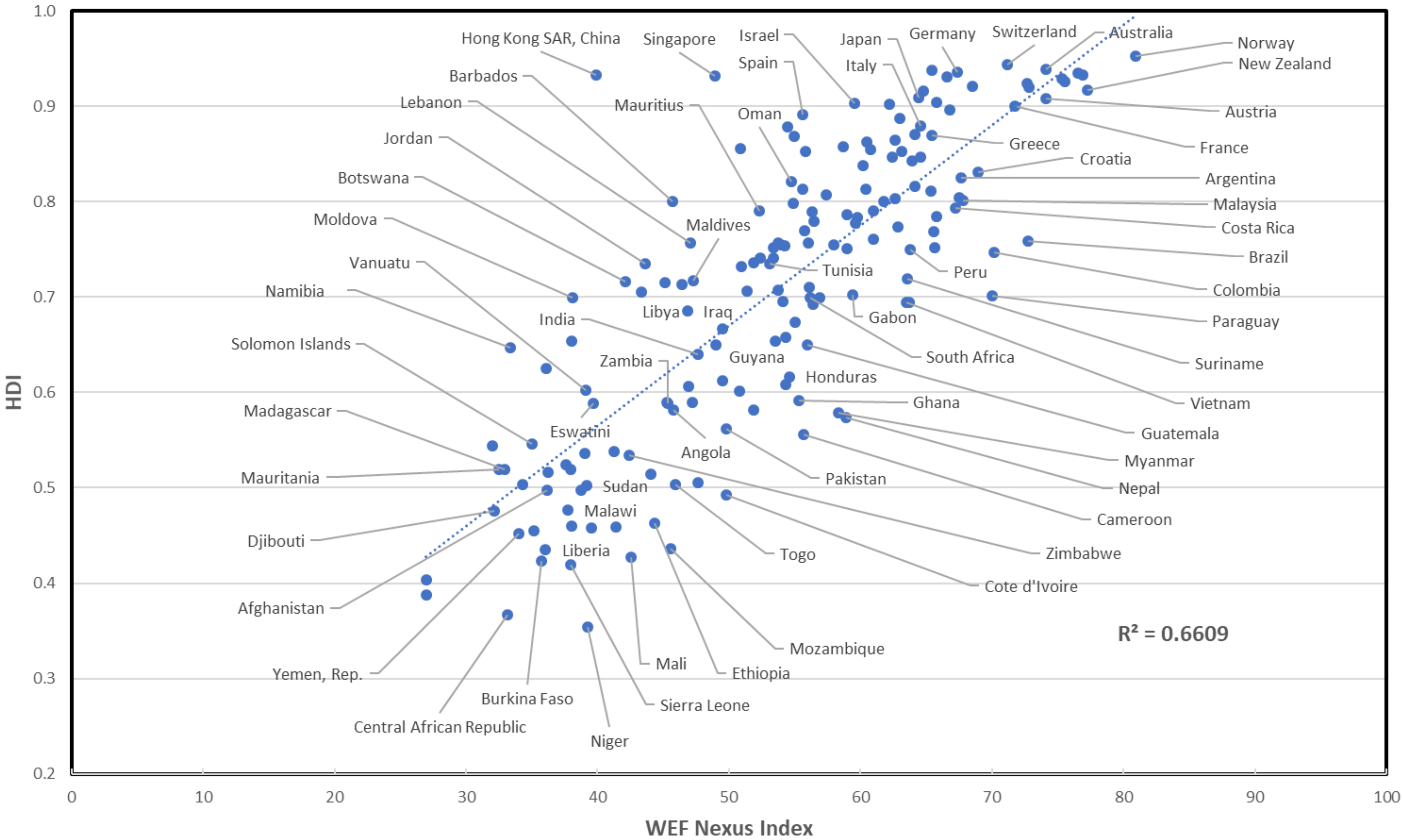


**Figure 4-3: Plot of Human Development Index (UNDP, 2018) against the WEF Nexus Index for selected countries**

# 5 APPLICATION OF INDEX TO SOUTH AFRICA AND SADC

The intention is that the WEF Nexus Index will be what the FAO (2014) term an "indicator-based assessment tool" that will be used to obtain an overview of the current state, key issues and trends related to the nexus. The scope of this report is to provide a status quo assessment of the WEF nexus in both South Africa and SADC, and subsequently to evaluate the WEF Nexus Index values for this country and region.

## 5.1 Status of WEF Nexus in South Africa

### 5.1.1 Water availability

With a mean annual precipitation of only 465 mm (refer to **Figure 5-1** and **Appendix C**), South Africa is ranked as the 30$^{th}$ driest country in the world. The global mean annual precipitation is 860 mm, nearly twice that of what South Africa receives (Pitman, 2011; DWA, 2016). The country has been described as having less available fresh water per capita than countries known to be much drier, such as Namibia and Botswana (DWA, 2013). The variability of climatic conditions and patterns across South Africa is largely influenced by the diverse topography, from deserts in the Northern Cape region to wet and humid conditions on the east coast (Benhin, 2006). Gauteng, the smallest province in South Africa, imports approximately 88% of its water via various inter-basin transfer schemes.

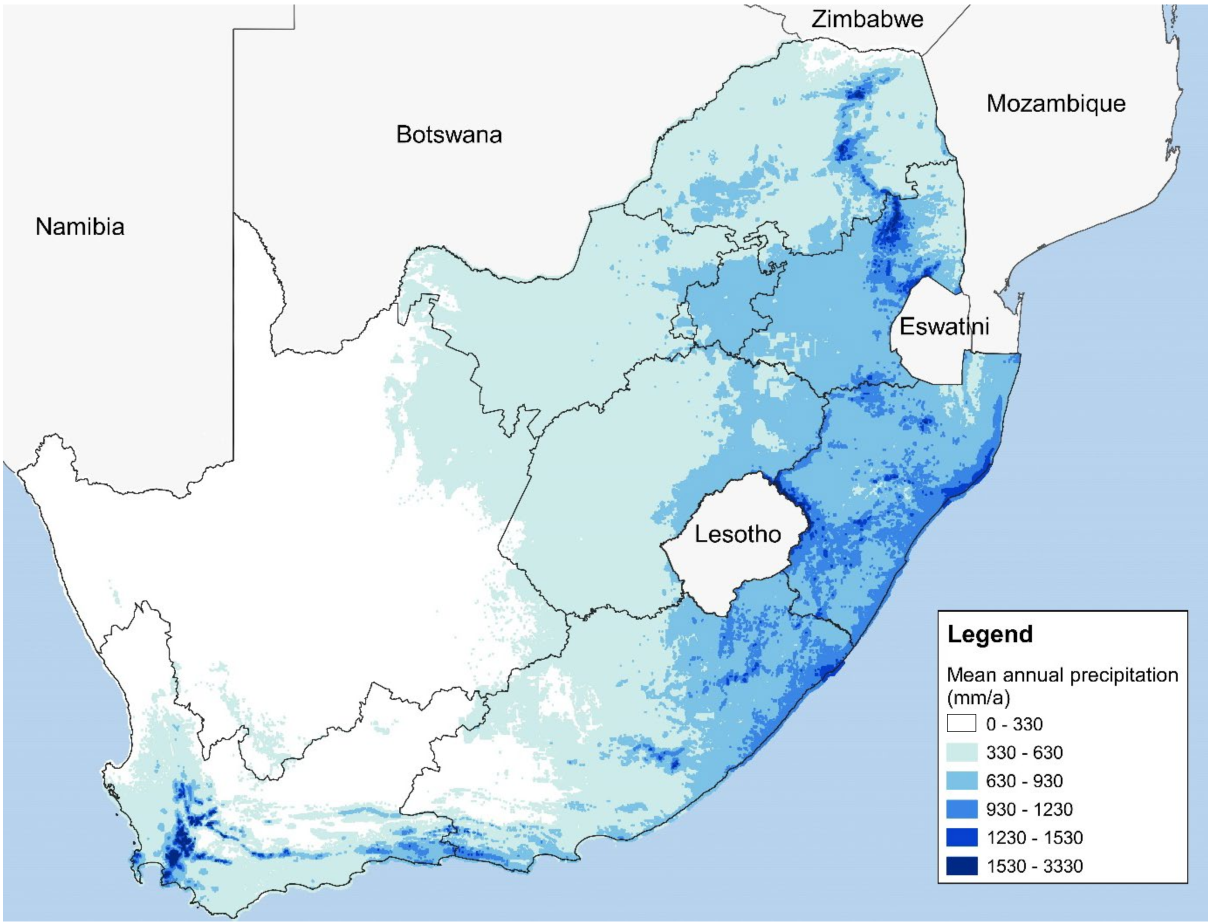


**Figure 5-1: Mean annual precipitation in South Africa; data obtained from WRC (2019)**

The current status of water resources in South Africa is summarised as follows (CER, 2019):

- Threatened and critically endangered river ecosystems – 60% and 23% respectively;
- Threatened and critically endangered wetlands – 65% and 48% respectively;
- Reliable water that has been allocated – 98%; and
- Water supply and demand – 17% deficit by 2030.

South Africa's water quality and quantity are managed within nine Water Management Areas (WMAs) which have been delineated by the Department of Water and Sanitation (DWS) based on catchment and aquifer boundaries, stakeholder interests, equity distribution and financial considerations (DWS, 2017). The WMAs are the Vaal, Pongola-Umzimkhulu, Mzimvubu, Tsitsikamma, Orange, Breede-Gouritz, Inkomati-Usuthu, Olifants and Berg-Olifants, as indicated in **Figure 5-2**.


**Figure 5-2: The nine Water Management Areas of South Africa; data obtained from DWS (2017)**

Le Maitre et al. (2018) updated the definition of Strategic Water Source Areas (SWSAs) as areas of land that supply a disproportionately large quantity of mean annual surface water runoff in relation to their size, and/or has high groundwater recharge. These water source areas are considered to be essential to South Africa's economy and thus a decrease in water quality and quantity within these SWSAs will have a negative impact on the functioning of downstream ecosystems and developments, some of which are transboundary in nature

(Viviroli et al., 2007). When considering the distribution of SWSAs in South Africa, presented in **Figure 5-3**, only 0.5% of these areas overlap with coalfields, with the Mfolozi Headwaters and Pongola Drakensberg being the most vulnerable to coal mining (WWF, 2013).

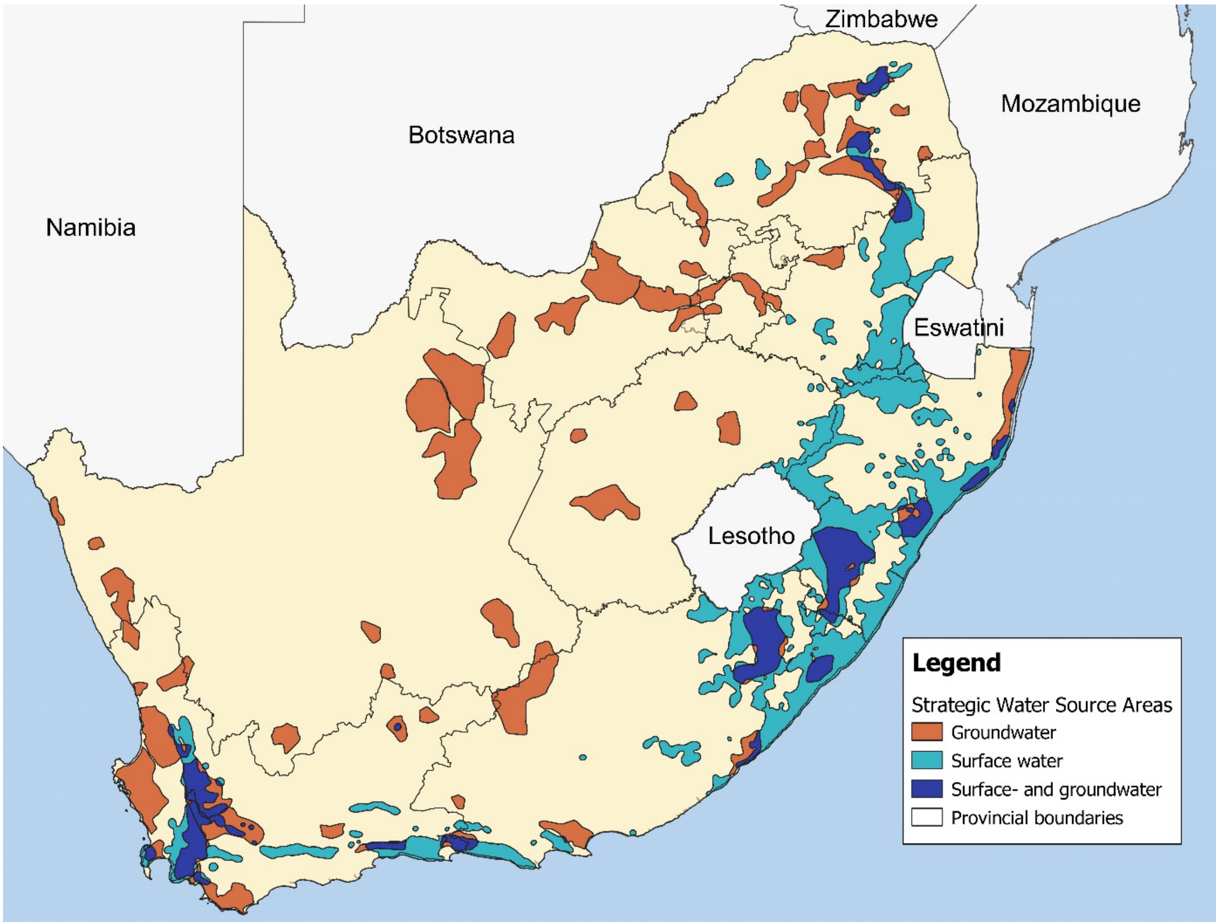


**Figure 5-3: Strategic Water Source Areas in South Africa; data obtained from SANBI (2019)**

Groundwater management in South Africa is generally underrepresented in national water legislation, most likely because it is not as perceptible and easily obtainable as surface water. **Figure 5-4** highlights the primary river systems in South Africa together with the groundwater recharge. Knüppe (2011) stated that the South African hydrogeological community considers groundwater to be underutilised and undervalued in many parts of the country. Groundwater only constitutes 15% of the total bulk water use in the country, amounting to approximately 3 000 million m³/a (DWAF, 2006; Nel, 2017). Similarly to surface water use, irrigation consumes the most groundwater (64%) while mining and domestic activities use 8% of the total groundwater that is extracted (CSIR, 2010). In many parts of the world, including areas in South Africa where long-term abstraction occurs from low replenishing aquifers (Nijsten et al., 2018), groundwater is being depleted at an alarming rate due to high water extraction and a reduction in recharge associated with extended droughts (Dalin et al., 2017).

The most significant impacts on water quantity and quality are associated with anthropogenic activities. Contamination plumes arising from abandoned mines, inadequate wastewater treatment works management, and nutrient contamination from fertilisers used on agricultural land are among the leading causes of water deterioration in South Africa (CSIR, 2010). These impacts can be attributed to South Africa's low rainfall, high evapotranspiration rates, relatively poor national and municipal regulation/governance and the urbanisation of areas with diminishing exploitable water resources.

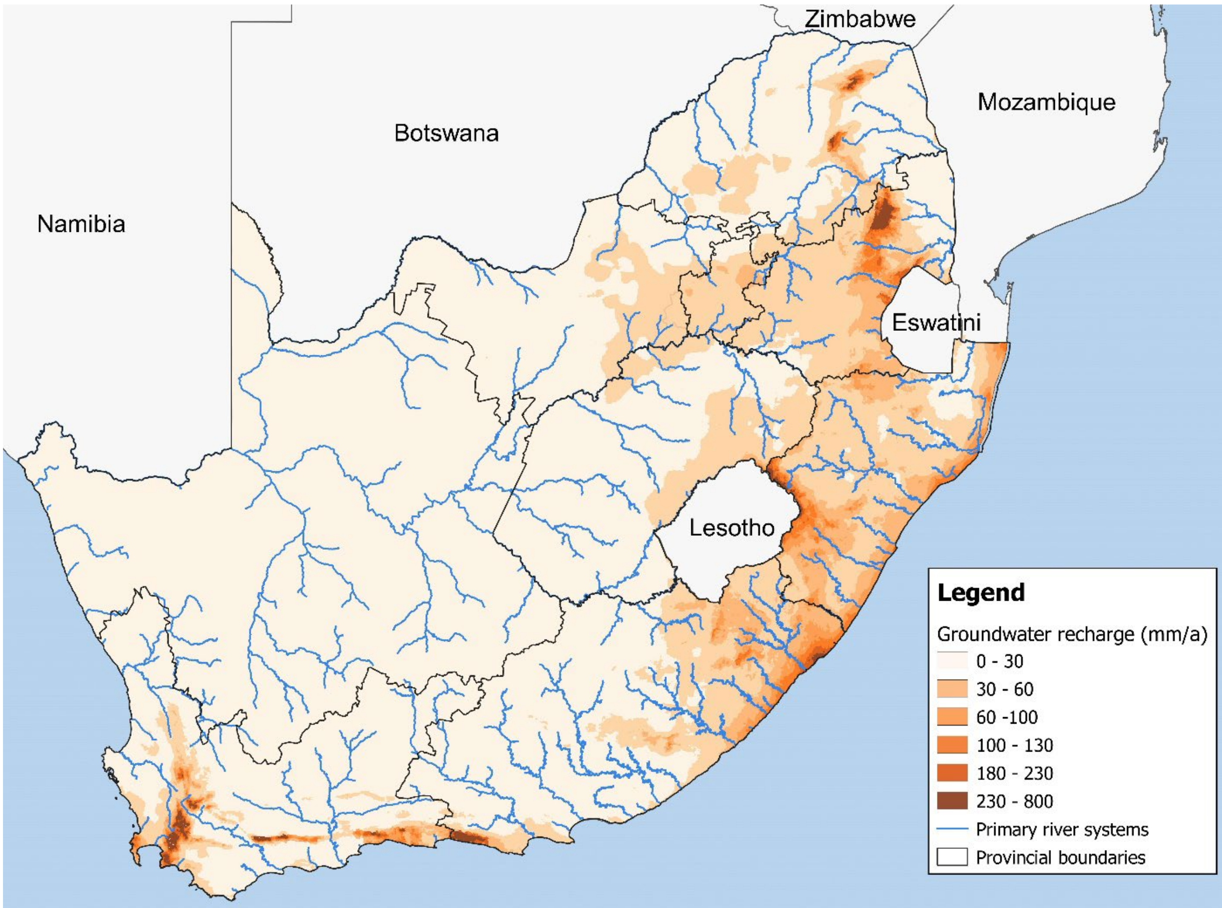


**Figure 5-4: South Africa's primary river systems and groundwater recharge; data obtained from DWS (2019)**

South Africa recently received international attention when Cape Town was predicted to be the first major city in the world to run out of water (Sousa et al., 2018). Since then, the state of the country's national water resources has been scrutinised by researchers (both nationally and internationally), authorities and the public. Water and energy resources in South Africa are closely linked, and ultimately determine the availability of each other.

In 2019, the Centre for Environmental Rights (CER) released a report on South Africa's water issues relating to coal mines (CER, 2019). Coal mining activities usually occur near water resources because water is needed to wash the coal to remove impurities. Groundwater is also impacted by coal mining since acid mine drainage (AMD) can be formed when oxygen encounters exposed coal seams in the presence of water. More than 650 active and abandoned mines contribute to the degeneration of water resources in the Olifants River Catchment, along with eutrophication resulting from the poor management of wastewater treatment facilities (Ashton and Dabrowski, 2011). The effects of coal mining on water resources have been documented extensively for the Olifants River Catchment in the

Mpumalanga Province (De Villiers and Mkwelo, 2009; McCarthy, 2011; Dabrowski et al., 2015; Oberholster et al., 2017) . The first recorded coal mining operation in the Witbank area (now known as eMalahleni) was documented in 1895 (Jeffrey et al., 2014). Since then, the majority of coal mines (active and abandoned) are now in the Mpumalanga Province, as indicated in a 2007 survey where 61 of the 73 active coal mines in South Africa were located in this province (Mathu, 2013). Consequently, water use in the Olifants River Catchment by the mining industry has dramatically increased over the years. However, a more significant water use demand has been for irrigation, as illustrated in **Figure 5-5**.

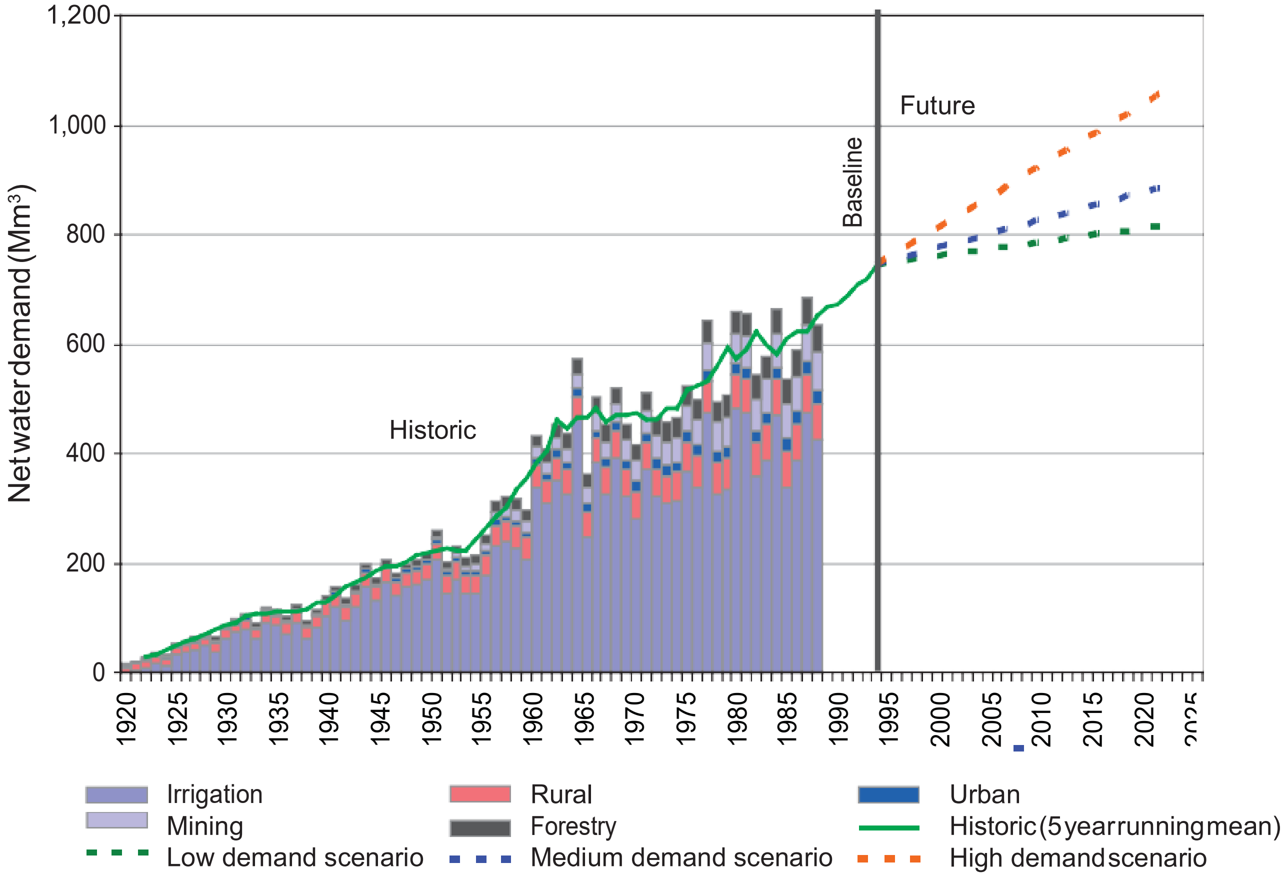


**Figure 5-5: Comparison of water demand in the Olifants River Catchment for the past, baseline and future scenarios (McCartney and Arranz, 2007)**

### 5.1.2 Energy generation

South Africa has relied on coal-based energy generation since the establishment of the country's state-owned enterprise, Eskom, in 1923 (Eskom, 2019). Not only does the country generate its own electricity from coal mining, but it also exports the best quality coal to contribute to national economic growth (Chamber of Mines of South Africa, 2018). As an African country, South Africa has 95% of the continent's proven coal reserves and is the seventh-largest producer and sixth-largest consumer of coal in the world, as shown in **Table** 5-1 (Agora, 2017; IEA, 2017).

Based on long-term domestic and international contracts, South Africa will likely continue to rely on coal-fired power stations for the next 30 to 50 years (Delport et al., 2015). Eskom is the largest supplier of electricity in South Africa, generating approximately 90% of the current electricity requirements, where municipalities and Independent Power Producers (IPPs) supply the remaining 10% (DoE, 2018b).

**Table 5-1: Top ten countries with the highest capacity of operating coal-fired power plants, modified from Liu et al. (2018)**

| Country | Operating capacity (MW) | Share (%) |
|---|---:|:---:|
| China | 935 472 | 47 |
| USA | 278 823 | 14 |
| India | 214 910 | 11 |
| Germany | 50 400 | 3 |
| Russia | 48 690 | 2 |
| Japan | 44 578 | 2 |
| South Africa | 41 307 | 2 |
| South Korea | 37 973 | 2 |
| Poland | 29 401 | 1 |
| Indonesia | 28 584 | 1 |

Eskom is classified as a “strategic” water user under South Africa’s *National Water Act 36 of 1998*, meaning that power generation is viewed as being strategically important. This classification provides Eskom with the highest assurance of water supply, at 99.5%, which is the same assurance level provided to basic domestic water supply (DWS, 2018). In addition to receiving the highest level of assurance for water supply, the power-generation industry also requires very good quality water (WWF, 2011). The implication of this is that in terms of water supply for power generation, coal-fired energy security is not threatened by water scarcity in South Africa.

South Africa’s water consumption within the energy sector is the greatest for energy generated from coal, as shown in **Figure 5-6**. Approximately 2% of the available fresh water in South Africa is used for power generation (Sparks et al., 2014), mostly for the operation of the various cooling technologies required in thermal power plants. In general, there are four types of cooling systems that can be used during power generation, with closed-loop (wet) cooling consuming the most water and dry (air) cooling using the least (Thopil and Pouris, 2016). Therefore, the specific cooling technology implemented will determine the consumption of water resources for fossil-fuel-based electricity generation.

Global Horizontal Irradiance (GHI) is the total amount of solar radiation received from above on a horizontal surface (Solargis, 2019). A map presenting the GHI for South Africa, together with implemented renewable energy projects, is shown in **Figure 5-7**. South Africa, therefore, has significant potential for energy generation, not only from coal resources but also from nondepletable renewable energy sources such as wind and solar. On average, the country receives 2 500 hours of sunshine per year with an annual average GHI of 1 224 to 2 337 $kWh/m^2$ (CRSES, 2017; Solargis, 2019). South Africa has 194 000 $km^2$ of high solar radiation potential, with the Northern Cape being one of the most optimal solar resource areas in the world (Aliyu et al., 2018). Although national renewable energy policies and legislation dating back to 1998, implementation of these policies has been slow, with the first renewable energy project (landfill gas-to-energy) commissioned in 2006 (DoE, 2015). By 2014, approximately 5 TWh of clean energy was being produced per year from various renewable energy sources (ibid.).

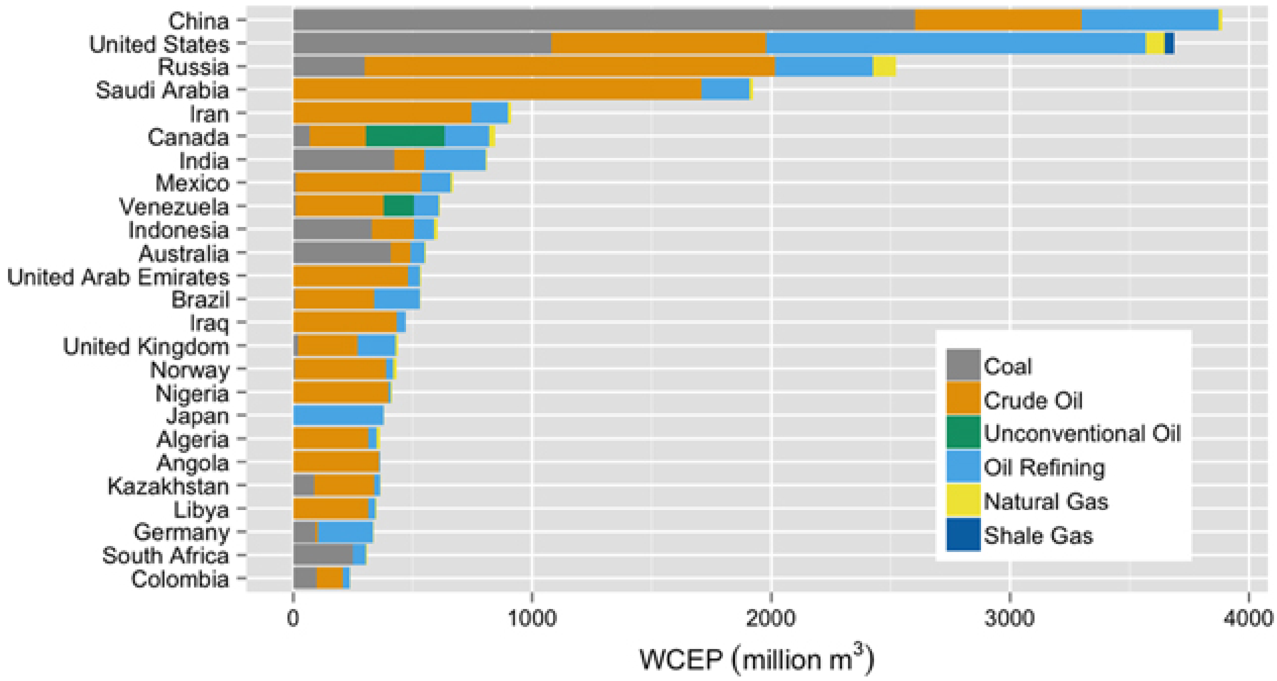


**Figure 5-6: Water consumption for energy production (WCEP) within energy sectors for 25 countries (Spang et al., 2014)**

Onshore wind renewable energy is the most prominent renewable energy technology currently in use in South Africa with an installed capacity of 2 094 MW (Eskom Holdings SOC Ltd, 2019). South Africa's wind resource potential has been described as being equally abundant as its solar potential, while only 0.6% of the country's surface area would be needed for wind energy farms to generate enough electricity for the entire population (CSIR, 2016). The same study suggests that theoretically, South Africa would be able to meet the entire world's electricity demand if wind farms were to be installed across the entirety of South Africa – excluding exclusion zones such as settled areas and national parks – which amounts to 6 700 GW (ibid).

In addition to the existing wind and photovoltaic (PV) energy power plants, energy in South Africa is also generated by means of biomass and landfill gas-to-energy conversion, as well as small hydropower plants (Nhamo et al., 2018). South Africa does not have large hydropower plants, most likely due to the country's water scarcity caused by the highly variable rainfall patterns in combination with the relatively high evapotranspiration rates. Mekonnen and Hoekstra (2012) calculated the evaporative loss of blue water from artificial reservoirs created for generating hydroelectricity to be approximately 90 $Gm^3$ per year, equating to 10% of the global crop production water footprint.

In 2011, the country had an installed hydropower capacity of 700 MW (Klunne, 2013). Since then, the 2019 Integrated Resource Plan (IRP) compiled by the Department of Energy (DoE) has planned the inclusion of 2 500 MW of hydropower in South Africa's energy mix by 2030, mostly from the Democratic Republic of Congo's Grand Inga project (DoE, 2018a). The South African government approved the ratification of the Grand Inga Treaty whereunder South Africa will purchase 2 500 MW of the projected 4 755 MW capacity (Taliotis et al., 2014).

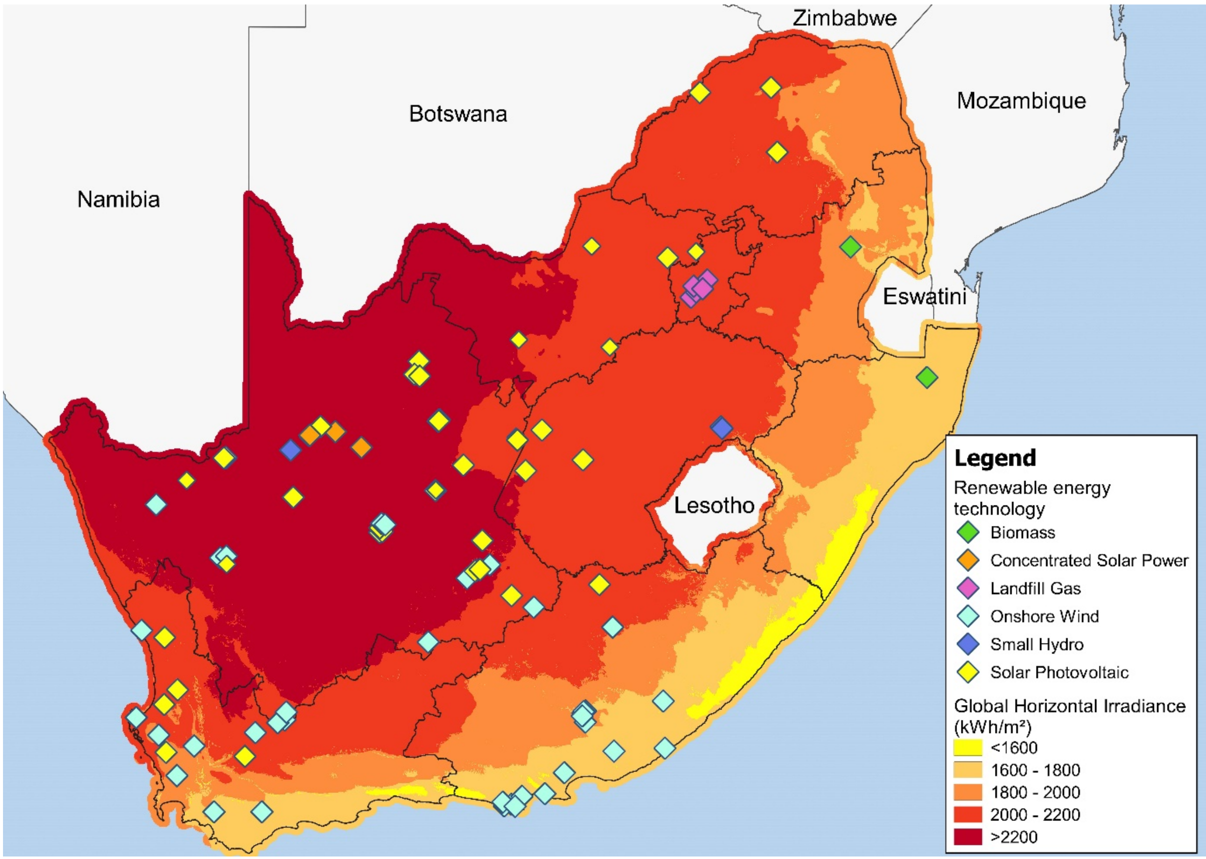


**Figure 5-7: Renewable energy projects and Global Horizontal Irradiance; data obtained from Eskom Holdings SOC Ltd (2019); Solargis (2019)**

### 5.1.3 Food production

Most of South Africa is located within arid and semi-arid zones and therefore has limited agricultural potential, particularly in the western and north-western parts of the country. Approximately a third of South Africa receives sufficient rain to produce rain-fed crops; however, only 12% of the country has arable soil (Directorate Agricultural Statistics, 2009)

Land capability in South Africa is classified according to soil and terrain characteristics and further considers climatic variables such as rainfall. A total of eight land capabilities were defined by Schoeman et al. (2000) for South Africa and are summarised as follows, and presented in **Figure 5-8**:

- Class I: Few limitations restricting land use. It may be used profitably and safely for cultivated crops. Soils are level and deep with a good water-holding capacity and drainage. Soils are easily cultivated, well supplied with plant nutrients and respond well to fertiliser. Soils need ordinary management and the climate is suitable for cropping.
- Class II: Some limitations reducing the choice of crops or requires moderate conservation practices. It may be used for cropping but with less latitude in the choice of crops and cultivation methods than Class I.

- Class III: Severe limitations that reduce the choice of crops or require special practices. It may be used for cultivated crops, but with more restrictions pertaining to crops and cultivation methods than for Class II land.
- Class IV: Very severe limitations that restrict the choice of crops and require very careful management. It may be used for crop production, but with more restrictions than Class III land.
- Class V: Little or no erosion hazard, but with other limitations restricting usage to pasture, range, woodland or wildlife food and cover. These limitations restrict plants to be grown and prevent normal tillage practices. The land is nearly level, may be wet or frequently flooded, stony with climatic limitations, or combinations of the mentioned conditions.
- Class VI: Severe limitations making it unsuitable for cultivation and constrain usage to pasture, range, woodland or wildlife food and cover. Limitations that cannot be corrected include steep slopes, severe erosion hazard, the effects of past erosion, stoniness, shallow topsoil, low water-holding capacity, salinity or sodicity and severe climate.
- Class VII: Severe limitations making it unsuitable for cultivation and constrain usage to pasture, range, woodland or wildlife food and cover. Restrictions are more severe than for Class VI and cannot be corrected, including very steep slopes, erosion, shallow soil, stones, salts, sodicity and severe climate.

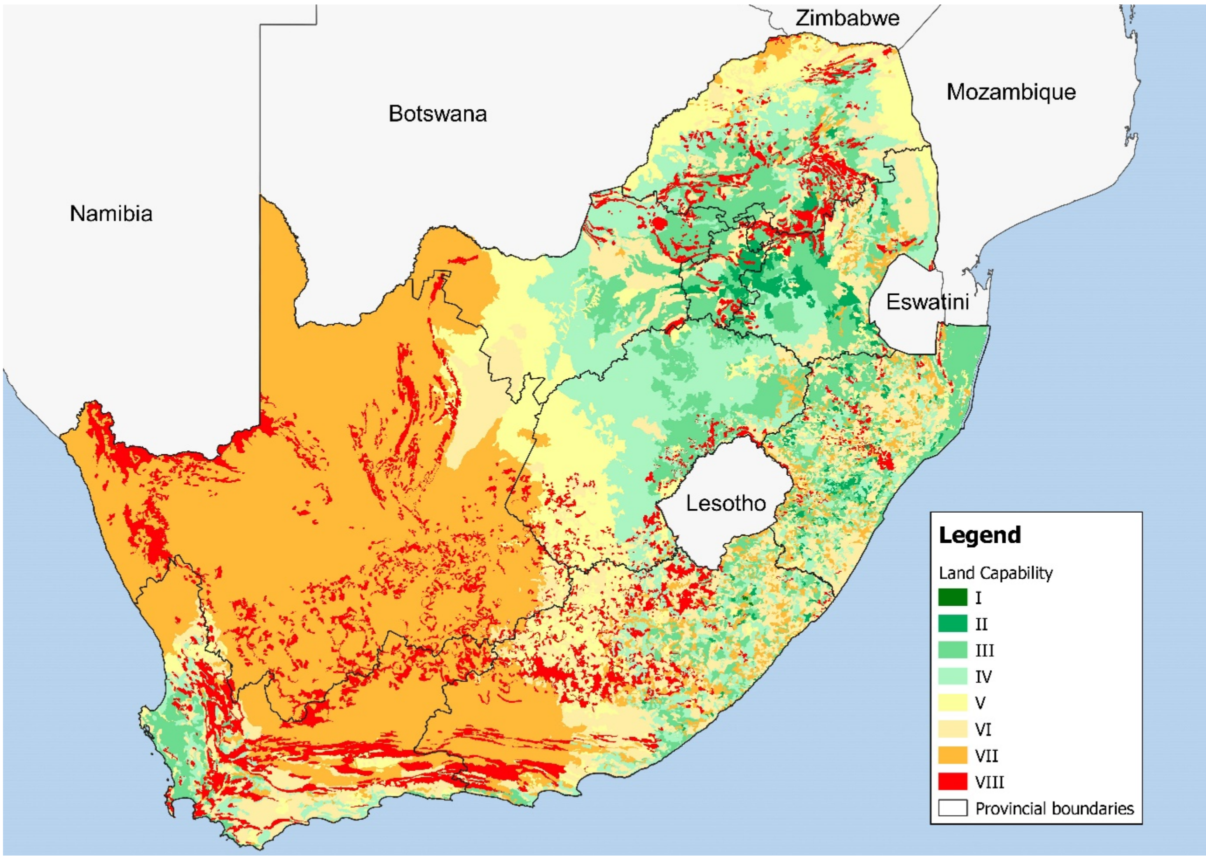


**Figure 5-8: South Africa's land capability map; data obtained from DEA (2016)**

- Class VIII: Limitations precluding use for plant production and restricts land usage for recreation, wildlife, water supply and aesthetic purposes. Limitations that cannot be corrected include erosion, erosion hazard, severe climate, stones, low water-holding capacity, salinity or sodicity.

Crop production, such as maize and wheat, requires a land capability of at least Class IV which is arable soil (Schoeman et al., 2000; ARC-ISCW, 2004). Clear linkages between food and water are noted when considering how the carrying capacity, or stocking rate, increases with rainfall, due to the increase in vegetation cover. Cattle grazing is concentrated in the eastern part of the country, along with the occurrence of coal deposits. As presented in **Figure** 5-9, the majority of South Africa's high potential arable land coincides with high concentrations of coal deposits.

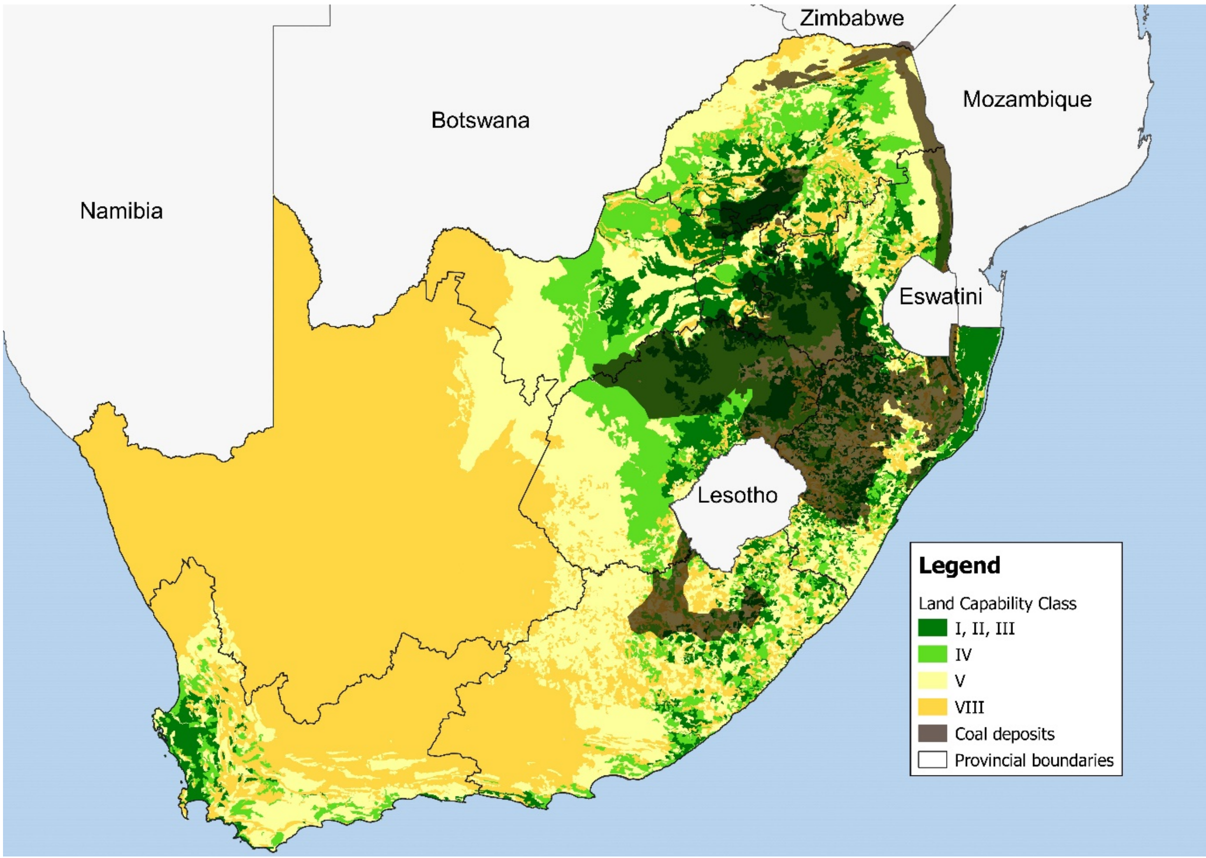


**Figure 5-9: Coal deposits overlaid with arable land in South Africa; data obtained from DEA (2016) and Merrill and Tewalt (2008)**

Maize is South Africa's most significant grain crop, providing the staple diet to the majority of the population, while approximately half of the maize produced is used for animal feed, 70% of which is allocated for poultry (WWF, 2010; BFAP, 2018). Over time, annual maize production varies with rainfall, but the average production of maize has not increased with population growth (ibid). South African agricultural activities are struggling to maintain the increased demand for animal feed, and hence the country is now a nett importer of poultry (ibid). Compared to 2003, meat consumption in South Africa increased by 54.4% in 2015 while it remained relatively constant from 1970 to 2003

(Taljaard et al., 2006, Delport et al., 2017). The water consumption associated with the production of various foods is shown in **Table 5-2**.

**Table 5-2: Quantities of water needed to produce one unit of food products (FAO, 2003)**

| Food product | Water equivalent in $m^3$ per unit | Unit |
|---|---|---|
| Cattle | 4000 | Head |
| Sheep and goat | 500 | Head |
| Beef | 15 | kg |
| Lamb | 10 | kg |
| Poultry | 6 | kg |
| Cereals | 1.5 | kg |
| Citrus fruit | 1 | kg |
| Roots, tubers and pulses | 1 | kg |

In developing countries, food insecurity is generally caused by poverty which is exacerbated by urbanisation, climate change, and political and socio-economic instability. Water scarcity, population growth, and changes in land use have resulted in a decrease in the number of farms in South Africa where there are now less than two-thirds of the number of farms compared to the 1990s (WWF, 2010). Less available agricultural land due to land-use changes has increased the pressure on the remaining farms to produce more food products for the country, and an associated surge in irrigation, fertiliser, fuel, and mechanisation has been noted (ibid).

