sustainability

MDPI

Article

Measuring Baseline Agriculture-Related Sustainable Development Goals Index for Southern Africa

Charles Nhemachena [1,*], Greenwell Matchaya [1], Charity R. Nhemachena [2], Selma Karuaihe [3], Binganidzo Muchara [2] and Sibusiso Nhlengethwa [1]

1 International Water Management Institute, Southern Africa Regional Office, 141 Cresswell St, Weavind Park, Pretoria 0184, South Africa; g.matchaya@cgiar.org (G.M.); s.nhlengethwa@cgiar.org (S.N.)
2 Department of Finance and Economics, Graduate School of Business Leadership, University of South Africa, Midrand 1685, South Africa; nhemachenacharity@gmail.com (C.R.N.); muchab@unisa.ac.za (B.M.)
3 Department of Agricultural Economics, Extension and Rural Development, University of Pretoria, Pretoria 0002, South Africa; selma.karuaihe@up.ac.za
* Correspondence: c.nhemachena@cgiar.org; Tel.: +27-12-845-9100

Received: 20 February 2018; Accepted: 13 March 2018; Published: 16 March 2018

Abstract: Sustainable development has become the main focus of the global development agenda as presented in the 2015 Sustainable Development Goals (SDGs). However, for countries to assess progress, they need to have reliable baseline indicators. Therefore, the objective of this paper is to develop a composite baseline index of the agriculture-related SDGs in Southern Africa to guide progress reporting. The paper identified eight of the SDG indicators related to the agriculture sector. The paper relies on data for indicators from five SDGs (SDGs 1, 2, 6, 7 and 15). Applying the arithmetic mean method of aggregation, an agriculture-related SDG composite index for Southern Africa between zero (0 = poor performance) and 100 (best possible performance) was computed for thirteen countries that had data on all identified indicators. The results show that the best performing countries (Botswana, Angola, Namibia, Zambia and South Africa) in the assessment recorded high scores in SDGs 1, 2 and 7. The three countries (Democratic Republic of Congo, Zimbabwe and Madagascar) that performed poorly on both SDG 1 and 2 also had the least scores on the overall agriculture-related SDG composite index. The water stress indicator for SDG 6 recorded the worst performance among most countries in the region. Possible approaches to improve the contribution of agriculture to SDGs may include investing more resources in priority areas for each agriculture-related SDG depending on baseline country conditions. The implementation, monitoring and evaluation of regional and continental commitments in the agriculture sector and the SDGs are critical for achievement of the targets at the national and local levels. While the methods employed are well-grounded in literature, data unavailability for some of the SDGs in some countries presented a limitation to the study, and future efforts should focus on collecting data for the other SDGs in order to permit a wider application.

Keywords: agriculture; SDGs; baseline composite index; Southern Africa

1. Introduction

The 2030 Agenda for Sustainable Development was adopted by the United Nations Heads of State and Government setting the world towards a sustainable development path [1]. The seventeen Sustainable Development Goals (SDGs) in the 2030 Agenda provide a global commitment for transformation of the world into a sustainable pathway while addressing the multiple and complex 21st century challenges currently facing the world [2,3]. Further, the 2030 Agenda builds on the achievements of the Millennium Development Goals (MDGs) and addresses areas that the MDGs could not achieve [1]. Overall, the SDGs focus on addressing these global challenges through

collaborative partnerships across and between member countries of the United Nations balancing the three sustainable development dimensions: economic growth, social inclusion and environmental sustainability [1,3].

Food and agriculture is important to the achievement of the 2030 Agenda for Sustainable Development ranging from goals to ending poverty and hunger (SDG1 & SDG2), addressing climate change (SDG11) and sustaining natural resources [2,4]. Failure to rapidly progress in reducing and eliminating hunger and malnutrition by 2030 adversely affects prospects of attaining other SDGs. Similarly, progress in other SDGs provide a platform for ending hunger and extreme poverty [5]. The challenges of increasing world population, global climate change, shortages of irrigation water, degradation of agricultural land increases the need to enhance agricultural production particularly in rainfed arable lands [6]. Estimates indicate that about 80% of the required improvements in agricultural production would have to come from intensification from current agricultural production systems if targets are to be met without further large scale conversion of land to agriculture [7]. The sustainability challenge for the agriculture sector is to provide enough food for the growing population with less resources such as water, farmland and biodiversity [4,5]. This requires transformative changes towards sustainability in agriculture and strengthening sustainable use and management of existing agricultural systems to sustain food production and the ecosystems in which the production occurs.