Most of the South African agricultural activities rely on irrigation systems to produce sufficient products for both domestic use and export markets. Although only 1.5% of the country's land is under irrigation (BFAP, 2018), this sector is still the largest consumer of fresh water in the country using approximately 60% of South Africa's available freshwater resources (Zhuwakinyu, 2012). Soft fruits produced in South Africa are exported to the water-abundant United Kingdom, highlighting the unbalanced approach to trade that is currently taking place on an international scale (WWF and SABMiller, 2014). Historically, South Africa was a nett exporter of food, but it has recently become a net importer due to agricultural productivity not increasing at the same pace as population growth (Bazilian et al., 2011).

Approximately 30% of South Africa's staple food is produced by means of irrigation (WWF, 2010). As such, the agricultural sector is directly dependent on the price and availability of electricity used to power these irrigation systems. Bazilian et al. (2011) noted that rain-fed agriculture would not be sustainable in supporting South Africa's national food security, especially when the uneven distribution and variability of rainfall in the country is borne in mind.

### 5.1.4 Climate change

The security of water, energy and food is directly impacted upon by anthropogenic climate change and this has become more evident as temperatures, rainfall patterns, droughts and storms are becoming increasingly unpredictable on a global scale. According to Albert et al. (2017), the sector that is the most vulnerable to climate change is water, which will subsequently have a direct impact on the other sectors within the WEF nexus.

Some consequences of climate change may be beneficial in certain areas of South Africa, depending on which climate change scenario is investigated. Where an increase in rainfall is predicted, a subsequent increase in maize yields could be expected even if the harvesting area is reduced by 25% from 2010 to 2050 (Johnston et al., 2012; Dube et al., 2013).

South Africa is a significant contributor to global GHG emissions due to its dependence on fossil fuel-generated electricity (Grafton et al., 2016). According to data from the *Global Carbon Atlas*, South Africa ranked as the fourteenth largest $CO_2$ emissions emitter in 2017, contributing 1.3% of the total global emissions (refer to **Table 3-5**). Approximately 83% of South Africa's total $CO_2$ emissions are generated by the energy sector (DEA, 2011).

Generally, climate change researchers agree that climate change will result in a global increase in temperature, where arid areas will be susceptible to greater evaporation rates, sporadic storms, and reduced water availability (Helfer et al., 2012; Pardoe et al., 2018). The increased evaporation rates in areas predicted to have higher temperatures will lead to less perennial rivers available for thermoelectric- or hydroelectric power generation (Ololade et al., 2017). These climate change events will also have an increasingly negative impact on societies, particularly in the southern African region (Shulze et al., 2001).

### 5.1.5 Synergies and Trade-offs

The Worldwide Fund for Nature (WWF) published a series of documents investigating the status of the WEF nexus in South Africa from different disciplinary perspectives and thereby initiated integrated discussions on the WEF nexus within South Africa (WWF, 2011, 2013; WWF and SABMiller, 2014). These reports emphasise the importance of building synergies across sectors; not only across the water, energy, and food sectors but also among the public and private sectors.

South Africa's legislation is similarly incorporating the involvement of different governmental departments and this is highlighted in the *Climate Change Bill* which was published for public comment on 8 June 2018 (DEA, 2018). Within this Bill, all functional areas (such as water and sanitation, mineral resources, agriculture, forestry and fisheries, etc.) are required to assess risks and adaptations to climate change at both a municipal and provincial scale, and the ministerial committee must coordinate across these sectors. Cooperation between, and among, sectors would aid in reducing trade-offs and enhancing synergies to further South Africa's progress in sustainable development and integrated resource management.

Although South African legislation calls for cooperation among sectors, trade-offs are still prevalent and are particularly evident within the Western Cape and Mpumalanga provinces. The Western Cape exports large amounts of virtual water in the form of fresh produce and other food products, such as wine. These products contribute significantly to the region's economy but may be unsustainable for an area with such extreme water scarcity. This highlights the trade-off between water for exported agriculture and economic growth and water for local consumption and domestic food production.

The Mpumalanga province is known for its vast coalfields and hence, numerous coal mines and power stations. The high agricultural potential of this province coincides with high coal deposits, as presented in **Figure 5-10**, with a substantial volume of the available fresh water being used to support the production of food and energy (BFAP, 2012). Water quality in the Mpumalanga region is heavily impacted by contaminated surface water run-off from agricultural land (due to fertilisers and erosion), while mining activities may cause AMD and the discharging of heavy metals into water resources (Dabrowski and de Klerk, 2013). The Olifants River catchment in Mpumalanga is considered be the energy heartland of South Africa, and has been affected by existing and defunct mines to such an extent that the water has been categorised in certain portions of its reach as being unsuitable for human or animal consumption (Dabrowski et al., 2010; Ashton and Dabrowski, 2011; Musingafi and Tom, 2014). As a result, the mine-affected water requires energy-intensive and costly treatment prior to being discharged into the watercourses (IRENA, 2015b). There is a constant competition for land between agriculture and mining in this province, as well as between water-for-energy and water-for-food (Simpson et al., 2019) and this unbalanced pattern of resource over-utilisation is prevalent throughout South Africa.

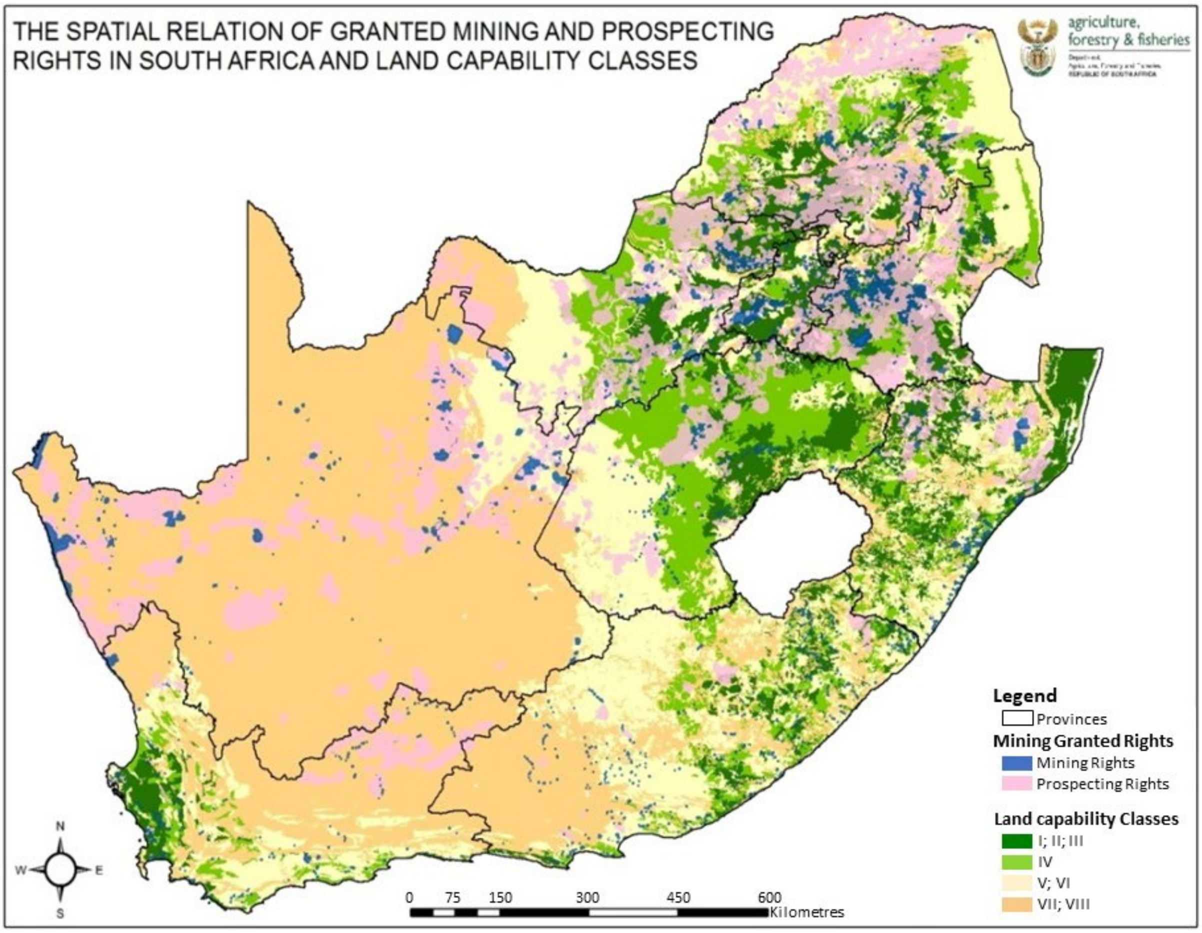


**Figure 5-10: Map showing the overlap of arable land capability and mining rights in South Africa (DAFF, 2015).**

## 5.2 Status of WEF Nexus in SADC

The African Union's *Agenda 2063* is titled "The Africa We Want." It calls for "a prosperous Africa based on inclusive growth and sustainable development" (African Development Bank, 2019). Much work remains to achieve this goal in a region such as Sub-Saharan Africa where more than 390 million people live on less than $1.90 a day in 2013 (World Bank, 2018a). The Southern African Development Community (SADC), which is part of the African Union, was established as a development coordinating conference (SADCC) in 1980 and subsequently transformed into a development community in 1992. It is made up of sixteen member states, namely Angola, Botswana, Comoros, Democratic Republic of Congo, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, United Republic of Tanzania, Zambia and Zimbabwe, as presented in **Figure 5-11**.

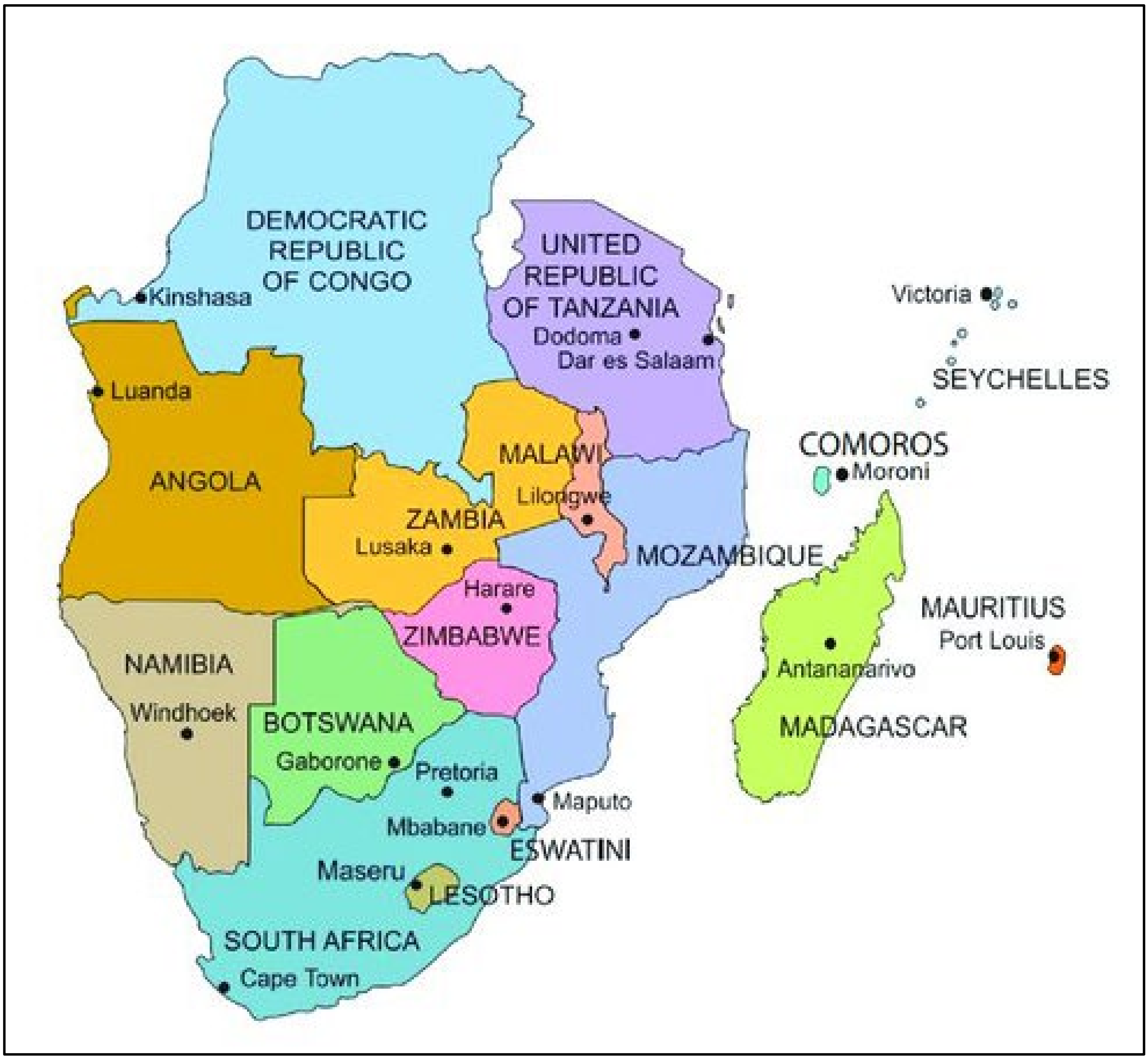


**Figure 5-11: Map of the SADC countries (Konstantinus et al., 2019)**

There have been various WEF nexus workshops, dialogues and consultations within Southern Africa, starting with the *Nexus Dialogue on Water Infrastructure Solutions* in 2013 (Mabhaudhi et al., 2018). These meetings have highlighted the interdependencies within the three resource sectors that constitute the WEF nexus. The necessity of regional cooperation in integrated resource management is highlighted by six of these countries being landlocked and three of them being island states. Schreiner and Baleta (2015) emphasise that the nexus approach has become a significant part of the current development discourse in Southern Africa, noting that there are clear opportunities for sharing resources internationally for the mutual benefit of the region. Mabhaudhi et al. (2016) however explain that there has been a gap between water and energy sector planning in terms of policy alignment and technical convergence, which hinders progress towards the SDGs.

### 5.2.1 Water availability

The national boundaries within SADC were determined politically and not hydrologically. This is evident when it is understood that 85% of the region's water resources are transboundary in nature (Mabhaudhi et al., 2016). SADC coordinates transboundary water cooperation in fifteen basins across Southern Africa (UN Water, 2013), as shown in **Table 5-3**. These shared basins present (or necessitate) ample opportunities for cooperation to enhance socio-economic security and ensure further progress with achieving the SDGs. However, the availability of resources within the region is not evenly distributed. Over 70% of SADC's freshwater resources are shared between two or more member states (Schreiner and Baleta, 2015).

**Table 5-3: Transboundary river basins in the SADC region (Mabhaudhi et al., 2016)**

| River Basin | Sharing States |
|---|---|
| Buzi | Mozambique, Zimbabwe |
| Congo | Angola, Democratic Republic of Congo, Tanzania, Zambia |
| Cuvelai | Angola, Namibia |
| Incomati | Mozambique, South Africa, Swaziland |
| Kunene | Angola, Namibia |
| Limpopo | Botswana, Mozambique, South Africa, Zimbabwe |
| Maputo | Mozambique, South Africa, Swaziland |
| Nile | Democratic Republic of Congo, Tanzania |
| Okavango | Angola, Botswana, Namibia |
| Orange | Botswana, Lesotho, Namibia, South Africa |
| Pungwe | Mozambique, Zimbabwe |
| Ruvuma | Malawi, Mozambique, Tanzania |
| Save | Mozambique, Zimbabwe |
| Umbeluzi | Mozambique, Swaziland |
| Zambezi | Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, Zimbabwe |

The ratification of SADC's revised protocol on shared watercourses together with the establishment of various river basin organizations has promoted cooperation and the sharing of benefits from these basins (Claassen, 2013). Hoff (2011) explains that one of the early nexus analyses focussed on the Zambezi River basin. This integrated project included the co-development of hydropower, new irrigation schemes and other water-related sectors, including wetlands and their ecosystem services.

UN Water (2018) state that 24% of people in Sub-Saharan Africa have access to safely managed drinking water services. **Figure 5-12** presents the percentage of the population in each of the SADC nations (excluding Comoros, for which no data was available) that had access to improved water sources between 1990 and 2015. This indicator is defined as:

> "Access to an improved water source refers to the percentage of the population using an improved drinking water source. The improved drinking water source includes piped water on premises (piped household water connection located inside the user's dwelling, plot or yard), and other improved drinking water sources (public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection)" (World Bank, 2018b).

While Mauritius, Botswana and Seychelles have high levels of access to improved water sources, and South Africa's service delivery has increased steadily since the end of Apartheid, several nations have relatively low (<60%) levels of access to improved water sources. What is even more concerning is that Zimbabwe's provision of access to improved water sources has declined during the period (1990 to 2014). Based on access to improved drinking water sources, the SADC region is, without doubt, a developing region with much work remaining to meet SDG 6.1 ("By 2030, achieve universal and equitable access to safe and affordable drinking water for all."). UN Water (2018) warns that "an acute lack of capacity is constraining water resources development and management in all its facets, across most developing countries, particularly in sub-Saharan Africa and South and South-eastern Asia."

SDG 6 addresses access to both improved water sources and improved sanitation facilities. **Figure 5-13** presents the proportion of the SADC countries' (excluding Comoros, for which there was no data) access to improved sanitation facilities, which is defined as follows:

> "Access to improved sanitation facilities refers to the percentage of the population using improved sanitation facilities. Improved sanitation facilities are likely to ensure hygienic separation of human excreta from human contact. They include flush/pour flush (to the piped sewer system, septic tank, pit latrine), ventilated improved pit (VIP) latrine, pit latrine with slab, and composting toilet" (World Bank, 2018b).

Seychelles and Mauritius both have very high levels of access to improved sanitation facilities. While the trajectory of the implementation of access to better sanitation facilities is positive for nearly all countries (except Zimbabwe), there remains much work to do, with all other nations having less than 70% access to improved sanitation facilities. More than half of the nations in the SADC region have less than 50% access to improved sanitation facilities. UN Water (2018) report that 220 million people in Sub-Saharan Africa still practice open defecation. SDG 6.2 specifically addresses this practice, stating that "By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations."

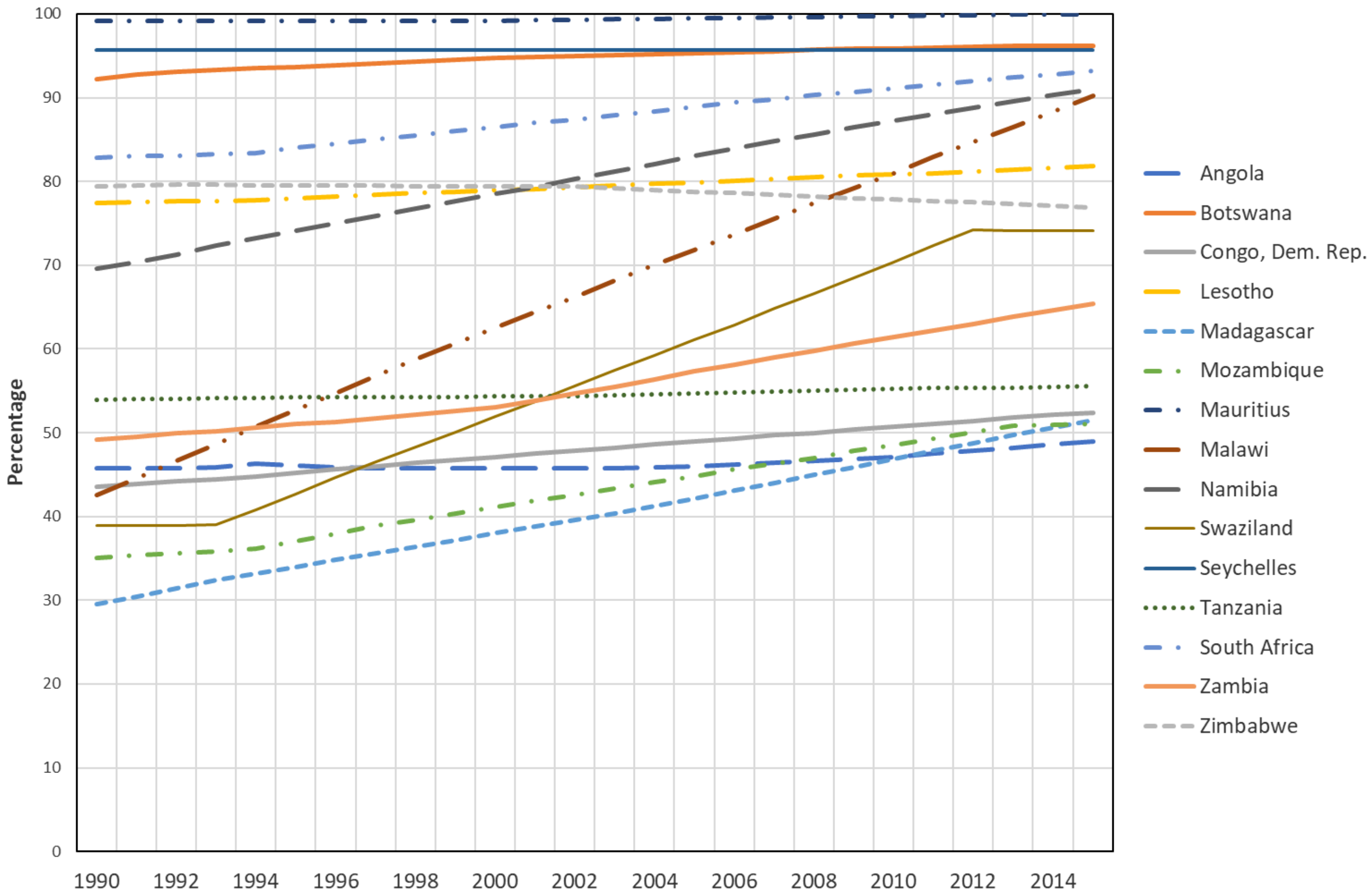


**Figure 5-12: Percentage of population with access to improved water sources in SADC countries – 1990 and 2015 (World Bank, 2018b)**

In terms of future water security, Conway et al. (2015) explain that most climate models project decreases in annual precipitation for Southern Africa, typically by as much as 20% by the 2080s. Scholes et al. (2015) state that the average annual air temperature in South Africa has risen by approximately 1.2°C during the time period within which accurate records have been maintained. They warn that projections of future warming in Southern Africa are a further 3-6°C within the twenty-first century, with the greatest warming occurring in the western interior of the subcontinent, particularly in the Kalahari region (ibid.).

### 5.2.2 Energy generation

Renewable energy accounts for a large proportion of energy consumption in Sub-Saharan Africa, but this is generally because of the burning of biomass in traditional ways in open fires (World Bank, 2018a). In Southern Africa, water and energy are inextricably linked. Conway et al. (2015) note that almost 100% of electricity production in the Democratic Republic of Congo, Lesotho, Malawi and Zambia is generated by means of hydropower. The SADC nations share an energy grid, termed the Southern African Power Pool (SAPP), and several countries within the region export and import power from each other to meet their local demand (Mabhaudhi et al., 2016). Hydropower forms a major component of the regional energy supply through extensive sharing within the SAPP. South Africa is the largest energy generator and consumer within the region and its focus and challenges in managing its own internal electricity generation have served to undermine the functionality of the SAPP master plan (Schreiner and Baleta, 2015). Regarding energy in the SADC region, “challenges include low tariffs, poor project preparation, issues with power purchase agreements, and absent regulatory frameworks that stunt investment and financing in the energy sector” (ibid.).

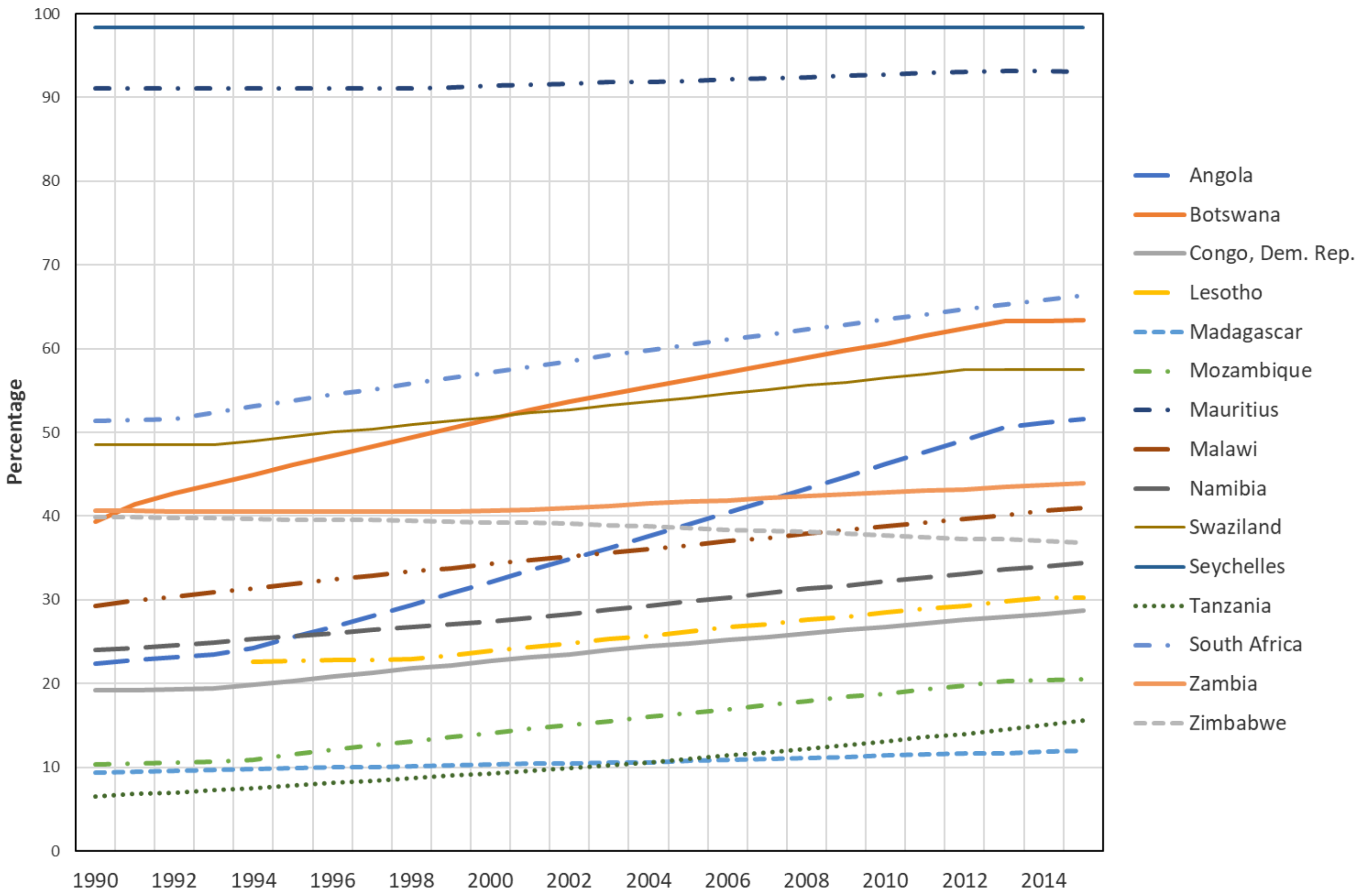


**Figure 5-13: Percentage of population with access to improved sanitation facilities in SADC countries: 1990-2015 (World Bank, 2018b)**

**Figure 5-14** presents the proportion of access to electricity per SADC country (excluding Comoros, for which there was no data). Access to electricity is very high for Mauritius and Seychelles, while Swaziland, Namibia, Botswana and South Africa’s service delivery in terms of electricity has been significant since 1990. While there has been a general upward trend in access to electricity levels, these levels are below 45% for nine of the fifteen countries. Alarmingly, the level of provision of access to electricity for the population of Angola has decreased markedly since 1990.

Southern Africa is endowed with significant potential in terms of solar and wind power generation (Gies, 2016). This could lead to the development of a SADC “Desertec” (Simpson et al., 2019) similar to the large-scale renewable power generation and distribution project that was touted for North Africa, the Middle East and Europe. Another project that could transform the SADC region is the development of the vast hydropower potential of the Inga Falls in the Congo River. The Grand Inga Dam Project, which has been discussed for half a century, could produce 40 GW of hydroelectric power, more than one-third of the total electricity currently generated in Africa (Sachs, 2015). Political obstacles have, until now, limited the development of this project. SADC has identified four hydropower plants as priority developments. They are the Mpanda-Nkuwa in Mozambique, Inga III in the Democratic Republic of Congo, the Batoka Gorge project between Zambia and Zimbabwe, and the Lesotho Highlands Water Project Phase II in Lesotho (Schreiner and Baleta, 2015).

Hoff (2011) explains that one of the first nexus trade-off studies was an analysis of sugar versus biofuel production in Mauritius. This study indicated that this island state can improve its economic water use efficiency by changing sugar production to bio-ethanol production.

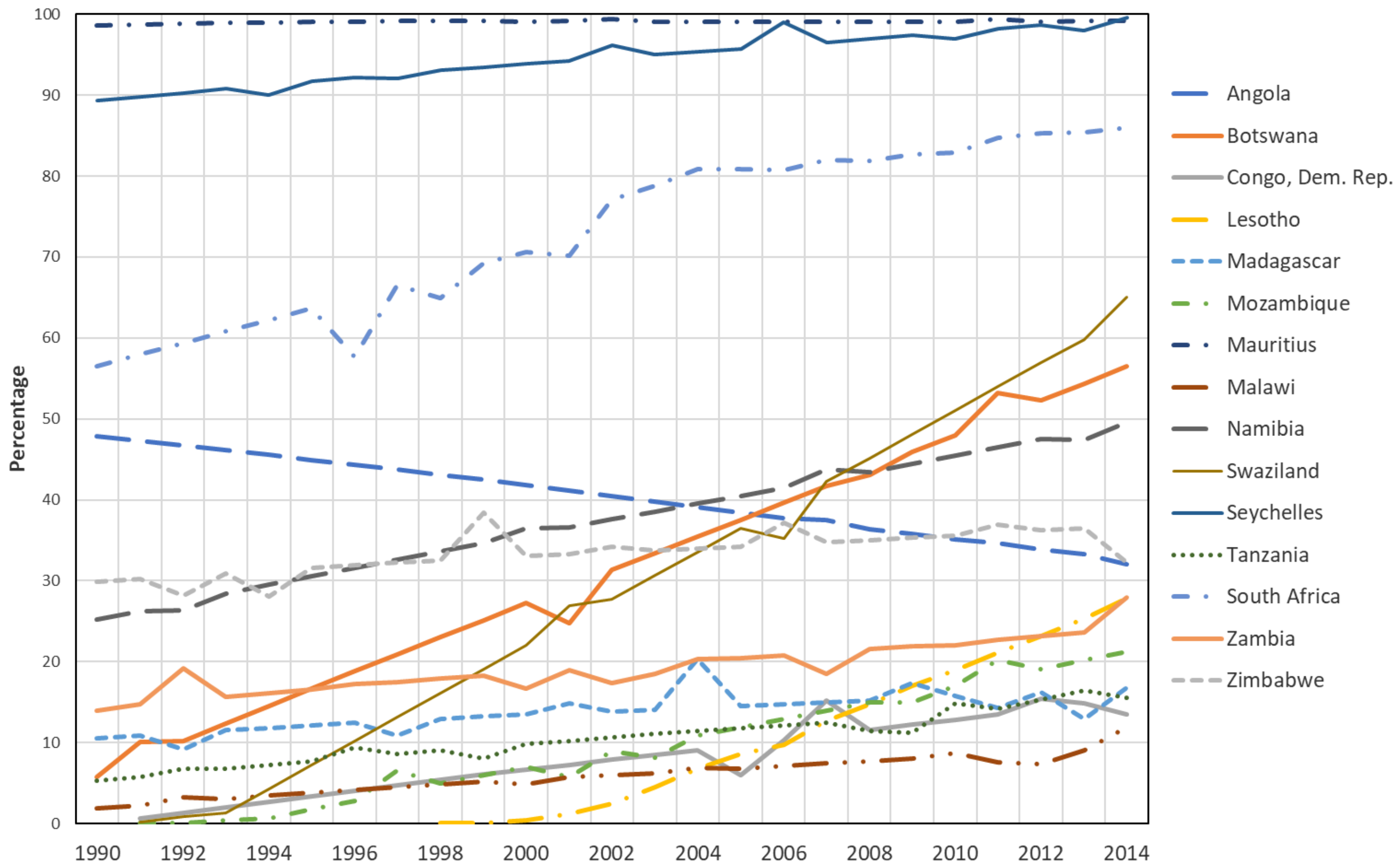


**Figure 5-14: Percentage of population with access to electricity in SADC countries between 1990 and 2014 (World Bank, 2018b)**

### 5.2.3 Food production

Sachs et al. (2016) lament that more than one-third of the population in tropical Africa, especially central and southern Africa, is undernourished. UN Water (2018) explain that Sub-Saharan Africa experiences the highest level of food insecurity, affecting almost 30% of the population. Much of the SADC region is characterised by economic scarcity. If future developments of water infrastructure related to agricultural production could focus on domestic consumption (rather than the export market) this could go a long way to reducing poverty and malnutrition in this region (Siciliano et al., 2017).

Most of the agriculture in the SADC region is rainfed, largely produced by small scale or subsistence farmers. Land ownership has been a source of tension in the SADC region since the colonial era. There are millions of smallholder farmers in the region, and it is estimated that more than 60% of the workforce in Sub-Saharan Africa is engaged in agriculture-related activities (UN Water, 2018). Brown (1970) wrote almost fifty years ago, that "As agriculture emerges from its traditional subsidence state to modern commercial farming … it becomes progressively more important to ensure that adequate rewards accrue directly to the man who tills the soil. Indeed, it is hard to see how there can be any meaningful modernisation of food production in Latin America and Africa south of the Sahara unless [the] land is registered, deeded, and distributed more equitably."

Sachs (2015) explains that on average, smallholder farmers in sub-Saharan Africa produce yields of between half a ton and one ton per hectare, which is very low when compared to international norms. He notes that other parts of the developing world achieve four- to five-times higher yields than that and lists key development challenges as being soil-nutrient depletion and a general lack of irrigation and good seed varieties.

The prevalence of undernourishment in SADC countries, from 1991 to 2015, is presented in **Figure 5-15**. Schreiner and Baleta (2015) suggest that the agricultural potential of countries like Zambia could be exploited for the benefit of the entire region. While this is true, it is ironic that fertile countries such as Zambia experience high levels of undernourishment that have increased since the late 1990s. The *Joint Child Malnutrition Estimates* report states that "Malnutrition rates remain alarming: stunting is declining too slowly while wasting still impacts the lives of far too many young children" (UNICEF/WHO/World Bank, 2019). Further, they report that Africa is the only region where the number of stunted children has risen between 2000 and 2018 (ibid.). Based on these statements, as well as the high levels of undernourishment in SADC countries, much work remains for SDG 2 to be achieved. SDG 2.1 is: "By 2030, end hunger and ensure access by all people, in particular, the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round."

UN Water (2018) state that "Poor WASH[13] contributes to undernutrition, which is both a rural and an urban health issue (but which is worse in rural communities). It is endemic among the poor in sub-Saharan Africa and Asia, where many people live in unsanitary conditions and do not get enough calories, protein and micronutrients in their diet."

## 5.3 WEF Nexus Index for South Africa

The WEF Nexus Index for South Africa is 56.1, which ranks this nation as 72$^{nd}$ out of the 170 countries assessed. The six sub-pillars associated with the WEF Nexus Index for South Africa are presented in **Table 5-4** and **Figure 5-16**. The highest-ranking sub-pillar for South Africa is the "Water-access" sub-pillar. This is due to the relatively high proportion of people having at least basic drinking water services (84.7%) and safely managed sanitation services (73.1%), as well as a comparatively high degree of IWRM implementation (65.5%). Service delivery in terms of improved drinking water and sanitation facilities has enhanced steadily since the end of Apartheid, as presented in **Figures 5-12** and **5-13**.

Access to water is however contrasted with the availability thereof, with South Africa having a relatively low mean annual precipitation (495 mm). This water-scarce country withdraws 34.6% of its available freshwater resources (refer to **Appendix C**).

[13] Water, Sanitation and Hygiene

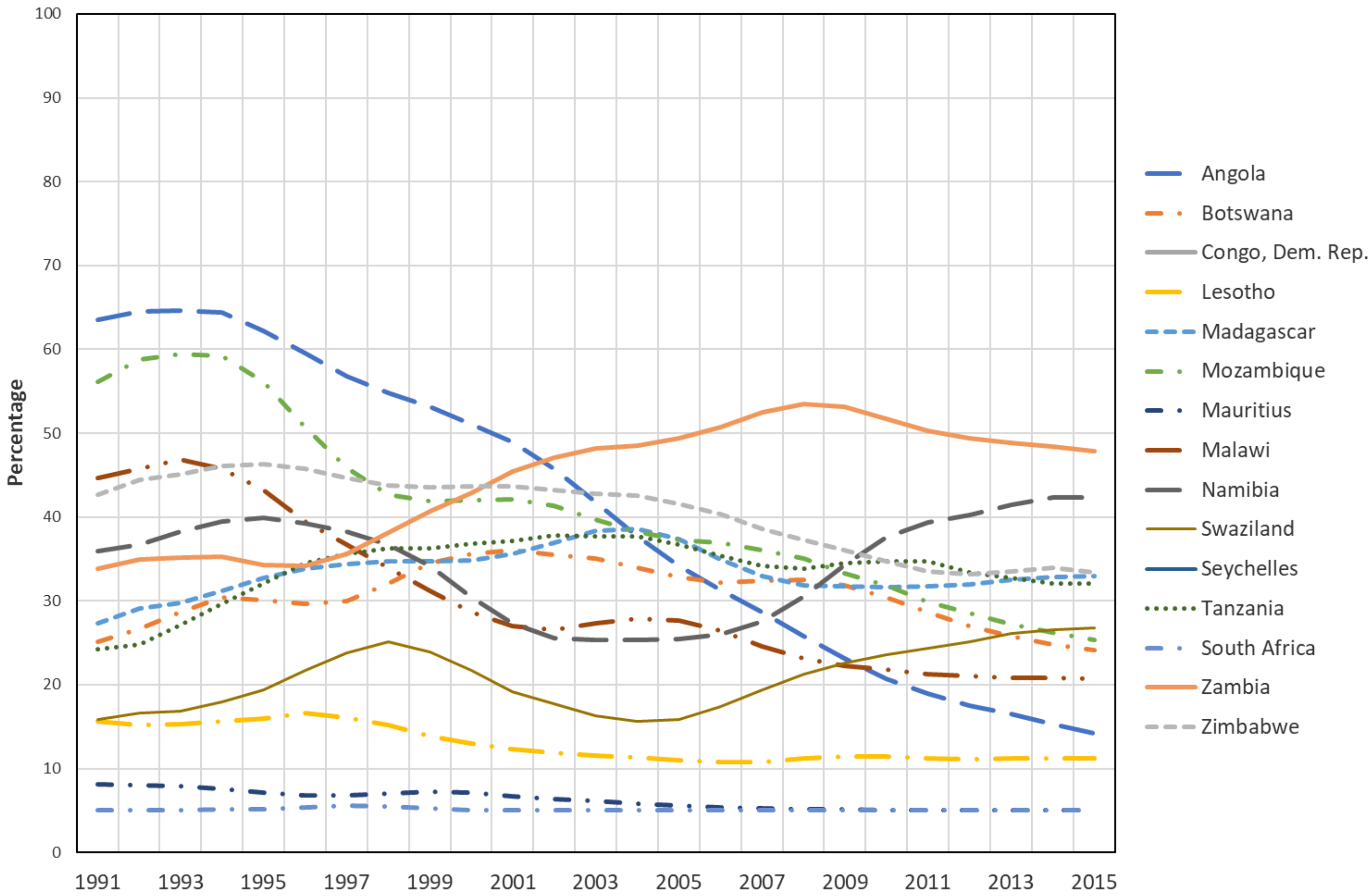


**Figure 5-15: Prevalence of undernourishment in SADC countries: 1991 and 2015 (World Bank, 2018b)**

**Table 5-4: WEF Nexus Index sub-pillar values for South Africa**

| Water-Access | Water-Availability | Energy-Access | Energy-Availability | Food-Access | Food-Availability |
|---|---|---|---|---|---|
| 69.3 | 41.2 | 54.6 | 63.4 | 67.6 | 40.5 |

As noted in **Sections 5.1** and **5.2**, South Africa is heavily dependent on fossil-fuel-based energy generation and is, therefore, able to provide electricity to 84.2% of its population. The "Energy-access" sub-pillar, however, relates to access to clean, affordable energy, and this indicator is reduced by South Africa's low level of renewable energy implementation and high $CO_2$ emissions. As presented in **Table 3-5**, South Africa is the fourteenth largest emitter of $CO_2$ in the world.

Regarding *Energy imports* (ind.13), South Africa has a value of -14.5% (refer to **Appendix C**) since it is self-sufficient in term of energy generation, and has a net export of 14.5% of its own energy supply, notwithstanding the fact that it imports some of its power, e.g. from the Cahora Bassa hydropower scheme in Mozambique. This indicator has been truncated at zero in order to provide an indication of the nation's independence in terms of energy security. South

Africa's electric power consumption per capita is less than a third of the United States of America's, and less than 13% of Iceland's.

In terms of the "Food-access" sub-pillar, the prevalence of undernourishment and wasting (the latter being for children under the age of five) are both relatively low at 6.1% and 2.5% respectively. The level of stunting in children under five years of age is however comparatively high at 27.4%, which within the SADC region is only lower in Zimbabwe (26.8%). Within this sub-pillar, the *Percentage of obesity in the adult population (18 years and older)* is a constituent indicator. Quite ironically, the level of obesity in South Africa in the adult population (27.0%) is almost the same as the level of stunting in children under five years of age (27.4%).

The lowest value for a sub-pillar within the WEF Nexus for South Africa is the "Food-availability" sub-pillar (40.5). Yet, within SADC this sub-pillar value is greater than all the other nation's values for this sub-pillar except Mauritius (40.7). For South Africa, the indicator that affects this sub-pillar most negatively is the *Average value of food production per capita*, at I$ 229 which is less than the average value of I$ 304 for the 170 countries assessed.

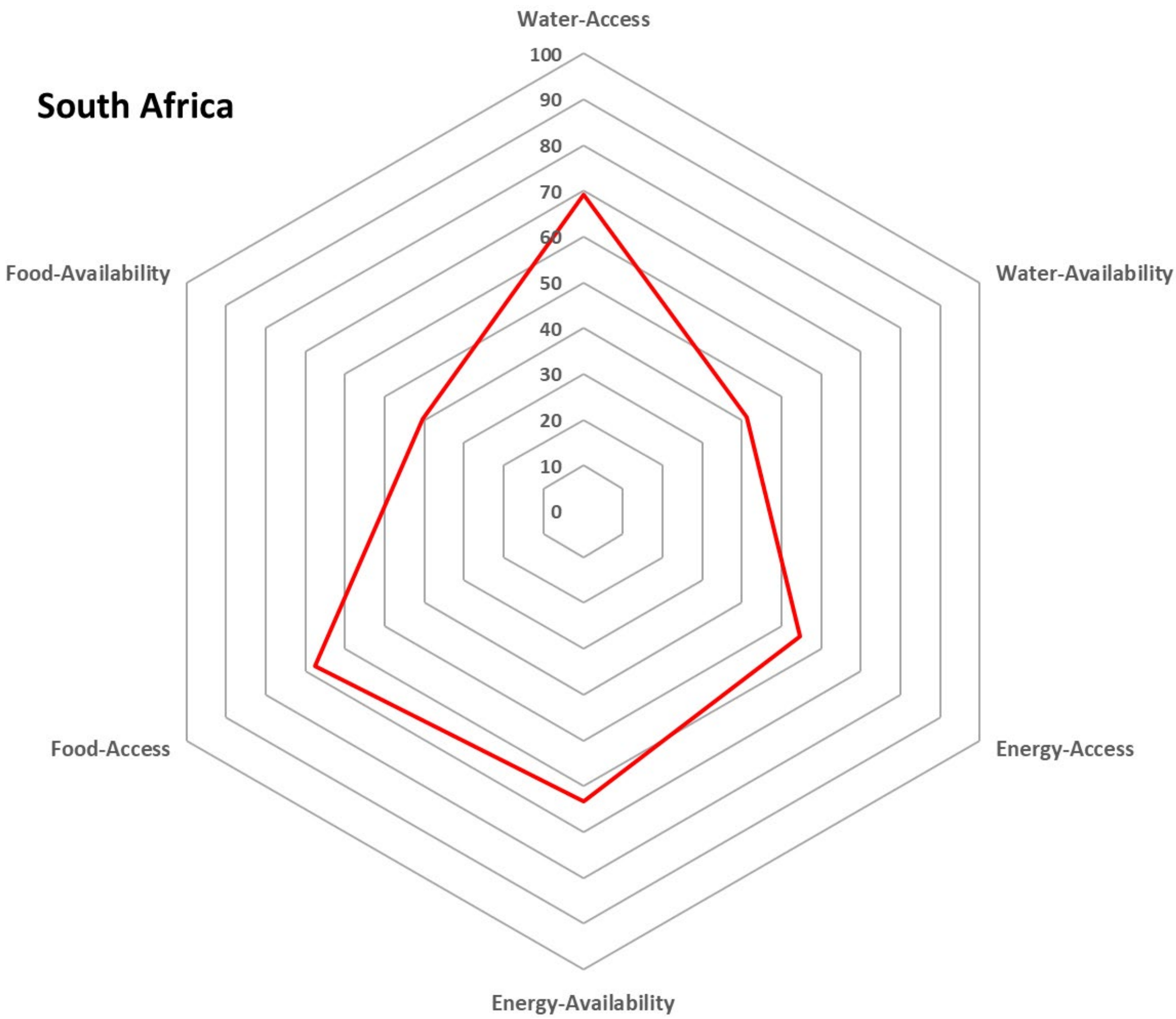


**Figure 5-16: Radar chart presenting the WEF Nexus Index sub-pillar values for South Africa**

## 5.4 WEF Nexus Index for SADC

There was adequate data at both a country and indicator level to ascertain the WEF Nexus Index for fifteen of the sixteen SADC countries. The country that did not have adequate data was Seychelles. Of the fifteen countries assessed:

- Twelve are located on the mainland, with six being landlocked nations; and
- Three are island states, namely Comoros, Mauritius and Madagascar, with the latter being the fourth largest island in the world.

The ranking of SADC countries in terms of the WEF Nexus Index is presented in **Table 5-5**, with South Africa being ranked in $72^{nd}$ position while Madagascar is $165^{th}$. The WEF Nexus Index values are presented graphically in **Figure 5-17**. The treated data is presented in the dashboard contained in **Table 5-6**, while **Table 5-7** presents the untreated data for the fifteen SADC countries assessed. Five of these nations are ranked in the bottom twenty nations for this composite indicator (refer to **Table 4-6**). A radar chart of the WEF Nexus Index sub-pillars for the SADC countries is presented in **Figure 5-18**. Individual radar charts for each of the fifteen SADC nations analysed are provided in **Appendix D**.

**Table 5-5: WEF Nexus Index ranking and index values for fifteen SADC countries**

| Country | WEF Nexus Index | Rank |
|---|---|---|
| Angola | 45.8 | 124 |
| Botswana | 42.1 | 136 |
| Comoros | 34.3 | 161 |
| Congo, Dem. Rep. | 39.5 | 141 |
| Eswatini | 39.7 | 140 |
| Lesotho | 37.9 | 151 |
| Madagascar | 32.9 | 165 |
| Malawi | 37.7 | 152 |
| Mauritius | 52.3 | 100 |
| Mozambique | 45.6 | 126 |
| Namibia | 33.4 | 163 |
| South Africa | 56.1 | 72 |
| Tanzania | 41.3 | 138 |
| Zambia | 45.3 | 127 |
| Zimbabwe | 42.4 | 135 |

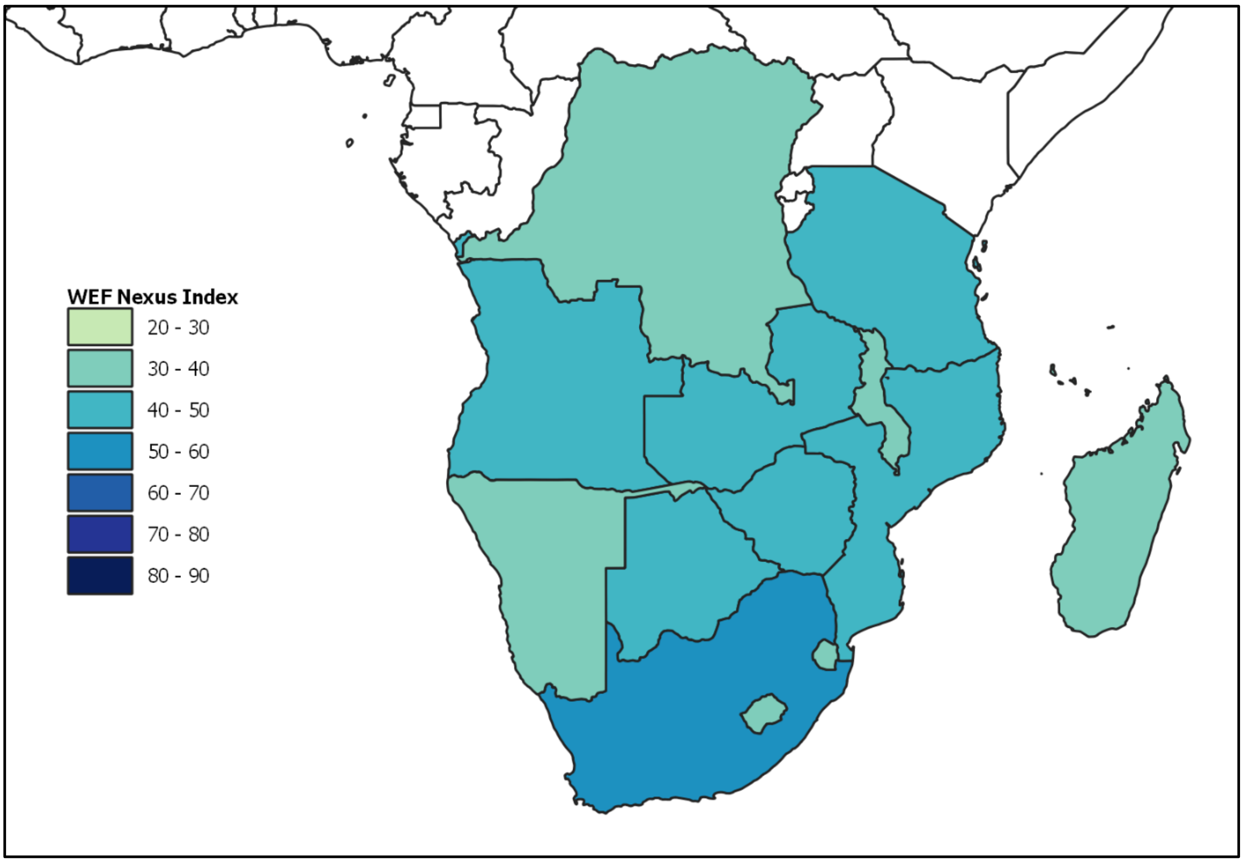


**Figure 5-17: Map of SADC countries presenting the relative WEF Nexus Index values**

In terms of the "Water-access" sub-pillar, Mauritius has, by some margin, the highest percentage of people having access to at least basic drinking water services and safely managed sanitation (99.9% and 93.1% respectively). South Africa and Botswana have a moderate level of service delivery related to both SDG indicators, while several of the other nations have very poor levels of provision of both amenities (or they score well for one, and poorly for the other, e.g. Comoros). Regarding indicator "ind.03", only South Africa (65.5%), Mauritius (64.4%), Zimbabwe (61.0%) and Namibia (59.1%) have reasonable levels of implementation of IWRM. Mauritius has the highest "Water-access" sub-pillar value at 84.1 while South Africa's is 69.3.

*Annual freshwater withdrawals* is a crucial indicator of potential future water scarcity. While eleven of the fifteen SADC nations analysed have very low withdrawal levels (< 9%) Eswatini (39.5%) and South Africa (34.6) withdraw comparatively high volumes. Also affecting the "Water-availability" sub-pillar is the volume of rainfall that falls annually. The three countries that receive the lowest mean annual precipitation are Namibia (285 mm), Botswana (416 mm) and South Africa (495 mm). These annual rainfall depths can be contrasted with Mauritius (2041 mm), the Democratic Republic of Congo (1543 mm) and Madagascar (1513 mm). As evident from **Figure 5-18**, the Democratic Republic of Congo and Madagascar have the highest values for SADC countries for the "Water-availability" sub-pillar.

The "Energy-access" sub-pillar represents SDG 7, namely access to clean, affordable energy. Mauritius (98.8%), South Africa (84.2%) and Comoros (77.8%) provide at least three-quarters of their respective populations with electricity. In terms of *Renewable electricity output*, Lesotho (100%), the Democratic Republic of Congo (99.8%), Namibia (97.8%), Zambia (97.0%) and Malawi (91.3%) provide all, or the vast majority, of their electricity from renewable sources. South Africa's $CO_2$ emissions per capita (9.0 metric tons per capita – refer to **Table 5-7**) are significantly higher than any of the other SADC nations, despite it having a population vastly larger than Mauritius and Botswana, which have the second and third highest $CO_2$/capita values at 3.4 and 3.2 metric tons per capita respectively. Mauritius and Eswatini have the highest "Energy-access" sub-pillar values at 69.3 and 66.5 respectively.

With its vast coal reserves and thirteen coal-fired power stations, South Africa is self-sufficient in terms of power generation, despite it importing additional capacity. Its *Electric power consumption per capita* is relatively low (4 198 kWh/capita) when compared to first world countries (e.g. Iceland, 53 832 kWh/capita), but is almost twice as much as the next highest SADC country, i.e. Mauritius (2 183 kWh/capita). Ironically, Mozambique exports power to South Africa, yet only 24.2% of its population has access to electricity.


**Figure 5-18: Radar chart of the WEF Nexus Index sub-pillars for the SADC countries**

The SADC country with the highest value for the “Food-access” sub-pillar is Lesotho, followed by Malawi and South Africa. This is because although South Africa has lower levels of undernourishment, wasting and stunting than Lesotho or Malawi, South Africa has a comparatively high level of obesity in their adult population (27.4%). The SADC country with the second and third highest percentages of their adult population with obesity are Botswana (16.1%) and Namibia (15.0%). Five SADC nations do not currently report on the level of stunting for children under five years of age, namely, Mauritius, Tanzania, Eswatini, the Democratic Republic of Congo and Namibia.

The dashboard in **Table 5-6** shows that for the “Food-availability” sub-pillar (ind.18 to ind.21) most of the countries fair very poorly, with only Mauritius and South Africa performing moderately well. An example of this is the *Cereal yield* indicator, where the maximum yield in SADC nations is less than 4000 kg/ha per country (in seven nations it is less than 1000 kg/ha). Several first world countries achieve more than double the maximum cereal yield that SADC countries have reported (refer to **Appendix C**). Examples in this regard include New Zealand (8 384 kg/ha), Ireland (8 223 kg/ha) and the United States of America (8 143 kg/ha). The *Average value of food production* is similarly comparatively low in SADC nations, with the highest value being I$ 237 in Eswatini. These values are significantly lower than those achieved in the Netherlands (I$ 2425), Uruguay (I$ 1152), Denmark (I$ 1067), Argentina (I$ 1030) and Australia (I$ 1009).

In evaluating a composite indicator, it is essential to ascertain if there is any correlation with other related indicators. To this end, the WEF Nexus Index has been plotted on the same set of axes as the SDG Index and the HDI for the SADC countries, in **Figures 5-19** and **5-20** respectively. These two figures contain the same data as for **Figure 4-2** and **4-3**, but only the data for the SADC nations are presented. In the plot of the SDG Index against the WEF Nexus Index for SADC countries, all fifteen countries have SDG Indices that are higher than their corresponding WEF Nexus Index. This suggests that these nations tend to perform better in the remaining fourteen SDGs than in the three represented by the WEF Nexus Index, i.e. SDGs 2, 6 and 7. Nations that outrank a certain nation for the SDG Index do not necessarily outrank it for the WEF Nexus Index, e.g. Mauritius and South Africa, Zambia and Botswana, or the Democratic Republic of Congo and Madagascar.

A similar pattern emerges for the plot of the HDI against the WEF Nexus Index (**Figure 5-20**), with Mozambique being the only country that has a higher WEF Nexus Index than HDI. This nation does have the lowest HDI out of all the SADC countries assessed and ranks 180$^{th}$ out of 189 countries in the UNDP (2018) report. All nine of the nations ranking lower than Mozambique for the HDI are African, which emphasises the development backlog on this continent. As with the relationship with the SDG Index, several nations that outrank another country for one composite indicator do not necessarily outrank it for another, with many of the same relationships being true for these two indices, i.e. Mauritius and South Africa, Zambia and Botswana, or the Democratic Republic of Congo and Madagascar.

## Table 5-6: WEF Nexus Index Dashboard (with treated data) for the SADC countries

| | | Water Sub-index | | | | | | | Energy Sub-index | | | | | | Food sub-index | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements ($10^6$ $m^3$/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | $CO_2$ emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| **Rank** | **Country** | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
| 72 | South Africa | 75.9 | 71.0 | 61.0 | 65.4 | 51.0 | 34.7 | 13.8 | 82.7 | 17.9 | 2.3 | 59.6 | 26.8 | 100.0 | 91.9 | 90.2 | 46.6 | 42.6 | 41.0 | 44.3 | 55.7 | 21.1 |
| 100 | Mauritius | 99.8 | 92.6 | 59.7 | 73.7 | 58.4 | n/a | 62.3 | 98.7 | 12.0 | 22.7 | 85.1 | 13.8 | 14.3 | 92.4 | n/a | n/a | 78.3 | 47.2 | 39.9 | 58.2 | 17.4 |
| 124 | Angola | 6.9 | 34.8 | 28.9 | 99.5 | 65.4 | 53.7 | 30.0 | 34.8 | 51.7 | 53.2 | 94.4 | 1.8 | 100.0 | 62.5 | 79.5 | 25.8 | 89.2 | 19.4 | 9.2 | 36.7 | 12.4 |
| 126 | Mozambique | 16.9 | 17.8 | 48.7 | 99.1 | 62.4 | 55.8 | 30.7 | 16.9 | 90.2 | 86.4 | 98.8 | 2.7 | 100.0 | 51.7 | 74.1 | 14.5 | 91.0 | 11.8 | 7.9 | 34.2 | 8.7 |
| 127 | Zambia | 38.8 | 25.8 | 39.1 | 98.1 | 64.9 | 44.6 | 30.3 | 20.2 | 91.8 | 97.0 | 98.9 | 4.3 | 91.6 | 28.5 | 73.2 | 20.9 | 89.9 | 11.8 | 27.3 | 17.7 | 10.6 |
| 135 | Zimbabwe | 47.3 | 33.9 | 55.9 | 70.9 | 50.7 | 26.6 | 18.9 | 32.2 | 85.4 | 52.7 | 96.7 | 3.2 | 84.5 | 25.1 | 87.1 | 47.9 | 76.5 | 23.6 | 4.9 | 10.1 | 6.6 |
| 136 | Botswana | 67.2 | 56.9 | 33.5 | 91.9 | 53.3 | 14.7 | 11.3 | 56.9 | 30.1 | 0.0 | 85.5 | 11.0 | 54.9 | 55.0 | 69.2 | 38.4 | 67.7 | 27.8 | 3.3 | 24.1 | 15.7 |
| 138 | Tanzania | 21.3 | 17.7 | n/a | 93.8 | 56.1 | 46.1 | 31.9 | 26.3 | 89.5 | 34.2 | 99.2 | 0.4 | 89.1 | 49.2 | 81.3 | n/a | 95.4 | 15.3 | 16.6 | 34.2 | 17.7 |
| 140 | Eswatini | 48.9 | 54.8 | 46.4 | 60.5 | 57.9 | 16.1 | 23.0 | 62.5 | 69.0 | 46.6 | 96.0 | n/a | n/a | 67.8 | 92.4 | n/a | 73.7 | 13.9 | 11.7 | 30.4 | 21.8 |
| 141 | Congo, Dem. Rep. | 8.2 | 13.6 | 22.4 | 99.9 | 71.5 | 78.4 | 46.7 | 9.1 | 100.0 | 99.8 | 100.0 | 0.4 | 98.0 | n/a | 65.2 | n/a | 91.9 | n/a | 7.2 | n/a | 4.3 |
| 151 | Lesotho | 55.2 | 39.5 | 24.2 | 99.2 | 59.3 | 9.4 | 23.0 | 22.9 | 54.4 | 100.0 | 95.0 | n/a | n/a | 80.9 | 88.8 | 34.8 | 73.7 | 5.6 | 4.0 | 44.3 | 6.4 |
| 152 | Malawi | 48.3 | 39.2 | 32.5 | 91.6 | 52.1 | 26.8 | 35.3 | 2.4 | 87.3 | 91.3 | 99.9 | n/a | n/a | 58.6 | 89.3 | 26.8 | 94.0 | 10.4 | 14.3 | 31.6 | 12.6 |
| 161 | Comoros | 74.3 | 29.2 | 16.1 | 99.2 | 56.0 | n/a | 26.5 | 75.7 | 47.3 | n/a | 99.3 | n/a | n/a | n/a | 51.8 | 37.0 | 88.9 | n/a | 14.4 | 32.9 | 8.0 |
| 163 | Namibia | n/a | n/a | 53.8 | 95.4 | 59.7 | 23.9 | 7.2 | 47.1 | 27.6 | 97.8 | 93.1 | 10.0 | 24.6 | 60.1 | n/a | n/a | 70.3 | 17.4 | 3.4 | 24.1 | 15.3 |
| 165 | Madagascar | 22.1 | 2.8 | 28.2 | 96.0 | 72.7 | 61.3 | 45.8 | 15.4 | 73.2 | 54.6 | 99.7 | n/a | n/a | 30.9 | 33.5 | 2.0 | 94.5 | 0.0 | 45.6 | 12.7 | 12.4 |

**Legend**

| | |
|---|---|
| 12.7 | : values between 0 and 25 |
| 31.4 | : values between 25 and 50 |
| 61.3 | : values between 50 and 75 |
| 78.9 | : values between 75 and 100 to 25 |

**Table 5-7: Untreated data for indicators that constitute the WEF Nexus Index for SADC countries**

| | Water Sub-Index | | | | | | | Energy Sub-Index | | | | | | Food Sub-index | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
| | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements (106 m3/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | CO2 emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| Angola | 41.0 | 39.4 | 37.1 | 0.48 | 5498 | 110.7 | 1010 | 40.5 | 49.6 | 53.2 | 1.3 | 312 | -541.0 | 23.9 | 4.9 | 37.6 | 6.8 | 52.0 | 935 | 108 | 137 |
| Botswana | 79.2 | 60.0 | 41.1 | 8.1 | 1107 | 2.7 | 416 | 60.7 | 28.9 | 0.0 | 3.2 | 1749 | 44.5 | 28.5 | 7.2 | 31.4 | 16.1 | 64.0 | 453 | 98 | 172 |
| Comoros | 83.7 | 34.2 | 25.7 | 0.8 | 1580 | n/a | 900 | 77.8 | 45.3 | n/a | 0.2 | n/a | n/a | n/a | 11.1 | 32.1 | 6.9 | n/a | 1356 | 105 | 90 |
| Congo, Dem. Rep. | 41.8 | 19.7 | 31.3 | 0.08 | 12208 | 981.7 | 1543 | 17.1 | 95.8 | 99.8 | 0.1 | 109 | 2.0 | n/a | 8.1 | n/a | 5.6 | n/a | 772 | n/a | 51 |
| Lesotho | 71.6 | 43.8 | 32.9 | 0.8 | 2437 | 1.3 | 788 | 29.7 | 52.1 | 100.0 | 1.2 | n/a | n/a | 12.8 | 2.8 | 33.2 | 13.5 | 32.0 | 508 | 114 | 73 |
| Madagascar | 50.6 | 9.7 | 36.5 | 4.02 | 14286 | 217.5 | 1513 | 22.9 | 70.2 | 54.6 | 0.1 | n/a | n/a | 43.1 | 15.2 | 49.2 | 4.5 | 24.0 | 3920 | 89 | 137 |
| Malawi | 67.2 | 43.5 | 40.3 | 8.4 | 946 | 9.5 | 1181 | 11.0 | 83.6 | 91.3 | 0.1 | n/a | n/a | 26.3 | 2.7 | 37.1 | 4.7 | 39.0 | 1347 | 104 | 139 |
| Mauritius | 99.9 | 93.1 | 64.4 | 26.4 | 2182 | n/a | 2041 | 98.8 | 11.5 | 22.7 | 3.4 | 2183 | 84.5 | 5.8 | n/a | n/a | 11.5 | 92.0 | 3455 | 125 | 190 |
| Mozambique | 47.3 | 23.6 | 54.6 | 0.9 | 3686 | 133.0 | 1032 | 24.2 | 86.4 | 86.4 | 0.3 | 463 | -54.6 | 30.5 | 6.1 | 43.1 | 6.0 | 41.0 | 824 | 106 | 97 |
| Namibia | n/a | n/a | 59.1 | 4.6 | 2598 | 7.2 | 285 | 51.8 | 26.5 | 97.8 | 1.6 | 1585 | 74.4 | 25.4 | n/a | n/a | 15.0 | 49.0 | 453 | 98 | 168 |
| South Africa | 84.7 | 73.1 | 65.5 | 34.6 | 821 | 20.1 | 495 | 84.2 | 17.2 | 2.3 | 9.0 | 4198 | -14.5 | 6.1 | 2.5 | 27.4 | 27.0 | 83.0 | 3810 | 123 | 229 |
| Eswatini | 67.6 | 58.0 | 52.6 | 39.5 | 2038 | 3.1 | 788 | 65.8 | 66.1 | 46.6 | 0.9 | n/a | n/a | 20.7 | 2.0 | n/a | 13.5 | 44.0 | 1138 | 103 | 237 |
| Tanzania | 50.1 | 23.5 | n/a | 6.2 | 1608 | 56.3 | 1071 | 32.8 | 85.7 | 34.2 | 0.2 | 99 | 10.7 | 32.0 | 4.5 | n/a | 4.1 | 46.0 | 1541 | 106 | 193 |
| Zambia | 61.2 | 31.1 | 46.1 | 2.0 | 5134 | 49.4 | 1020 | 27.2 | 88.0 | 97.0 | 0.3 | 707 | 8.3 | 44.5 | 6.3 | 40.0 | 6.5 | 41.0 | 2418 | 93 | 118 |
| Zimbabwe | 66.6 | 38.6 | 61.0 | 29.1 | 796 | 9.3 | 657 | 38.1 | 81.8 | 52.7 | 0.8 | 537 | 15.3 | 46.6 | 3.2 | 26.8 | 12.3 | 58.0 | 580 | 87 | 75 |

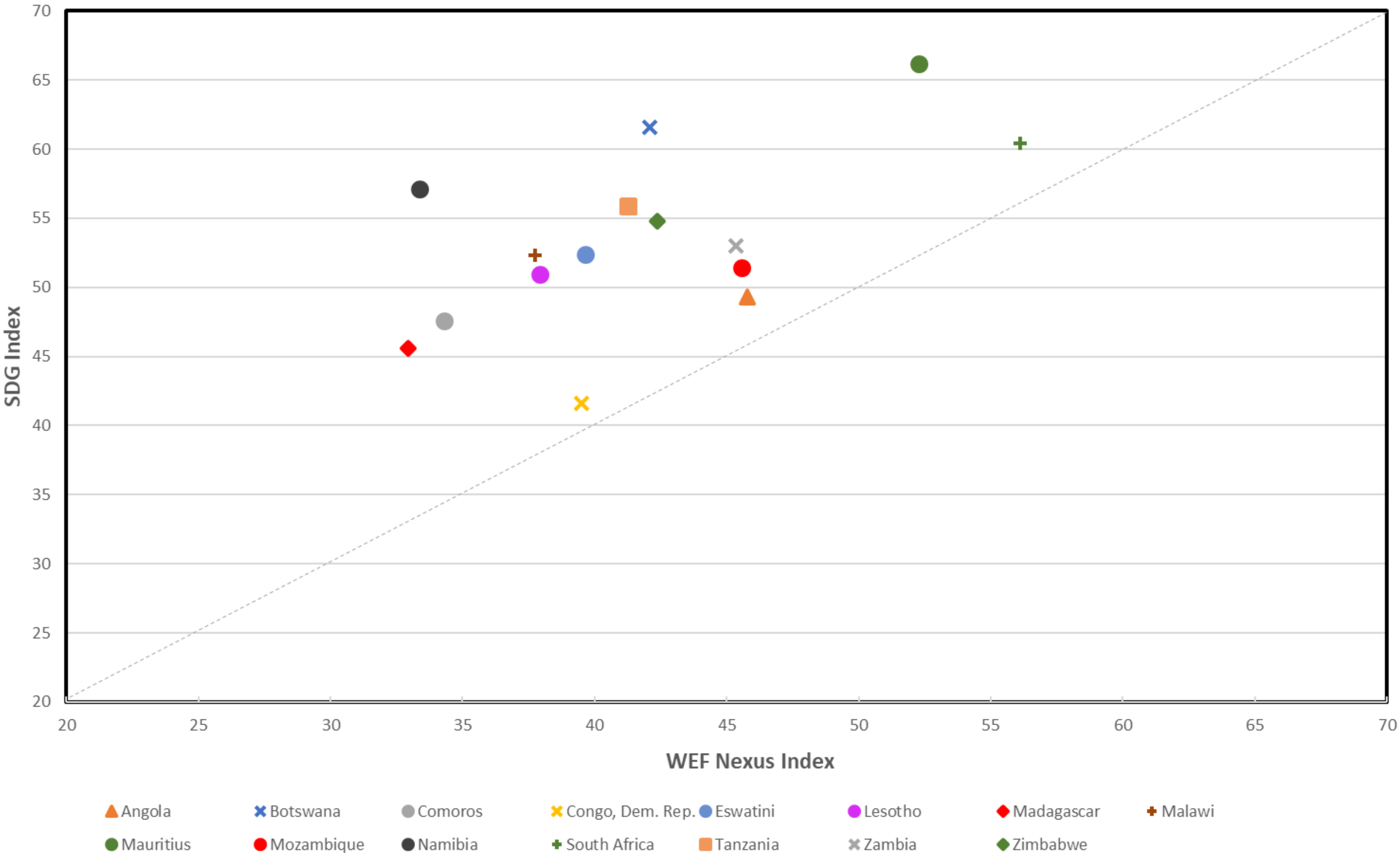


**Figure 5-19: Plot of SDG Index (Sachs et al., 2018) against the WEF Nexus Index for the SADC nations**

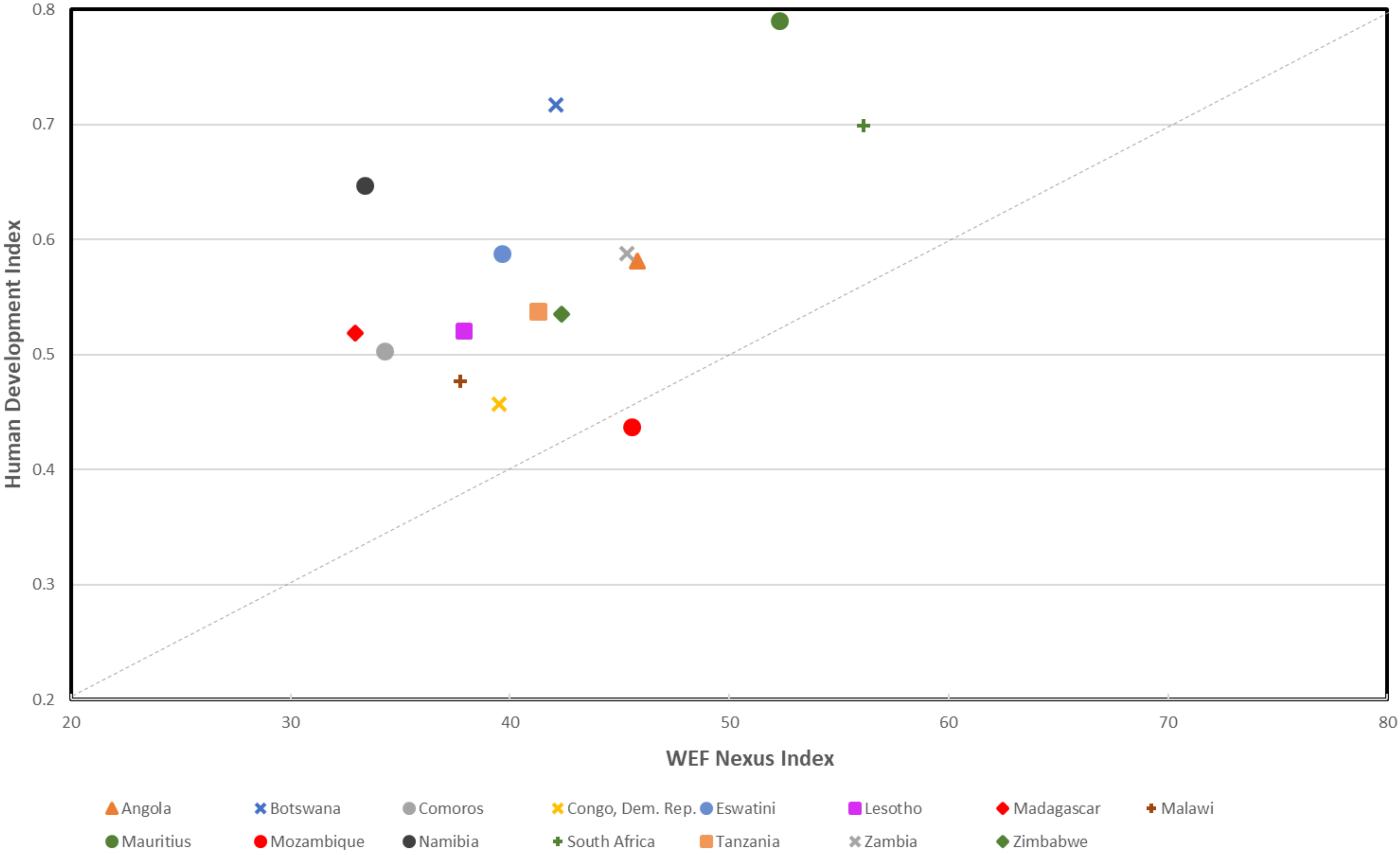


**Figure 5-20: Plot of Human Development Index (UNDP, 2018) against the WEF Nexus Index for SADC countries**

# 6 CONCLUSIONS

The goals of this project were (i) to present the development of the WEF Nexus Index and (ii) to apply this composite indicator to South Africa and SADC. Regarding the development of the composite indicator, a systematic approach following the ten-step guide set out by JRC-COIN has been followed, and an effort has been made to be transparent in the presentation of both the process and the results.

In this report, the background and context of the WEF nexus have been presented. An anthropocentric WEF nexus framework, which includes SDGs 2, 6 and 7 has been designed to guide the construction of the composite indicator.

A total of 87 indicators relevant to the WEF nexus were identified and subsequently reviewed in detail to ascertain their relevance and data coverage (at both a country and indicator level). Following an iterative process wherein the correlation of indicators with one another was assessed, together with a review of the conceptual reason for including each indicator, a total of 21 indicators were selected for inclusion in the WEF Nexus Index. They included seven water-, six energy- and eight food-related indicators. Adequate data were available for the WEF Nexus Index to be calculated for 170 countries. In the development of the composite indicator the three pillars – water, energy and food – were weighted equally. This is necessary to ensure that the multi-centric philosophy of the WEF nexus approach is preserved in the construction of the WEF Nexus Index. Each pillar included sub-pillars relating to “Access” and “Accessibility” associated with that resource sector.

Once the results of the WEF Nexus Index were determined, these results were plotted on two separate graphs against the SDG Index and the HDI. The R-squared values for the two plots are 0.72 and 0.66 respectively. If these R-squared values exceeded 0.9, then the WEF Nexus Index would be rendered redundant since the existing indices and the WEF Nexus Index would be providing the same results. These graphs, however, yield interesting insights. In the plot of the HDI versus the WEF Nexus Index, for example, countries that plot above the regression line typically have living standards (or levels of development) that exceed their respective domestic resource base (as represented by “Access” and “Availability” associated with the WEF Nexus Index). The opposite is true of nations that plot below the regression line. By following the JRC-COIN process the development of this proposed composite indicator has been both sensible and transparent, and if the results are utilised responsibly, it can contribute to the sustainable development and integrated resource management discourse.

The top twenty ranking nations for the WEF Nexus Index are dominated by first-world countries, with Norway, New Zealand and Sweden ranking highest. Five South American countries feature in the top twenty, with Brazil being the highest of these. One Asian nation (Malaysia) features in the top twenty, while no African nations make this list. Three-quarters of the bottom twenty ranking nations are from Africa.

South African ranks 72$^{nd}$ of the 170 nations assessed. While South Africa ranked highly in terms of its “Water-access” and “Food-access” sub-pillars, it performed relatively poorly in terms of the two associated “Availability” sub-pillars. Similarly, although the proportion of South Africans with access to electricity is relatively high, much of this energy is generated by burning fossil fuels. Because of this, this country has a relatively high level of $CO_2$ emissions. The “Energy-Access” sub-pillar is linked to SDG 7, and the comparatively high level of access to electricity is to a large degree nullified in this sub-pillar by the high emissions and low level of renewable energy adoption in this country.

The ranking of SADC countries in terms of the WEF Nexus Index has South Africa ranked in the highest position, while Madagascar is 162nd. With much of the developed world having built their nations on the foundation of fossil-fuel-based energy generation, it is evident that the general absence of coal in Africa outside of South Africa has hindered its development. Ironically, much of the world is moving away from coal-fired power generation, but they can do so because they have reached the point where they can afford to do so. The three resource sectors are interconnected, but it is evident that many SADC nations are not utilising their available freshwater (this does not include South Africa, Zimbabwe, Mauritius and Eswatini). This is to a large degree because these nations do not have sufficient access to affordable energy to advance both agricultural and economic development. The "Food-availability" sub-pillar is generally the poorest performing sub-pillar within the WEF Nexus Index for SADC countries.

In SADC, amongst other factors such as access to land ownership and good governance, large scale access to affordable, modern, scalable, clean energy will be essential as an enabler for economic development. When electricity is available, water can be pumped, treated and used for irrigation. Energy enables the harvesting, storage and processing of food. Power systems are however expensive, even with the constantly plummeting cost of renewables. This points to all the SDGs being intimately linked (Rockström and Sukhdev, 2016), since unless SDG 8 is achieved, i.e. decent work and economic growth, the electricity cannot be paid for. If it was a simple problem, then it would have been solved already. The SDGs are indeed noble goals, but unless a concerted effort is made by all stakeholders, both within and outside of Africa, 2030 will pass with SADC lagging behind in the global effort to attain sustainability.

# 7 RECOMMENDATIONS

South Africa has 95% of the continent's proven coal reserves and is the seventh-largest producer and sixth largest consumer of coal in the world. Many of the objections raised against coal-fired power stations are based on the $CO_2$ emissions that they contribute to climate change. Climate change is however intangible to many people in their day-to-day lives. What this WEF nexus project and associated work (Simpson et al., 2019) has highlighted is that coal mining has several other negative impacts. In South Africa, this relates primarily to the pollution of water resources and the progressive depletion of arable land, especially high potential arable land, as a result of large-scale coal mining. Coupled with this are the health impacts resulting from both coal mining and fossil-fuel based power stations. It is hereby proposed that South Africa's Department of Mineral Resources and energy accelerate the just transition to a low(er) carbon economy. To this end the Draft IRP 2018 scenario "IRP1" represents the least-cost, the lowest $CO_2$ emissions and the joint-lowest water use. Further, it is proposed that the National Government, the Department of Mineral Resources and Energy, Eskom and Municipalities remove obstacles and provide incentives for distributed, small-scale embedded generation (SSEG) at both household and business levels. This includes a change in how some municipalities charge businesses a set rate and peak charge for delivering power to their property, with no incentive or benefit for either reducing electricity usage or adopting SSEG. Separate proposed policy recommendations relating to South Africa and SADC are contained in **Appendix H**.

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# Appendix A: Indicator Selection Table

## Appendix A: WEF Nexus Index – Indicator selection table

| No. | Sector | Indicator | Definition[14] | Source | Units | Data availability | SDG Indicator? (Y/N) | Reason/motivation for inclusion/exclusion |
|---|---|---|---|---|---|---|---|---|
| 1 | Water (SDG 6) | The percentage of people using at least basic drinking water services | This indicator encompasses both people using basic water services as well as those using safely managed water services. Basic drinking water services are defined as drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip. Improved water sources include piped water, boreholes or tube wells, protected dug wells, protected springs, and packaged or delivered water (*FAO.org 2018, Accessed 2019-03-01*). | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk **Source:** World Bank: http://data.worldbank.org/indicator/SH.H2O.BASW.ZS. **Original source:** WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply, Sanitation and Hygiene (washdata.org). Accessed 2019-03-01 | % | 2015 Very good data coverage. The indicator is utilised in SDG Index for SDG 6 | No, but 6.1.1 (Proportion of population using safely managed drinking water services) and 6.3.2 are SDG indices. It is FAO indicator I_4.1 | **Yes**; very good data, and the indicator is relevant to SDG 6. Alternative to official indicator 6.1.1 since it has better data coverage for many nations |
| 2 | Water (SDG 6) | People using safely managed drinking water services | The percentage of the population using drinking water from an improved water source which is located on premises, available when needed and free from faecal and priority chemical contamination (*FAO.org 2018, Accessed 2019-03-01*) | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk **Source:** World Bank: http://data.worldbank.org/indicator/SH.H2O.SMDW.ZS **Original source:** World Health Organization and United Nations Children's Fund, Joint Measurement Programme (JMP) (http://www.wssinfo.org/). Accessed 2019-03-01 | % | 2015 Data coverage relatively sparse | Yes, 6.1.1. It is FAO indicator I_4.2 | No; rather use "The percentage of people using at least basic drinking water services" as equivalent indicator since it has better data coverage |
| 3 | Water (SDG 6) | Percentage of people using at least basic sanitation services. | The percentage of people using at least basic sanitation services, that is, improved sanitation facilities that are not shared with other households. This indicator encompasses both people using basic sanitation services as well as those using safely managed sanitation services. Improved sanitation facilities include flush/pour flush to piped sewer systems, septic tanks or pit latrines; ventilated improved pit latrines, compositing toilets or pit latrines with slabs (*FAO.org 2018, Accessed 2019-03-01*). | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk **Source:** World Development Indicators: World Bank: http://data.worldbank.org/indicator/SH.STA.BASS.ZS. **Original source:** World Health Organization and United Nations Children's Fund, Joint Measurement Programme (JMP) (http://www.wssinfo.org/). Accessed 2019-03-01 | % | 2015 Very good data coverage. The indicator is utilised in SDG Index for SDG 6 | No, but 6.2.1 and 6.3.1 are SDG indices. It is FAO indicator I_4.3 | No; very good data, and the indicator is relevant to SDG 6, but "Percentage of people using safely managed sanitation services" is an official SDG indicator, 6.2.1, and FAO lists the exact same data for the two. |
| 4 | Water (SDG 6) | Percentage of people using safely managed sanitation services. | The percentage of the population using improved sanitation facilities which are not shared with other households and where excreta are safely disposed in situ or transported and treated off-site (*FAO.org 2018, Accessed 2019-03-01*). | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk **Source:** World Development Indicators: World Bank: http://data.worldbank.org/indicator/SH.STA.SMSS.ZS. | % | 2015 Very good data coverage. Data is identical to "Percentage of people using at | Yes, 6.2.1 and it is FAO indicator I_4.4 | **Yes**; very good data coverage and indicator is an official SDG indicator |

[14] Definitions from websites listed in "Source" column of table

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| | | | | **Original source:** World Health Organization and United Nations Children's Fund, Joint Measurement Programme (JMP) (http://www.wssinfo.org/). Accessed 2019-03-01 | | least basic sanitation services." | | |
| 5 | Water (SDG 6) | Infrastructure leakage index | Performance indicator for real losses, which measures the ratio of current annual real losses to system-specific unavoidable annual real losses. It is the ideal indicator for making international comparison (Winarni, 2009). The Infrastructure Leakage Index (ILI) is a performance indicator that is used to indicate the level of Real Losses (i.e. Physical leakage) in a water distribution system (Mckenzie et al., 2012). The ILI is a non-dimensional indicator and ranges from 1 to over 100 and could be considered as an alternative to the Non-Revenue Water value. An ILI value of 1 equates to the "world's best practice" and indicates that the level of physical leakage in a system is as low as it can be, while a value of ten would indicate that the physical leakage is ten times larger than the lowest value. | | - | On an international level uniformity in measuring, interpreting or reporting of the ILI does not exist. | No | No, data not comparable on an international level |
| 6 | Water (SDG 6) | Non-Revenue Water | A measure of the municipal efficiency of water management, Non-Revenue Water is the sum of unbilled authorised water, commercial losses and real or physical losses. | | Million $m^3$/annum | On an international level uniformity in measuring, interpreting or reporting of the non-revenue water does not exist. | No | No, data not comparable on an international level |
| 7 | Water (SDG 6) | Annual freshwater withdrawals, total (% of internal resources) | Annual freshwater withdrawals refer to total water withdrawals, not counting evaporation losses from storage basins. Withdrawals also include water from desalination plants in countries where they are a significant source. Withdrawals can exceed 100 percent of total renewable resources where extraction from nonrenewable aquifers or desalination plants is considerable or where there is significant water reuse. Withdrawals for agriculture and industry are total withdrawals for irrigation and livestock production and for direct industrial use (including withdrawals for cooling thermoelectric plants). Withdrawals for domestic uses include drinking water, municipal use or supply, and use for public services, commercial establishments, and homes *(World Bank 2019-03-01)* | https://data.worldbank.org/indicator/ER.H2O.FWTL.ZS?view=chart **Source:** Food and Agriculture Organization, AQUASTAT data | % | 2002-2014 Limited data coverage. Indicator utilised in SDG Index for SDG 6. Need to use the most recent values from the database | Yes, 6.4.2 C060402 | **Yes**, this is an official SDG indicator, and utilising the most recent values from 2002-2014 a good coverage of data is obtained. This dataset will however require Winsorization in order to remove the distorting effect of outliers, and to avoid too large a space in the dataset. Data could be truncated at 200%, which represents double the available fresh water resources of the country. |

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| 8 | Water (SDG 6) | Water withdrawal in the agriculture sector | Annual quantity of self-supplied water withdrawn for irrigation, livestock and aquaculture purposes. It can include water from primary renewable and secondary freshwater resources, as well as water from over-abstraction of renewable groundwater or withdrawal from fossil groundwater, direct use of agricultural drainage water, direct use of (treated) wastewater, and desalinated water. Water for the dairy and meat industries and industrial processing of harvested agricultural products is included under industrial water withdrawal *(FAO 2019-05-25)* | http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en **Source:** Food and Agriculture Organization, AQUASTAT data | $10^9$ $m^3$ /year | Data available from 1965-2017 with many missing data per year. Most data are available for 2000 for 68 countries. | No | No, although data is available for many countries, the data is missing for many monitoring years resulting in an incomplete dataset. |
| 9 | Water (SDG 6) | Water withdrawal in the industry sector | Annual quantity of self-supplied water withdrawn for industrial uses. It can include water from primary renewable and secondary freshwater resources, as well as water from over-abstraction of renewable groundwater or withdrawal from fossil groundwater, direct use of agricultural drainage water, direct use of (treated) wastewater, and desalinated water. This sector refers to self-supplied industries not connected to the public distribution network. The ratio between net consumption and withdrawal is estimated at less than 5%. It includes water for the cooling of thermoelectric and nuclear power plants, but it does not include hydropower. Water withdrawn by industries that are connected to the public supply network is generally included in municipal water withdrawal. *(FAO 2019-05-25)* | http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en **Source:** Food and Agriculture Organization, AQUASTAT data | $10^9$ $m^3$ /year | Data available from 1965-2017 with many missing data per year. Most data are available for 2000 for 93 countries. | No | No, although data is available for many countries, the data is missing for many monitoring years resulting in an incomplete dataset. |
| 10 | Water (SDG 6) | Water withdrawal in the industry sector | Annual quantity of water withdrawn primarily for the direct use by the population. It can include water from primary renewable and secondary freshwater resources, as well as water from over-abstraction of renewable groundwater or withdrawal from fossil groundwater, direct use of agricultural drainage water, direct use of (treated) wastewater, and desalinated water. It is usually computed as the total water withdrawn by the public distribution network. It can include that part of the industries and urban agriculture, which is connected to the municipal network. The ratio between the net consumption and the water withdrawn can vary from 5 to 15% in urban areas and from 10 to 50% in rural areas. *(FAO 2019-05-25)* | http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en **Source:** Food and Agriculture Organization, AQUASTAT data | $10^9$ $m^3$ /year | Data available from 1965-2017 with many missing data per year. Most data are available for 2000 for 91 countries. | No | No, although data is available for many countries, the data is missing for many monitoring years resulting in an incomplete dataset. |
| 11 | Water (SDG 6) | Fresh groundwater withdrawal (primary and secondary) – Total | Annual gross amount of water extracted from aquifers. It can include withdrawal of renewable primary and secondary groundwater, as well as water from over-abstraction of renewable groundwater or withdrawal from fossil groundwater.*(FAO 2019-05-25)* | http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en **Source:** Food and Agriculture Organization, AQUASTAT data | $10^9$ $m^3$ /year | Data available from 1965-2017 with many missing data per year. Most data are | No | No, although data is available for many countries, the data is missing for many monitoring years |

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| | | | | | | available for 2000 for 91 countries. | | resulting in an incomplete dataset. |
| 12 | Water (SDG 6) | Desalinated water produced | Water produced annually by desalination of brackish or salt water. It is estimated annually on the basis of the total capacity of water desalination installations.*(FAO 2019-05-25)* | http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en **Source:** Food and Agriculture Organization, AQUASTAT data | $10^9$ $m^3$ /year | Data available from 1980-2015 with many missing data per year. Most data are available for 2000 for 49 countries. | No | No, although data is available for many countries, the data is missing for many monitoring years resulting in an incomplete dataset. |
| 13 | Water (SDG 6) | Treated municipal water | Treated wastewater (primary, secondary and tertiary) annually produced by municipal wastewater treatment facilities in the country.<br>Primary treatment: municipal wastewater effectively treated by a physical and/or chemical process involving settlement of suspended solids, or other process in which the BOD5 of the incoming wastewater is reduced by at least 20% and the total suspended solids of the incoming wastewater are reduced by at least 50% before discharge. Treatment processes can include: sedimentation tank, septic tank, skimming, chemical enhanced primary treatment.<br>Secondary treatment: municipal wastewater effectively treated by a process generally involving biological treatment with a secondary settlement or other process, resulting in a BOD removal of at least 70% and a COD removal of at least 75% before discharge. Treatment processes can include: aerated lagoon, activated sludge, up-flow anaerobic sludge blanket, trickling filters, rotating biological contactors, oxidation ditch, settling basin digester. For the purpose of this database natural biological treatment processes are also considered under secondary treatment as the constituents of the effluents from this type of treatment is similar to the conventional secondary treatment. Natural biological treatment refers to the process other than conventional wastewater treatment (primary, secondary, tertiary). This treatment makes use of natural bio-chemical processes to treat wastewater and can include: waste stabilization pond, constructed wetlands, overland treatment, nutrient film techniques, soil aquifer treatment, high-rate algal pond, floating aquatic macrophyte systems.<br>Tertiary treatment: municipal wastewater effectively treated by a process in addition to secondary treatment of nitrogen and/or phosphorous and/or any other specific pollutant affecting the quality or a specific use of water: microbiological pollution, colour, etc. This treatment is meant to remove at least 95% for | http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en **Source:** Food and Agriculture Organization, AQUASTAT data | $10^9$ $m^3$ /year | Data available from 1967-2017 with many missing data per year. Most data are available for 2012 for 25 countries. | No | No, although data is available for many countries, the data is missing for many monitoring years resulting in an incomplete dataset. |

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| | | | BOD and 85% for COD and/or a nitrogen removal of at least 70% and/or a phosphorus removal of at least 80% and/or a microbiological removal. Treatment process can include: membrane filtration (micro-; nano-; ultra- and reverse osmosis), infiltration / percolation, activated carbon, disinfection (chlorination, ozone, UV). ..*(FAO 2019-05-25)* | | | | | |
| 14 | Water (SDG 6) | Direct use of treatment municipal water | Treated municipal wastewater (primary, secondary, tertiary effluents) directly used, i.e. with no or little prior dilution with freshwater during most of the year. | http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en **Source:** Food and Agriculture Organization, AQUASTAT data | $10^9$ $m^3$ /year | Data available from 1967-2013 with many missing data per year. Most data are available for 2000 for 15 countries. | No | No, although data is available for many countries, the data is missing for many monitoring years resulting in an incomplete dataset. |
| 15 | Water (SDG 6) | Environmental flow requirements | The quantity and timing of freshwater flows and levels necessary to sustain aquatic ecosystems which, in turn, support human cultures, economies, sustainable livelihoods, and wellbeing" (Adapted from Arthington, A.H., et al., 2018). | http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en **Source:** Food and Agriculture Organization, AQUASTAT data | $10^9$ $m^3$ /year | Data available from 1962-2017 with many missing data per year. Most data are available for 2017 for 154 countries. | No | Yes, it is important that water's contribution required for sustaining the environment is taken into account. Good correlation with renewable internal fresh water resources (0.58) |
| 16 | Water (SDG 6) | Percentage of area equipped for irrigation by surface water | Area equipped for irrigation irrigated by surface water as percentage of the total area equipped for irrigation | http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en **Source:** Food and Agriculture Organization, AQUASTAT data | % | Data available from 1962-2014 with many missing data per year. Most data are available for 1994 for 19 countries. | No | No, although data is available for many countries, the data is missing for many monitoring years resulting in an incomplete dataset. |
| 17 | Water (SDG 6) | Percentage of area equipped for irrigation by ground water | Equipped for irrigation area irrigated by groundwater as percentage of the total equipped for irrigation area. | http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en **Source:** Food and Agriculture Organization, AQUASTAT data | % | Data available from 1962-2014 with many missing data per year. Most data are available for 1994 for 17 countries. | No | No, although data is available for many countries, the data is missing for many monitoring years resulting in an incomplete dataset. |
| 18 | Water (SDG 6) | Percentage of total grain production irrigated | Percent of the total grain production of the country (rainfed and irrigated) that is irrigated in a given year, expressed in percentage. | http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en **Source:** Food and Agriculture Organization, AQUASTAT data | % | Data available from 1984-1995 with many missing data per year. Most data are available for 1994 for 13 countries. | No | No, although data is available for many countries, the data is missing for many monitoring years resulting in an incomplete dataset. |
| 19 | Water (SDG 6) | Renewable internal freshwater resources per capita (cubic meters) | Renewable internal freshwater resources flows refer to internal renewable resources (internal river flows and groundwater from rainfall) in the country. Renewable internal freshwater resources per capita are calculated | https://data.worldbank.org/indicator/ER.H2O.INTR.PC?view=chart **Source:** Food and Agriculture Organization, AQUASTAT data | $m^3$/capita | 2014 Very good data coverage | No | **Yes**, very good data coverage, and the "per capita" unit provides a helpful measure |

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| | | | using the World Bank's population estimates (*World Bank 2019-03-01*). | | | | | between countries with an indicator of relative scarcity. Good correlation with annual fresh water resources, but not too high to warrant exclusion (0.78) |
| 20 | Water (SDG 6) | Renewable internal freshwater resources, total (billion cubic meters) | Renewable internal freshwater resources flows refer to internal renewable resources (internal river flows and groundwater from rainfall) in the country (World Bank 2019-03-04). | https://data.worldbank.org/indicator/ER.H2O.INTR.K3?view=chart **Source:** Food and Agriculture Organization, AQUASTAT data | Billion $m^3$ | 2014 Very good data coverage | No | No, this is the same data as the "Renewable internal freshwater resources per capita (cubic meters)" but as a quantum instead of per capita |
| 21 | Water (SDG 6) | Hydropower electricity capacity (MW) | Hydropower and renewable hydropower | https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Technologies **Source**: Source: IRENA (2019), Renewable capacity statistics 2019; and IRENA (2018), Renewable Energy Statistics 2018, The International Renewable Energy Agency, Abu Dhabi. | MW | Data available from 2000-2018 with minimal missing data per year. Most data are available for 2018 for 159 countries. | No | No, this data is included in the renewable energy consumption and output indicators |
| 22 | Water (SDG 6) | Hydropower electricity generation (GWh) | Hydropower and renewable hydropower | https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Technologies **Source**: Source: IRENA (2019), Renewable capacity statistics 2019; and IRENA (2018), Renewable Energy Statistics 2018, The International Renewable Energy Agency, Abu Dhabi. | GWh | Data available from 2000-2016 with minimal missing data per year. Most data are available for 2016 for 159 countries. | No | No, this data is included in the renewable energy consumption and output indicators |
| 23 | Water (SDG 6) | Average precipitation in depth (mm per year) | Average precipitation is the long-term average in depth (over space and time) of annual precipitation in the country. Precipitation is defined as any kind of water that falls from clouds as a liquid or a solid (*World Bank 2019-03-04*). | https://data.worldbank.org/indicator/AG.LND.PRCP.MM **Source:** Food and Agriculture Organization, electronic files and website | mm/ year | 2014 Very good data coverage | No | **Yes**; this data is widely available and provides a good indication of available fresh water. This indicator directly influences food production and energy generation. Good correlation with annual freshwater withdrawals |
| 24 | Water (SDG 6) | Proportion of wastewater safely treated | Percentage of wastewater generated by households (sewage and faecal sludge) and economic activities (based on ISIC categories) that is safely treated (UN Water, 2016). | http://www.fao.org/nr/water/aquastat/data/query/results.html Source: FAO. 2016. AQUASTAT Main Database, Food and Agriculture Organization of the United Nations | $10^9$ $m^3$/year | Data available from 1993-2017 for 93 countries with missing data entries for most years | Yes; indicator 6.3.1 | No, although data is available for many countries, the data is missing for many monitoring years |

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| | | | | (FAO). Website accessed on [13/03/2019 8:28] | | | | resulting in an incomplete dataset. |
| 25 | Water (SDG 6) | Proportion of bodies of water with good ambient water quality | Percentage of water bodies (area) in a country with good ambient water quality. "Good" indicates an ambient water quality that does not damage ecosystem function and human health according to core ambient water quality parameters. Overall water quality is estimated based on a core set of five parameters that inform on major water quality impairments present in many parts of the world: electric conductivity/total dissolved solids; percentage dissolved oxygen; dissolved inorganic nitrogen/total nitrogen; dissolved inorganic phosphorus/total phosphorus; and faecal coliform/Escherichia coli bacteria (UNWater, 2016). | UNEP GEMStat | | Initial baseline data collected in 2017 for 48 countries. Data is not accessible yet | Yes; indicator 6.3.2 | No, only baseline data has been collected for 48 countries. The baseline data is not accessible and cannot be used. |
| 26 | Water (SDG 6) | Change in water-use efficiency over time | Output from a given economic activity (based on ISIC categories), per volume of net water withdrawn by the economic activity. This indicator includes water use by all economic activities, focusing on agriculture (excluding the portion generated by rain-fed agriculture), manufacturing, electricity, and water collection, treatment and supply (looking at distribution efficiency and capturing network leakages). By assessing changes over time, the sectoral values can be aggregated into one (UNWater, 2016). | http://www.fao.org/nr/water/aquastat/data/query/results.html | USD/$m^3$ | Data can be calculated from water used per sector and economic contribution, but data specific for this indicator is not available. | Yes; indicator 6.4.1 | No; this indicator is calculated per economic sector in a country and not as one value per country. |
| 27 | Water (SDG 6) | Degree of integrated water resources management implementation (0-100) | The degree to which IWRM is implemented, by assessing the four components of policies, institutions, management tools and financing. It takes into account the various users and uses of water, with the aim of promoting positive social, economic and environmental impacts at all levels, including the transboundary level, where appropriate (UNWater, 2016). | http://iwrmdataportal.unepdhi.org/dataoverview.html | % | Data is available for 2017 for 175 countries. | Yes; indicator 6.5.1 | Yes; IWRM implementation provides a good indication of water governance, and has a strong correlation with the implementation of basic drinking water and sanitation facilities. |
| 28 | Water (SDG 6) | Proportion of transboundary basin area with an operational arrangement for water cooperation | Percentage of transboundary basin area within a country that has an operational agreement or other arrangement for water cooperation. For the purpose of the indicator, "basin area" is defined for surface waters as the extent of the catchment, and for groundwater as the extent of the aquifer. An "arrangement for water cooperation" is a bilateral or multilateral treaty, convention, agreement or other formal arrangement among riparian countries that provides a framework for cooperation on transboundary water management. The criteria for the arrangement to be considered "operational" are based on key aspects of substantive cooperation in water management, such as the existence of institutional mechanisms, regular communication among riparian countries, joint or | http://geftwap.org/data-portal | % | Data is not included in the National Statistical Systems yet. | Yes; indicator 6.5.2 | No; there is no usable data available yet, but this indicator will play an important role in terms of catchment management. |

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| | | | coordinated management plans or objectives, as well as a regular exchange of data and information (UNWater, 2016). | | | | | |
| 29 | Water (SDG 6) | Change in the extent of water-related ecosystems over time | Changes over time in (1) the spatial extent of water-related ecosystems (wetlands, forests and drylands); (2) the quantity of water in ecosystems (rivers, lakes and groundwater); and (3) the resulting health of ecosystems. In addition, indicator 6.3.2 on ambient water quality and indicator 6.4.2 on environmental water requirements are critically important for understanding ecosystems and need to be factored into the assessment of indicator 6.6.1 (UNWater, 2016). | Not available yet | - | Data not available or not easily accessible. | Yes; indicator 6.6.1 | No, insufficient data at this time. |
| 30 | Water (SDG 6) | Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan | Amount and percentage of ODA that is included in a government coordinated spending plan, whether: (1) on treasury or (2) on budget. ODA flows are official financing with the main objective of promoting economic development and welfare of developing countries; they are concessional in character with a grant element of at least 25%. By convention, ODA flows comprise contributions from donor government agencies, at all levels, to developing countries, either bilaterally or through multilateral institutions. A government coordinated spending plan is defined as a financing plan/budget for water and sanitation projects, clearly assessing the available sources of finance and strategies for financing future needs (UNWater, 2016). | https://datacatalog.worldbank.org/<br><br>Source: The World Bank | US$ per year | Data available from 2002-2011 for 59 countries | Yes; indicator 6.a.1 | No; data is specific to developing countries and only covers 59 countries which is inefficient for the purpose of developing the WEF nexus index. |
| 31 | Water (SDG 6) | Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management | Percentage of local administrative units within a country with established and operational policies and procedures for participation of local communities in water and sanitation management. Local administrative units refer to subdistricts, municipalities, communes or other local community level units covering both urban and rural areas to be defined by the government. Policies and procedures for participation of local communities in water and sanitation management define a mechanism by which individuals and communities can meaningfully contribute to decisions and directions on water and sanitation management (UNWater, 2016). | Not available | % | None | Yes; indicator 6.b.1 | No; there is no usable data available yet. |
| 32 | Water (SDG 6) | Average evapotranspiration in volume (mm per year) | Important for water management policies in arid countries. Would affect water allocation | http://data.un.org/Data.aspx?d=ENV&f=variableID%3A7<br>**Source**: United Nations Statistics Division | Million $m^3$/annum | 1990-2015<br>Fair coverage<br>Data available for approximately 64 countries | No | No; data is only available for 64 countries. The JRC-COIN guideline is that at an indicator level 65% of countries should have valid data. |

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| 33 | Water (SDG 6) | Dam storage capacity | Water storage capacity as a proxy for ability to manage Rainfall variability between seasons. Underscores the importance of a basic platform of hydraulic infrastructure, but insensitive application may encourage 'hydraulic mission' and heavy engineering at the expense of other solutions | http://www.fao.org/nr/water/aquastat/data/query/index.html Source: FAO. 2016. AQUASTAT Main Database, Food and Agriculture Organization of the United Nations (FAO). Website accessed on [13/03/2019 8:28] | $km^3$ | Data available from 1990-2017 for 130 countries, with missing data for some years. | No | No; although there is data per country available, it is fragmented. Also, it is uncertain whether dam storage is positive or negative, since there is a conflict between system flows and storage |
| 34 | Water (SDG 6) | Virtual water footprint | Many potential policy applications and implications, e.g. could be used to focus attention on the potential for virtual water trade to mitigate against localised water scarcity, but thinking is relatively young and virtual water footprint data needs careful interpretation | Mekonnen, M.M. and Hoekstra, A.Y. (2010) The green, blue and grey water footprint of crops and derived crop products, Value of Water Research Report Series No. 47, UNESCO-IHE, Delft, the Netherlands. http://www.waterfootprint.org/Reports/Report47-WaterFootprintCrops-Vol1.pdf **Source**: Water Footprint Network | ton of crop or derived crop product | 1996-2005 (collated data) | No | No; data is available, but it has been collated into a single dataset instead of data per country. |
| 35 | Water (SDG 6) | Total agricultural water managed area | Sum of total area equipped for irrigation and areas with other forms of agricultural water management (non-equipped flood recession cropping area and non-equipped cultivated wetlands and inland valley bottoms) (FAO, 2019-03-13) | http://www.fao.org/nr/water/aquastat/data/query/index.html Source: FAO. 2016. AQUASTAT Main Database, Food and Agriculture Organization of the United Nations (FAO). Website accessed on [13/03/2019 8:28] | 1000 ha | Data available from 1988-2017 for 52 countries, with missing data for some years. | No | No; data is only available for 52 countries. The JRC-COIN guideline is that at an indicator level 65% of countries should have valid data. |
| 36 | Water (SDG 6) | Population affected by water related diseases | Three types of water-related diseases exist: (i) water-borne diseases are those diseases that arise from infected water and are transmitted when the water is used for drinking or cooking (for example cholera, typhoid); (ii) water-based diseases are those in which water provides the habitant for host organisms of parasites ingested (for example shistomasomiasis or bilharzia); (iii) water-related insect vector diseases are those in which insect vectors rely on water as habitat but transmission is not through direct contact with water (for example malaria, onchocerciasis or river blindness, elephantiasis). | http://www.fao.org/nr/water/aquastat/data/query/index.html Source: FAO. 2016. AQUASTAT Main Database, Food and Agriculture Organization of the United Nations (FAO). Website accessed on [13/03/2019 8:28] | 1000 inhabitants | Data available from 1992-2011 for 32 countries, with most data missing for some years. | No | No; data is only available for 32 countries. The JRC-COIN guideline is that at an indicator level 65% of countries should have valid data. |
| 37 | Energy (SDG 7) | Access to electricity (% of the population) | Access to electricity is the percentage of population with access to electricity. Electrification data are collected from industry, national surveys and international sources (*World Bank 2019-03-04*) | https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?view=chart **Source:** World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program. | % | 2016 Very good data coverage. Indicator utilised in SDG Index for SDG 7 | Yes, Indicator 7.1.1 (C070101) | **Yes**; essential indicator for SDG 7 with good data coverage. |

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| 38 | Energy (SDG 7) | Renewable energy consumption (% of total final energy consumption) | Renewable energy consumption is the share of renewables energy in total final energy consumption (*World Bank 2019-03-04*). | https://data.worldbank.org/indicator/EG.FEC.RNEW.ZS **Source:** World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program. | % | 2015 Very good data coverage. Indicator utilised in SDG Index for SDG 7 | Yes, Indicator 7.2.1 (C070201) | **Yes**; essential indicator for SDG 7 with good data coverage. |
| 39 | Energy (SDG 7) | Renewable electricity output (% of total electricity output) | Renewable electricity is the share of electricity generated by renewable power plants in total electricity generated by all types of plants (*World Bank 2019-03-04*). | https://data.worldbank.org/indicator/EG.ELC.RNEW.ZS?view=chart **Source:** IEA Statistics © OECD/IEA 2018 (http://www.iea.org/stats/index.asp) | % | 2015 Very good data coverage | No | **Yes**; since "Renewable energy consumption" refers to energy, while this indicator considers electricity only. Correlation with Renewable energy consumption is good, but not too high |
| 40 | Energy (SDG 7) | Total greenhouse gas emissions (kt of $CO_2$ equivalent) | Total greenhouse gas emissions in kt of $CO_2$ equivalent are composed of $CO_2$ totals excluding short-cycle biomass burning (such as agricultural waste burning and Savannah burning) but including other biomass burning (such as forest fires, post-burn decay, peat fires and decay of drained peatlands), all anthropogenic $CH_4$ sources, $N_2O$ sources and F-gases (HFCs, PFCs and SF6). (*World Bank 2019-03-04*) | https://data.worldbank.org/indicator/EN.ATM.GHGT.KT.CE?view=chart **Source:** European Commission, Joint Research Centre (JRC)/Netherlands Environmental Assessment Agency (PBL). Emission Database for Global Atmospheric Research (EDGAR), EDGARv4.2 FT2012: http://edgar.jrc.ec.europa.eu/ | kt of $CO_2$ equivalent | 2012 Very good data coverage | No | No; since this indicator represents all of the GHGs as $CO_2$ equivalent and includes biomass burning, methane, and other non-energy related GHG sources. |
| 41 | Energy (SDG 7) | $CO_2$ emissions (metric tons per capita) | Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring (*World Bank 2019-03-05*). | https://data.worldbank.org/indicator/EN.ATM.CO2E.PC **Source:** Carbon Dioxide Information Analysis Centre, Environmental Sciences Division, Oak Ridge National Laboratory, Tennessee, United States. https://data.worldbank.org/indicator/EN.ATM.CO2E.PC | metric tons per capita | 2014 Very good data coverage. Similar indicator utilised in SDG Index for SDG 7 | No | **Yes**; this data provides an indication of fossil fuel-related power generation. The per capita rating takes cognisance of the size of the impact relative to the population |
| 42 | Energy (SDG 7) | $CO_2$ emissions (kt) | Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring (*World Bank 2019-03-05*). | https://data.worldbank.org/indicator/EN.ATM.CO2E.KT?view=chart **Source:** Carbon Dioxide Information Analysis Centre, Environmental Sciences Division, Oak Ridge National Laboratory, Tennessee, United States. | kt | 2014 Very good data coverage | No | No; same parameter being measured as $CO_2$ emissions (metric tons per capita), except that this is not per capita, but the quantum per country. |
| 43 | Energy (SDG 7) | Energy use (kg of oil equivalent per capita) | Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport (*World Bank 2019-03-05*). | https://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE?view=chart **Source:** IEA Statistics © OECD/IEA 2014 (http://www.iea.org/stats/index.asp) | kg of oil equivalent per capita | 2015,2014,2013 Good data coverage, although will need to utilise latest data since very | No, but consider including 7.1.2 "Proportion of population with primary reliance | No; although this is a relevant indicator with readily available data it has a very high correlation (0.94) with electric power |

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| | | | | | | limited data for 2015. | on clean fuels and technology" | consumption per capita, and would therefore constitute 'double accounting'. It is therefore excluded |
| 44 | Energy (SDG 7) | Energy imports, net (% of energy use) | Net energy imports are estimated as energy use less production, both measured in oil equivalents. A negative value indicates that the country is a net exporter. Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport (*World Bank 2019-03-05*). | https://data.worldbank.org/indicator/EG.IMP.CONS.ZS?view=chart **Source:** IEA Statistics © OECD/IEA 2014 (http://www.iea.org/stats/index.asp) | % | 2015,2014,2013 Good data coverage, although will need to utilise latest data since very limited data for 2015. | No | **Yes**; this indicator provides a helpful indication of national energy security. But this indicator will be truncated at zero to exclude exports, since the primary concern is energy security and the indicator is essentially measuring imports and exports. |
| 45 | Energy (SDG 7) | Firms experiencing electrical outages (% of firms) | Percent of firms experiencing electrical outages during the previous fiscal year (*World Bank 2019-03-05*). | https://data.worldbank.org/indicator/IC.ELC.OUTG.ZS **Source:** World Bank, Enterprise Surveys | % | 2013-2017 Relatively poor data coverage. Will need to use the latest value | No | No, relatively poor data coverage. |
| 46 | Energy (SDG 7) | Electric power consumption (kWh per capita) | Electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants (*World Bank 2019-03-05*). | https://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC?view=chart **Source**: IEA Statistics © OECD/IEA 2014 (http://www.iea.org/stats/index.asp) | kWh per capita | 2014 Very good data coverage | No | **Yes**; very good data coverage and very relevant, since it provides a helpful indication of a nation's generation capacity. |
| 47 | Energy (SDG 7) | Proportion of population with primary reliance on clean fuels and technology | This is measured as the share of the total population with access to clean fuels and technologies for cooking. Access to clean fuels or technologies such as clean cookstoves reduce exposure to indoor air pollutants, a leading cause of death in low-income households (UN Stats, 2018) | Households that use solid fuels for cooking: http://apps.who.int/gho/data/view.main.vEQSOLIDFUELSTOTv Source: World Health Organization (MICS and DHS) | % | Data available from 1998-2013 for 93 countries, with data missing for some years. | Yes; indicator 7.1.2 | No; data is only available for 93 countries. The JRC-COIN guideline is that at an indicator level 65% of countries should have valid data. |
| 48 | Energy (SDG 7) | Energy intensity measured in terms of primary energy and GDP | This is measured as the energy intensity of economies (collectively across all sectors). Energy intensity is measured as the quantity of kilowatt-hours produced per 2011 international-$ of gross domestic product (kWh per 2011 int-$) (UN Stats, 2018). Total primary energy supply is defined as the sum of production and imports subtracting exports and storage changes. | https://www.iea.org/statistics/?country=WORLD&year=2016&category=Energy%20supply&indicator=TPESbyGDP&mode=map&dataTable=BALANCES **Source**: International Energy Agency | TPES/GDP | Data available for 2016 for 142 countries, with data missing for some years. | Yes; indicator 7.3.1 | No; this indicator is an SDG indicator and data are available for 142 countries, but it has a negative, low correlation with all other indicators associated with availability. |
| 49 | Energy (SDG 7) | International financial flows to developing countries in support of clean energy | The flows covered by the OECD are defined as all official loans, grants and equity investments received by countries on the DAC List of ODA Recipients from foreign governments and multilateral agencies, for the purpose of clean energy research and development | http://resourceirena.irena.org/gateway/dashboard/?topic=6&subTopic=8 **Source**: International Renewable Energy Agency | Million USD | Data is available from 2006-2017 for 141 countries with data missing for some years. | Yes; indicator 7. a.1 | No; although this indicator is an SDG indicator and data are available for 141 countries |

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| | | research and development and renewable energy production, including in hybrid systems | and renewable energy production, including in hybrid systems extracted from the OECD/DAC Creditor Reporting System (CRS).<br>The flows covered by IRENA are defined as all additional loans, grants and equity investments received by developing countries (defined as countries in developing regions, as listed in the UN M49 composition of regions) from all foreign governments, multilateral agencies and additional development finance institutions (including export credits, where available) for the purpose of clean energy research and development and renewable energy production, including in hybrid systems. These additional flows cover the same technologies and other activities (research and development, technical assistance, etc.) as listed above and exclude all flows extracted from the OECD/DAC CRS (UN Stats, 2018) | | | | | developed/donor and developing countries who have significant domestic expenditure on renewable energy projects are 'penalised' in the calculation of this index. It was therefore decided to exclude this indicator from the composite indicator |
| 50 | Energy (SDG 7) | Investments in energy efficiency as a percentage of GDP and the amount of foreign direct investment in financial transfer for infrastructure and technology to sustainable development services | Not defined yet. | Not available | % | None | Yes; indicator 7. b.1 | No; the definition for this indicator is not yet well defined and therefore not well understood yet. There is no data easily available for this indicator. |
| 51 | Energy (SDG 7) | Amount of fossil-fuel subsidies per unit of GDP (production and consumption) and as a proportion of total national expenditure on fossil fuels | In order to measure fossil fuel subsidies at the national, regional and global level, three sub-indicators are recommended for reporting on this indicator: 1) direct transfer of government funds; 2) induced transfers (price support); and as an optional sub-indicator 3) tax expenditure, other revenue foregone, and underpricing of goods and services. The definitions of the IEA Statistical Manual (IEA, 2005) and the Agreement on Subsidies and Countervailing Measures (ASCM) under the World Trade Organization (WTO) (WTO, 1994) are used to define fossil fuel subsidies. Standardised descriptions from the United Nations Statistical Office's Central Product Classification should be used to classify individual energy products. It is proposed to drop the wording "as a proportion of total national expenditure on fossil fuels" and thus this indicator is effectively "Amount of fossil fuel subsidies per unit of GDP (production and consumption)". (UN Stats, 2018) | Not available | USD/GDP | None; baseline assessment was conducted. Reporting on induced transfers started in 2018; reporting on data for direct transfers and tax revenue will take place in 2020. | Yes; indicator 12.c.1 | No; no data readily available |

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| 52 | Food (SDG 2) | Prevalence of undernourishment[15] | The prevalence of undernourishment expresses the probability that a randomly selected individual from the population consumes a number of calories that is insufficient to cover her/his energy requirement for an active and healthy life. The indicator is computed by comparing a probability distribution of habitual daily dietary energy consumption with a threshold level called the minimum dietary energy Requirement. Both are based on the notion of an average individual in the reference population (*FAO 2019-03-05*). | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk <br>**Source:** FAOSTAT and ESS calculations: | % | 2015-2017 <br>Very good data coverage. Indicator utilised in SDG Index for SDG 2 | Yes, 2.1.1 (C020101). Could consider a health indicator such as 3.2.1 "Under-5 mortality rate" as an additional indicator of 'healthy' food? | **Yes**; it was the official Millennium Development Goal indicator for Goal 1, Target 1.9, and is now an SDG indicator |
| 53 | Food (SDG 2) | Percentage of children under 5 years of age affected by wasting[16] [17] | Wasting prevalence is the proportion of children under five whose weight for height is more than two standard deviations below the median for the international reference population ages 0-59 months (*FAO 2019-03-05*). | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk <br>**Source:** World Development Indicators: http://data.worldbank.org/indicator/SH.STA.WAST.ZS <br>+ UNICEF et al. (2016) report an average prevalence of wasting in high-income countries of **0.75%**, which has been assumed for high-income countries with missing data. The classification as a high-income country is based on the World Bank's listing of high-income countries: https://data.worldbank.org/income-level/high-income | % | 2016 <br>Limited data. Need to utilise latest since coverage for the final year alone is scarce. Indicator utilised in SDG Index for SDG 2 | No | **Yes**; if there is a strong correlation of data with SDG indicator 2.2.1's data, one of the two indicators will be used to avoid noise in the dataset. However the correlation is good, but not too high. Both indicators can therefore be retained. |
| 54 | Food (SDG 2) | Percentage of children under 5 years of age who are stunted[18] | Percentage of stunting (height-for-age less than -2 standard deviations of the WHO Child Growth Standards median) among children aged 0-59 months (*FAO 2019-03-05*). | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk <br>**Source:** World Development Indicators: http://data.worldbank.org/indicator/SH.STA.WAST.ZS + UNICEF et al. (2016) report an average prevalence of wasting in high income countries of **2.58%**, which has been assumed for high-income countries with missing data. The classification as a high- | % | 2016 <br>Limited data. Need to utilise most recent coverage for the final year alone is scarce. Indicator utilised in SDG Index for SDG 2 | Yes, 2.2.1 (C020201) | **Yes**; this is an SDG indicator with sufficient data available for 153 countries. |

[15] "This is the traditional FAO hunger indicator, adopted as official Millennium Development Goal indicator for Goal 1, Target 1.9." (http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk).

[16] "Child growth is the most widely used indicator of nutritional status in a community and is internationally recognized as an important public-health indicator for monitoring health in populations. In addition, children who suffer from growth retardation as a result of poor diets and/or recurrent infections tend to have a greater risk of suffering illness and death." (http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk)

[17] The "two official indicators for the hunger target [are] the prevalence of undernourishment and the proportion of underweight children under 5 years of age" (http://www.fao.org/3/a-i4671e.pdf)

[18] "This indicator belongs to a set of indicators whose purpose is to measure nutritional imbalance and malnutrition resulting in undernutrition (assessed by underweight, stunting and wasting) and overweight. Child growth is the most widely used indicator of nutritional status in a community and is internationally recognized as an important public-health indicator for monitoring health in populations. In addition, children who suffer from growth retardation as a result of poor diets and/or recurrent infections tend to have a greater risk of suffering illness and death." (http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk)

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| | | | | income country is based on the World Bank's listing of high-income countries: https://data.worldbank.org/income-level/high-income | | | | |
| 55 | Food (SDG 2) | The depth of the food deficit (kilocalories per person per day)[19] | The depth of the food deficit indicates how many calories would be needed to lift the undernourished from their status, everything else being constant. The average intensity of food deprivation of the undernourished, estimated as the difference between the average dietary energy requirement and the average dietary energy consumption of the undernourished population (food-deprived), is multiplied by the number of undernourished to provide an estimate of the total food deficit in the country, which is then normalized by the total population (*World Bank 2019-03-06*). | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk Version 15 Sep 2017 **Source**: ESS calculations | kCal/ day | 2014-2016 Very good data coverage. | No | No – Many countries, such as Denmark, Finland, Switzerland, Sweden, Norway have no data but are assumed to be close to zero (patched to 2.5 for geometric mean). Although this indicator has very good data, it has a very high correlation with the prevalence of undernourishment (0.95), and it has therefore been excluded in order to avoid double accounting |
| 56 | Food (SDG 2) | Average protein supply[20] | National average protein supply (expressed in grams per caput per day) (*FAO 2019-03-06*) | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk **Source**: FAOSTAT | gr/caput/da y | 2011-2013 Very good data coverage | No, but it is FAO Indicator I_1.4 | **Yes**; very good data availability and provides an indication of a healthy, varied diet |
| 57 | Food (SDG 2) | Prevalence of obesity in the adult population (18 years and older) | Prevalence of obesity in the adult population is the percentage of adults ages 18 and over whose Body Mass Index (BMI) is more than 30 $kg/m^2$. Body Mass Index (BMI) is a simple index of weight-for-height or the weight in kilograms divided by the square of the height in meters (*FAO 2019-05-06*). | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk **Source**: World Health Organization Global Health Observatory (GHO) http://apps.who.int/gho/data/node.main.A900A?lang=en | % | 2016 Very good data coverage. Indicator utilised in SDG Index for SDG 2 | No, but it is FAO Indicator I_4.8 | **Yes**; since it is utilised within the SDG Index. Although it has a negative correlation with the levels of undernourishment, stunting and wasting, it measures a different portion of the population, i.e. adults >18 years old vs children <5 years old. It is viewed as being a key indicator of access to food despite the negative correlation |

[19] "Complementary indicator to assess the multiple dimensions and manifestations of food insecurity and the policies for more effective interventions and responses" (http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk – *not available in latest update of downloadable data)

[20] "This indicator provides information on the quality of the diet" (http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk)

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| | | | | | | | | with the other indicators listed in the access to food sub-index |
| 58 | Food (SDG 2) | Average dietary energy supply adequacy[21] | The indicator expresses the Dietary Energy Supply (DES) as a percentage of the Average Dietary Energy Requirement (ADER). Each country's or region's average supply of calories for food consumption is normalized by the average dietary energy requirement estimated for its population to provide an index of adequacy of the food supply in terms of calories (*FAO 2019-05-06*). | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk **Source**: FAOSTAT and ESS calculations | % | 2015-2017 Very good data coverage | No, but it is FAO Indicator I_1.1 | **Yes**; less than 10% missing data |
| 59 | Food (SDG 2) | Cereal import dependency ratio | The cereal imports dependency ratio tells how much of the available domestic food supply of cereals has been imported and how much comes from the country's own production. It is computed as (cereal imports – cereal exports)/(cereal production + cereal imports – cereal exports) * 100 Given this formula the indicator assumes only values <= 100. Negative values indicate that the country is a net exporter of cereals (*FAO 2019-03-06*). | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96UkBU: **Source:** FAOSTAT and ESS calculations | % | 2011-2013 Good data coverage | No, but it is FAO indicator I_3.1 | No; it is a good indicator, but several high-income countries do not measure this ratio since it is not relevant to them (30.9% missing data for 181 countries). This indicator can be truncated at zero in order to exclude exports from this indicator, since the indicator is essentially measuring both imports and exports. Imports are important to this index as they speak of the level of self-sufficiency in food production and security. Yet this indicator has a negative correlation with the other indicators within the "Access" sub-pillar of the "Food" sub-index, and is therefore excluded. |
| 60 | Food (SDG 2) | Prevalence of severe food | The prevalence of severe food insecurity in an estimate of the percentage of people in the population who live in households classified as severely food insecure. | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk **Source:** National surveys/Gallup World Poll and ESS calculations | % | 2015-2017 Data missing for many countries | Yes, indicator 2.1.2 (C020102) and FAO indicator I_2.4 | No; >60% of countries do not have records for this indicator. This is very low. The JRC-COIN |

21 "Analysed together with the prevalence of undernourishment, it allows discerning whether undernourishment is mainly due to insufficiency of the food supply or to particularly bad distribution." (http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk)

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| | | insecurity in the total population[22] | The assessment is conducted using data collected with the Food Insecurity Experience Scale or a compatible experience-based food security measurement questionnaire (such as the HFSSM, the HFIAS, the EBIA, the ELCSA, etc.).<br>The probability to be food insecure is estimated using the one-parameter logistic Item Response Theory model (the Rasch model) and thresholds for classification are made cross country comparable by calibrating the metrics obtained in each country against the FIES global reference scale, maintained by FAO. The threshold to classify "severe" food insecurity corresponds to the severity associated with the item "having not eaten for an entire day" on the global FIES scale.<br>In simpler terms, a household is classified as severely food insecure when at least one adult in the household has reported to have been exposed, at times during the year, to several of the most severe experiences described in the FIES questions, such as to have been forced to reduce the quantity of the food, to have skipped meals, having gone hungry, or having to go for a whole day without eating because of a lack of money or other resources.<br>It is an indicator of lack of food access (FAO 2019-03-06) | | | | | guideline is that at an indicator level 65% of countries should have valid data. On this basis, this indicator is unfortunately excluded. It is unfortunate because this is an official SDG indicator. |
| 61 | Food (SDG 2) | Number of severely food insecure people | Estimated number of people living in households classified as severely food insecure. It is calculated by multiplying the estimated percentage of people affected by severe food insecurity (I_2.4) by the total population. | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk<br>**Source:** ESS calculations | Millions of people | 2015-2017<br>Poor data coverage | No | No, for same reason as "Prevalence of severe food insecurity in the total population" |
| 62 | Food (SDG 2) | The share of food expenditure of the poor[23] | The proportion of food consumption over total consumption (food and non-food) for the lowest income quintile of the population. Due to the way in which the share of food expenditures is defined in the sources of data, this indicator captures the monetary value of food obtained from all the possible food sources (purchases, own-production, gift, in-kind | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk<br>**Source:** ESS calculations | % | 2014*<br>Very poor data coverage | No | No, very poor data coverage, and this indicator is not included in latest list of FAO indicators. |

[22] "This is indicator 2.1.2 in the SDG framework, to monitor target 2.1 ("By 2030, end hunger and ensure access by all people, […], to safe, nutritious and sufficient food all year round")." (http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk)

[23] "According to the Engel's Law, the higher the income of a household, the lower the proportion of income spent on food. When applied at the National level, this indicator reflects the living standard of a country, as well as the vulnerability of a country to food price increases. Due to the lack/unreliability of income data, this indicator has been built as the ratio between food consumption and total consumption, hence using total consumption as a proxy income. Finally, given the higher vulnerability of the poorer households to food price increase, this indicator only encompasses the share of food consumption of the lowest income quintile of a country population" (http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.WDmBh9V96Uk – *not available in latest update of downloadable data)

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| | | | payment, etc.), rather than just the monetary value of purchased food. Total consumption expenditures include both food and non-food expenditures and exclude non-consumption expenditures such as taxes, insurances, etc. | | | | | |
| 63 | Food (SDG 2) | Cereal yield | Cereal yield, measured as kilograms per hectare of harvested land, includes wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains. Production data on cereals relate to crops harvested for dry grain only. Cereal crops harvested for hay or harvested green for food, feed, or silage and those used for grazing are excluded. The FAO allocates production data to the calendar year in which the bulk of the harvest took place. Most of a crop harvested near the end of a year will be used in the following year (*World Bank 2019-03-06*). | https://data.worldbank.org/indicator/AG.YLD.CREL.KG?view=chart Source: World Bank | kg per hectare | 2016 Very good data coverage. Indicator utilised in SDG Index for SDG 2 | No | **Yes**; good data availability and the indicator is relevant to food security |
| 64 | Food (SDG 2) | Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size | Volume of agricultural production of small-scale food producer in crop, livestock, fisheries, and forestry activities per number of days (UN Stats, 2018) | Not available | Volume/ production unit | None | Yes; indicator 2.3.1 | No; there is no usable data available yet |
| 65 | Food (SDG 2) | Average income of small-scale food producers, by sex and indigenous status | measures income from on-farm production activities, which is related to the production of food and agricultural products. This includes income from crop production, livestock production, fisheries and aquaculture production, and from forestry production. The indicator is computed as annual income (UN Stats, 2018) | Not available | Annual income | None; data is still not available in a systematic and harmonized fashion | Yes; indicator 2.3.2 | No; there is no usable data available yet |
| 66 | Food (SDG 2) | Proportion of agricultural area under productive and sustainable agriculture | measure both the extent of land under productive and sustainable agriculture, as well as the extent of land area under agriculture. Focuses on agricultural land, and therefore primarily on land that is used to grow crops and raise livestock (UN Stats, 2018) | Not available | Percentage | None | Yes; indicator 2.4.1 | No, no data readily available |
| 67 | Food (SDG 2) | Number of plant and animal genetic resources for food and agriculture secured in either medium or long-term conservation facilities | The conservation of plant and animal genetic resources for food and agriculture (GRFA) in medium or long term conservation facilities (ex situ in genebanks) represents the most trusted means of conserving genetic resources worldwide. Plant and animal GRFA conserved in these facilities can be easily used in breeding programmes as well, even directly on-farm (UN Stats, 2018) | Not available yet, although data compilers have been appointed per country. http://www.fao.org/dad-is/sdg-251/en/ | No. of species | None | Yes; indicator 2.5.1 | No; there is no usable data available yet |
| 68 | Food (SDG 2) | Proportion of local breeds classified as being at risk, not-at-risk or at unknown | The indicator presents the percentage of livestock breeds classified as being at risk, not at risk or of unknown risk of extinctions at a certain moment in | http://www.fao.org/dad-is/dataexport/en/ Source: FAO | Percentage | Data collection dates are not specified. Data is available for | Yes; indicator 2.5.2 | No; although data is available per country, it seems like the data was only collected once as no |

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| | | level of risk of extinction | time, as well as the trends for those percentages (UN Stats, 2018) | | | various species per country. | | sampling dates are specified |
| 69 | Food (SDG 2) | The agriculture orientation index for government expenditures | The Agriculture Orientation Index (AOI) for Government Expenditures is defined as the Agriculture Share of Government Expenditures, divided by the Agriculture Share of GDP, where Agriculture refers to the agriculture, forestry, fishing and hunting sector. The measure in a currency-free index, calculated as the ratio of these two shares. National governments are requested to compile Government Expenditures according to the international Classification of Functions of Government (COFOC), and Agriculture Share of GDP according to the System of National Accounts (SNA) (UN Stats, 2018) | http://www.fao.org/faostat/en/#data/IG/visualize Source: FAOSTAT | Percentage | Data can be calculated using government expenditure and GDP, but data specific for this indicator is not available. | Yes; indicator 2. a.1 | No; although there is data per country available, it is fragmented. Further, it is not best practice to incorporate an index as part of another index. |
| 70 | Food (SDG 2) | Total official flows (official development assistance plus other official flows) to the agriculture sector | Gross disbursements of total ODA and other official flows from all donors to the agriculture sector (UN Stats, 2018) | Food aid: https://www.oecd-ilibrary.org/development/data/oecd-international-development-statistics/official-and-private-flows_data-00072-en | Million USD | Data is available from 1995-2017 for 35 countries with data missing for some years. | Yes; indicator 2. a.2 | No; data is only available for 35 countries. The JRC-COIN guideline is that at an indicator level 65% of countries should have valid data. |
| 71 | Food (SDG 2) | Agricultural export subsidies | Agricultural export subsidies are defined as export subsidies budgetary outlays and quantities as notified by WTO Members in Tables ES:1 and supporting Tables ES:2 (following templates in document G/AG/2 dated 30 June 1995) (UN Stats, 2018) | https://www.wto.org/english/tratop_e/agric_e/transparency_toolkit_e.htm Source: World Trade Organization | Million USD | Data is available from 1995-2014 for 24 countries. | Yes; indicator 2. b.1 | No; although it is important to consider financial flows of food export, this level of detail is not yet required in this WEF nexus framework |
| 72 | Food (SDG 2) | Indicator of food price anomalies | The indicator of food price anomalies (IFPA) identifies markets prices that are abnormally high. The IFPA relies on a weighted compound growth rate that accounts for both within year and across year price growth. The indicator directly evaluates growth in prices over a particular month over many years, taking into account seasonality in agricultural markets and inflation, allowing to answer the question of whether or not a change in price is abnormal for any particular period (UN Stats, 2018) | http://www.fao.org/giews/food-prices/tool/public/#/dataset/international | - | Data available for 2016 for 57 countries (specifically for rice; data also available for wheat, sorghum, maize, and millet) | Yes; indicator 2. c.1 | No; data is difficult to manage as it does not download to an excel format. Further, it is not best practice to incorporate an index as part of another index. |
| 73 | Food (SDG 2) | Global food loss index | *No data for this indicator is currently available and its methodology is still under development (UN Stats, 2018)* | Not available yet | - | None | Yes; indicator 12.3.1 | No; although this indicator is an SDG indicator it is not best practice to incorporate an index as part of another index. |
| 74 | Food (SDG 2) | Average value of food production | The indicator expresses the food net production value (in constant 2004-06 international dollars), as | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.XIix_8t7lhG | I$ per caput | Data available from 1999-2014 for 201 countries. | No, but it is FAO indicator I_1.2 | **Yes**; very good data coverage that includes data from 201 countries. |

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| | | | estimated by FAO and published by FAOSTAT, in per capita terms (FAO 2019-03-06) | | | | | The data can be used to infer priorities in terms of resource allocation in the WEF nexus. |
| 75 | Food (SDG 2) | Value of food imports over total merchandise exports | Value of food (excl. fish) imports over total merchandise exports (FAO 2019-03-06) | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.XIix_8t7lhG | Percentage | Data available from 1999-2011 for 193 countries | No, but it is FAO indicator I_3.3 | No, very good data coverage that includes data from 193 countries. However, there is a low correlation (<0.4) with other key indicators relating to food availability. |
| 76 | Food (SDG 2) | Agricultural machinery | Agricultural machinery refers to the number of wheel and crawler tractors (excluding garden tractors) in use in agriculture at the end of the calendar year specified or during the first quarter of the following year. Arable land includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded (FAO: 2019-04-29) | https://data.worldbank.org/indicator/AG.LND.TRAC.ZS?view=chart Source: Food and Agriculture Organization, electronic files and web site | Tractors/ 100 km² of arable land | Data available from 1961-2009; for only 8 countries in 2009 but for approximately 164 countries in 1965 | No | No, this indicator was measured widely up until 2000, and to some degree until 2008, but is no longer recorded. |
| 77 | Food (SDG 2) | Percent of arable land equipped for irrigation | Ratio between arable land equipped for irrigation and total arable land.<br><br>Arable land is defined as the land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category. Data for arable land are not meant to indicate the amount of land that is potentially cultivable.<br><br>Total arable land equipped for irrigation is defined as the area equipped to provide water (via irrigation) to the crops. It includes areas equipped for full and partial control irrigation, equipped lowland areas, pastures, and areas equipped for spate irrigation (FAO: 2019-04-29). | http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.XIix_8t7lhG Source: FAOSTAT and ESS calculations (11 Sep 2018) | % | Data available from 1999 to-2015 for 178 countries with missing data for some years. | No, but it is FAO indicator I_3.2 | No, irrigation is a major user of water worldwide, and a key component of the WEF nexus, despite it having a poor correlation with some of the other indicators in food availability. This indicator has a negative correlation with the other indicators within the "Access" sub-pillar of the "Food" sub-index, and is therefore excluded. |
| 78 | Food (SDG 2) | Agriculture, forestry and fishery, value added | Agriculture corresponds to ISIC divisions 1-5 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of | https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS **Source:** Food and Agriculture Organization, AQUASTAT data | % of GDP | Data available from 1966-2017 with many missing data per year. Most recent data are available for | No | No, very good data availability and very relevant indicator regarding the value of land and water-based products/food to the economy, but low |

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| | | | natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. Note: This value is not specific to crop production, so care should be taken to ensure proper implementation.(FAO 2019-05-25) | | | 2012 for 171 countries. | | correlation with most indicators contributing to food availability |
| 79 | Food (SDG 2) | Electricity capacity in MW for renewable municipal waste | ??? | https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Technologies **Source**: Source: IRENA (2019), Renewable capacity statistics 2019; and IRENA (2018), Renewable Energy Statistics 2018, The International Renewable Energy Agency, Abu Dhabi. | MW | Data available from 2000-2018 with many missing data per country. Most recent data are available for 2018 for 41 countries. | No | No; data is only available for 41 countries. The JRC-COIN guideline is that at an indicator level 65% of countries should have valid data. |
| 80 | Food (SDG 2) | Electricity generation in GWh for renewable municipal waste | ??? | https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Technologies **Source**: Source: IRENA (2019), Renewable capacity statistics 2019; and IRENA (2018), Renewable Energy Statistics 2018, The International Renewable Energy Agency, Abu Dhabi. | GWh | Data available from 2000-2016 with many missing data per country. Most recent data are available for 2016 for 37 countries. | No | No; data is only available for 37 countries. The JRC-COIN guideline is that at an indicator level 65% of countries should have valid data. |
| 81 | Food (SDG 2) | Electricity capacity in MW for solid biofuel | | https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Technologies **Source**: Source: IRENA (2019), Renewable capacity statistics 2019; and IRENA (2018), Renewable Energy Statistics 2018, The International Renewable Energy Agency, Abu Dhabi. | MW | Data available from 2000-2018 with many missing data per country. Most recent data are available for 2018 for 108 countries. | No | No, this data is included in the renewable energy consumption and output indicators |
| 82 | Food (SDG 2) | Electricity generation in GWh for solid biofuel | | https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Technologies **Source**: Source: IRENA (2019), Renewable capacity statistics 2019; and IRENA (2018), Renewable Energy Statistics 2018, The International Renewable Energy Agency, Abu Dhabi. | GWh | Data available from 2000-2016 with many missing data per country. Most recent data are available for 2016 for 103 countries. | No | No, this data is included in the renewable energy consumption and output indicators |
| 83 | Food (SDG 2) | Electricity capacity in MW for liquid biofuel | | https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Technologies | MW | Data available from 2000-2018 with many missing data per country. Most recent data are available for 2018 for 14 countries. | No | No; data is only available for 14 countries. The JRC-COIN guideline is that at an indicator level 65% of countries should have valid data. |

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| 84 | Food (SDG 2) | Electricity generation in GWh for liquid biofuel | | **Source**: Source: IRENA (2019), Renewable capacity statistics 2019; and IRENA (2018), Renewable Energy Statistics 2018, The International Renewable Energy Agency, Abu Dhabi. | GWh | Data available from 2000-2016 with many missing data per country. Most recent data are available for 2016 for 17 countries. | No | No; data is only available for 17 countries. The JRC-COIN guideline is that at an indicator level 65% of countries should have valid data. |
| 85 | Food (SDG 2) | Alien invasive species | Area of agricultural land that has been encroached by alien invasive species, resulting is less arable land for food production and an increase in water consumption | Not available | Ha/year | None | No | No; there is no usable data available yet however it is important to consider alien invasive plant species as they affect food and water security |
| 86 | Food (SDG 2) | Proportion of countries adopting relevant national legislation and adequately resourcing the prevention or control of invasive alien species | Commitment by countries to relevant multinational agreements, specifically: (1) National adoption of invasive alien species-relevant international policy. (2) Percentage of countries with (a) national strategies for preventing and controlling invasive alien species; and (b) national legislation and policy relevant to invasive alien species. The translation of policy arrangements into action by countries to implement policy and actively prevent and control invasive alien species IAS and the resourcing of this action, specifically: (3) National allocation of resources towards the prevention or control of invasive alien species. (UN Stats, 2018) | Not available | % | None | Yes; indicator 15.8.1 | No; there is no usable data available yet |
| 87 | Food (SDG 2) | Pests destroying crops [2] | Hectares of crops that are lost per year due to the invasion of pest species (armyworm, corn root worm, etc.) and diseases caused by fungi and bacteria (potato blight, coffee leaf rust, etc.) | Not available | Ha/year or kg/ha | None | No | No; there is no usable data available yet however it is important to consider pests as they are seen as the greatest threat to food security, and indirectly affects water security. |

# Appendix B: WEF Nexus Index Dashboard (with treated data values)

| | | Water Sub-index | | | | | | | Energy Sub-index | | | | | | Food sub-index | | | | | | | |
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| | | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements ($10^6$ $m^3$/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | $CO_2$ emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| **Rank** | **Country** | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
| 1 | NOR | 100.0 | 98.0 | 58.7 | 99.2 | 85.2 | 63.4 | 42.7 | 100.0 | 60.3 | 97.7 | 58.2 | 100.0 | 100.0 | 100.0 | 98.0 | 97.4 | 47.2 | 87.5 | 54.0 | 72.2 | 24.0 |
| 2 | NZL | 100.0 | 100.0 | 52.1 | 98.4 | 85.0 | 60.6 | 52.7 | 100.0 | 32.1 | 80.1 | 65.4 | 58.9 | 80.3 | 100.0 | 98.0 | 97.4 | 31.1 | 64.6 | 100.0 | 55.7 | 100.0 |
| 3 | SWE | 100.0 | 99.2 | 87.0 | 98.4 | 74.3 | 53.1 | 18.0 | 100.0 | 55.6 | 63.3 | 80.0 | 88.0 | 75.0 | 100.0 | 98.0 | 97.4 | 53.9 | 75.0 | 64.1 | 59.5 | 26.8 |
| 4 | ISL | 100.0 | 98.7 | 45.6 | 97.9 | 100.0 | 52.1 | 59.2 | 100.0 | 80.4 | 100.0 | 72.8 | 100.0 | 88.3 | 100.0 | n/a | 97.4 | 51.6 | 86.1 | n/a | 72.2 | 31.9 |
| 5 | CAN | 98.3 | 98.4 | n/a | 98.7 | 85.8 | 86.1 | 15.2 | 100.0 | 23.0 | 63.0 | 31.8 | 100.0 | 100.0 | 100.0 | 98.0 | 97.4 | 32.7 | 86.1 | 45.5 | 77.2 | 69.8 |
| 6 | DNK | 100.0 | 99.6 | 92.1 | 89.4 | 52.9 | 13.5 | 20.4 | 100.0 | 34.6 | 65.5 | 73.3 | 38.1 | 98.2 | 100.0 | 98.0 | 97.4 | 55.8 | 75.7 | 73.7 | 67.1 | 100.0 |
| 7 | AUS | 100.0 | 100.0 | 83.6 | 96.9 | 75.6 | 62.6 | 15.1 | 100.0 | 9.6 | 13.6 | 30.6 | 65.6 | 100.0 | 100.0 | 98.0 | 98.6 | 34.8 | 87.5 | 23.1 | 67.1 | 94.5 |
| 8 | AUT | 100.0 | 100.0 | 90.0 | 93.7 | 66.6 | 42.7 | 33.2 | 100.0 | 35.9 | 76.5 | 69.1 | 54.5 | 35.6 | 100.0 | 98.0 | 97.4 | 54.4 | 100.0 | 86.1 | 87.3 | 44.0 |
| 9 | FIN | 100.0 | 99.4 | 71.3 | 93.9 | 75.1 | 48.2 | 15.2 | 100.0 | 45.1 | 44.5 | 61.0 | 99.6 | 54.1 | 100.0 | 98.0 | 97.4 | 47.5 | 79.2 | 41.4 | 67.1 | 32.3 |
| 10 | BRA | 96.1 | 85.0 | 44.2 | 98.7 | 77.7 | 100.0 | 53.6 | 100.0 | 45.7 | 74.0 | 88.5 | 16.8 | 88.0 | 100.0 | 94.2 | 88.1 | 53.5 | 63.9 | 48.8 | 64.6 | 63.9 |
| 11 | USA | 98.7 | 100.0 | n/a | 85.2 | 69.1 | 83.2 | 20.8 | 100.0 | 9.1 | 13.2 | 25.5 | 84.8 | 92.6 | 100.0 | 99.1 | 98.4 | 18.9 | 95.1 | 97.1 | 86.1 | 65.8 |
| 12 | FRA | 100.0 | 98.6 | 100.0 | 85.1 | 60.9 | 52.2 | 25.6 | 100.0 | 14.1 | 15.9 | 79.5 | 45.2 | 55.3 | 100.0 | 98.0 | 97.4 | 51.4 | 93.8 | 67.1 | 77.2 | 55.7 |
| 13 | CHE | 100.0 | 99.9 | 78.9 | 95.1 | 64.6 | 38.0 | 46.6 | 100.0 | 26.4 | 62.2 | 80.7 | 49.0 | 49.2 | 100.0 | 98.0 | 97.4 | 56.0 | 90.3 | 60.4 | 65.8 | 28.3 |
| 14 | COL | 94.5 | 83.2 | 44.0 | 99.5 | 81.4 | 84.6 | 100.0 | 98.9 | 24.6 | 68.2 | 92.3 | 8.2 | 100.0 | 91.3 | 97.3 | 76.7 | 53.9 | 38.9 | 48.9 | 60.8 | 26.1 |
| 15 | PRY | 98.3 | 90.5 | 23.0 | 98.0 | 74.4 | 63.2 | 33.8 | 98.2 | 64.4 | 100.0 | 96.3 | 10.0 | 100.0 | 83.5 | 96.9 | 91.2 | 61.1 | 47.2 | 51.8 | 40.5 | 80.0 |

| | | Water Sub-index | | | | | | | Energy Sub-index | | | | | | Food sub-index | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements ($10^6$ $m^3$/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | $CO_2$ emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| **Rank** | **Country** | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
| 16 | HRV | 99.4 | 97.3 | 88.5 | 98.3 | 69.1 | 46.9 | 33.3 | 100.0 | 34.6 | 66.8 | 82.2 | 24.1 | 53.5 | 100.0 | 98.0 | 97.4 | 42.4 | 61.1 | 80.0 | 55.7 | 32.6 |
| 17 | GBR | 100.0 | 99.0 | 73.6 | 94.5 | 58.6 | 51.1 | 36.7 | 100.0 | 9.1 | 24.8 | 70.8 | 33.3 | 64.9 | 100.0 | 98.0 | 97.4 | 36.9 | 79.2 | 83.4 | 74.7 | 23.9 |
| 18 | MYS | 94.3 | 99.6 | 35.3 | 98.1 | 74.9 | 67.8 | 88.6 | 100.0 | 5.4 | 10.0 | 63.8 | 29.8 | 100.0 | 97.2 | 50.0 | 60.3 | 69.6 | 44.4 | 37.2 | 58.2 | 43.8 |
| 19 | ARG | 99.4 | 94.4 | 30.2 | 87.1 | 67.0 | 71.1 | 16.9 | 100.0 | 10.5 | 28.1 | 78.7 | 19.7 | 86.8 | 95.7 | 96.0 | 85.9 | 39.2 | 62.5 | 59.9 | 70.9 | 96.5 |
| 20 | URY | 98.7 | 95.4 | n/a | 96.1 | 77.5 | 55.9 | 39.2 | 100.0 | 60.6 | 88.6 | 91.3 | 19.8 | 55.0 | 100.0 | 95.5 | 80.8 | 38.2 | 54.9 | 58.0 | 68.4 | 100.0 |
| 21 | DEU | 100.0 | 99.1 | 86.4 | 69.2 | 54.6 | 50.2 | 20.4 | 100.0 | 14.8 | 29.2 | 60.0 | 45.8 | 37.8 | 100.0 | 96.9 | 100.0 | 45.6 | 82.6 | 85.4 | 73.4 | 38.6 |
| 22 | CRI | 99.5 | 96.9 | 35.9 | 97.9 | 76.6 | 45.7 | 90.2 | 100.0 | 40.4 | 99.0 | 92.9 | 12.6 | 49.5 | 94.7 | 96.9 | 91.2 | 45.6 | 45.1 | 46.9 | 50.6 | 59.2 |
| 23 | SVN | 99.2 | 99.0 | 52.4 | 93.8 | 69.2 | 32.9 | 34.8 | 100.0 | 21.8 | 29.4 | 72.1 | 43.8 | 50.8 | 100.0 | 98.0 | 97.4 | 53.0 | 66.0 | 76.6 | 60.8 | 29.0 |
| 24 | NLD | 100.0 | 97.5 | 92.3 | 2.5 | 49.2 | 41.8 | 22.8 | 100.0 | 6.1 | 12.4 | 55.3 | 43.7 | 64.5 | 100.0 | 98.0 | 97.4 | 51.6 | 69.4 | 92.6 | 58.2 | 75.8 |
| 25 | LUX | 100.0 | 97.4 | 89.0 | 95.7 | 56.9 | 13.5 | 27.7 | 100.0 | 9.4 | 32.4 | 21.6 | 90.9 | 2.4 | 100.0 | 98.0 | 97.4 | 49.1 | 79.9 | 58.8 | 74.7 | 31.8 |
| 26 | ALB | 86.4 | 97.5 | 35.7 | 95.1 | 69.4 | 30.5 | 45.0 | 100.0 | 40.3 | 100.0 | 91.3 | 14.9 | 86.0 | 92.9 | 59.4 | 55.4 | 53.5 | 55.6 | 55.3 | 63.3 | 43.0 |
| 27 | ECU | 88.3 | 85.0 | 34.2 | 97.8 | 77.8 | 64.8 | 69.7 | 99.9 | 14.4 | 52.8 | 87.7 | 8.8 | 100.0 | 89.1 | 94.2 | 53.8 | 60.4 | 47.9 | 41.4 | 45.6 | 34.6 |
| 28 | BIH | 96.4 | 94.4 | 55.8 | 99.1 | 70.0 | 35.9 | 30.6 | 100.0 | 42.5 | 35.5 | 72.0 | 21.8 | 77.0 | 100.0 | 91.1 | 84.5 | 60.1 | 34.0 | 61.1 | 62.0 | 23.3 |
| 29 | IRL | 98.3 | 91.6 | 78.0 | 98.5 | 70.4 | 39.5 | 33.5 | 100.0 | 9.5 | 28.0 | 67.1 | 36.9 | 13.2 | 100.0 | n/a | 97.4 | 42.9 | 72.2 | 98.0 | 84.8 | 91.4 |
| 30 | GRC | 100.0 | 98.9 | 81.1 | 83.5 | 65.2 | 34.1 | 18.8 | 100.0 | 17.9 | 28.7 | 72.2 | 32.9 | 35.0 | 100.0 | 98.0 | 97.4 | 41.7 | 86.8 | 48.3 | 70.9 | 55.3 |

| Rank | Country | Water Sub-index | | | | | | | Energy Sub-index | | | | | | Food sub-index | | | | | | | |
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| Rank | Country | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
| 31 | ROU | 100.0 | 80.4 | 68.9 | 84.9 | 58.2 | 53.1 | 18.4 | 100.0 | 24.7 | 39.7 | 84.3 | 16.7 | 83.0 | 100.0 | 85.7 | 76.5 | 48.4 | 54.9 | 46.2 | 70.9 | 45.0 |
| 32 | BEL | 100.0 | 99.5 | 74.6 | 50.0 | 53.0 | 27.4 | 25.0 | 100.0 | 9.6 | 20.8 | 62.5 | 50.2 | 18.8 | 100.0 | 98.0 | 97.4 | 48.4 | 96.5 | 83.0 | 86.1 | 40.1 |
| 33 | PRT | 99.8 | 99.4 | 70.7 | 75.9 | 62.3 | 38.2 | 25.2 | 100.0 | 28.3 | 47.5 | 80.6 | 30.3 | 22.1 | 100.0 | 98.0 | 97.4 | 51.4 | 80.6 | 51.7 | 75.9 | 39.1 |
| 34 | ITA | 100.0 | 99.2 | 48.6 | 70.6 | 60.8 | 49.7 | 24.5 | 100.0 | 17.2 | 38.7 | 76.4 | 32.5 | 22.6 | 100.0 | 98.0 | 97.4 | 52.1 | 91.7 | 66.1 | 79.7 | 43.9 |
| 35 | JPN | 98.3 | 100.0 | 93.1 | 81.1 | 61.7 | 61.1 | 50.7 | 100.0 | 6.6 | 16.0 | 57.0 | 51.0 | 5.7 | 100.0 | 91.1 | 88.1 | 94.7 | 43.8 | 58.5 | 43.0 | 12.1 |
| 36 | RUS | 94.3 | 87.9 | 76.3 | 98.6 | 78.3 | 91.0 | 12.8 | 100.0 | 3.4 | 15.9 | 46.5 | 43.0 | 100.0 | 100.0 | n/a | n/a | 45.6 | 54.9 | 30.1 | 74.7 | 30.3 |
| 37 | EST | 99.4 | 99.6 | 77.4 | 86.5 | 69.7 | 17.2 | 18.0 | 100.0 | 28.7 | 14.4 | 33.0 | 43.8 | 100.0 | 97.4 | n/a | 97.4 | 50.0 | 46.5 | 30.2 | 62.0 | 40.2 |
| 38 | CHL | 100.0 | 99.9 | 12.5 | 96.0 | 82.3 | 71.4 | 46.1 | 100.0 | 26.0 | 43.6 | 79.0 | 25.4 | 33.9 | 96.5 | 100.0 | 99.0 | 38.5 | 43.1 | 81.4 | 58.2 | 42.4 |
| 39 | PER | 84.1 | 75.0 | 20.5 | 99.2 | 82.7 | 82.0 | 52.9 | 94.4 | 26.6 | 52.7 | 91.2 | 8.3 | 100.0 | 87.5 | 96.9 | 75.9 | 60.8 | 18.1 | 48.9 | 48.1 | 27.0 |
| 40 | IDN | 83.4 | 65.4 | 41.4 | 94.4 | 68.2 | 81.4 | 83.1 | 97.4 | 38.5 | 10.7 | 92.0 | 5.1 | 100.0 | 89.3 | 41.1 | 28.2 | 88.9 | 22.2 | 63.7 | 57.0 | 22.4 |
| 41 | SUR | 91.6 | 77.6 | 4.0 | 99.4 | 92.0 | 50.5 | 71.5 | 85.9 | 26.0 | 60.1 | 83.8 | 23.5 | 100.0 | 89.4 | 79.0 | 84.7 | 43.8 | 38.9 | 51.9 | 48.1 | 22.9 |
| 42 | VNM | 86.1 | 76.5 | 29.6 | 77.2 | 62.8 | 69.1 | 55.5 | 100.0 | 36.5 | 36.7 | 92.1 | 9.0 | 100.0 | 84.2 | 72.8 | n/a | 100.0 | 32.6 | 64.2 | 55.7 | 27.8 |
| 43 | BRN | 99.2 | 96.0 | n/a | 98.9 | 75.5 | 21.8 | 83.8 | 100.0 | 0.0 | 0.0 | 0.0 | 66.8 | 100.0 | 97.7 | 88.4 | 62.4 | 71.0 | 40.3 | 8.1 | 57.0 | 10.5 |
| 44 | CZE | 99.8 | 99.0 | 76.6 | 87.5 | 54.2 | 23.0 | 19.6 | 100.0 | 15.5 | 11.4 | 58.7 | 40.7 | 68.0 | 100.0 | 80.8 | n/a | 39.2 | 77.1 | 74.8 | 62.0 | 32.2 |
| 45 | MEX | 97.3 | 88.4 | 42.9 | 80.0 | 61.5 | 60.1 | 22.2 | 100.0 | 9.6 | 15.4 | 82.7 | 13.4 | 100.0 | 95.7 | 96.9 | 77.3 | 39.4 | 47.2 | 43.5 | 67.1 | 27.1 |

| | | Water Sub-index | | | | | | | Energy Sub-index | | | | | | Food sub-index | | | | | | | |
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| **Rank** | **Country** | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
| 46 | POL | 96.7 | 98.0 | 31.6 | 78.6 | 55.1 | 39.7 | 17.2 | 100.0 | 12.4 | 13.8 | 66.2 | 25.8 | 71.1 | 100.0 | 98.0 | 97.4 | 45.9 | 65.3 | 46.6 | 73.4 | 45.8 |
| 47 | KWT | 100.0 | 100.0 | 79.1 | 0.0 | 0.0 | n/a | 2.2 | 100.0 | n/a | n/a | 0.0 | 99.4 | 100.0 | 100.0 | 87.5 | 92.6 | 19.6 | 63.2 | 100.0 | 78.5 | 8.0 |
| 48 | LVA | 97.8 | 92.4 | 59.6 | 98.6 | 68.7 | 33.5 | 18.5 | 100.0 | 39.8 | 50.2 | 84.4 | 22.7 | 54.2 | 100.0 | n/a | 97.4 | 45.6 | 65.3 | 44.5 | 63.3 | 43.9 |
| 49 | KOR | 99.4 | 99.9 | 63.7 | 55.2 | 54.3 | 40.9 | 38.4 | 100.0 | 2.8 | 1.9 | 47.8 | 68.5 | 17.5 | 100.0 | 96.0 | n/a | 93.5 | 54.9 | 80.6 | 70.9 | 18.5 |
| 50 | KAZ | 86.0 | 97.6 | 21.1 | 69.0 | 62.5 | 41.2 | 6.2 | 100.0 | 1.6 | 8.9 | 35.2 | 36.4 | 100.0 | 100.0 | 87.5 | 86.3 | 55.8 | 75.0 | 14.3 | 74.7 | 40.0 |
| 51 | VEN | 95.9 | 94.5 | n/a | 97.2 | 77.3 | 78.9 | 62.5 | 99.6 | 13.4 | 63.7 | 72.9 | 17.1 | 100.0 | 82.7 | 83.0 | n/a | 46.8 | 41.7 | 39.6 | 32.9 | 18.5 |
| 52 | TUR | 98.3 | 96.1 | 65.5 | 81.5 | 60.7 | 49.6 | 17.0 | 100.0 | 14.0 | 32.0 | 79.9 | 18.4 | 23.8 | 100.0 | 93.8 | 83.2 | 30.6 | 66.7 | 35.7 | 100.0 | 45.1 |
| 53 | SVK | 96.7 | 98.8 | 61.3 | 95.6 | 58.9 | 37.9 | 24.2 | 100.0 | 14.0 | 22.7 | 74.6 | 33.4 | 38.5 | 97.5 | 98.0 | n/a | 53.2 | 61.1 | 76.2 | 50.6 | 26.3 |
| 54 | ARE | 99.4 | 100.0 | 71.7 | 0.0 | 20.6 | n/a | 0.8 | 100.0 | 0.1 | 0.2 | 0.0 | 73.5 | 100.0 | 100.0 | 98.0 | 97.4 | 35.9 | 44.4 | 100.0 | 59.5 | 5.7 |
| 55 | BGR | 98.9 | 84.9 | 55.0 | 72.8 | 60.6 | 24.7 | 17.5 | 100.0 | 18.4 | 18.0 | 73.6 | 30.6 | 63.0 | 97.0 | 87.1 | 84.7 | 41.7 | 48.6 | 56.5 | 48.1 | 42.6 |
| 56 | HUN | 100.0 | 97.8 | 69.8 | 15.8 | 48.7 | 43.8 | 16.9 | 100.0 | 16.2 | 10.6 | 80.9 | 25.7 | 41.6 | 100.0 | 98.0 | 97.4 | 38.9 | 77.1 | 60.0 | 51.9 | 51.2 |
| 57 | TTO | 95.1 | 91.5 | 15.2 | 91.3 | 60.4 | 13.1 | 67.4 | 100.0 | 0.3 | n/a | 0.0 | 46.5 | 100.0 | 93.9 | 73.2 | 80.2 | 59.4 | 45.1 | 15.9 | 63.3 | 9.2 |
| 58 | CUB | 92.4 | 90.1 | 77.8 | 81.8 | 61.6 | 26.2 | 40.3 | 100.0 | 20.1 | 3.9 | 86.4 | 9.1 | 49.6 | 100.0 | 90.6 | 88.3 | 43.3 | 29.2 | 33.7 | 86.1 | 23.4 |
| 59 | ISR | 100.0 | 100.0 | 83.0 | 0.0 | 34.2 | 5.3 | 12.0 | 100.0 | 3.9 | 1.9 | 64.6 | 43.0 | 34.2 | 100.0 | 98.0 | 97.4 | 43.3 | 87.5 | 58.4 | 100.0 | 31.7 |
| 60 | GAB | 80.3 | 36.4 | 3.3 | 99.9 | 86.5 | 56.2 | 55.8 | 90.6 | 85.6 | 43.7 | 87.7 | 7.4 | 100.0 | 86.5 | 86.2 | 66.9 | 74.0 | 23.6 | 17.4 | 57.0 | 12.3 |

| | | Water Sub-index | | | | | | | Energy Sub-index | | | | | | Food sub-index | | | | | | | |
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| 61 | SRB | 86.1 | 94.2 | 20.7 | 50.6 | 53.7 | 49.1 | 19.9 | 100.0 | 22.1 | 26.9 | 76.3 | 27.7 | 70.8 | 92.7 | 83.9 | 90.4 | 50.7 | 37.5 | 73.1 | 39.2 | 36.4 |
| 62 | UKR | 96.4 | 95.6 | 31.0 | 73.1 | 54.0 | 52.3 | 16.1 | 100.0 | 4.3 | 4.4 | 77.5 | 22.1 | 72.4 | 96.5 | 64.7 | 55.8 | 44.7 | 46.5 | 54.5 | 50.6 | 55.0 |
| 63 | NPL | 80.6 | 42.0 | 24.2 | 95.2 | 67.3 | 52.1 | 45.4 | 89.8 | 89.0 | 100.0 | 99.0 | 0.7 | 83.1 | 86.3 | 58.0 | 29.4 | 96.1 | 20.1 | 29.6 | 49.4 | 18.6 |
| 64 | LTU | 95.9 | 93.1 | 51.0 | 96.0 | 65.1 | 27.9 | 19.0 | 100.0 | 30.2 | 39.4 | 80.4 | 24.8 | 24.0 | 100.0 | n/a | 97.4 | 39.4 | 50.0 | 44.8 | 74.7 | 63.1 |
| 65 | MMR | 48.7 | 62.0 | 17.9 | 96.7 | 75.0 | 72.7 | 64.0 | 52.8 | 64.2 | 58.9 | 98.4 | 1.2 | 100.0 | 84.7 | 70.1 | 42.9 | 91.7 | 31.9 | 41.8 | 49.4 | 29.9 |
| 66 | THA | 97.2 | 94.6 | n/a | 74.5 | 61.5 | 59.8 | 49.3 | 100.0 | 23.9 | 8.5 | 79.3 | 16.4 | 57.9 | 87.1 | 77.2 | 81.2 | 80.0 | 24.3 | 34.8 | 44.3 | 35.9 |
| 67 | BLR | 96.8 | 93.9 | 30.0 | 95.6 | 62.2 | 38.1 | 17.8 | 100.0 | 7.1 | 0.8 | 69.9 | 23.8 | 12.1 | 100.0 | 91.5 | 93.5 | 43.5 | 74.3 | 36.9 | 65.8 | 53.5 |
| 68 | PHL | 85.0 | 73.1 | 44.6 | 83.0 | 64.4 | 57.3 | 72.0 | 90.1 | 28.6 | 25.4 | 95.5 | 4.3 | 53.6 | 79.4 | 69.6 | 34.4 | 91.0 | 19.4 | 40.8 | 48.1 | 18.0 |
| 69 | GEO | 89.4 | 83.7 | 26.7 | 96.9 | 73.4 | 40.0 | 30.6 | 100.0 | 29.9 | 78.0 | 89.3 | 17.4 | 30.3 | 89.8 | 94.2 | 79.6 | 51.2 | 27.8 | 28.5 | 45.6 | 14.9 |
| 70 | BOL | 88.8 | 49.0 | 42.8 | 99.3 | 78.0 | 68.1 | 34.3 | 92.4 | 18.3 | 31.4 | 91.5 | 4.7 | 100.0 | 69.3 | 92.4 | n/a | 61.8 | 19.4 | 23.3 | 32.9 | 33.0 |
| 71 | PAN | 92.1 | 75.1 | 28.5 | 99.3 | 79.5 | 20.1 | 90.2 | 92.8 | 22.2 | 65.3 | 90.0 | 13.3 | 18.0 | 86.8 | 96.0 | 63.6 | 53.0 | 36.1 | 29.1 | 54.4 | 21.9 |
| 72 | ZAF | 75.9 | 71.0 | 61.0 | 65.4 | 51.0 | 34.7 | 13.9 | 82.7 | 17.9 | 2.3 | 59.6 | 27.2 | 100.0 | 91.9 | 90.2 | 46.6 | 42.6 | 41.0 | 44.3 | 55.7 | 21.1 |
| 73 | UZB | 86.6 | 100.0 | 38.0 | 0.0 | 47.7 | 30.8 | 4.9 | 100.0 | 3.1 | 20.7 | 84.7 | 10.5 | 100.0 | 89.8 | 81.3 | 62.6 | 69.6 | 33.3 | 54.0 | 45.6 | 29.8 |
| 74 | AZE | 75.4 | 88.5 | 61.5 | 0.0 | 51.3 | 29.2 | 12.4 | 100.0 | 2.4 | 7.0 | 82.4 | 14.2 | 100.0 | 100.0 | 87.5 | 65.8 | 59.0 | 23.6 | 34.4 | 64.6 | 24.6 |
| 75 | GTM | 89.9 | 64.9 | 15.1 | 97.0 | 67.1 | 48.5 | 61.0 | 91.0 | 66.4 | 60.4 | 95.0 | 3.5 | 66.7 | 75.9 | 98.2 | 7.6 | 61.5 | 22.2 | 24.1 | 44.3 | 28.0 |

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| Rank | Country | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
| 76 | SAU | 100.0 | 100.0 | 51.1 | 0.0 | 33.0 | n/a | 0.3 | 100.0 | 0.0 | 0.0 | 11.8 | 61.6 | 100.0 | 92.9 | 48.7 | 83.6 | 24.2 | 54.9 | 61.7 | 70.9 | 9.2 |
| 77 | LKA | 87.9 | 93.8 | 15.5 | 75.5 | 59.6 | 41.9 | 52.1 | 95.2 | 55.2 | 48.5 | 96.2 | 3.2 | 49.1 | 84.0 | 33.9 | 67.3 | 92.4 | 16.7 | 45.3 | 41.8 | 10.9 |
| 78 | CMR | 45.3 | 34.1 | 25.2 | 99.7 | 71.5 | 61.1 | 48.7 | 56.2 | 79.9 | 76.1 | 98.8 | 1.6 | 100.0 | 89.9 | 78.1 | 37.8 | 82.9 | 22.2 | 17.9 | 59.5 | 22.5 |
| 79 | ESP | 99.8 | 99.9 | 80.2 | 67.0 | 59.1 | 41.7 | 18.3 | 100.0 | 17.0 | 34.9 | 77.4 | 34.8 | 27.6 | 100.0 | 98.0 | 97.4 | n/a | n/a | 39.6 | n/a | 61.4 |
| 80 | MNE | 96.2 | 95.6 | 25.8 | 0.0 | n/a | n/a | 6.0 | 100.0 | 44.9 | 49.7 | 84.1 | 29.9 | 72.1 | 100.0 | 88.8 | 83.4 | 47.5 | 72.9 | 37.6 | 78.5 | 14.2 |
| 81 | GHA | 65.0 | 7.8 | 42.0 | 96.8 | 53.4 | 40.2 | 35.6 | 77.3 | 43.2 | 50.9 | 97.8 | 2.1 | 100.0 | 91.9 | 80.4 | 64.2 | 82.5 | 15.3 | 20.3 | 70.9 | 26.6 |
| 82 | SLV | 89.0 | 90.4 | 11.1 | 86.5 | 59.4 | 27.5 | 54.3 | 98.5 | 25.5 | 57.8 | 95.7 | 5.9 | 50.1 | 85.0 | 92.0 | 74.8 | 52.5 | 24.3 | 31.3 | 46.8 | 13.9 |
| 83 | CYP | 100.0 | 99.4 | 89.5 | 71.6 | 49.5 | 0.2 | 14.0 | 100.0 | 10.4 | 8.8 | 76.4 | 23.5 | 4.7 | 94.4 | 98.0 | 97.4 | 52.8 | 65.3 | 24.5 | 36.7 | 24.9 |
| 84 | IRN | 92.0 | 87.4 | 53.7 | 27.6 | 56.2 | 36.0 | 5.6 | 100.0 | 0.9 | 5.1 | 62.7 | 19.3 | 100.0 | 93.9 | 83.5 | n/a | 46.1 | 34.7 | 24.2 | 65.8 | 29.5 |
| 85 | OMN | 85.6 | 99.2 | 24.5 | 15.3 | 44.6 | n/a | 2.3 | 100.0 | n/a | n/a | 30.3 | 42.7 | 100.0 | 93.1 | 67.9 | 73.8 | 52.1 | 43.8 | 67.2 | 58.2 | 10.3 |
| 86 | HND | 87.7 | 78.3 | 10.2 | 98.2 | 70.2 | 46.3 | 60.4 | 86.4 | 53.8 | 42.3 | 95.4 | 3.9 | 46.3 | 76.7 | 95.1 | 56.2 | 60.1 | 33.3 | 19.1 | 46.8 | 17.8 |
| 87 | MLT | 100.0 | 100.0 | 72.0 | 55.7 | 36.0 | n/a | 16.0 | 100.0 | 5.6 | 7.7 | 75.8 | 32.0 | 0.3 | 100.0 | 98.0 | 97.4 | 33.4 | 63.2 | 55.7 | 69.6 | 15.4 |
| 88 | BGD | 95.7 | 42.8 | 43.5 | 65.9 | 49.3 | 72.8 | 82.0 | 73.6 | 36.3 | 1.2 | 98.2 | 1.8 | 82.9 | 76.9 | 37.5 | 28.8 | 97.0 | 3.5 | 54.2 | 38.0 | 12.5 |
| 89 | NIC | 72.1 | 74.5 | n/a | 99.0 | 77.2 | 53.3 | 69.9 | 80.0 | 50.3 | 50.1 | 96.6 | 3.5 | 58.6 | 75.2 | 91.5 | 67.3 | 54.6 | 25.0 | 19.4 | 48.1 | 21.9 |
| 90 | DZA | 89.7 | 86.5 | 41.5 | 30.6 | 43.0 | 19.5 | 1.2 | 99.4 | 0.1 | 0.3 | 83.4 | 8.6 | 100.0 | 94.2 | 83.0 | 78.7 | 43.5 | 35.4 | 16.9 | 81.0 | 20.2 |

| | | Water Sub-index | | | | | | | Energy Sub-index | | | | | | Food sub-index | | | | | | | |
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| **Rank** | **Country** | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
| 91 | EGY | 97.5 | 92.7 | 32.6 | 0.0 | 22.0 | 14.5 | 0.0 | 100.0 | 6.0 | 8.3 | 90.3 | 10.6 | 100.0 | 94.1 | 58.9 | 57.1 | 33.2 | 27.8 | 84.5 | 92.4 | 21.9 |
| 92 | ARM | 98.3 | 91.0 | 27.6 | 57.1 | 59.0 | 15.1 | 16.0 | 100.0 | 16.5 | 28.3 | 91.6 | 12.6 | 27.7 | 94.9 | 82.6 | 83.4 | 56.7 | 46.5 | 35.3 | 51.9 | 39.6 |
| 93 | MKD | 95.0 | 90.2 | n/a | 89.8 | 59.7 | n/a | 17.8 | 100.0 | 25.3 | 35.9 | 83.9 | 22.6 | 47.5 | 95.2 | 93.3 | n/a | 49.8 | 54.2 | 44.9 | 49.4 | 34.5 |
| 94 | BLZ | 95.4 | 86.2 | 9.5 | 99.4 | 81.1 | 30.6 | 51.9 | 91.5 | 36.5 | 45.2 | 93.9 | n/a | n/a | 91.3 | 93.3 | 72.0 | 53.2 | 35.4 | 36.4 | 54.4 | 42.2 |
| 95 | GUY | 92.3 | 85.1 | 4.6 | 99.4 | 96.2 | 61.8 | 73.3 | 82.7 | 26.4 | n/a | 88.3 | n/a | n/a | 89.6 | 72.8 | 78.1 | 60.6 | 23.6 | 40.7 | 53.2 | 50.8 |
| 96 | MNG | 73.5 | 56.1 | 35.6 | 98.4 | 71.3 | 35.3 | 6.0 | 80.0 | 3.6 | 3.1 | 68.0 | 13.0 | 100.0 | 71.1 | 96.9 | 80.6 | 59.7 | 44.4 | 13.4 | 34.2 | 29.2 |
| 97 | CHN | n/a | n/a | 71.2 | 78.7 | 58.0 | 83.0 | 18.6 | 100.0 | 12.9 | 23.9 | 66.1 | 25.5 | 84.8 | 87.6 | n/a | n/a | 89.6 | 49.3 | 71.3 | 65.8 | 35.2 |
| 98 | TUN | 90.9 | 92.6 | 48.6 | 23.3 | 45.0 | 5.6 | 4.9 | 100.0 | 13.1 | 2.8 | 88.5 | 9.2 | 63.3 | 93.9 | 88.8 | 82.0 | 41.9 | 45.8 | 16.6 | 79.7 | 33.2 |
| 99 | FJI | 90.1 | 95.4 | n/a | 99.7 | 78.9 | n/a | 79.7 | 98.5 | 32.6 | 45.0 | 94.3 | n/a | n/a | 94.7 | 73.2 | 87.3 | 35.7 | 47.9 | 34.6 | 57.0 | 20.1 |
| 100 | MUS | 99.8 | 92.6 | 59.7 | 73.7 | 58.4 | n/a | 62.4 | 98.7 | 12.0 | 22.7 | 85.1 | 14.0 | 14.3 | 92.4 | n/a | n/a | 78.3 | 47.2 | 39.9 | 58.2 | 17.4 |
| 101 | DOM | 91.3 | 81.4 | 27.1 | 69.6 | 58.7 | 21.2 | 42.6 | 100.0 | 17.2 | 11.6 | 90.9 | 10.1 | 12.1 | 84.8 | 90.6 | 88.1 | 42.9 | 45.8 | 55.9 | 44.3 | 26.9 |
| 102 | KHM | 60.6 | 44.9 | 38.5 | 98.2 | 68.2 | 63.6 | 58.1 | 44.9 | 67.8 | 46.4 | 98.3 | 1.5 | 66.4 | 71.5 | 58.5 | 36.4 | 96.8 | 6.9 | 40.0 | 36.7 | 26.0 |
| 103 | TKM | 91.3 | 96.3 | n/a | 0.0 | 42.1 | 21.0 | 3.4 | 100.0 | 0.0 | n/a | 43.5 | 17.3 | 100.0 | 92.9 | 82.6 | 79.1 | 64.5 | 41.0 | 10.9 | 53.2 | 30.1 |
| 104 | JAM | 88.8 | 84.3 | 35.5 | 92.5 | 62.6 | n/a | 62.7 | 98.0 | 17.5 | 10.3 | 88.5 | 6.7 | 16.9 | 87.3 | 85.3 | 90.0 | 48.6 | 36.1 | 11.1 | 43.0 | 17.6 |
| 105 | QAT | 100.0 | 100.0 | 79.9 | 0.0 | 23.5 | n/a | 0.7 | 100.0 | n/a | n/a | 0.0 | 100.0 | 100.0 | n/a | 98.0 | 97.4 | 26.7 | n/a | 55.0 | n/a | 2.0 |

| | | Water Sub-index | | | | | | | Energy Sub-index | | | | | | Food sub-index | | | | | | | |
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| **Rank** | **Country** | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
| 106 | LAO | 69.1 | 70.5 | n/a | 98.2 | 78.1 | 59.2 | 55.9 | 85.8 | 61.9 | 86.4 | 98.9 | n/a | n/a | 74.6 | 72.8 | n/a | 94.5 | 9.0 | 54.2 | 34.2 | 33.0 |
| 107 | NGA | 48.4 | 27.4 | 26.6 | 94.4 | 54.2 | 57.6 | 34.5 | 55.4 | 90.4 | 18.2 | 97.8 | 0.7 | 100.0 | 83.0 | 53.1 | 13.5 | 86.9 | 22.9 | 15.4 | 48.1 | 19.4 |
| 108 | CIV | 57.6 | 24.5 | 23.3 | 98.0 | 61.8 | 47.0 | 40.7 | 60.8 | 67.3 | 16.7 | 98.0 | 1.6 | 92.8 | 67.8 | 74.6 | n/a | 84.1 | 23.6 | 23.8 | 50.6 | 25.0 |
| 109 | PAK | 81.9 | 55.1 | 43.2 | 0.0 | 43.2 | 50.5 | 13.9 | 99.1 | 48.5 | 31.4 | 96.2 | 2.8 | 75.6 | 68.2 | 54.5 | 10.6 | 86.9 | 34.7 | 35.2 | 36.7 | 18.0 |
| 110 | PRK | 99.4 | 75.3 | 30.5 | 87.1 | 59.9 | 43.8 | 31.5 | 33.4 | 24.1 | 72.8 | 92.9 | 3.7 | 100.0 | 30.4 | 83.5 | n/a | 88.5 | 7.6 | 47.6 | 10.1 | 12.9 |
| 111 | MAR | 73.2 | 82.2 | 59.2 | 64.3 | 51.2 | 25.2 | 9.3 | 100.0 | 11.8 | 14.3 | 92.3 | 5.6 | 8.1 | 95.5 | 91.1 | 72.2 | 45.9 | 30.6 | 9.2 | 86.1 | 23.1 |
| 112 | BTN | 96.2 | 60.1 | 23.7 | 99.6 | 87.5 | 45.6 | 67.4 | 100.0 | 90.7 | 100.0 | 94.4 | n/a | n/a | n/a | 75.0 | 33.9 | 91.5 | n/a | 39.4 | n/a | 23.7 |
| 113 | TJK | 59.1 | 95.2 | n/a | 82.4 | 67.9 | 23.3 | 20.1 | 100.0 | 46.6 | 98.5 | 97.4 | 9.4 | 63.3 | n/a | 57.1 | 47.9 | 75.8 | 24.3 | 38.6 | 22.8 | 12.9 |
| 114 | SGP | 100.0 | 100.0 | 100.0 | 68.3 | 35.6 | n/a | 76.7 | 100.0 | 0.7 | 1.8 | 53.5 | 57.7 | 1.0 | n/a | 85.3 | 93.7 | 89.6 | n/a | n/a | n/a | 0.0 |
| 115 | IND | 80.4 | 39.9 | n/a | 55.2 | 53.3 | 77.9 | 32.4 | 83.0 | 37.6 | 15.3 | 92.4 | 5.0 | 65.2 | 77.6 | 7.6 | 24.1 | 96.1 | 19.4 | 34.3 | 36.7 | 17.0 |
| 116 | SEN | 60.9 | 44.5 | 47.2 | 91.4 | 56.8 | 34.7 | 19.9 | 61.1 | 44.6 | 10.4 | 97.5 | 1.2 | 46.6 | 83.3 | 69.2 | 67.9 | 87.8 | 33.3 | 14.3 | 40.5 | 9.2 |
| 117 | MDV | 96.7 | 95.6 | 27.1 | 84.4 | 32.5 | n/a | 60.2 | 100.0 | 1.0 | 1.3 | 85.4 | n/a | n/a | 83.8 | 55.8 | 61.1 | 86.6 | 26.4 | 27.6 | 45.6 | 1.2 |
| 118 | KEN | 34.5 | 24.4 | 46.4 | 84.5 | 46.4 | 33.8 | 18.2 | 51.7 | 75.8 | 87.5 | 98.8 | 0.8 | 82.6 | 62.0 | 83.5 | 49.5 | 91.0 | 16.0 | 14.8 | 27.8 | 13.6 |
| 119 | LBN | 87.9 | 95.0 | 23.3 | 77.2 | 51.3 | 9.9 | 19.1 | 100.0 | 3.8 | 2.6 | 80.8 | 18.7 | 0.8 | 84.0 | 71.9 | 68.9 | 32.7 | 54.2 | 34.6 | 44.3 | 17.0 |
| 120 | COG | 50.0 | 8.5 | 23.2 | 100.0 | 81.5 | 74.0 | 50.0 | 52.4 | 65.1 | 53.3 | 97.4 | 1.0 | 100.0 | 40.1 | 64.7 | n/a | 85.5 | 15.3 | 7.9 | 19.0 | 7.7 |

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| 121 | IRQ | 78.1 | 84.6 | 15.3 | 0.0 | 52.5 | 33.9 | 5.2 | 100.0 | 0.8 | 3.7 | 78.4 | 8.3 | 100.0 | 56.3 | 68.3 | 56.4 | 41.7 | 28.5 | 35.6 | 40.5 | 4.5 |
| 122 | WSM | 92.9 | 96.3 | 66.0 | 0.0 | n/a | n/a | 48.0 | 100.0 | 35.8 | 30.4 | 95.6 | n/a | n/a | 96.9 | 84.8 | 93.0 | 0.0 | 79.2 | n/a | 63.3 | 26.8 |
| 123 | TGO | 41.3 | 7.3 | 23.0 | 98.6 | 56.0 | 25.1 | 35.0 | 41.8 | 74.4 | 75.3 | 98.6 | 0.7 | 79.8 | 75.2 | 71.4 | 46.4 | 88.5 | 17.4 | 11.6 | 44.3 | 11.0 |
| 124 | AGO | 6.9 | 34.8 | 28.9 | 99.5 | 65.4 | 53.7 | 30.1 | 34.8 | 51.7 | 53.2 | 94.4 | 1.8 | 100.0 | 62.5 | 79.5 | 25.8 | 89.2 | 19.4 | 9.2 | 36.7 | 12.4 |
| 125 | BRB | 97.0 | 96.2 | 34.1 | 12.5 | 42.8 | n/a | 43.0 | 100.0 | 2.9 | n/a | 79.9 | n/a | n/a | 95.9 | 71.0 | 86.9 | 47.7 | 44.4 | 32.5 | 53.2 | 13.2 |
| 126 | MOZ | 16.9 | 17.8 | 48.7 | 99.1 | 62.4 | 55.8 | 30.8 | 16.9 | 90.2 | 86.4 | 98.8 | 2.8 | 100.0 | 51.7 | 74.1 | 14.5 | 91.0 | 11.8 | 7.9 | 34.2 | 8.7 |
| 127 | ZMB | 38.8 | 25.8 | 39.1 | 98.1 | 64.9 | 44.6 | 30.4 | 20.2 | 91.8 | 97.0 | 98.9 | 4.4 | 91.6 | 28.5 | 73.2 | 20.9 | 89.9 | 11.8 | 27.3 | 17.7 | 10.6 |
| 128 | STP | 68.0 | 35.5 | 12.8 | 99.7 | 71.0 | n/a | 98.7 | 62.1 | 42.8 | 10.5 | 97.6 | n/a | n/a | 85.1 | 83.5 | 67.5 | 80.4 | 36.1 | 23.4 | 43.0 | 13.4 |
| 129 | DMA | 94.5 | 76.2 | 32.2 | 90.0 | 60.2 | n/a | 63.7 | 100.0 | 8.2 | 16.2 | 91.8 | n/a | n/a | 93.4 | n/a | n/a | 39.9 | 36.8 | 18.5 | 54.4 | 34.5 |
| 130 | ETH | 3.9 | 0.0 | 22.4 | 93.6 | 54.2 | 51.3 | 25.0 | 37.4 | 96.2 | 100.0 | 99.7 | 0.2 | 94.0 | 66.7 | 57.1 | 24.1 | 96.5 | 1.4 | 28.1 | 32.9 | 10.3 |
| 131 | BEN | 47.9 | 7.3 | 57.9 | 98.8 | 52.5 | 30.1 | 31.0 | 35.7 | 53.1 | 5.6 | 97.5 | 0.4 | 52.8 | 84.8 | 81.3 | 33.1 | 85.9 | 17.4 | 15.6 | 55.7 | 19.7 |
| 132 | JOR | 97.8 | 96.4 | 58.6 | 0.0 | 32.9 | 0.0 | 1.9 | 100.0 | 3.4 | 1.0 | 86.6 | 12.1 | 1.9 | 79.7 | 90.6 | 86.7 | 27.9 | 52.8 | 16.5 | 41.8 | 13.8 |
| 133 | LBY | 95.0 | 99.7 | 40.0 | 0.0 | 35.8 | n/a | 0.2 | 98.4 | 2.0 | n/a | 58.6 | 11.9 | 100.0 | n/a | 72.3 | 59.7 | 31.6 | n/a | 6.5 | 77.2 | 16.6 |
| 134 | MLI | 59.5 | 26.0 | 47.2 | 91.4 | 62.1 | 45.9 | 7.2 | 28.8 | 64.2 | 43.5 | 99.9 | n/a | n/a | 92.1 | 41.1 | 40.5 | 88.5 | 26.4 | 17.4 | 79.7 | 22.5 |
| 135 | ZWE | 47.3 | 33.9 | 55.9 | 70.9 | 50.7 | 26.6 | 19.0 | 32.2 | 85.4 | 52.7 | 96.7 | 3.3 | 84.5 | 25.1 | 87.1 | 47.9 | 76.5 | 23.6 | 4.9 | 10.1 | 6.6 |

| | | Water Sub-index | | | | | | | Energy Sub-index | | | | | | Food sub-index | | | | | | | |
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| 136 | BWA | 67.2 | 56.9 | 33.5 | 91.9 | 53.3 | 14.7 | 11.4 | 56.9 | 30.1 | 0.0 | 85.5 | 11.2 | 54.9 | 55.0 | 69.2 | 38.4 | 67.7 | 27.8 | 3.3 | 24.1 | 15.7 |
| 137 | GIN | 48.6 | 16.0 | 14.3 | 99.8 | 74.9 | 57.9 | 50.2 | 27.1 | 79.6 | 78.8 | 99.3 | n/a | n/a | 69.5 | 65.2 | 36.4 | 89.6 | 25.7 | 12.2 | 45.6 | 15.9 |
| 138 | TZA | 21.3 | 17.7 | n/a | 93.8 | 56.1 | 46.1 | 32.0 | 26.3 | 89.5 | 34.2 | 99.2 | 0.4 | 89.1 | 49.2 | 81.3 | n/a | 95.4 | 15.3 | 16.6 | 34.2 | 17.7 |
| 139 | HKG | 100.0 | 96.0 | n/a | 0.0 | n/a | n/a | n/a | 100.0 | 0.9 | 0.3 | 71.3 | 39.6 | 0.0 | 100.0 | 98.0 | n/a | n/a | 77.8 | 22.2 | 69.6 | 0.0 |
| 140 | SWZ | 48.9 | 54.8 | 46.4 | 60.5 | 57.9 | 16.1 | 23.1 | 62.5 | 69.0 | 46.6 | 96.0 | n/a | n/a | 67.8 | 92.4 | n/a | 73.7 | 13.9 | 11.7 | 30.4 | 21.8 |
| 141 | COD | 8.2 | 13.6 | 22.4 | 99.9 | 71.5 | 78.4 | 46.8 | 9.1 | 100.0 | 99.8 | 100.0 | 0.5 | 98.0 | n/a | 65.2 | n/a | 91.9 | n/a | 7.2 | n/a | 4.3 |
| 142 | NER | 14.5 | 6.2 | 43.1 | 71.9 | 39.5 | 27.9 | 3.1 | 8.1 | 82.4 | 0.8 | 99.7 | 0.1 | 100.0 | 78.2 | 55.4 | 16.4 | 94.0 | 21.5 | 4.3 | 55.7 | 16.5 |
| 143 | SDN | 35.2 | 29.6 | 32.1 | 0.0 | 35.0 | 31.6 | 6.2 | 32.6 | 64.3 | 64.5 | 98.9 | 1.0 | 100.0 | 60.4 | 28.6 | 24.5 | 87.8 | 31.3 | 6.2 | 34.2 | 14.9 |
| 144 | VUT | 85.0 | 49.9 | 30.9 | 0.0 | 80.3 | n/a | 4.9 | 53.7 | 37.7 | 21.3 | 97.5 | n/a | n/a | 90.3 | 81.7 | 44.4 | 50.7 | 55.6 | 5.3 | 62.0 | 25.8 |
| 145 | SYR | 94.8 | 92.4 | n/a | 0.0 | 44.9 | 21.4 | 6.3 | 100.0 | 0.5 | 2.3 | 93.0 | 6.0 | 51.5 | n/a | 50.0 | 46.4 | 45.4 | n/a | 17.5 | 69.6 | 23.5 |
| 146 | HTI | 43.5 | 25.2 | 20.2 | 88.9 | 54.1 | 16.2 | 43.6 | 32.8 | 79.4 | 8.0 | 99.0 | 0.0 | 77.7 | 26.4 | 78.1 | 57.9 | 57.6 | 17.4 | 10.2 | 21.5 | 12.2 |
| 147 | MDA | 79.0 | 76.7 | n/a | 34.3 | 46.5 | 21.3 | 12.5 | 100.0 | 14.9 | 5.4 | 94.0 | 8.8 | 8.8 | n/a | 92.9 | n/a | 58.5 | 42.4 | 36.8 | 32.9 | 29.1 |
| 148 | GMB | 68.6 | 37.2 | 20.7 | 97.0 | 55.9 | 16.8 | 24.6 | 42.7 | 53.8 | n/a | 99.0 | n/a | n/a | 86.1 | 51.8 | n/a | 84.8 | 33.3 | 8.1 | 51.9 | 5.9 |
| 149 | CPV | 78.7 | 62.5 | n/a | 93.3 | 48.2 | n/a | 5.6 | 91.9 | 27.7 | 20.2 | 96.0 | n/a | n/a | 81.7 | n/a | n/a | 80.4 | 31.3 | 0.0 | 43.0 | 6.4 |
| 150 | SLE | 33.9 | 8.0 | 8.1 | 99.9 | 76.2 | 54.3 | 77.6 | 12.6 | 81.0 | 61.0 | 99.4 | n/a | n/a | 59.9 | 59.4 | 25.2 | 87.6 | 22.9 | 20.9 | 38.0 | 16.2 |

| | | Water Sub-index | | | | | | | Energy Sub-index | | | | | | Food sub-index | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements ($10^6$ $m^3$/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | $CO_2$ emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| **Rank** | **Country** | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
| 151 | LSO | 55.2 | 39.5 | 24.2 | 99.2 | 59.3 | 9.4 | 23.1 | 22.9 | 54.4 | 100.0 | 95.0 | n/a | n/a | 80.9 | 88.8 | 34.8 | 73.7 | 5.6 | 4.0 | 44.3 | 6.4 |
| 152 | MWI | 48.3 | 39.2 | 32.5 | 91.6 | 52.1 | 26.8 | 35.4 | 2.4 | 87.3 | 91.3 | 99.9 | n/a | n/a | 58.6 | 89.3 | 26.8 | 94.0 | 10.4 | 14.3 | 31.6 | 12.6 |
| 153 | RWA | 31.7 | 59.4 | 26.2 | 98.4 | 51.1 | 27.5 | 36.4 | 22.5 | 90.4 | 56.9 | 99.9 | n/a | n/a | 42.4 | 91.5 | 25.2 | 93.8 | 1.4 | 16.4 | 26.6 | 19.2 |
| 154 | UGA | 3.6 | 13.0 | 53.3 | 98.4 | 52.5 | 44.6 | 35.4 | 19.6 | 92.9 | 93.0 | 99.6 | n/a | n/a | 33.7 | 85.3 | 43.6 | 88.5 | 16.0 | 21.1 | 20.3 | 10.8 |
| 155 | AFG | 41.6 | 34.6 | 0.0 | 57.0 | 55.2 | 38.4 | 8.7 | 82.6 | 19.2 | 86.1 | 98.9 | n/a | n/a | 52.0 | 58.9 | 19.0 | 94.5 | 6.3 | 22.0 | 20.3 | 9.3 |
| 156 | TLS | 53.0 | 39.7 | 2.9 | 85.8 | 67.0 | 18.4 | 45.4 | 59.8 | 19.0 | n/a | 98.5 | n/a | n/a | 57.1 | 52.2 | 0.0 | 98.2 | 16.7 | 27.7 | 29.1 | 8.6 |
| 157 | LBR | 52.5 | 10.5 | 4.0 | 100.0 | 81.5 | 59.0 | 73.4 | 12.0 | 87.5 | n/a | 99.3 | n/a | n/a | 38.0 | 76.3 | 37.0 | 85.0 | 25.0 | 13.9 | 27.8 | 6.5 |
| 158 | BFA | 27.3 | 16.6 | 57.7 | 93.5 | 49.9 | 15.8 | 21.9 | 11.3 | 77.4 | 9.4 | 99.5 | n/a | n/a | 66.8 | 67.4 | 46.8 | 94.5 | 25.7 | 12.2 | 54.4 | 11.0 |
| 159 | GNB | 51.4 | 15.5 | n/a | 98.9 | 69.4 | 34.5 | 47.9 | 6.4 | 90.6 | n/a | 99.5 | n/a | n/a | 59.1 | 74.6 | 46.2 | 85.9 | 27.1 | 15.2 | 29.1 | 19.6 |
| 160 | SLB | 43.2 | 26.0 | 16.1 | 0.0 | 85.6 | n/a | 93.4 | 42.9 | 66.1 | 2.3 | 98.7 | n/a | n/a | 81.7 | 66.1 | 38.0 | 57.6 | 16.7 | 18.0 | 43.0 | 18.5 |
| 161 | COM | 74.3 | 29.2 | 16.1 | 99.2 | 56.0 | n/a | 26.6 | 75.7 | 47.3 | n/a | 99.3 | n/a | n/a | n/a | 51.8 | 37.0 | 88.9 | n/a | 14.4 | 32.9 | 8.0 |
| 162 | YEM | 53.3 | 56.6 | n/a | 0.0 | 33.2 | n/a | 3.6 | 68.9 | 2.4 | n/a | 96.3 | 1.2 | 100.0 | 45.2 | 28.6 | n/a | 72.4 | 14.6 | 10.0 | 20.3 | 5.6 |
| 163 | NAM | n/a | n/a | 53.8 | 95.4 | 59.7 | 23.9 | 7.3 | 47.1 | 27.6 | 97.8 | 93.1 | 10.1 | 24.6 | 60.1 | n/a | n/a | 70.3 | 17.4 | 3.4 | 24.1 | 15.3 |
| 164 | CAF | 27.6 | 19.4 | 22.0 | 100.0 | 78.6 | 54.5 | 40.5 | 5.7 | 79.9 | 99.4 | 99.9 | n/a | n/a | 0.0 | 68.3 | 19.4 | 90.3 | 26.4 | 8.6 | 0.0 | 18.5 |
| 165 | MDG | 22.1 | 2.8 | 28.2 | 96.0 | 72.7 | 61.3 | 45.8 | 15.4 | 73.2 | 54.6 | 99.7 | n/a | n/a | 30.9 | 33.5 | 2.0 | 94.5 | 0.0 | 45.6 | 12.7 | 12.4 |

| | | Water Sub-index | | | | | | | Energy Sub-index | | | | | | Food sub-index | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements ($10^6$ $m^3$/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | $CO_2$ emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| **Rank** | **Country** | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
| 166 | MRT | 52.1 | 40.4 | 38.3 | 0.0 | 34.8 | 8.9 | 1.3 | 36.0 | 33.6 | 13.4 | 97.2 | n/a | n/a | 83.3 | 35.3 | 45.6 | 78.8 | 37.5 | 12.7 | 59.5 | 13.9 |
| 167 | DJI | 63.6 | 47.7 | n/a | 93.8 | 44.0 | n/a | 5.3 | 47.1 | 16.0 | n/a | 96.7 | n/a | n/a | 69.5 | 5.4 | 34.2 | 76.7 | 24.3 | 21.3 | 36.7 | 6.9 |
| 168 | PNG | 0.0 | 12.4 | 15.2 | 100.0 | 87.7 | 70.9 | 96.9 | 15.5 | 54.8 | 34.5 | 96.6 | n/a | n/a | n/a | 37.5 | 1.4 | 60.1 | n/a | 55.6 | 26.6 | 32.6 |
| 169 | SSD | 21.8 | 3.6 | 30.3 | 97.5 | 58.7 | 40.4 | 26.6 | 0.1 | 40.8 | 0.6 | 99.7 | 0.0 | 100.0 | n/a | 0.0 | 39.1 | n/a | n/a | 16.3 | n/a | 13.3 |
| 170 | TCD | 9.3 | 2.6 | 23.0 | 94.2 | 53.2 | 37.2 | 8.5 | 0.0 | 93.3 | n/a | 100.0 | n/a | n/a | 36.5 | 43.3 | 21.1 | 93.8 | 16.0 | 8.1 | 24.1 | 14.0 |

**Legend**

| | |
|---|---|
| 12.7 | : values between 0 and 25 |
| 31.4 | : values between 25 and 50 |
| 61.3 | : values between 50 and 75 |
| 78.9 | : values between 75 and 100 to 25 |

# Appendix C: Untreated Data

| | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements (106 m$^3$/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | $CO_2$ emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| AFG | 63.0 | 39.2 | 11.5 | 43.0 | 1439 | 28.3 | 327.0 | 84.1 | 18.4 | 86.1 | 0.3 | n/a | n/a | 30.3 | 9.5 | 40.9 | 4.5 | 33.0 | 1981 | 95.0 | 104.0 |
| ALB | 91.4 | 97.7 | 43.1 | 4.9 | 9311 | 13.6 | 1485 | 100.0 | 38.6 | 100.0 | 2.0 | 2309 | 13.8 | 5.5 | 9.4 | 23.1 | 22.3 | 104.0 | 4716 | 129.0 | 462.0 |
| DZA | 93.5 | 87.5 | 48.2 | 69.4 | 288 | 4.6 | 89.0 | 99.4 | 0.1 | 0.3 | 3.7 | 1356 | -177.1 | 4.7 | 4.1 | 11.7 | 26.6 | 75.0 | 1560 | 143.0 | 220.0 |
| AGO | 41.0 | 39.4 | 37.1 | 0.5 | 5498 | 110.7 | 1010 | 40.5 | 49.6 | 53.2 | 1.3 | 312 | -541.0 | 23.9 | 4.9 | 37.6 | 6.8 | 52.0 | 934.7 | 108.0 | 137.0 |
| ARG | 99.6 | 94.8 | 38.2 | 12.9 | 6794 | 515.8 | 591.0 | 100.0 | 10.0 | 28.1 | 4.7 | 3052 | 13.0 | 3.8 | 1.2 | 8.2 | 28.5 | 114.0 | 5096 | 135.0 | 1030 |
| ARM | 98.9 | 91.6 | 35.9 | 42.9 | 2360 | 2.8 | 562.0 | 100.0 | 15.8 | 28.3 | 1.9 | 1966 | 71.3 | 4.3 | 4.2 | 9.4 | 20.9 | 91.0 | 3076 | 120.0 | 426.0 |
| AUS | 100.0 | 100.0 | 85.5 | 3.1 | 20932 | 243.3 | 534.0 | 100.0 | 9.2 | 13.6 | 15.4 | 10059 | -190.2 | 1.2 | 0.8 | 2.0 | 30.4 | 150.0 | 2074 | 132.0 | 1009 |
| AUT | 100.0 | 100.0 | 91.1 | 6.3 | 6435 | 41.5 | 1110 | 100.0 | 34.4 | 76.5 | 6.9 | 8356 | 63.5 | 1.2 | 0.8 | 2.6 | 21.9 | 168.0 | 7245 | 148.0 | 472.0 |
| AZE | 84.4 | 89.3 | 66.0 | 147.5 | 851 | 12.0 | 447.0 | 100.0 | 2.3 | 7.0 | 3.9 | 2202 | -310.4 | 1.2 | 3.1 | 18.0 | 19.9 | 58.0 | 3004 | 130.0 | 266.0 |
| BGD | 97.3 | 46.9 | 50.0 | 34.2 | 659 | 600.3 | 2666 | 75.9 | 34.7 | 1.2 | 0.5 | 310 | 16.8 | 15.2 | 14.3 | 36.1 | 3.4 | 29.0 | 4628 | 109.0 | 138.0 |
| BRB | 98.1 | 96.5 | 41.7 | 87.5 | 282 | n/a | 1422 | 100.0 | 2.8 | n/a | 4.5 | n/a | n/a | 3.7 | 6.8 | 7.7 | 24.8 | 88.0 | 2848 | 121.0 | 145.0 |
| BLR | 98.0 | 94.3 | 38.1 | 4.5 | 3589 | 27.6 | 618.0 | 100.0 | 6.8 | 0.8 | 6.7 | 3680 | 86.8 | 1.2 | 2.2 | 4.5 | 26.6 | 131.0 | 3207 | 131.0 | 573.0 |
| BEL | 100.0 | 99.5 | 77.5 | 50.0 | 1071 | 10.2 | 847.0 | 100.0 | 9.2 | 20.8 | 8.3 | 7709 | 80.1 | 1.2 | 0.8 | 2.6 | 24.5 | 163.0 | 6984 | 147.0 | 431.0 |
| BLZ | 97.1 | 87.2 | 19.9 | 0.7 | 43390 | 13.7 | 1705 | 92.2 | 35.0 | 45.2 | 1.4 | n/a | n/a | 6.5 | 1.8 | 15.0 | 22.4 | 75.0 | 3164 | 122.0 | 453.0 |
| BEN | 67.0 | 13.9 | 62.8 | 1.3 | 1001 | 13.1 | 1039 | 41.4 | 50.9 | 5.6 | 0.6 | 100 | 46.6 | 10.4 | 4.5 | 34.0 | 8.2 | 49.0 | 1455 | 123.0 | 214.0 |
| BTN | 97.6 | 62.9 | 32.4 | 0.4 | 10045<br>7 | 54.1 | 2200 | 100.0 | 86.9 | 100.0 | 1.3 | n/a | n/a | n/a | 5.9 | 33.6 | 5.8 | n/a | 3410 | n/a | 257.0 |
| BOL | 92.9 | 52.6 | 49.4 | 0.7 | 28735 | 396.6 | 1146 | 93.0 | 17.5 | 31.4 | 1.9 | 753 | -178.0 | 19.8 | 2.0 | n/a | 18.7 | 52.0 | 2092 | 105.0 | 355.0 |

| | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements (106 m$^3$/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | $CO_2$ emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| BIH | 97.7 | 94.8 | 60.9 | 0.9 | 9955 | 22.4 | 1028 | 100.0 | 40.8 | 35.5 | 6.2 | 3366 | 22.7 | 1.2 | 2.3 | 8.9 | 19.4 | 73.0 | 5191 | 128.0 | 252.0 |
| BWA | 79.2 | 60.0 | 41.1 | 8.1 | 1107 | 2.7 | 416.0 | 60.7 | 28.9 | 0.0 | 3.2 | 1749 | 44.5 | 28.5 | 7.2 | 31.4 | 16.1 | 64.0 | 452.8 | 98.0 | 172.0 |
| BRA | 97.5 | 86.1 | 50.7 | 1.3 | 27721 | 6532 | 1761 | 100.0 | 43.8 | 74.0 | 2.6 | 2601 | 11.9 | 1.2 | 1.6 | 7.1 | 22.3 | 116.0 | 4180 | 130.0 | 684.0 |
| BRN | 99.5 | 96.3 | n/a | 1.1 | 20646 | 5.8 | 2722 | 100.0 | 0.0 | 0.0 | 22.1 | 10243 | -357.4 | 2.6 | 2.9 | 19.7 | 14.7 | 82.0 | 844.2 | 124.0 | 116.0 |
| BGR | 99.3 | 86.0 | 60.2 | 27.2 | 2907 | 7.8 | 608.0 | 100.0 | 17.7 | 18.0 | 5.9 | 4709 | 36.6 | 3.0 | 3.2 | 8.8 | 27.4 | 94.0 | 4817 | 117.0 | 457.0 |
| BFA | 53.9 | 22.5 | 62.6 | 6.5 | 711 | 3.0 | 748.0 | 19.2 | 74.2 | 9.4 | 0.2 | n/a | n/a | 21.3 | 7.6 | 27.3 | 4.5 | 61.0 | 1181 | 122.0 | 122.0 |
| CPV | 86.5 | 65.2 | n/a | 6.8 | 570 | n/a | 228.0 | 92.6 | 26.6 | 20.2 | 0.9 | n/a | n/a | 12.3 | n/a | n/a | 10.6 | 69.0 | 178.0 | 113.0 | 73.0 |
| KHM | 75.0 | 48.8 | 45.6 | 1.8 | 7897 | 265.4 | 1904 | 49.8 | 64.9 | 46.4 | 0.4 | 271 | 33.1 | 18.5 | 9.6 | 32.4 | 3.5 | 34.0 | 3459 | 108.0 | 281.0 |
| CMR | 65.3 | 38.8 | 33.8 | 0.4 | 12275 | 213.4 | 1604 | 60.1 | 76.5 | 76.1 | 0.3 | 281 | -28.3 | 7.3 | 5.2 | 31.7 | 9.5 | 56.0 | 1643 | 126.0 | 244.0 |
| CAN | 98.9 | 98.5 | n/a | 1.4 | 80202 | 1931 | 537.0 | 100.0 | 22.0 | 63.0 | 15.1 | 15546 | -72.5 | 1.2 | 0.8 | 2.6 | 31.3 | 148.0 | 3908 | 140.0 | 746.0 |
| CAF | 54.1 | 25.1 | 31.0 | 0.1 | 31227 | 119.4 | 1343 | 14.0 | 76.6 | 99.4 | 0.1 | n/a | n/a | 61.8 | 7.4 | 40.7 | 6.3 | 62.0 | 879.8 | 79.0 | 202.0 |
| TCD | 42.5 | 9.5 | 31.8 | 5.9 | 1105 | 25.2 | 322.0 | 8.8 | 89.4 | n/a | 0.1 | n/a | n/a | 39.7 | 13.0 | 39.9 | 4.8 | 47.0 | 844.7 | 98.0 | 154.0 |
| CHL | 100.0 | 99.9 | 22.6 | 4.0 | 50245 | 529.3 | 1522 | 100.0 | 24.9 | 43.6 | 4.7 | 3912 | 65.2 | 3.3 | 0.3 | 1.8 | 28.8 | 86.0 | 6858 | 125.0 | 455.0 |
| CHN | n/a | n/a | 74.5 | 21.3 | 2062 | 1471 | 645.0 | 100.0 | 12.4 | 23.9 | 7.5 | 3927 | 15.0 | 8.7 | n/a | n/a | 6.6 | 95.0 | 6029 | 131.0 | 379.0 |
| COL | 96.5 | 84.4 | 50.4 | 0.5 | 44882 | 1692 | 3240 | 99.0 | 23.6 | 68.2 | 1.8 | 1290 | -274.1 | 6.5 | 0.9 | 12.7 | 22.1 | 80.0 | 4191 | 127.0 | 282.0 |
| COM | 83.7 | 34.2 | 25.7 | 0.8 | 1580 | n/a | 900.0 | 77.8 | 45.3 | n/a | 0.2 | n/a | n/a | n/a | 11.1 | 32.1 | 6.9 | n/a | 1355 | 105.0 | 90.0 |
| COD | 41.8 | 19.7 | 31.3 | 0.1 | 12208 | 981.7 | 1543 | 17.1 | 95.8 | 99.8 | 0.1 | 109 | 2.0 | n/a | 8.1 | n/a | 5.6 | n/a | 771.5 | n/a | 51.0 |

| | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements (106 $m^3$/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | $CO_2$ emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| COG | 68.3 | 15.0 | 32.0 | 0.0 | 45575 | 664.4 | 1646 | 56.6 | 62.4 | 53.3 | 0.6 | 197 | -496.6 | 37.5 | 8.2 | n/a | 8.4 | 46.0 | 828.2 | 94.0 | 87.0 |
| CRI | 99.7 | 97.1 | 43.3 | 2.1 | 23752 | 54.4 | 2926 | 100.0 | 38.7 | 99.0 | 1.6 | 1958 | 49.8 | 4.4 | 1.0 | 5.6 | 25.7 | 89.0 | 4027 | 119.0 | 634.0 |
| CIV | 73.1 | 29.9 | 32.1 | 2.0 | 3410 | 61.3 | 1348 | 64.3 | 64.5 | 16.7 | 0.5 | 276 | 7.1 | 20.7 | 6.0 | n/a | 9.0 | 58.0 | 2133 | 119.0 | 271.0 |
| HRV | 99.6 | 97.5 | 89.8 | 1.7 | 8895 | 60.5 | 1113 | 100.0 | 33.1 | 66.8 | 4.0 | 3714 | 45.9 | 1.2 | 0.8 | 2.6 | 27.1 | 112.0 | 6742 | 123.0 | 351.0 |
| CUB | 95.2 | 90.8 | 80.4 | 18.3 | 3332 | 9.1 | 1335 | 100.0 | 19.3 | 3.9 | 3.0 | 1434 | 49.8 | 1.2 | 2.4 | 7.0 | 26.7 | 66.0 | 2939 | 147.0 | 254.0 |
| CYP | 100.0 | 99.4 | 90.7 | 28.4 | 677 | 0.0 | 498.0 | 100.0 | 9.9 | 8.8 | 5.3 | 3625 | 94.0 | 4.6 | 0.8 | 2.6 | 22.6 | 118.0 | 2191 | 108.0 | 269.0 |
| CZE | 99.9 | 99.1 | 79.3 | 12.5 | 1249 | 6.6 | 677.0 | 100.0 | 14.8 | 11.4 | 9.2 | 6259 | 31.6 | 1.2 | 4.6 | n/a | 28.5 | 135.0 | 6317 | 128.0 | 347.0 |
| DNK | 100.0 | 99.6 | 93.0 | 10.6 | 1063 | 2.3 | 703.0 | 100.0 | 33.2 | 65.5 | 5.9 | 5859 | 1.8 | 1.2 | 0.8 | 2.6 | 21.3 | 133.0 | 6222 | 132.0 | 1067 |
| DJI | 76.9 | 51.4 | n/a | 6.3 | 329 | n/a | 220 | 51.8 | 15.4 | n/a | 0.8 | n/a | n/a | 19.7 | 21.5 | 33.5 | 12.2 | 59.0 | 1925 | 108.0 | 78.0 |
| DMA | 96.5 | 77.9 | 40.0 | 10.0 | 2748 | n/a | 2083 | 100.0 | 7.8 | 16.2 | 1.9 | n/a | n/a | 5.2 | n/a | n/a | 28.2 | 77.0 | 1696 | 122.0 | 371.0 |
| DOM | 94.5 | 82.7 | 35.5 | 30.4 | 2258 | 5.5 | 1410 | 100.0 | 16.5 | 11.6 | 2.1 | 1578 | 86.7 | 10.4 | 2.4 | 7.1 | 26.9 | 90.0 | 4761 | 114.0 | 291.0 |
| ECU | 92.6 | 86.1 | 41.8 | 2.2 | 27818 | 296.2 | 2274 | 99.9 | 13.8 | 52.8 | 2.8 | 1381 | -114.7 | 7.8 | 1.6 | 23.9 | 19.3 | 93.0 | 3575 | 115.0 | 372.0 |
| EGY | 98.4 | 93.2 | 40.3 | 4100 | 20 | 2.6 | 51.0 | 100.0 | 5.7 | 8.3 | 2.2 | 1658 | -7.4 | 4.8 | 9.5 | 22.3 | 31.1 | 64.0 | 7114 | 152.0 | 238.0 |
| SLV | 93.0 | 91.1 | 21.3 | 13.6 | 2488 | 10.2 | 1784 | 98.6 | 24.4 | 57.8 | 1.0 | 939 | 49.2 | 10.3 | 2.1 | 13.6 | 22.7 | 59.0 | 2745 | 116.0 | 153.0 |
| EST | 99.6 | 99.6 | 80.0 | 13.5 | 9669 | 3.6 | 626.0 | 100.0 | 27.5 | 14.4 | 14.8 | 6732 | -2.7 | 2.8 | n/a | 2.6 | 23.8 | 91.0 | 2658 | 128.0 | 432.0 |
| ETH | 39.1 | 7.1 | 31.3 | 6.4 | 1253 | 89.3 | 848.0 | 42.9 | 92.2 | 100.0 | 0.1 | 70 | 5.9 | 21.4 | 9.9 | 38.4 | 3.6 | 26.0 | 2484 | 105.0 | 114.0 |
| FJI | 93.7 | 95.7 | n/a | 0.3 | 32231 | n/a | 2592 | 98.6 | 31.3 | 45.0 | 1.3 | n/a | n/a | 4.4 | 6.3 | 7.5 | 30.0 | 93.0 | 3017 | 124.0 | 218.0 |

| | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements (106 $m^3$/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | $CO_2$ emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| FIN | 100.0 | 99.4 | 74.6 | 6.1 | 19592 | 67.8 | 536.0 | 100.0 | 43.2 | 44.5 | 8.7 | 15250 | 45.3 | 1.2 | 0.8 | 2.6 | 24.9 | 138.0 | 3574 | 132.0 | 348.0 |
| FRA | 100.0 | 98.7 | 100.0 | 14.9 | 3016 | 96.8 | 867.0 | 100.0 | 13.5 | 15.9 | 4.6 | 6940 | 44.1 | 1.2 | 0.8 | 2.6 | 23.2 | 159.0 | 5686 | 140.0 | 597.0 |
| GAB | 87.5 | 40.9 | 14.4 | 0.1 | 87433 | 138.3 | 1831 | 91.4 | 82.0 | 43.7 | 2.8 | 1173 | -213.4 | 9.4 | 3.4 | 17.5 | 13.4 | 58.0 | 1604 | 124.0 | 136.0 |
| GMB | 80.1 | 41.7 | 29.8 | 3.0 | 1564 | 3.4 | 836.0 | 47.8 | 51.5 | n/a | 0.3 | n/a | n/a | 9.6 | 11.1 | n/a | 8.7 | 72.0 | 840.7 | 120.0 | 68.0 |
| GEO | 93.3 | 84.9 | 35.1 | 3.1 | 15597 | 32.6 | 1026 | 100.0 | 28.7 | 78.0 | 2.4 | 2688 | 68.8 | 7.4 | 1.6 | 11.3 | 23.3 | 64.0 | 2517. | 115.0 | 163.0 |
| DEU | 100.0 | 99.2 | 88.0 | 30.8 | 1321 | 81.0 | 700.0 | 100.0 | 14.2 | 29.2 | 8.9 | 7035 | 61.4 | 1.2 | 1.0 | 1.3 | 25.7 | 143.0 | 7182 | 137.0 | 415.0 |
| GHA | 77.8 | 14.3 | 48.6 | 3.2 | 1124 | 33.3 | 1187 | 79.3 | 41.4 | 50.9 | 0.5 | 355 | -8.2 | 6.1 | 4.7 | 18.8 | 9.7 | 46.0 | 1842 | 135.0 | 287.0 |
| GRC | 100.0 | 99.0 | 83.2 | 16.5 | 5325 | 19.0 | 652.0 | 100.0 | 17.2 | 28.7 | 6.2 | 5063 | 64.2 | 1.2 | 0.8 | 2.6 | 27.4 | 149.0 | 4144 | 135.0 | 592.0 |
| GTM | 93.6 | 67.4 | 24.9 | 3.0 | 6858 | 70.0 | 1996 | 91.8 | 63.7 | 60.4 | 1.2 | 578 | 32.8 | 15.8 | 0.7 | 46.5 | 18.8 | 56.0 | 2152 | 114.0 | 302.0 |
| GIN | 67.4 | 22.0 | 24.1 | 0.2 | 19144 | 161.0 | 1651 | 33.5 | 76.3 | 78.8 | 0.2 | n/a | n/a | 19.7 | 8.1 | 32.4 | 6.6 | 61.0 | 1180 | 115.0 | 174.0 |
| GNB | 69.2 | 21.5 | n/a | 1.1 | 9271 | 19.7 | 1577 | 14.7 | 86.9 | n/a | 0.2 | n/a | n/a | 26.0 | 6.0 | 27.6 | 8.2 | 63.0 | 1426 | 102.0 | 213.0 |
| GUY | 95.1 | 86.2 | 15.6 | 0.6 | 315696 | 227.2 | 2387 | 84.2 | 25.3 | n/a | 2.6 | n/a | n/a | 7.5 | 6.4 | 12.0 | 19.2 | 58.0 | 3516 | 121.0 | 545.0 |
| HTI | 64.2 | 30.5 | 29.4 | 11.1 | 1231 | 3.2 | 1440 | 38.7 | 76.1 | 8.0 | 0.3 | 39 | 22.0 | 45.8 | 5.2 | 21.9 | 20.5 | 49.0 | 1012 | 96.0 | 135.0 |
| HND | 92.2 | 79.8 | 20.5 | 1.8 | 10291 | 57.4 | 1976 | 87.6 | 51.5 | 42.3 | 1.1 | 630 | 53.0 | 15.3 | 1.4 | 22.7 | 19.4 | 72.0 | 1748 | 116.0 | 194.0 |
| HKG | 100.0 | 96.3 | n/a | n/a | n/a | n/a | n/a | 100.0 | 0.9 | 0.3 | 6.4 | 6083 | 98.7 | 1.2 | 0.8 | n/a | n/a | 136.0 | 2000 | 134.0 | 5.0 |
| HUN | 100.0 | 98.0 | 73.3 | 84.2 | 608 | 46.1 | 589.0 | 100.0 | 15.6 | 10.6 | 4.3 | 3966 | 57.7 | 1.2 | 0.8 | 2.6 | 28.6 | 135.0 | 5099 | 120.0 | 549.0 |

| | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
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| | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements (106 $m^3$/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | $CO_2$ emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| ISL | 100.0 | 98.8 | 51.9 | 2.1 | 519265 | 96.4 | 1940 | 100.0 | 77.0 | 100.0 | 6.1 | 53832 | 11.6 | 1.2 | n/a | 2.6 | 23.1 | 148.0 | n/a | 136.0 | 344.0 |
| IND | 87.6 | 44.2 | n/a | 44.8 | 1118 | 937.1 | 1083 | 84.5 | 36.0 | 15.3 | 1.7 | 806 | 34.3 | 14.8 | 21.0 | 38.4 | 3.8 | 52.0 | 2992 | 108.0 | 186.0 |
| IDN | 89.5 | 67.9 | 48.2 | 5.6 | 7914 | 1269 | 2702 | 97.6 | 36.9 | 10.7 | 1.8 | 812 | -103.1 | 7.7 | 13.5 | 36.4 | 6.9 | 56.0 | 5405 | 124.0 | 243.0 |
| IRN | 94.9 | 88.3 | 59.0 | 72.5 | 1639 | 22.7 | 228.0 | 100.0 | 0.9 | 5.1 | 8.3 | 2986 | -33.4 | 4.9 | 4.0 | n/a | 25.5 | 74.0 | 2166 | 131.0 | 318.0 |
| IRQ | 86.1 | 85.7 | 25.1 | 187.5 | 1006 | 18.7 | 216.0 | 100.0 | 0.8 | 3.7 | 4.8 | 1306 | -229.4 | 27.7 | 7.4 | 22.6 | 27.4 | 65.0 | 3100 | 111.0 | 53.0 |
| IRL | 98.9 | 92.2 | 80.5 | 1.5 | 10520 | 31.2 | 1118 | 100.0 | 9.1 | 28.0 | 7.3 | 5672 | 85.7 | 1.2 | n/a | 2.6 | 26.9 | 128.0 | 8223 | 146.0 | 976.0 |
| ISR | 100.0 | 100.0 | 85.0 | 189.2 | 91 | 0.6 | 435.0 | 100.0 | 3.7 | 1.9 | 7.9 | 6601 | 65.0 | 1.2 | 0.8 | 2.6 | 26.7 | 150.0 | 4969 | 158.0 | 342.0 |
| ITA | 100.0 | 99.3 | 54.5 | 29.5 | 3002 | 77.8 | 832.0 | 100.0 | 16.5 | 38.7 | 5.3 | 5002 | 76.4 | 1.2 | 0.8 | 2.6 | 22.9 | 156.0 | 5599 | 142.0 | 471.0 |
| JAM | 92.9 | 85.4 | 42.9 | 7.5 | 3780 | n/a | 2051 | 98.2 | 16.8 | 10.3 | 2.6 | 1056 | 82.0 | 8.9 | 3.6 | 6.2 | 24.4 | 76.0 | 1090 | 113.0 | 192.0 |
| JPN | 98.9 | 100.0 | 93.9 | 18.9 | 3378 | 212.5 | 1668 | 100.0 | 6.3 | 16.0 | 9.5 | 7820 | 93.0 | 1.2 | 2.3 | 7.1 | 4.4 | 87.0 | 4975 | 113.0 | 133.0 |
| JOR | 98.6 | 96.7 | 63.4 | 124.5 | 77 | 0.0 | 111.0 | 100.0 | 3.2 | 1.0 | 3.0 | 1888 | 96.8 | 13.5 | 2.4 | 7.8 | 33.4 | 100.0 | 1530 | 112.0 | 152.0 |
| KAZ | 91.1 | 97.8 | 30.2 | 31.0 | 3722 | 36.3 | 250.0 | 100.0 | 1.6 | 8.9 | 14.4 | 5600 | -116.9 | 1.2 | 3.1 | 8.0 | 21.3 | 132.0 | 1347 | 138.0 | 430.0 |
| KEN | 58.5 | 29.8 | 52.6 | 15.5 | 450 | 18.6 | 630.0 | 56.0 | 72.7 | 87.5 | 0.3 | 167 | 17.2 | 24.2 | 4.0 | 26.0 | 6.0 | 47.0 | 1390 | 101.0 | 149.0 |
| PRK | 99.6 | 77.1 | 38.5 | 12.9 | 2668 | 45.9 | 1054 | 39.2 | 23.1 | 72.8 | 1.6 | 600 | -74.8 | 43.4 | 4.0 | n/a | 7.1 | 35.0 | 4083 | 87.0 | 142.0 |
| KOR | 99.6 | 99.9 | 67.9 | 44.8 | 1278 | 35.4 | 1274 | 100.0 | 2.7 | 1.9 | 11.6 | 10497 | 81.4 | 1.2 | 1.2 | n/a | 4.9 | 103.0 | 6795 | 135.0 | 202.0 |
| KWT | 100.0 | 100.0 | 81.5 | n/a | 3 | n/a | 121.0 | 100.0 | n/a | n/a | 25.2 | 15213 | -391.1 | 1.2 | 3.1 | 4.9 | 37.0 | 115.0 | 13345 | 141.0 | 90.0 |
| LAO | 80.4 | 72.6 | n/a | 1.8 | 28952 | 180.1 | 1834 | 87.1 | 59.3 | 86.4 | 0.3 | n/a | n/a | 16.6 | 6.4 | n/a | 4.5 | 37.0 | 4626 | 106.0 | 355.0 |

| | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
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| | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements (106 $m^3$/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | $CO_2$ emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| LVA | 98.6 | 92.9 | 64.3 | 1.4 | 8496 | 18.0 | 641.0 | 100.0 | 38.1 | 50.2 | 3.5 | 3507 | 45.2 | 1.2 | n/a | 2.6 | 25.7 | 118.0 | 3828 | 129.0 | 471.0 |
| LBN | 92.3 | 95.4 | 32.2 | 22.8 | 857 | 1.4 | 661.0 | 100.0 | 3.6 | 2.6 | 4.3 | 2893 | 97.9 | 10.9 | 6.6 | 16.5 | 31.3 | 102.0 | 3013 | 114.0 | 186.0 |
| LSO | 71.6 | 43.8 | 32.9 | 0.8 | 2437 | 1.3 | 788.0 | 29.7 | 52.1 | 100.0 | 1.2 | n/a | n/a | 12.8 | 2.8 | 33.2 | 13.5 | 32.0 | 508.3 | 114.0 | 73.0 |
| LBR | 69.9 | 16.9 | 15.0 | 0.1 | 45550 | 176.8 | 2391 | 19.8 | 83.8 | n/a | 0.2 | n/a | n/a | 38.8 | 5.6 | 32.1 | 8.6 | 60.0 | 1322 | 101.0 | 74.0 |
| LBY | 96.8 | 99.7 | 46.9 | 822.9 | 113 | n/a | 56.0 | 98.5 | 2.0 | n/a | 9.2 | 1857 | -103.0 | n/a | 6.5 | 21.0 | 31.8 | n/a | 715.0 | 140.0 | 181.0 |
| LTU | 97.4 | 93.6 | 56.6 | 4.1 | 5272 | 10.6 | 656.0 | 100.0 | 29.0 | 39.4 | 4.4 | 3821 | 75.0 | 1.2 | n/a | 2.6 | 28.4 | 96.0 | 3853 | 138.0 | 675.0 |
| LUX | 100.0 | 97.6 | 90.2 | 4.3 | 1798 | 2.3 | 934.0 | 100.0 | 9.0 | 32.4 | 17.4 | 13915 | 96.3 | 1.2 | 0.8 | 2.6 | 24.2 | 139.0 | 4999 | 138.0 | 343.0 |
| MKD | 96.8 | 90.9 | n/a | 10.2 | 2599 | n/a | 619.0 | 100.0 | 24.2 | 35.9 | 3.6 | 3497 | 51.8 | 4.1 | 1.8 | n/a | 23.9 | 102.0 | 3858 | 118.0 | 371.0 |
| MDG | 50.6 | 9.7 | 36.5 | 4.0 | 14286 | 217.5 | 1513 | 22.9 | 70.2 | 54.6 | 0.1 | n/a | n/a | 43.1 | 15.2 | 49.2 | 4.5 | 24.0 | 3920 | 89.0 | 137.0 |
| MWI | 67.2 | 43.5 | 40.3 | 8.4 | 946 | 9.5 | 1181 | 11.0 | 83.6 | 91.3 | 0.1 | n/a | n/a | 26.3 | 2.7 | 37.1 | 4.7 | 39.0 | 1347 | 104.0 | 139.0 |
| MYS | 96.4 | 99.6 | 42.8 | 1.9 | 19187 | 385.0 | 2875 | 100.0 | 5.2 | 10.0 | 8.0 | 4596 | -5.5 | 2.9 | 11.5 | 20.7 | 15.3 | 88.0 | 3226 | 125.0 | 470.0 |
| MDV | 97.9 | 95.9 | 35.5 | 15.7 | 73 | n/a | 1972 | 100.0 | 1.0 | 1.3 | 3.3 | n/a | n/a | 11.0 | 10.2 | 20.3 | 7.9 | 62.0 | 2445 | 115.0 | 18.0 |
| MLI | 74.3 | 31.3 | 53.3 | 8.6 | 3537 | 55.2 | 282.0 | 35.1 | 61.5 | 43.5 | 0.1 | n/a | n/a | 6.0 | 13.5 | 30.4 | 7.1 | 62.0 | 1607 | 142.0 | 244.0 |
| MLT | 100.0 | 100.0 | 75.3 | 44.4 | 116 | n/a | 560.0 | 100.0 | 5.4 | 7.7 | 5.4 | 4925 | 98.4 | 1.2 | 0.8 | 2.6 | 31.0 | 115.0 | 4744 | 134.0 | 169.0 |
| MRT | 69.6 | 44.6 | 45.4 | 337.0 | 98 | 1.2 | 92.0 | 41.7 | 32.2 | 13.4 | 0.7 | n/a | n/a | 11.3 | 14.8 | 27.9 | 11.3 | 78.0 | 1221 | 126.0 | 153.0 |
| MUS | 99.9 | 93.1 | 64.4 | 26.4 | 2182 | n/a | 2041 | 98.8 | 11.5 | 22.7 | 3.4 | 2183 | 84.5 | 5.8 | n/a | n/a | 11.5 | 92.0 | 3455 | 125.0 | 190.0 |
| MEX | 98.3 | 89.2 | 49.5 | 20.0 | 3293 | 195.3 | 758.0 | 100.0 | 9.2 | 15.4 | 3.9 | 2090 | -4.7 | 3.8 | 1.0 | 12.4 | 28.4 | 92.0 | 3748 | 132.0 | 293.0 |

| | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
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| | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements (106 $m^3$/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | $CO_2$ emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| MDA | 86.7 | 78.4 | n/a | 65.7 | 456 | 5.5 | 450.0 | 100.0 | 14.3 | 5.4 | 1.4 | 1386 | 90.0 | n/a | 1.9 | n/a | 20.1 | 85.0 | 3196 | 105.0 | 314.0 |
| MNG | 83.2 | 59.2 | 43.0 | 1.6 | 11902 | 21.2 | 241.0 | 81.8 | 3.4 | 3.1 | 7.1 | 2018 | -168.1 | 18.7 | 1.0 | 10.8 | 19.6 | 88.0 | 1279 | 106.0 | 315.0 |
| MNE | 97.6 | 95.9 | 34.4 | n/a | n/a | n/a | 241.0 | 100.0 | 43.0 | 49.7 | 3.6 | 4612 | 27.6 | 1.2 | 2.8 | 9.4 | 24.9 | 129.0 | 3261 | 141.0 | 156.0 |
| MAR | 83.0 | 83.5 | 63.9 | 35.7 | 845 | 8.2 | 346.0 | 100.0 | 11.3 | 14.3 | 1.7 | 901 | 90.7 | 3.9 | 2.3 | 14.9 | 25.6 | 68.0 | 936.2 | 147.0 | 250.0 |
| MOZ | 47.3 | 23.6 | 54.6 | 0.9 | 3686 | 133.0 | 1032 | 24.2 | 86.4 | 86.4 | 0.3 | 463 | -54.6 | 30.5 | 6.1 | 43.1 | 6.0 | 41.0 | 823.8 | 106.0 | 97.0 |
| MMR | 67.5 | 64.7 | 27.3 | 3.3 | 19317 | 595.0 | 2091 | 57.0 | 61.5 | 58.9 | 0.4 | 217 | -33.0 | 10.5 | 7.0 | 29.2 | 5.7 | 70.0 | 3607 | 118.0 | 323.0 |
| NAM | n/a | n/a | 59.1 | 4.6 | 2598 | 7.2 | 285.0 | 51.8 | 26.5 | 97.8 | 1.6 | 1585 | 74.4 | 25.4 | n/a | n/a | 15.0 | 49.0 | 453.1 | 98.0 | 168.0 |
| NPL | 87.7 | 46.1 | 32.9 | 4.8 | 6998 | 95.9 | 1500 | 90.7 | 85.3 | 100.0 | 0.3 | 139 | 16.7 | 9.5 | 9.7 | 35.8 | 3.8 | 53.0 | 2605 | 118.0 | 203.0 |
| NLD | 100.0 | 97.7 | 93.2 | 97.5 | 652 | 38.3 | 778.0 | 100.0 | 5.9 | 12.4 | 9.9 | 6713 | 35.0 | 1.2 | 0.8 | 2.6 | 23.1 | 124.0 | 7776 | 125.0 | 810.0 |
| NZL | 100.0 | 100.0 | 57.6 | 1.6 | 72510 | 204.3 | 1732 | 100.0 | 30.8 | 80.1 | 7.7 | 9026 | 19.5 | 1.2 | 0.8 | 2.6 | 32.0 | 117.0 | 8383 | 123.0 | 2425 |
| NIC | 82.3 | 76.3 | n/a | 1.0 | 25973 | 107.2 | 2280 | 81.8 | 48.2 | 50.1 | 0.8 | 580 | 40.9 | 16.2 | 2.2 | 17.3 | 21.8 | 60.0 | 1768 | 117.0 | 238.0 |
| NER | 45.8 | 12.9 | 49.7 | 28.1 | 183 | 10.6 | 151.0 | 16.2 | 78.9 | 0.8 | 0.1 | 51 | -5.8 | 14.4 | 10.3 | 42.2 | 4.7 | 55.0 | 530.3 | 123.0 | 180.0 |
| NGA | 67.3 | 32.6 | 35.1 | 5.6 | 1252 | 157.2 | 1150 | 59.3 | 86.6 | 18.2 | 0.5 | 144 | -93.0 | 11.5 | 10.8 | 43.6 | 7.8 | 57.0 | 1443 | 117.0 | 211.0 |
| NOR | 100.0 | 98.1 | 63.4 | 0.8 | 74359 | 261.5 | 1414 | 100.0 | 57.8 | 97.7 | 9.3 | 23000 | -581.3 | 1.2 | 0.8 | 2.6 | 25.0 | 150.0 | 4607 | 136.0 | 260.0 |
| OMN | 90.9 | 99.3 | 33.2 | 84.7 | 353 | n/a | 125.0 | 100.0 | n/a | n/a | 15.4 | 6554 | -206.2 | 5.4 | 7.5 | 14.1 | 22.9 | 87.0 | 5689 | 125.0 | 114.0 |
| PAK | 88.5 | 58.3 | 49.8 | 333.6 | 296 | 83.8 | 494.0 | 99.1 | 46.5 | 31.4 | 0.9 | 471 | 24.1 | 20.5 | 10.5 | 45.0 | 7.8 | 74.0 | 3064 | 108.0 | 196.0 |
| PAN | 95.0 | 76.9 | 36.7 | 0.8 | 34990 | 4.9 | 2928 | 93.4 | 21.2 | 65.3 | 2.3 | 2063 | 80.9 | 9.2 | 1.2 | 19.1 | 22.5 | 76.0 | 2569 | 122.0 | 238.0 |

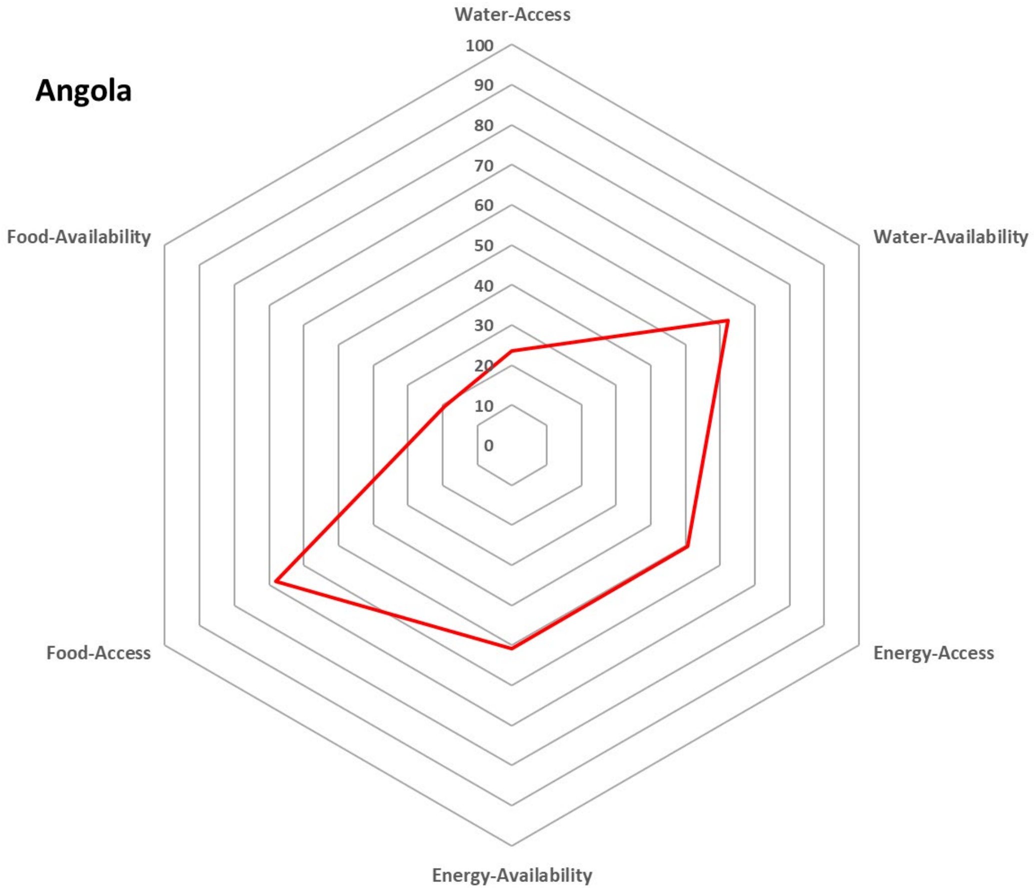
| | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements (106 $m^3$/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | $CO_2$ emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| PNG | 36.6 | 18.6 | 25.0 | 0.0 | 103278 | 504.5 | 3142 | 22.9 | 52.5 | 34.5 | 0.8 | n/a | n/a | n/a | 14.3 | 49.5 | 19.4 | n/a | 4737 | 100.0 | 351.0 |
| PRY | 98.9 | 91.2 | 31.9 | 2.1 | 17856 | 256.3 | 1130 | 98.4 | 61.7 | 100.0 | 0.9 | 1564 | -36.9 | 11.2 | 1.0 | 5.6 | 19.0 | 92.0 | 4425 | 111.0 | 855.0 |
| PER | 89.9 | 76.8 | 29.6 | 0.8 | 52981 | 1343 | 1738 | 94.9 | 25.5 | 52.7 | 2.0 | 1308 | -14.9 | 8.8 | 1.0 | 13.1 | 19.1 | 50.0 | 4187 | 117.0 | 292.0 |
| PHL | 90.5 | 75.0 | 51.0 | 17.0 | 4785 | 151.9 | 2348 | 91.0 | 27.5 | 25.4 | 1.1 | 699 | 45.8 | 13.7 | 7.1 | 33.4 | 6.0 | 52.0 | 3529 | 117.0 | 196.0 |
| POL | 97.9 | 98.1 | 39.5 | 21.4 | 1410 | 31.6 | 600.0 | 100.0 | 11.9 | 13.8 | 7.5 | 3972 | 28.5 | 1.2 | 0.8 | 2.6 | 25.6 | 118.0 | 3999 | 137.0 | 491.0 |
| PRT | 99.9 | 99.4 | 74.1 | 24.1 | 3653 | 27.6 | 854.0 | 100.0 | 27.2 | 47.5 | 4.3 | 4663 | 76.9 | 1.2 | 0.8 | 2.6 | 23.2 | 140.0 | 4422 | 139.0 | 420.0 |
| QAT | 100.0 | 100.0 | 82.2 | 387.5 | 24 | n/a | 74.0 | 100.0 | n/a | n/a | 45.4 | 15309 | -399.0 | n/a | 0.8 | 2.6 | 33.9 | n/a | 4692 | n/a | 26.0 |
| ROU | 100.0 | 81.8 | 72.5 | 15.1 | 2129 | 105.2 | 637.0 | 100.0 | 23.7 | 39.7 | 3.5 | 2584 | 16.8 | 1.2 | 3.5 | 12.8 | 24.5 | 103.0 | 3971 | 135.0 | 483.0 |
| RUS | 96.4 | 88.8 | 79.0 | 1.4 | 29982 | 2953 | 460.0 | 100.0 | 3.3 | 15.9 | 11.9 | 6603 | -83.7 | 1.2 | n/a | n/a | 25.7 | 103.0 | 2650 | 138.0 | 327.0 |
| RWA | 56.7 | 62.3 | 34.7 | 1.6 | 837 | 10.3 | 1212 | 29.4 | 86.7 | 56.9 | 0.1 | n/a | n/a | 36.1 | 2.2 | 37.9 | 4.8 | 26.0 | 1522 | 100.0 | 209.0 |
| WSM | 95.5 | 96.6 | 69.9 | n/a | n/a | n/a | 1583 | 100.0 | 34.3 | 30.4 | 1.0 | n/a | n/a | 3.1 | 3.7 | 4.7 | 45.5 | 138.0 | n/a | 129.0 | 290.0 |
| STP | 79.7 | 40.1 | 22.8 | 0.3 | 11398 | n/a | 3200 | 65.4 | 41.1 | 10.5 | 0.6 | n/a | n/a | 10.2 | 4.0 | 17.2 | 10.6 | 76.0 | 2098 | 113.0 | 147.0 |
| SAU | 100.0 | 100.0 | 56.7 | 943.3 | 78 | n/a | 59.0 | 100.0 | 0.0 | 0.0 | 19.5 | 9444 | -191.5 | 5.5 | 11.8 | 9.3 | 35.0 | 103.0 | 5243 | 135.0 | 103.0 |
| SEN | 75.2 | 48.4 | 53.3 | 8.6 | 1774 | 20.2 | 686.0 | 64.5 | 42.7 | 10.4 | 0.6 | 223 | 52.7 | 11.3 | 7.2 | 17.0 | 7.4 | 72.0 | 1349 | 111.0 | 103.0 |
| SRB | 91.2 | 94.6 | 29.9 | 49.4 | 1179 | 73.5 | 686.0 | 100.0 | 21.2 | 26.9 | 5.3 | 4272 | 28.8 | 5.6 | 3.9 | 6.0 | 23.5 | 78.0 | 6173 | 110.0 | 392.0 |
| SLE | 58.1 | 14.5 | 18.6 | 0.1 | 22602 | 117.2 | 2526 | 20.3 | 77.7 | 61.0 | 0.2 | n/a | n/a | 25.5 | 9.4 | 37.9 | 7.5 | 57.0 | 1889 | 109.0 | 177.0 |
| SGP | 100.0 | 100.0 | 100.0 | 31.7 | 110 | n/a | 2497. | 100.0 | 0.7 | 1.8 | 10.3 | 8845 | 97.7 | n/a | 3.6 | 4.4 | 6.6 | n/a | n/a | n/a | 5.0 |

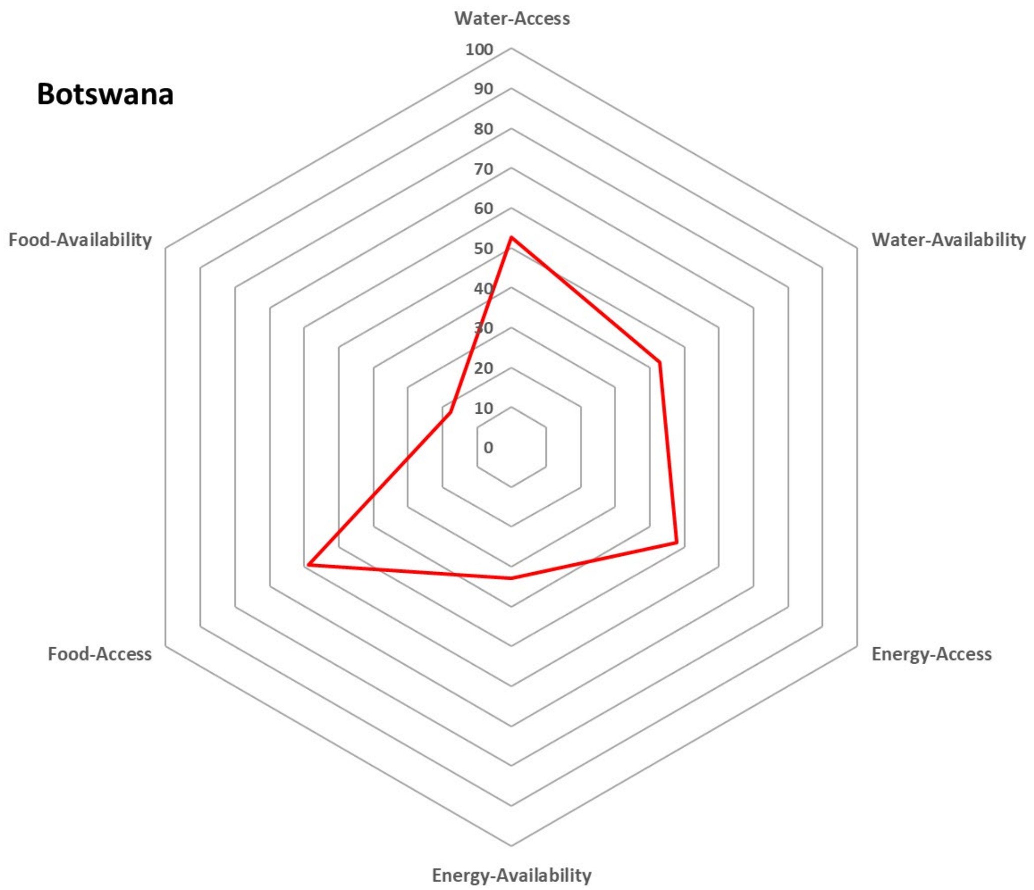
| | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements (106 m$^3$/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | $CO_2$ emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| SVK | 97.9 | 98.9 | 65.8 | 4.4 | 2325 | 26.9 | 824.0 | 100.0 | 13.4 | 22.7 | 5.7 | 5137 | 60.7 | 2.7 | 0.8 | n/a | 22.4 | 112.0 | 6430 | 119.0 | 284.0 |
| SVN | 99.5 | 99.1 | 57.9 | 6.2 | 9054 | 17.1 | 1162 | 100.0 | 20.9 | 29.4 | 6.2 | 6728 | 48.5 | 1.2 | 0.8 | 2.6 | 22.5 | 119.0 | 6464 | 127.0 | 313.0 |
| SLB | 64.0 | 31.3 | 25.8 | n/a | 77671 | n/a | 3028 | 47.9 | 63.3 | 2.3 | 0.4 | n/a | n/a | 12.3 | 7.9 | 31.6 | 20.5 | 48.0 | 1657 | 113.0 | 202.0 |
| ZAF | 84.7 | 73.1 | 65.5 | 34.6 | 821 | 20.1 | 495.0 | 84.2 | 17.2 | 2.3 | 9.0 | 4198 | -14.5 | 6.1 | 2.5 | 27.4 | 27.0 | 83.0 | 3809 | 123.0 | 229.0 |
| SSD | 50.4 | 10.4 | 38.3 | 2.5 | 2255 | 33.9 | 900.0 | 8.9 | 39.1 | 0.6 | 0.1 | 40 | -1058 | n/a | 22.7 | 31.1 | n/a | n/a | 1511 | n/a | 146.0 |
| ESP | 99.9 | 99.9 | 82.5 | 33.0 | 2392 | 38.2 | 636.0 | 100.0 | 16.3 | 34.9 | 5.0 | 5356 | 71.4 | 1.2 | 0.8 | 2.6 | n/a | n/a | 3430 | n/a | 657.0 |
| LKA | 92.3 | 94.2 | 25.3 | 24.5 | 2542 | 38.5 | 1712 | 95.6 | 52.9 | 48.5 | 0.9 | 531 | 50.3 | 10.9 | 15.1 | 17.3 | 5.4 | 48.0 | 3897 | 112.0 | 121.0 |
| SDN | 58.9 | 34.6 | 39.9 | 673.3 | 102 | 15.1 | 250.0 | 38.5 | 61.6 | 64.5 | 0.3 | 190 | -9.0 | 25.2 | 16.3 | 38.2 | 7.4 | 69.0 | 684.8 | 106.0 | 163.0 |
| SUR | 94.7 | 79.2 | 15.1 | 0.6 | 180681 | 83.4 | 2331 | 87.2 | 24.9 | 60.1 | 3.6 | 3632 | -43.8 | 7.6 | 5.0 | 8.8 | 26.5 | 80.0 | 4433 | 117.0 | 248.0 |
| SWZ | 67.6 | 58.0 | 52.6 | 39.5 | 2038 | 3.1 | 788.0 | 65.8 | 66.1 | 46.6 | 0.9 | n/a | n/a | 20.7 | 2.0 | n/a | 13.5 | 44.0 | 1138 | 103.0 | 237.0 |
| SWE | 100.0 | 99.3 | 88.5 | 1.6 | 17636 | 104.7 | 624.0 | 100.0 | 53.2 | 63.3 | 4.5 | 13480 | 24.7 | 1.2 | 0.8 | 2.6 | 22.1 | 132.0 | 5438 | 126.0 | 290.0 |
| CHE | 100.0 | 99.9 | 81.4 | 5.0 | 4934 | 27.3 | 1537 | 100.0 | 25.3 | 62.2 | 4.3 | 7520 | 50.1 | 1.2 | 0.8 | 2.6 | 21.2 | 154.0 | 5132 | 131.0 | 306.0 |
| SYR | 96.7 | 92.9 | n/a | 198.3 | 371 | 5.6 | 252.0 | 100.0 | 0.5 | 2.3 | 1.6 | 950 | 47.8 | n/a | 11.5 | 27.5 | 25.8 | n/a | 1614 | 134.0 | 255.0 |
| TJK | 74.1 | 95.5 | n/a | 17.6 | 7588 | 6.8 | 691.0 | 100.0 | 44.7 | 98.5 | 0.6 | 1480 | 36.2 | n/a | 9.9 | 26.8 | 12.6 | 59.0 | 3348 | 97.0 | 142.0 |
| TZA | 50.1 | 23.5 | n/a | 6.2 | 1608 | 56.3 | 1071 | 32.8 | 85.7 | 34.2 | 0.2 | 99 | 10.7 | 32.0 | 4.5 | n/a | 4.1 | 46.0 | 1540 | 106.0 | 193.0 |
| THA | 98.2 | 95.0 | n/a | 25.5 | 3281 | 189.6 | 1622 | 100.0 | 22.9 | 8.5 | 4.6 | 2540 | 41.6 | 9.0 | 5.4 | 10.5 | 10.8 | 59.0 | 3031 | 114.0 | 386.0 |
| TLS | 70.2 | 44.0 | 14.1 | 14.3 | 6774 | 4.1 | 1500 | 63.4 | 18.2 | n/a | 0.4 | n/a | n/a | 27.2 | 11.0 | 50.2 | 2.9 | 48.0 | 2454 | 102.0 | 96.0 |

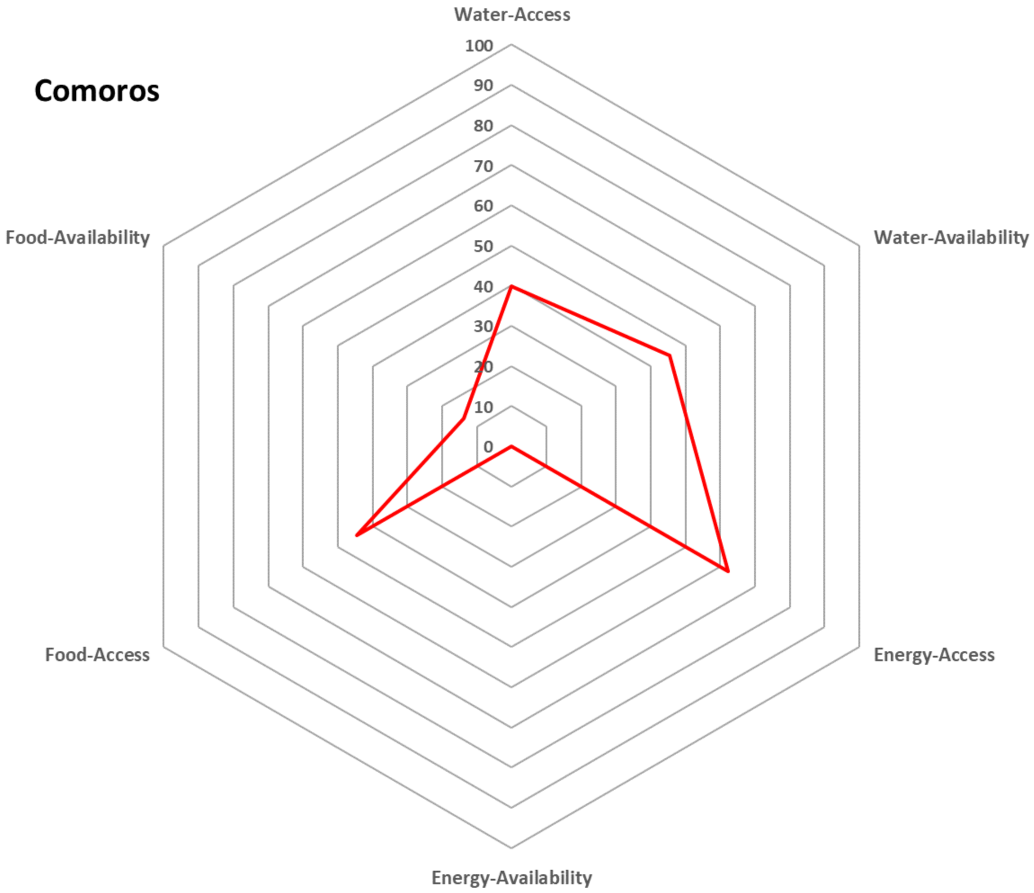
| | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements (106 $m^3$/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | $CO_2$ emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| TGO | 62.8 | 13.9 | 31.9 | 1.5 | 1591 | 8.1 | 1168 | 46.9 | 71.3 | 75.3 | 0.4 | 153 | 20.0 | 16.2 | 6.7 | 27.5 | 7.1 | 49.0 | 1131 | 114.0 | 122.0 |
| TTO | 96.9 | 92.1 | 25.0 | 8.8 | 2835 | 2.2 | 2200 | 100.0 | 0.3 | n/a | 34.2 | 7134 | -102.7 | 4.9 | 6.3 | 11.0 | 19.7 | 89.0 | 1480 | 129.0 | 103.0 |
| TUN | 94.2 | 93.1 | 54.5 | 76.7 | 376 | 0.7 | 207.0 | 100.0 | 12.6 | 2.8 | 2.6 | 1444 | 36.2 | 4.9 | 2.8 | 10.1 | 27.3 | 90.0 | 1541 | 142.0 | 358.0 |
| TUR | 98.9 | 96.4 | 69.5 | 18.5 | 2947 | 77.0 | 593.0 | 100.0 | 13.4 | 32.0 | 4.5 | 2855 | 75.2 | 1.2 | 1.7 | 9.5 | 32.2 | 120.0 | 3105 | 158.0 | 484.0 |
| TKM | 94.5 | 96.6 | n/a | 1983 | 257 | 5.4 | 161.0 | 100.0 | 0.0 | n/a | 12.5 | 2679 | -191.5 | 5.5 | 4.2 | 11.5 | 17.5 | 83.0 | 1075 | 121.0 | 325.0 |
| UGA | 38.9 | 19.2 | 58.7 | 1.6 | 1004 | 49.2 | 1180 | 26.7 | 89.1 | 93.0 | 0.1 | n/a | n/a | 41.4 | 3.6 | 28.9 | 7.1 | 47.0 | 1906 | 95.0 | 120.0 |
| UKR | 97.7 | 95.9 | 38.9 | 27.0 | 1217 | 98.1 | 565.0 | 100.0 | 4.1 | 4.4 | 5.0 | 3419 | 27.2 | 3.3 | 8.2 | 22.9 | 26.1 | 91.0 | 4652 | 119.0 | 589.0 |
| ARE | 99.6 | 100.0 | 74.9 | 1866 | 17 | n/a | 78.0 | 100.0 | 0.1 | 0.2 | 23.3 | 11264 | -183.8 | 1.2 | 0.8 | 2.6 | 29.9 | 88.0 | 21487 | 126.0 | 66.0 |
| GBR | 100.0 | 99.1 | 76.7 | 5.5 | 2244 | 88.4 | 1220 | 100.0 | 8.7 | 24.8 | 6.5 | 5130 | 34.6 | 1.2 | 0.8 | 2.6 | 29.5 | 138.0 | 7022 | 138.0 | 259.0 |
| USA | 99.2 | 100.0 | n/a | 14.9 | 8844 | 1491 | 715.0 | 100.0 | 8.7 | 13.2 | 16.5 | 12984 | 7.3 | 1.2 | 0.5 | 2.1 | 37.3 | 161.0 | 8142 | 147.0 | 704.0 |
| URY | 99.2 | 95.7 | n/a | 4.0 | 26963 | 134.8 | 1300 | 100.0 | 58.0 | 88.6 | 2.0 | 3068 | 44.4 | 1.2 | 1.3 | 10.7 | 28.9 | 103.0 | 4940 | 133.0 | 1152 |
| UZB | 91.5 | 100.0 | 45.2 | 300.9 | 531 | 14.0 | 206.0 | 100.0 | 3.0 | 20.7 | 3.4 | 1645 | -26.2 | 7.4 | 4.5 | 19.6 | 15.3 | 72.0 | 4613 | 115.0 | 321.0 |
| VUT | 90.5 | 53.5 | 38.9 | n/a | 38632 | n/a | 206.0 | 57.8 | 36.1 | 21.3 | 0.6 | n/a | n/a | 7.1 | 4.4 | 28.5 | 23.5 | 104.0 | 612.5 | 128.0 | 279.0 |
| VEN | 97.4 | 94.9 | n/a | 2.8 | 26189 | 1025 | 2044 | 99.6 | 12.8 | 63.7 | 6.0 | 2658 | -178.8 | 11.7 | 4.1 | n/a | 25.2 | 84.0 | 3426 | 105.0 | 201.0 |
| VNM | 91.2 | 78.2 | 37.7 | 22.8 | 3884 | 432.6 | 1821 | 100.0 | 35.0 | 36.7 | 1.8 | 1411 | -15.1 | 10.8 | 6.4 | n/a | 2.1 | 71.0 | 5448 | 123.0 | 300.0 |
| YEM | 70.4 | 59.7 | n/a | 168.6 | 80 | n/a | 167.0 | 71.6 | 2.3 | n/a | 0.9 | 216 | -120.6 | 34.4 | 16.3 | n/a | 14.1 | 45.0 | 995.3 | 95.0 | 65.0 |
| ZMB | 61.2 | 31.1 | 46.1 | 2.0 | 5134 | 49.4 | 1020 | 27.2 | 88.0 | 97.0 | 0.3 | 707 | 8.3 | 44.5 | 6.3 | 40.0 | 6.5 | 41.0 | 2418 | 93.0 | 118.0 |

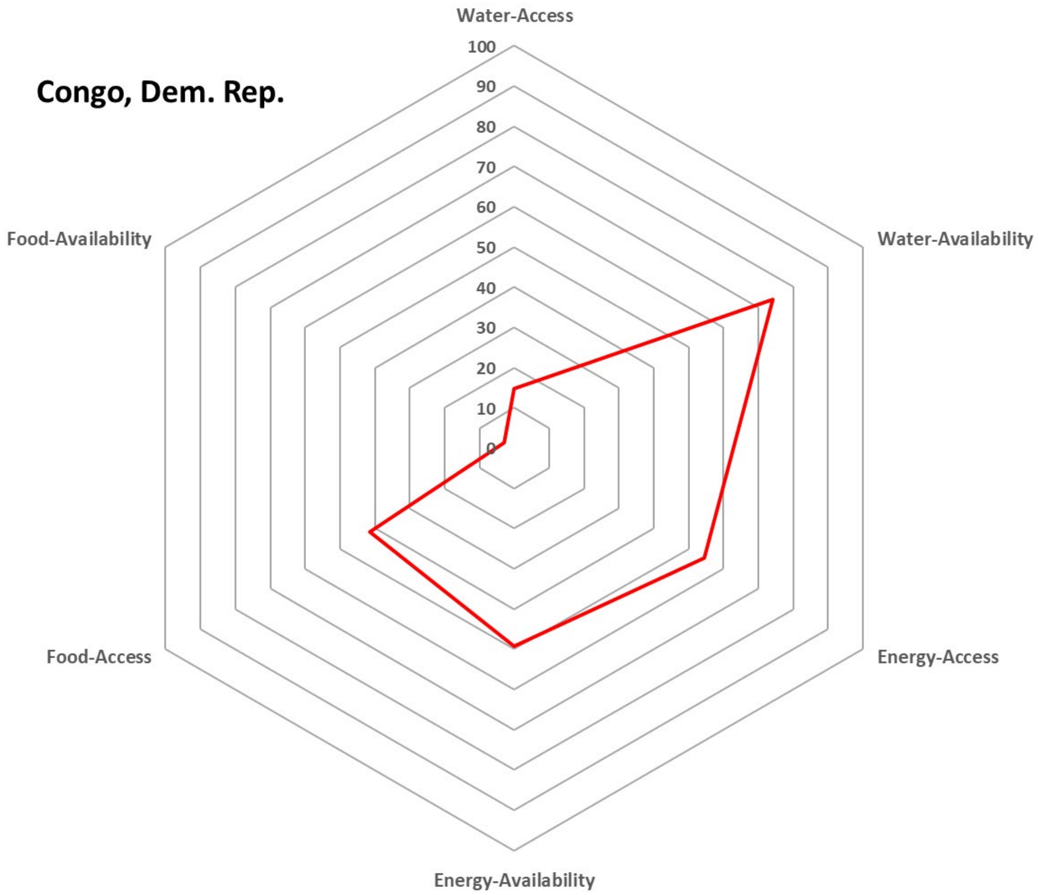
| | ind.01 | ind.02 | ind.03 | ind.04 | ind.05 | ind.06 | ind.07 | ind.08 | ind.09 | ind.10 | ind.11 | ind.12 | ind.13 | ind.14 | ind.15 | ind.16 | ind.17 | ind.18 | ind.19 | ind.20 | ind.21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | The percentage of people using at least basic drinking water services | Percentage of people using safely managed sanitation services. | Degree of IWRM implementation (1-100) | Annual freshwater withdrawals, total (% of internal resources) | Renewable internal freshwater resources per capita (cubic meters) | Environmental flow requirements (106 m$^3$/annum) | Average precipitation in depth (mm per year) | Access to electricity (% of population) | Renewable energy consumption (% of total final energy consumption) | Renewable electricity output (% of total electricity output) | $CO_2$ emissions (metric tons per capita) | Electric power consumption (kWh per capita) | Energy imports, net (% of energy use) | Prevalence of undernourishment (%) | Percentage of children under 5 years of age affected by wasting (%) | Percentage of children under 5 years of age who are stunted (%) | Prevalence of obesity in the adult population (18 years and older) | Average protein supply (gr/caput/day) | Cereal yield (kg per hectare) | Average Dietary Energy Supply Adequacy (ADESA) (%) | Average value of food production (I$ per caput) |
| ZWE | 66.6 | 38.6 | 61.0 | 29.1 | 796 | 9.3 | 657.0 | 38.1 | 81.8 | 52.7 | 0.8 | 537 | 15.3 | 46.6 | 3.2 | 26.8 | 12.3 | 58.0 | 580.0 | 87.0 | 75.0 |

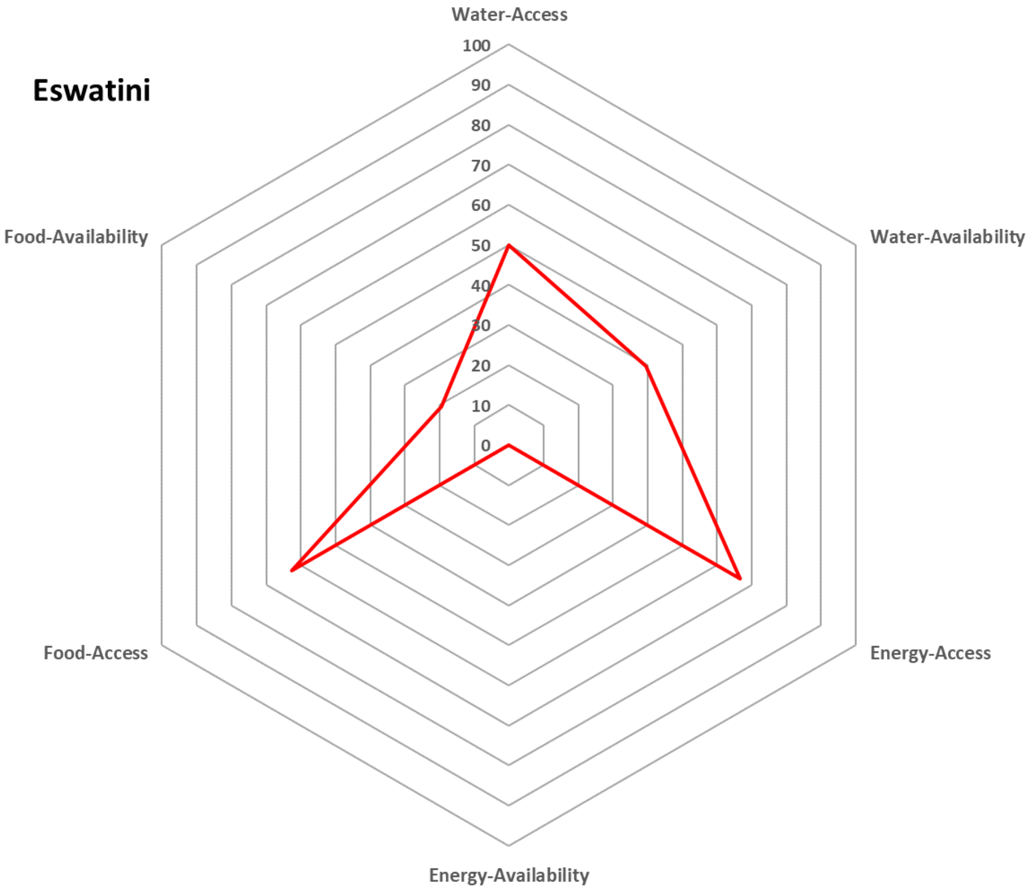
# Appendix D: Radar charts of the WEF Nexus Index sub-pillars for SADC countries

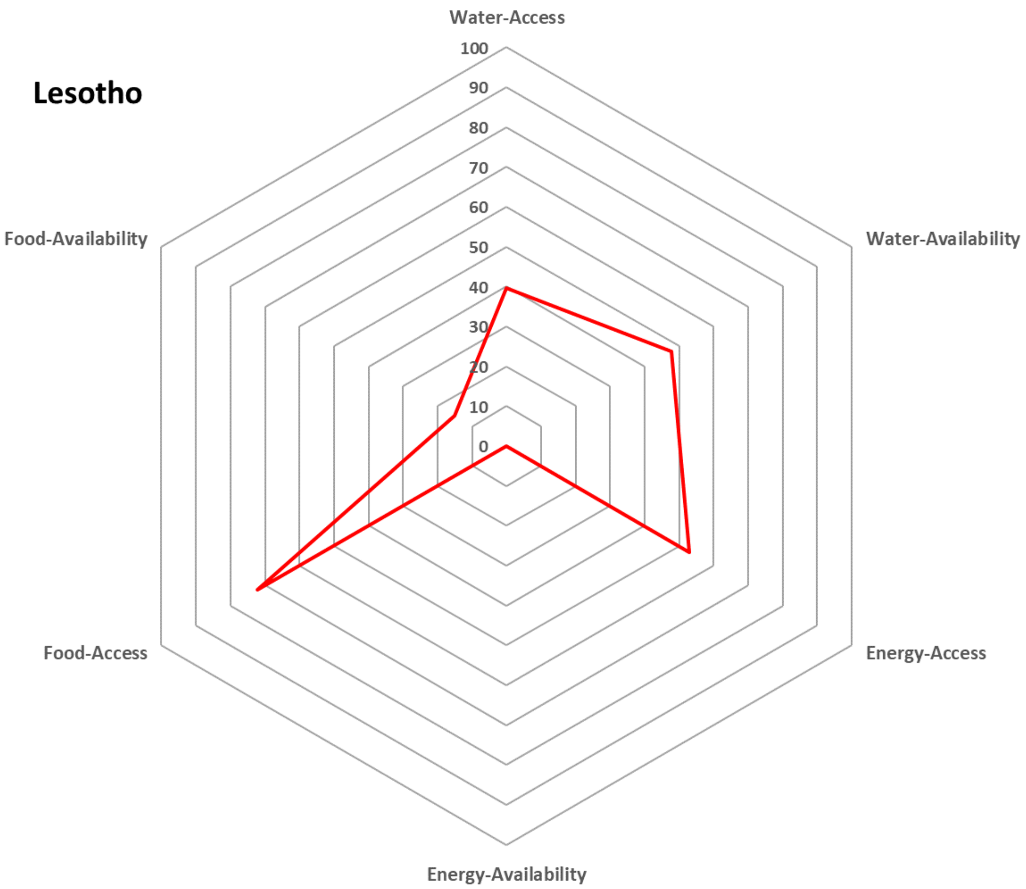

Angola
Water-Access
Water-Availability
Energy-Access
Energy-Availability
Food-Access
Food-Availability
100
90
80
70
60
50
40
30
20
10
0

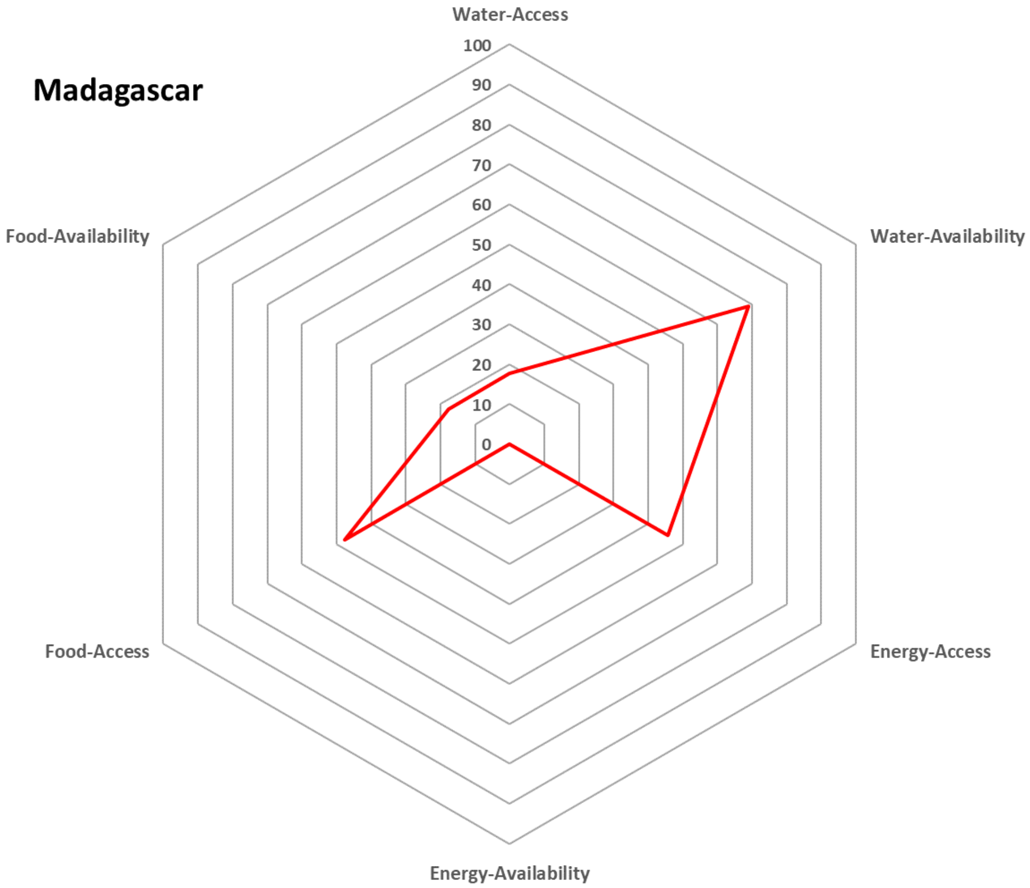

Botswana
Water-Access
Water-Availability
Energy-Access
Energy-Availability
Food-Access
Food-Availability
100
90
80
70
60
50
40
30
20
10
0

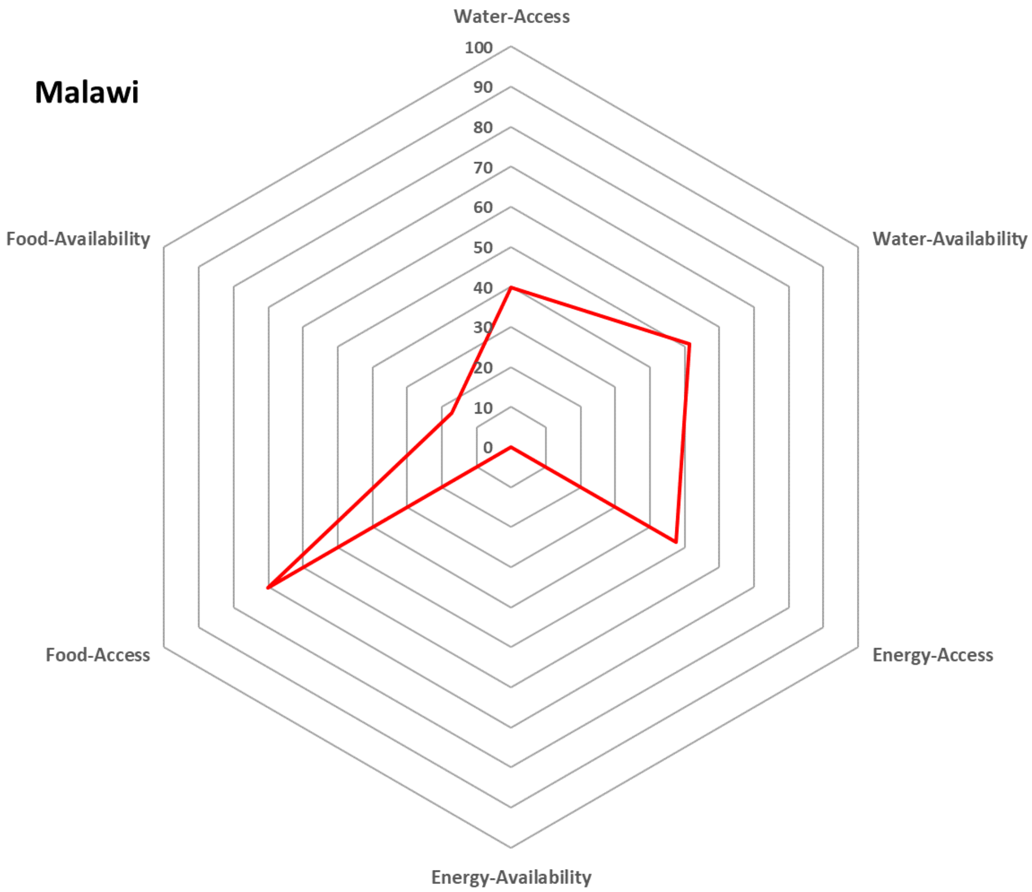

Comoros
Water-Access
100
90
80
70
60
50
40
30
20
10
0
Water-Availability
Energy-Access
Energy-Availability
Food-Access
Food-Availability

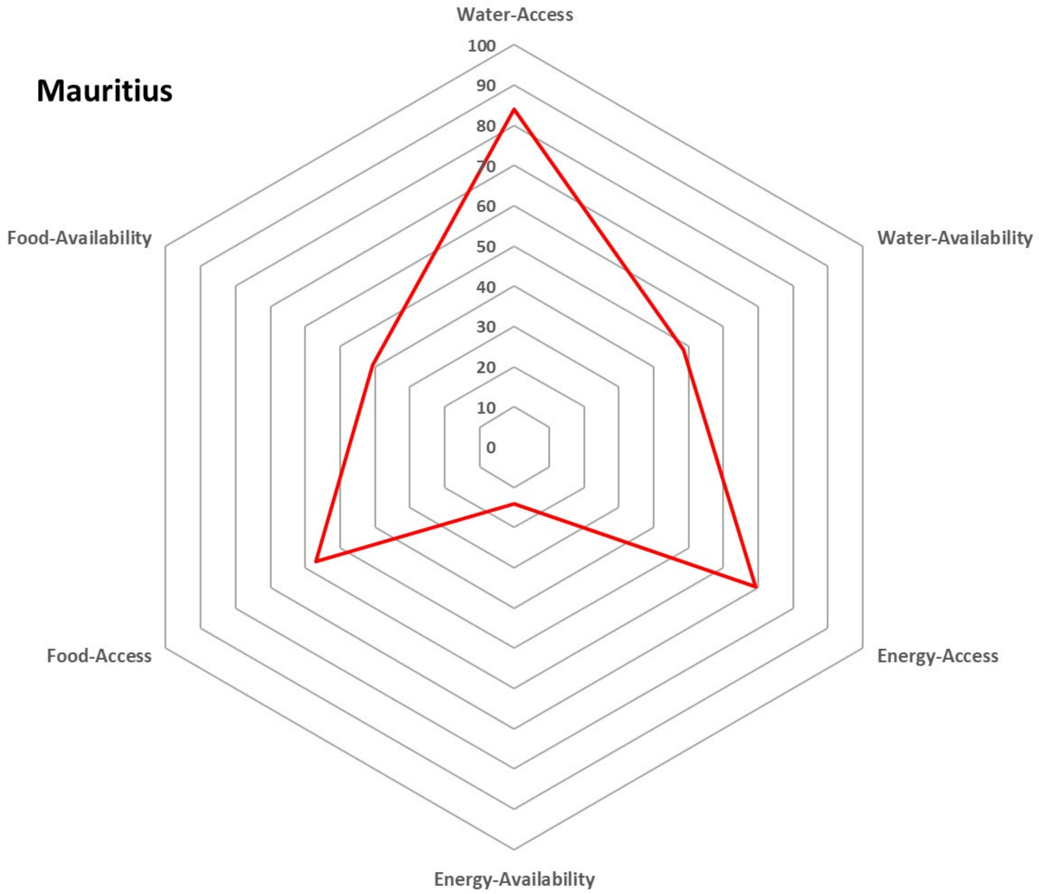

Congo, Dem. Rep.
Water-Access
100
90
80
70
60
50
40
30
20
10
0
Water-Availability
Energy-Access
Energy-Availability
Food-Access
Food-Availability

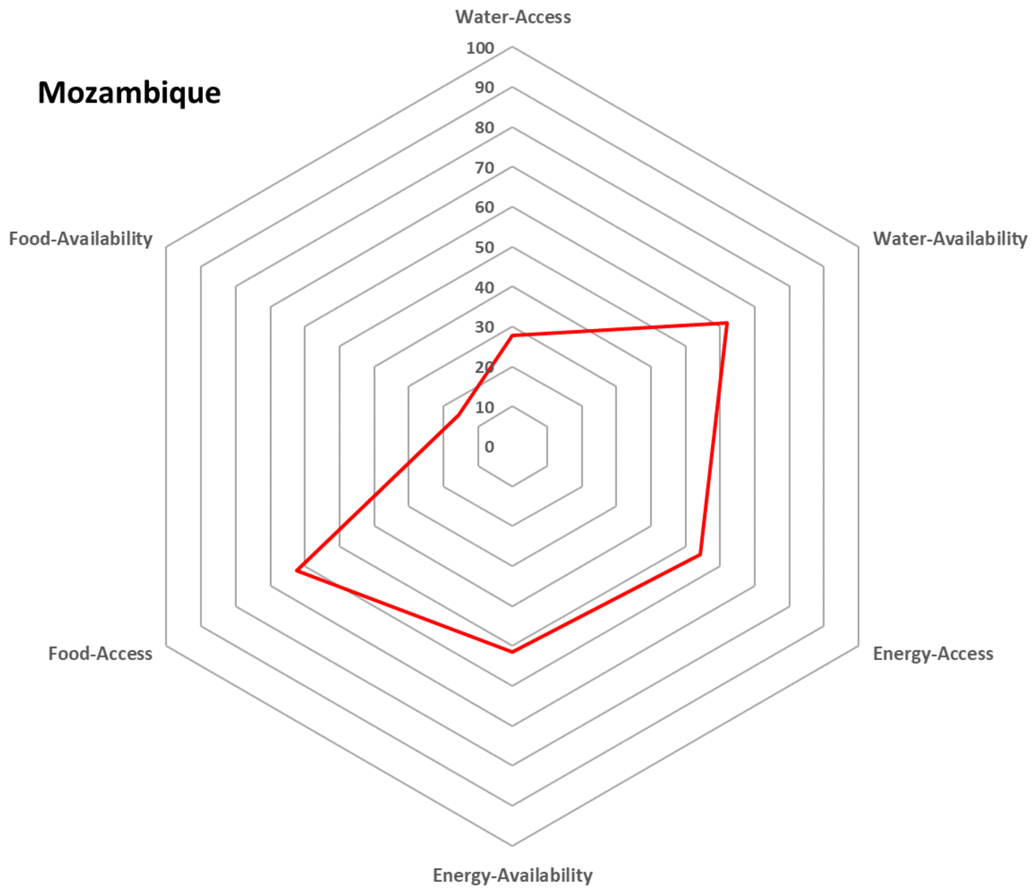

Eswatini
Water-Access
Water-Availability
Energy-Access
Energy-Availability
Food-Access
Food-Availability
100
90
80
70
60
50
40
30
20
10
0

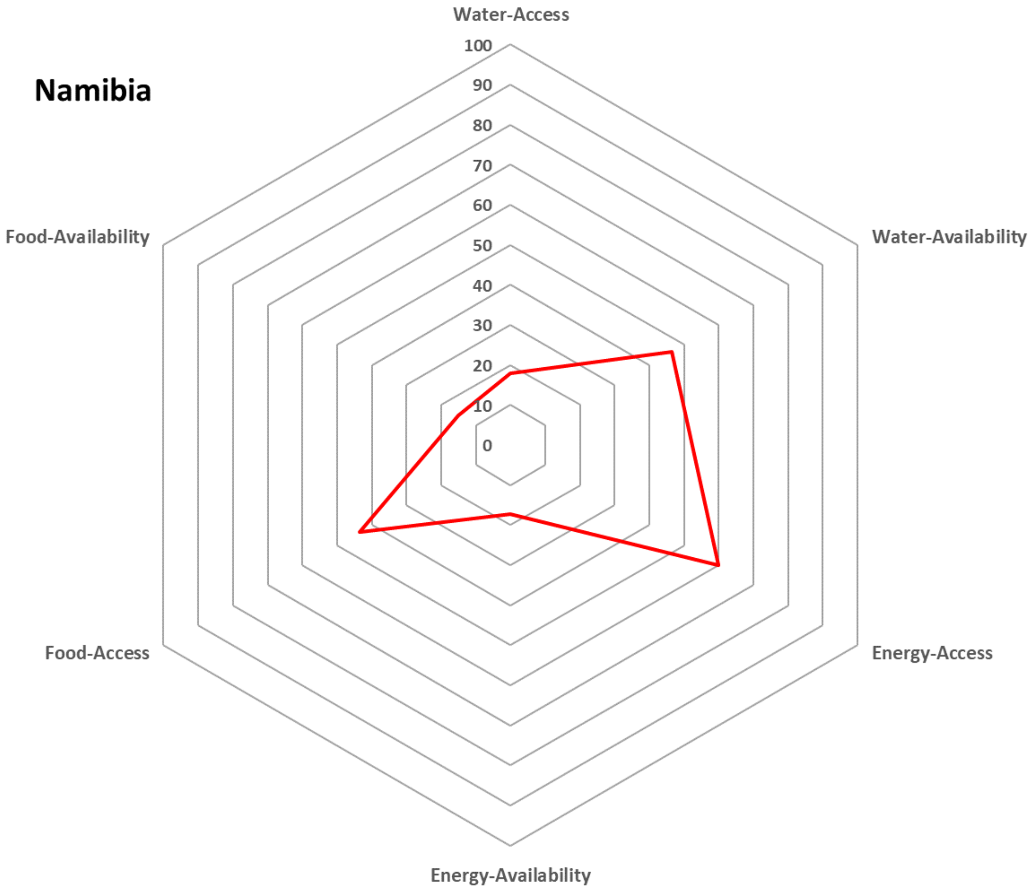

Lesotho
Water-Access
Water-Availability
Energy-Access
Energy-Availability
Food-Access
Food-Availability
100
90
80
70
60
50
40
30
20
10
0


Madagascar
Water-Access
100
90
80
70
60
50
40
30
20
10
0
Water-Availability
Energy-Access
Energy-Availability
Food-Access
Food-Availability


Malawi
Water-Access
100
90
80
70
60
50
40
30
20
10
0
Water-Availability
Energy-Access
Energy-Availability
Food-Access
Food-Availability


Mauritius
Water-Access
100
90
80
70
60
50
40
30
20
10
0
Water-Availability
Energy-Access
Energy-Availability
Food-Access
Food-Availability


Mozambique
Water-Access
100
90
80
70
60
50
40
30
20
10
0
Water-Availability
Energy-Access
Energy-Availability
Food-Access
Food-Availability


Namibia
Water-Access
Water-Availability
Energy-Access
Energy-Availability
Food-Access
Food-Availability
100
90
80
70
60
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30
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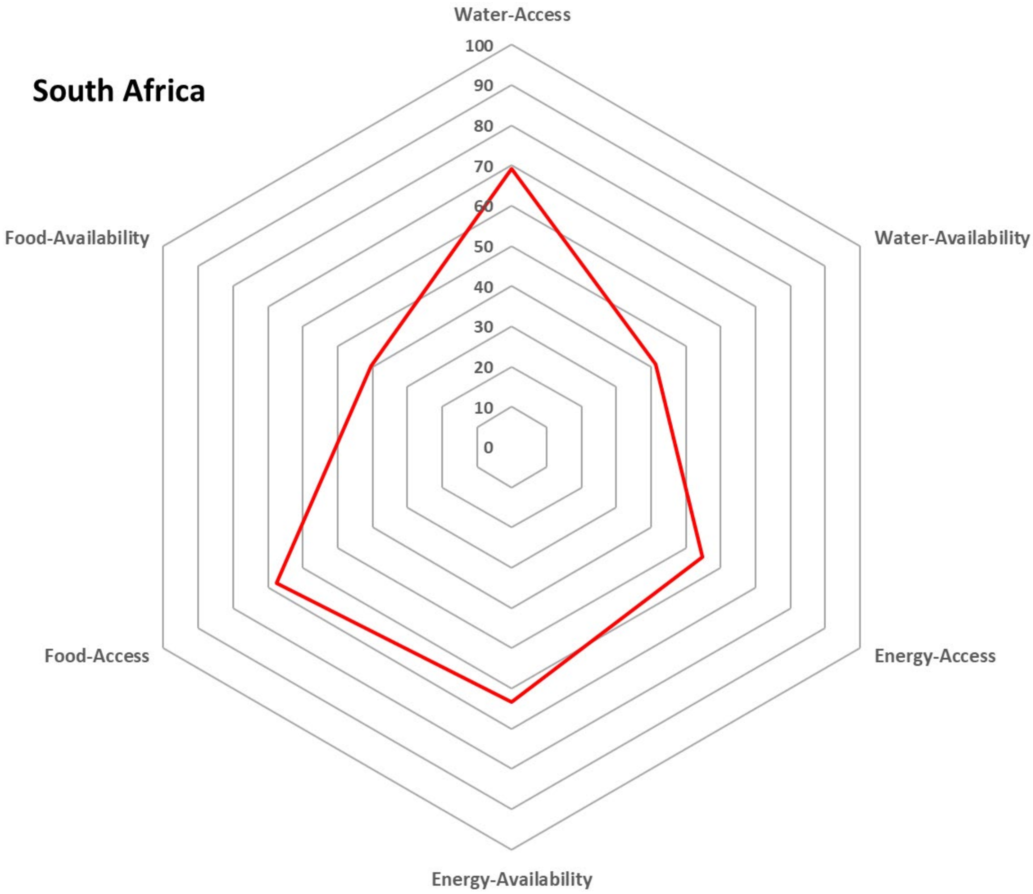
10
0


South Africa
Water-Access
Water-Availability
Energy-Access
Energy-Availability
Food-Access
Food-Availability
100
90
80
70
60
50
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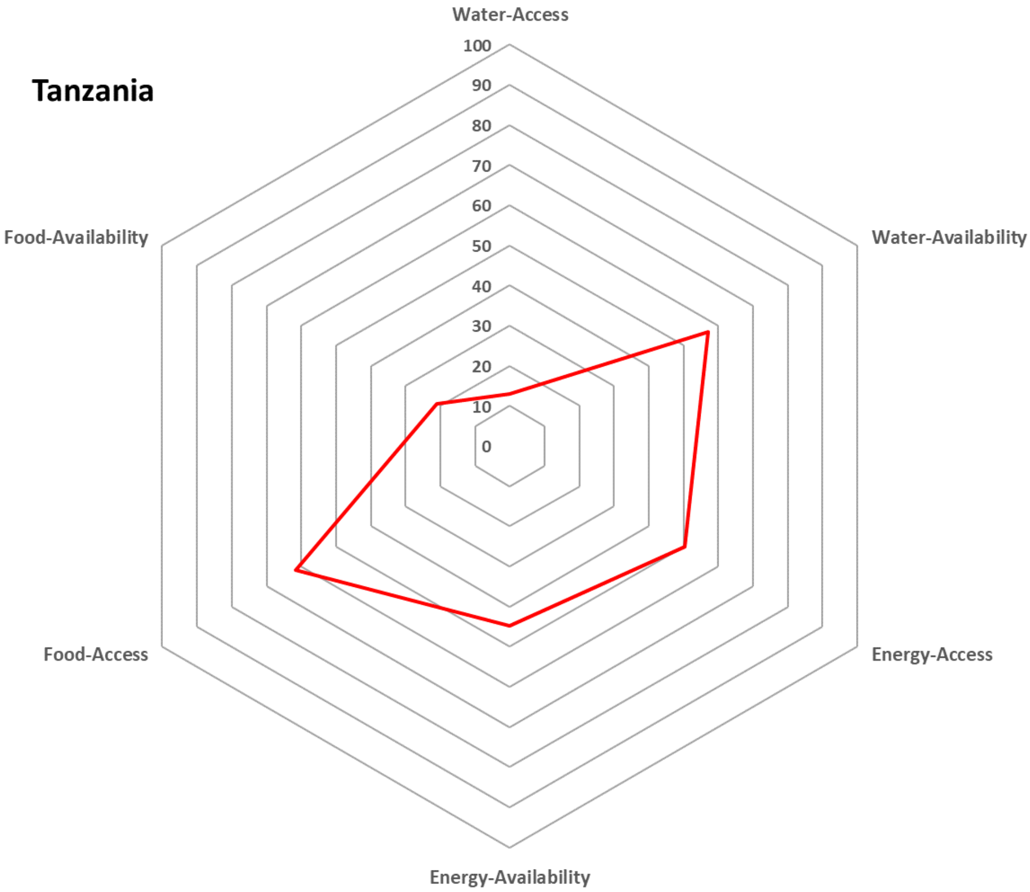
10
0


Tanzania
Water-Access
Water-Availability
Energy-Access
Energy-Availability
Food-Access
Food-Availability
100
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70
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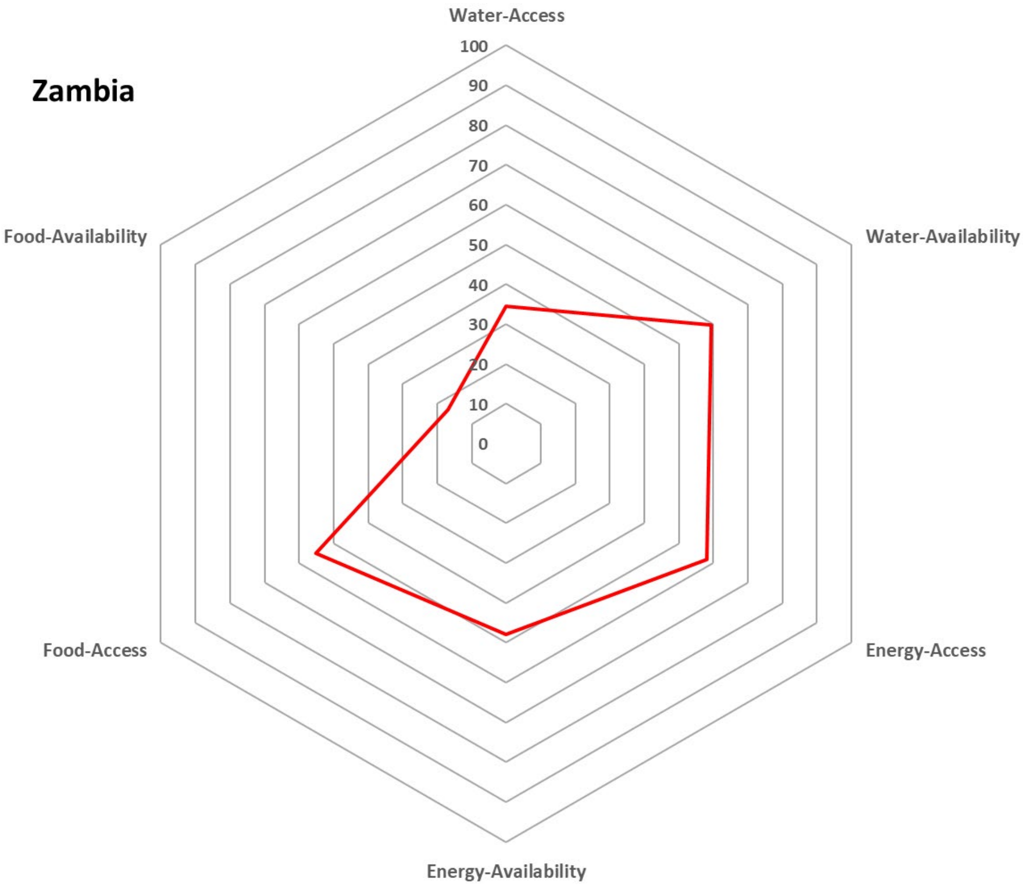
Zambia
Water-Access
Water-Availability
Energy-Access
Energy-Availability
Food-Access
Food-Availability
100
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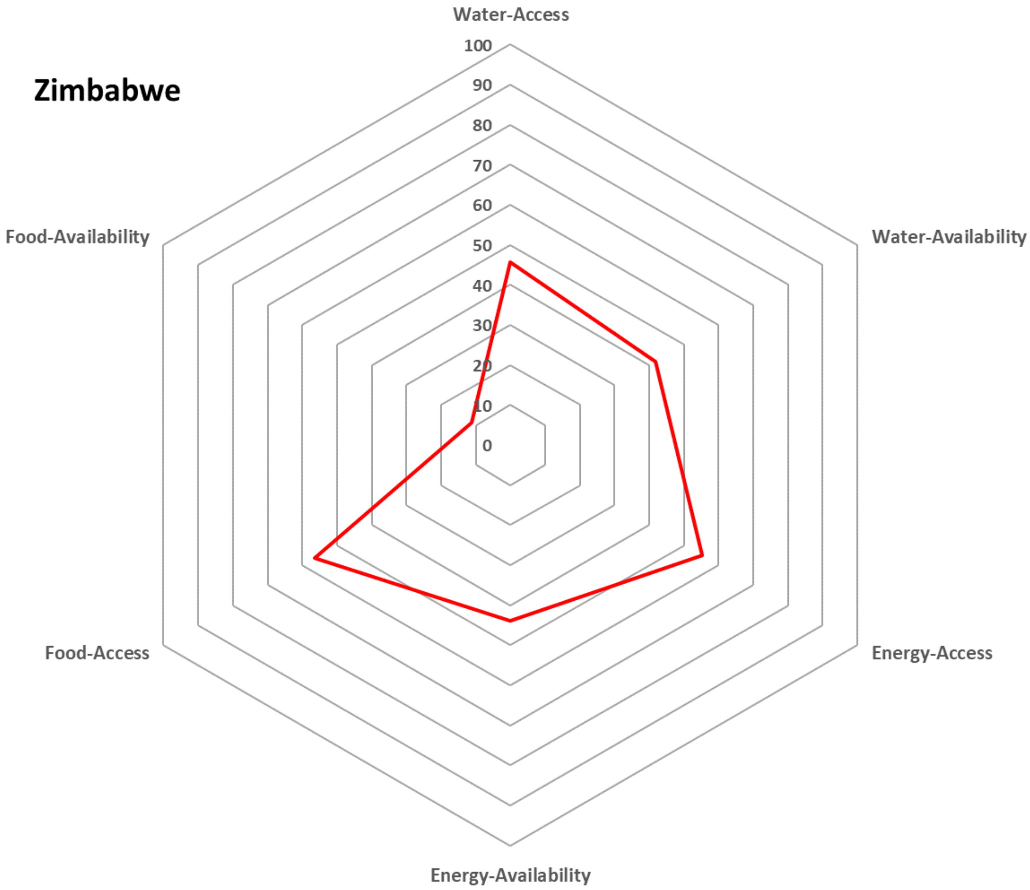
Zimbabwe
Water-Access
Water-Availability
Energy-Access
Energy-Availability
Food-Access
Food-Availability
100
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0

# Appendix E: SDG Index and HDI values per country

| Country | WEF Nexus Index | SDG Index | HDI |
|---|---|---|---|
| Norway | 80.88 | 81.17 | 0.95 |
| New Zealand | 77.29 | 77.86 | 0.92 |
| Sweden | 76.87 | 84.98 | 0.93 |
| Iceland | 76.57 | 79.75 | 0.93 |
| Canada | 75.51 | 76.79 | 0.93 |
| Denmark | 75.32 | 84.61 | 0.93 |
| Australia | 74.10 | 72.89 | 0.94 |
| Austria | 74.06 | 79.95 | 0.91 |
| Finland | 72.83 | 83.00 | 0.92 |
| Brazil | 72.75 | 69.69 | 0.76 |
| United States of America | 72.67 | 73.05 | 0.92 |
| France | 71.74 | 81.22 | 0.90 |
| Switzerland | 71.19 | 80.09 | 0.94 |
| Colombia | 70.12 | 66.61 | 0.75 |
| Paraguay | 69.99 | 67.21 | 0.70 |
| Croatia | 68.96 | 76.52 | 0.83 |
| United Kingdom | 68.53 | 78.67 | 0.92 |
| Malaysia | 67.79 | 70.01 | 0.80 |
| Argentina | 67.63 | 70.28 | 0.82 |
| Uruguay | 67.52 | 70.42 | 0.80 |
| Germany | 67.38 | 82.28 | 0.94 |
| Costa Rica | 67.23 | 73.15 | 0.79 |
| Slovenia | 66.79 | 79.98 | 0.90 |
| Netherlands | 66.54 | 79.47 | 0.93 |
| Luxembourg | 65.77 | 76.09 | 0.90 |
| Albania | 65.75 | 68.91 | 0.78 |
| Ecuador | 65.62 | 70.77 | 0.75 |
| Bosnia and Herzegovina | 65.53 | 67.31 | 0.77 |
| Ireland | 65.45 | 77.47 | 0.94 |
| Greece | 65.43 | 70.64 | 0.87 |
| Romania | 65.35 | 71.22 | 0.81 |
| Belgium | 64.78 | 79.00 | 0.92 |
| Portugal | 64.58 | 74.03 | 0.85 |
| Italy | 64.53 | 74.21 | 0.88 |
| Japan | 64.41 | 78.52 | 0.91 |
| Russian Federation | 64.15 | 68.90 | 0.82 |
| Estonia | 64.11 | 78.32 | 0.87 |
| Chile | 63.93 | 72.79 | 0.84 |
| Peru | 63.75 | 68.45 | 0.75 |
| Indonesia | 63.71 | 62.84 | 0.69 |
| Suriname | 63.54 | 67.97 | 0.72 |
| Vietnam | 63.48 | 69.67 | 0.69 |
| Brunei Darussalam | 63.13 | | 0.85 |
| Czech Republic | 62.98 | 78.72 | 0.89 |

| Country | WEF Nexus Index | SDG Index | HDI |
|---|---|---|---|
| Mexico | 62.85 | 65.21 | 0.77 |
| Poland | 62.64 | 73.67 | 0.87 |
| Kuwait | 62.60 | 61.14 | 0.80 |
| Latvia | 62.44 | 74.75 | 0.85 |
| Korea, Rep. | 62.22 | 77.41 | 0.90 |
| Kazakhstan | 61.77 | 68.13 | 0.80 |
| Venezuela, RB | 60.99 | 64.00 | 0.76 |
| Turkey | 60.97 | 65.96 | 0.79 |
| Slovak Republic | 60.73 | 75.60 | 0.86 |
| United Arab Emirates | 60.47 | 69.22 | 0.86 |
| Bulgaria | 60.41 | 73.13 | 0.81 |
| Hungary | 60.17 | 74.96 | 0.84 |
| Trinidad and Tobago | 59.77 | 67.51 | 0.78 |
| Cuba | 59.62 | 71.34 | 0.78 |
| Israel | 59.54 | 71.85 | 0.90 |
| Gabon | 59.38 | 62.84 | 0.70 |
| Serbia | 58.99 | 72.14 | 0.79 |
| Ukraine | 58.95 | 72.34 | 0.75 |
| Nepal | 58.92 | 62.75 | 0.57 |
| Lithuania | 58.70 | 72.90 | 0.86 |
| Myanmar | 58.29 | 59.03 | 0.58 |
| Thailand | 57.97 | 69.24 | 0.75 |
| Belarus | 57.37 | 75.99 | 0.81 |
| Philippines | 56.90 | 65.03 | 0.70 |
| Georgia | 56.44 | 70.65 | 0.78 |
| Bolivia | 56.41 | 68.08 | 0.69 |
| Panama | 56.28 | 64.89 | 0.79 |
| South Africa | 56.16 | 60.83 | 0.70 |
| Uzbekistan | 56.13 | 70.29 | 0.71 |
| Azerbaijan | 56.02 | 70.80 | 0.76 |
| Guatemala | 55.95 | 58.24 | 0.65 |
| Saudi Arabia | 55.83 | 62.92 | 0.85 |
| Sri Lanka | 55.72 | 64.56 | 0.77 |
| Cameroon | 55.66 | 55.78 | 0.56 |
| Spain | 55.63 | 75.42 | 0.89 |
| Montenegro | 55.58 | 67.63 | 0.81 |
| Ghana | 55.31 | 62.81 | 0.59 |
| El Salvador | 55.04 | 64.09 | 0.67 |
| Cyprus | 54.93 | 70.36 | 0.87 |
| Iran, Islamic Rep. | 54.88 | 65.54 | 0.80 |
| Oman | 54.76 | 63.91 | 0.82 |
| Honduras | 54.63 | 63.64 | 0.62 |
| Malta | 54.43 | 74.20 | 0.88 |
| Bangladesh | 54.34 | 59.35 | 0.61 |

| Country | WEF Nexus Index | SDG Index | HDI |
|---|---|---|---|
| Nicaragua | 54.33 | 66.38 | 0.66 |
| Algeria | 54.23 | 67.88 | 0.75 |
| Egypt | 54.08 | #N/A | 0.70 |
| Armenia | 53.92 | 69.27 | 0.76 |
| Macedonia, FYR | 53.74 | 68.95 | 0.76 |
| Belize | 53.71 | 62.32 | 0.71 |
| Guyana | 53.52 | 61.90 | 0.65 |
| Mongolia | 53.37 | 63.86 | 0.74 |
| China | 53.35 | 70.05 | 0.75 |
| Tunisia | 53.06 | 66.15 | 0.73 |
| Fiji | 52.40 | | 0.74 |
| Mauritius | 52.30 | 64.50 | 0.79 |
| Dominican Republic | 51.88 | 66.42 | 0.74 |
| Cambodia | 51.86 | 60.38 | 0.58 |
| Turkmenistan | 51.39 | 59.47 | 0.71 |
| Jamaica | 50.94 | 65.90 | 0.73 |
| Qatar | 50.85 | 60.85 | 0.86 |
| Lao PDR | 50.76 | 60.63 | 0.60 |
| Nigeria | 50.16 | 47.48 | |
| Cote d'Ivoire | 49.80 | 55.18 | 0.49 |
| Pakistan | 49.79 | 54.89 | 0.56 |
| Korea, Dem. People’s Rep. | 49.54 | #N/A | #N/A |
| Morocco | 49.53 | 66.27 | 0.67 |
| Bhutan | 49.49 | 65.39 | 0.61 |
| Tajikistan | 49.01 | 67.18 | 0.65 |
| Singapore | 48.92 | 71.31 | 0.93 |
| India | 47.62 | 59.05 | 0.64 |
| Senegal | 47.61 | 57.17 | 0.51 |
| Maldives | 47.26 | | 0.72 |
| Kenya | 47.22 | 56.83 | 0.59 |
| Lebanon | 47.05 | 64.79 | 0.76 |
| Congo, Rep. | 46.90 | 52.38 | 0.61 |
| Iraq | 46.82 | 53.75 | 0.69 |
| Samoa | 46.39 | | 0.71 |
| Togo | 45.90 | 52.00 | 0.50 |
| Angola | 45.79 | 49.56 | 0.58 |
| Barbados | 45.70 | | 0.80 |
| Mozambique | 45.58 | 50.66 | 0.44 |
| Zambia | 45.35 | 53.13 | 0.59 |
| Sao Tome and Principe | 45.27 | | 0.59 |
| Dominica | 45.15 | | 0.72 |
| Ethiopia | 44.33 | 53.23 | 0.46 |
| Benin | 44.06 | 48.98 | 0.51 |
| Jordan | 43.63 | 64.36 | 0.74 |

| Country | WEF Nexus Index | SDG Index | HDI |
|---|---|---|---|
| Libya | 43.34 | | 0.71 |
| Mali | 42.53 | 49.72 | 0.43 |
| Zimbabwe | 42.37 | 58.76 | 0.53 |
| Botswana | 42.12 | 58.46 | 0.72 |
| Guinea | 41.38 | 52.12 | 0.46 |
| Tanzania | 41.28 | 55.15 | 0.54 |
| Hong Kong SAR, China | 39.88 | #N/A | 0.93 |
| Eswatini | 39.66 | 50.67 | 0.59 |
| Congo, Dem. Rep. | 39.51 | 43.39 | 0.46 |
| Niger | 39.22 | 48.51 | 0.35 |
| Sudan | 39.19 | 49.58 | 0.50 |
| Vanuatu | 39.11 | | 0.60 |
| Syrian Arab Republic | 39.02 | 55.02 | 0.54 |
| Haiti | 38.77 | 49.16 | 0.50 |
| Moldova | 38.11 | 74.51 | 0.70 |
| Gambia, The | 38.00 | 51.58 | 0.46 |
| Cabo Verde | 38.00 | 64.68 | 0.65 |
| Sierra Leone | 37.98 | 49.11 | 0.42 |
| Lesotho | 37.93 | 51.51 | 0.52 |
| Malawi | 37.75 | 49.97 | 0.48 |
| Rwanda | 37.62 | 56.09 | 0.52 |
| Uganda | 36.27 | 54.93 | 0.52 |
| Afghanistan | 36.14 | 46.24 | 0.50 |
| Timor-Leste | 36.08 | | 0.62 |
| Liberia | 36.03 | 48.30 | 0.44 |
| Burkina Faso | 35.74 | 50.88 | 0.42 |
| Guinea-Bissau | 35.18 | | 0.46 |
| Solomon Islands | 35.05 | | 0.55 |
| Comoros | 34.31 | | 0.50 |
| Yemen, Rep. | 33.98 | 45.66 | 0.45 |
| Namibia | 33.39 | 58.93 | 0.65 |
| Central African Republic | 33.15 | 37.66 | 0.37 |
| Madagascar | 32.94 | 45.59 | 0.52 |
| Mauritania | 32.54 | 51.57 | 0.52 |
| Djibouti | 32.13 | 50.63 | 0.48 |
| Papua New Guinea | 32.00 | | 0.54 |
| South Sudan | 26.97 | | 0.39 |
| Chad | 26.96 | 42.81 | 0.40 |

# Appendix F: Minutes and attendance registers

| | |
|---|---|
| **WATER RESEARCH COMMISSION**<br>WEF NEXUS INDEX AND DASHBOARD<br><u>SELECTION OF INDICATORS FOR THE WEF NEXUS INDEX</u><br>**<u>MINUTES OF RESEARCH ON TAP SEMINAR (REVISION 0)</u>**<br>Held on **25 April 2019** at Centre for Water Resources Research, University of KwaZulu-Natal | Distribution Date: 27-04-2019<br>Job No: **H605**<br>Our Ref: h605_r0_jbgs_min-01_cwrr_seminar_minutes<br><br>Next meeting: N/A |

**PRESENT:**

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| Jessica Badenhorst (JB) | J&W | 0827381930 | jessica@jaws.co.za |
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| Trisha Sukhdeo (TS) | UKZN | 0622743376 | Trishasukhdeo31@gmail.com |
| Sayuri Srikissan (SS) | UKZN | 0728831331 | sayurisrikissan@gmail.com |
| Kivana Naidoo (KN) | UKZN | 0794950203 | Kivana.naidoo@yahoo.com |
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| Gumede Mxolisi (GM) | UKZN/CWRR | 0839491870 | Gumede_mp@yahoo.com |
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| Nkosinathi Dlamini (ND) | UKZN | 0746022174 | |
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| Khodami Khalatu (KK) | UKZN | 0846410070 | |
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| Gareth Lagerwall (GL) | UKZN | 0332605177 | lagerwall@ukzn.ac.za |
| Jeff Smithers (JS) | UKZN | | Smithers@ukzn.ac.za |

**APOLOGIES:**

| Name: | Company: | Cell | Email |
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| Sylvester Mpandeli | Water Research Commission | 083 268 7857 | sylvesterm@wrc.org.za |

**DITRIBUTION:**

| Name: | Company: | Cell | Email |
|---|---|---|---|
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- **MINUTES OF MEETING**

| | Action | DATE |
|---|---|---|
| **1. WELCOME** | | |

| | | Action | DATE |
|---|---|---|---|
| 1.1 | Rebecka Henriksson Malinga (RHM) welcomed attendees to the second Research on Tap seminar hosted by the Centre for Water Resources Research (CWRR) for 2019 and introduced the speaker (Gareth Simpson - GS). | | |
| **2.** | **ATTENDANCE AND APOLOGIES** | | |
| 2.1 | An attendance register was circulated and completed by the attendees. A copy of the attendance register is attached in **Appendix A**. | | |
| **3.** | **PRESENTATION** | | |
| 3.1 | GS gave a presentation titled “Selection of Indicators for the Water-Energy-Food Nexus Index and Dashboard”. | | |
| 3.2 | Jessica Badenhorst (JB) handed out printed versions of the draft indicators that have provisionally been selected for inclusion in the WEF nexus index. A copy of the hand-out is attached in **Appendix B**. | | |
| **4.** | **QUESTIONS & DISCUSSIONS** | | |
| 4.1 | Professor Roland Schulze (RS) asked what the extent of the project is and whether it will consider South Africa as well as regions within the country. GS responded that the index resulting from this project will be determined at a country level. However, the main focus of the project in terms of application is South Africa and the other SADC countries. In addition, the Appendix of the PhD will include a paper appertaining to the WEF nexus in the Mpumalanga Province. Further, two policy briefs will emanate from this WRC project, one for South Africa and one for the SADC region. | | |
| 4.2 | Mark Horan (MH) asked how indicators such as the “degree of integrated water resources management (IWRM) implementation” are measured as it seems like quite a subjective indicator. GS referred to the definition of the IWRM indicator where it was specified how to measure the indicator in a repeatable manner. | | |
| 4.3 | Prof Jeff Smithers (JS) enquired why an indicator such as “agricultural land under irrigation” was not identified as an indicator. GS checked the table with all 65 indicators but could not locate such an indicator. Following the seminar, JB verified that the indicator “total agricultural water managed area” was examined but was excluded based on limited data availability. GS and JB will further investigate including an indicator that refers specifically to water use in the agricultural sector. | GS, JB | |
| 4.4 | JS suggested the inclusion of an indicator that refers to the degree of agricultural machinery used in food production per capita. GS to research the possibility of including such an indicator. | GS | |
| 4.5 | Katharine Vincent (KV) asked whether the index is data-driven and if a theoretical link to the WEF nexus could be added to the indicator selection process. GS indicated that the first step of the indicator identification process was its relevance to the WEF nexus; however, an extra column could be added to the indicator table that provides greater justification for each indicator’s relevance to the WEF nexus. | | |
| 4.6 | GS asked KV if it would be useful to differentiate between indicators that relate to resource access and resource security. KV indicated that it may be worth considering. GS and JB to evaluate and discuss the suggestion. | GS, JB | |

| | | Action | DATE |
|---|---|---|---|
| 4.7 | The question was asked whether the final index could be used as a climate change adaptation tool for South Africa, and who the target audience for this index. GS responded that by including indicators related to SDG 7 (clean energy) the index will address climate change adaptation at a national level. GS explained that as the author of the index, his primary target audience is the governmental departments of South Africa (DMR, DEA, DAFF, DoE, etc.) but with the intention that it would be a practical index for researchers, policymakers, and other sectors so as to encourage cooperation between sectors. | | |
| 4.8 | A question was raised regarding the equations that would be used to model the index. GS indicated that he is using an Excel spreadsheet (JRC-COIN) that he acquired at the JRC conference in Italy in November 2018. This spreadsheet is specifically designed to constitute composite indicators. | | |
| 4.9 | It was asked if equal weighting will be given to all indicators. Specific reference was made to the "dam storage capacity" indicator, where this indicator would be important in some countries and almost negligible in others. GS replied that currently, all indicators have equal weighting within the sub-index but that as the dataset becomes more refined, the weighting of each indicator will be considered. | | |
| 4.10 | RS asked how the compilation of the index will consider transient issues such as conceptual change and practical change in data. GS responded that the intention of the index is to be applicable for as long as possible so that the analysed data for different sampling periods would be comparable. GS however added that it is inevitable that new indicators will become available, and that the recording of data for existing indicators may cease. It is for that reason that, where possible, SDG Indicators with relevant data have been utilised. | | |
| 4.11 | RS enquired on the layout of the anthropogenic WEF nexus figure, specifically what the reason is to have humankind in the middle of the WEF nexus as opposed to ecosystem services at the centre, with humankind as the envelope. GS explained that he considers humankind to be the main pulling force of the WEF nexus based on human demand for resources. GS indicated that he will evaluate the possibility of having ecosystem services as the centre of the WEF nexus; however, this figure is currently in the process of being published and would therefore not change significantly. Ashiel Jumman (AJ) noted that the proposed framework is aligned to systems complexity thinking, with humanity being the cause, and the environment/climate being the effect. | GS | |
| 4.12 | AJ commented that he agrees that humankind should be at the centre of the WEF nexus as human demand is the main driver of resource utilisation in the WEF nexus, especially when considering resource governing. AJ asked who the custodians of this WEF nexus index would be and who would oversee the governing of the index. GS replied that currently the various departments in the South African government address issues in a silo-based approach and that the custodians and overseers of the index would need to follow an integrated approach. | | |
| 4.13 | It was asked how the index would account for variations in terms of when the data were collected for different indicators. GS responded that as a general rule, the most recent data available for each indicator is used in the model and that this will be elaborated on in the report. | | |

| | | Action | DATE |
|---|---|---|---|
| 4.14 | Gareth Lagerwall (GL) enquired on the exclusion of other food staple indicators such as potato yield. GL indicated that, for example, cereal does not form a large part of South African diets as opposed to maize. GS confirmed that the exclusion of other food staple indicators would be based on limited data availability, but that JB would investigate the possibility of including other similar indicators. | JB | |
| 4.15 | Duncan May (DM) asked whether the data would be normalised by each country's population size. GS explained that some of the indicator data have already been normalised per capita but that for other indicators this is not applicable. | | |
| 4.16 | Susan Risko (SR) commented on the exclusion of water quality indicators from the list of indicators that will be used in the WEF nexus index. As this comment was made on paper and handed to GS after the seminar, a response could not be made; however, a motivation for the selected indicators will be included in the report. | | |
| **5.** | **CLOSURE** | | |
| 5.1 | RHM thanked GS for the presentation and the attendees for attending the seminar. | | |
| 5.2 | GS thanked JS and the CWRR for hosting the seminar and RHM for organising the event. | | |

Minuted by:

**Jessica Badenhorst**
<u>for Jones & Wagener</u>

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# ATTENDANCE / REGISTER

JOB NO H605

HELD at CWRR, UKZN ON 25 April 2019 AT 14H30

**PROJECT NAME: H605 – WRC WEF Nexus**

**Research on Tap Seminar: Towards a Water-Energy-Food Nexus Index**

## 1. ATTENDANCE

| NO | NAME | SURNAME | CONTACT NUMBER | E-MAIL | COMPANY | SIGNATURE |
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# ATTENDANCE / REGISTER

JOB NO H605

HELD at CWRR, UKZN ON 25 April 2019 AT 14H30

**PROJECT NAME: H605 – WRC WEF Nexus**

**Research on Tap Seminar: Towards a Water-Energy-Food Nexus Index**

## 1. ATTENDANCE

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## 2. ADDITIONAL DISTRIBUTION

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# Appendix G: Academic publications associated with this report

## Published papers:

- ***The Development of the Water-Energy-Food Nexus as a Framework for Achieving Resource Security: A Review*** by Gareth B. Simpson and Graham P. W. Jewitt (2019), published in Frontiers in Environmental Science, Volume 7, Issue 8. https://doi.org/10.3389/fenvs.2019.00008

- ***Competition for Land: The Water-Energy-Food Nexus and Coal Mining in Mpumalanga Province, South Africa*** by Simpson GB, Badenhorst J, Jewitt GPW, Berchner M and Davies E (2019), published in Frontiers in Environmental Science Volume 7, Issue 86. https://doi.org/10.3389/fenvs.2019.00086

## Papers under review:

- ***The Water-Energy-Food Nexus in the Anthropocene*** by Gareth B. Simpson and Graham P.W. Jewitt, submitted to "Current Opinion in Environmental Sustainability" (Elsevier)

  Abstract:
  The WEF nexus has emerged as a multi-centric lens for assessing integrated resources management and sustainable development in the last decade. This paper initially reviews the current status of this approach, which has received some critique for being largely conceptual. The call to operationalise the nexus is heralded in many recent publications. To this end, this paper subsequently seeks to present the way forward as proposed in contemporary academic journal articles and grey literature. Amongst these methods is the development of a central data portal for WEF nexus data and information, the integration of quantitative and qualitative studies, and the need for clarity regarding who is responsible for catalysing and implementing nexus thinking and approaches at both operational and regulatory levels. A common message within current literature is that a toolkit for WEF nexus implementation must be developed to guide future use of this method and that "nexus thinking" must evolve into "nexus doing".

- ***Leave No One Behind: A Southern African Perspective on Water-Energy-Food Nexus Analyses and Innovations*** by Gareth B. Simpson and Graham P.W. Jewitt, submitted to "Environmental Science & Policy" (Elsevier)

  Abstract:
  The anthropogenic impact on Earth is significant in both developed and developing countries. But in developing countries, there is a need to address both macro-level resource security and distributional justice. Much focussed work remains in regions such as Southern Africa if the SDGs are to be achieved in the next ten years. The WEF nexus, which includes SDG 2, 6 and 7 has garnered significant attention as a lens for addressing sustainable development and integrated resource management in the second decade of the twentieth century. This paper presents an anthropocentric WEF nexus framework that emphasises both the availability of and access to, water, energy and food – which are crucial development concerns in Southern Africa. This framework can be utilised in WEF nexus analyses and applications such as models, composite indicators, serious games or innovations. Finally, vignettes of selected projects in the Southern African Development Community (SADC) are presented as examples/evidence of water-, energy- or food-related innovations.

# Appendix H: Policy recommendations for South Africa and SADC

## Water-Energy-Food (WEF) Nexus: Policy Recommendations – South Africa and the 'just transition' to a low carbon economy

**Water Research Commission project: K5/2959//4**

South Africa has 95% of the continent's proven coal reserves and is the seventh-largest producer and sixth largest consumer of coal in the world. Many of the objections raised against coal-fired power stations relate to their $CO_2$ emissions that contribute to climate change. Climate change is however intangible for much of the public. Coal mining in South Africa has several other negative impacts. In South Africa, this relates primarily to the pollution of water resources (both surface water and groundwater in all provinces where coal mining occurs) and the progressive depletion of arable land, especially high potential arable land in the Mpumalanga Province. Coupled with the health impacts of both coal mining and power stations it is hereby proposed that:

- The Department of Energy accelerates the 'just transition' to a low carbon economy. To this end the Draft IRP 2018 scenario "IRP1" represents the least-cost, the lowest $CO_2$ emissions and the joint-lowest water use,
- The National Government, the Department of Energy, Eskom and Municipalities remove obstacles and provide incentives for distributed, small-scale embedded generation (SSEG) at both a household and business level.
- The WEF nexus approach is utilised to guide integrated mine closure, especially in terms of the selection of beneficial post-mining land uses on mining-impacted land.
- A WEF nexus co-ordinating body is established by the South African government. This body should report directly to the National Planning Commission and must include representatives of the:
    - Department of Human Settlements, Water and Sanitation,
    - Water Research Commission,
    - Department of Forestry and Fisheries and Environmental Affairs,
    - Department of Mineral Resources and Energy,
    - Department of Agriculture, Rural Development and Land Reform, and
    - Key research institutions.

  One of the co-ordinating body's mandates should be to facilitate mine closure by:
    - Defining the integrated regulatory process and framework for setting relinquishment criteria for mine closure,
    - Streamlining regulations appertaining to mine closure to facilitate regional mine closure planning, and
    - Setting out a Spatial Development Plan (SDP) for the Mpumalanga Province to define, limit and control coal mine development within Strategic Water Source Areas (SWSA), on high-potential soils and in conservation/protected areas.
- In terms of research projects that will support and guide the initiatives listed above, the following is recommended:
    - Undertake catchment-based assessments of selected catchments using the WEF nexus as a framework to identify resilient upstream policy recommendations, e.g. Orange, Vaal, Olifants, Inkomati, Usuthu and Umgeni Rivers,

- To develop a roadmap to achieve SDGs 2, 6 and 7 by 2030 in South Africa utilising the WEF nexus approach, and
- Undertake sector-specific policy harmonisation to promote integrated resource planning and sustainable development in South Africa.

# Water-Energy-Food (WEF) Nexus: Policy Recommendations – Southern African Development Community (SADC)

**Water Research Commission project: K5/2959//4**

In terms of the WEF nexus approach, SADC has two key main objectives:

1. Developing a nexus framework that will drive the nexus thinking in the region – how can the three sectors of water, energy and food work together?
2. Identifying nexus investments that the region will prioritise.

With reference to the SADC "Protocol on Energy 1996" and "Revised Protocol on Shared Watercourses 2000" the following policy recommendations are proposed:

- That the WEF Nexus Index and the associated dashboard be utilised as a contribution towards the development of the WEF nexus framework that SADC is working towards.
- Based on the WEF Nexus Index project, it is proposed that for nexus investments to be identified, the development of broader access to, and an increased generation of, renewable energy must be prioritised since access to electricity is an enabler of development. In order to attain SDG 7, SADC countries must work both corporately and individually to secure non-burdensome development funding to build utility-scale solar and (where applicable) wind, geothermal, hydropower, pumped storage, and bioenergy installations. This funding must include grid integration and the maintenance, and the upgrading and extension of the transmission and distribution network within the Southern African Power Pool (SAPP). It is essential that transparent tender-based procurement is implemented for these projects.
- In terms of research projects that will support and guide the development of the framework for SADC, as well as the identification of priority nexus investments, it is proposed that SADC:
    - Undertake catchment-based assessments of selected catchments using the WEF nexus approach to identify resilient upstream policy recommendations. This is especially important when the transboundary nature of so many river basins within the SADC region is considered,
    - To develop an integrated roadmap to achieve SDGs 2, 6 and 7 by 2030 in SADC utilising the WEF nexus approach.
- In order to facilitate nexus investments within the region, it will be necessary to undertake sector-specific SADC protocol harmonisations to promote integrated resource planning and sustainable development within this region.
- In terms of facilitating nexus developments, national governments of SADC countries should be very cautious when allowing large-scale land acquisitions (LSLAs). While these transactions introduce foreign capital, the acquisitions are undertaken to secure the energy and food security of developed countries, i.e. not the host nations. Many of these SADC countries have high levels of undernourishment, stunting and wasting. By entering into these agreements SADC nations relinquish land and export 'virtual water' which could both be utilised to secure domestic food security. To plant bioenergy crops in Africa to secure energy security for developed nations, while many in these African nations are undernourished is ethically indefensible. SADC nations must instead provide incentives and facilitate trade for nexus investments such that

African entrepreneurs can obtain funding and other support mechanisms to develop these vast tracts of land to produce food for their own nations' nutritional needs. Clear rules regarding land tenure must be established to facilitate this process.