Reflecting on current progress on the different dimensions of sustainable development (economic, social and environmental) in terms of status of countries, sectors, regions or cities is important for helping to understand priorities for implementation. Specifically, a sound indicator framework for the SDGs and the accompanying targets makes them an important management tool that can be used to develop implementation strategies and allocate resources to realize the targets [8,9]. There are global efforts to measure progress of countries on the sustainable development goals (SDGs) such as the SDG Index by Sustainable Development Solutions Network (SDSN), 2017 World Bank Atlas of Sustainable Development Goals and others. However, there is no regional assessment that has focused on measuring progress and or provide baseline assessment of agriculture-related SDGs in Southern Africa, despite the importance of the sector in the region. Therefore, the main objective of this paper is to develop a baseline assessment of the agriculture-related SDGs in Southern Africa, focusing on the members of the Southern African development Community (SADC). The current assessment provides knowledge for the debate on progress on attainment of these SDGs and identification of priority areas for implementation including challenges and gaps that must be addressed in the region.

The results from the analyses could be useful for different stakeholders (such as governments, civil society, academia etc.) as a tool for mobilization and tracking progress and ensuring accountability to commitments, and as a management tool to facilitate achievement of transformations required to attain set targets. This is important for countries in the SADC region as they develop and, or revise national agriculture investment plans in the implementation of the Comprehensive Africa Agriculture Development Programme (CAADP) agenda. The national agriculture investment plans identify priority areas that would advance performance of the sector as well as sustainable development goals. In addition, assessing progress in agriculture related SDGs contributes to measuring progress towards sustainable development and ensuring accountability to achieving sectoral targets for sustainable development of the countries and the region. The development of a composite indicator attempted in this paper complements efforts for mutual accountability for the implementation of the CAADP agenda by SADC member states such as Joint Sector Reviews and the Biennial Reviews.

2. Review of Literature

2.1. Agriculture-Related SDG Indicators in the SDG Framework and Selection of Indicators

The SDGs were adopted by 193 member states of the United Nations on 25 September 2015 as a global plan to transform the world into a sustainable and resilient pathway. A successor to the MDGs, the SDGs provide a global vision for ending poverty and hunger while simultaneously

restoring and sustainably managing natural resources [2,3]. A total of 169 targets which are "global in nature and universally applicable, taking into account different national realities, capacities and levels of development and respecting national policies and priorities" have been developed to measure progress in the 17 SDGs [1]. At least 8 out of the 17 SDGs are either directly or indirectly related to agriculture indicating the multi-dimensional status of the sector [5]. Enhancing performance of agriculture-related SGDs contributes to addressing national, regional and continental commitments related to inclusive economic transformation for improved wellbeing in the region. The current paper reflects on the progress of Southern Africa member states in each of these SDGs where data are available and develops a regional agriculture-related SDGs index/indicator. In view of this, the paper builds and adapt on the existing framework to establish a link between the SDGs and agriculture as presented in Table 1. The indicators selected for this study are taken from the SDG indicator framework developed by the Inter-agency and Expert Group (IAEG). Establishing this link is necessary in identifying the relevant indicators and key variables required to construct the composite index for sustainable development, based on selected SDG targets.

Table 1. Summary of agriculture related Sustainable Development Goals (SDGs).

SDG	Description of the SDG and Linkage to Agriculture
SDG1: End poverty	- Agriculture remains a main source of livelihoods especially for the rural communities. - Growth in the agriculture sector, particularly in low-income and agrarian economies is at least twice effective in reducing hunger and poverty than from any other sector.
SDG2 : Zero hunger	- Food insecurity and malnutrition should be comprehensively addressed while simultaneously promoting sustainable agriculture to attain zero hunger. - Transforming food systems and agriculture are important for ensuring enough food is produced to feed the growing population through sustainable utilization of planet resources.
SDG6: Water	- Agriculture uses at least 70% of all water withdrawals. - The challenge for sustainable agricultural systems is to ensure that food production is increased to feed growing population using less water in future.
SDG7: Energy	- Energy plays an important role in achieving food security and better nutrition. - Food prices are affected by changes in energy prices. - Future food production systems would have to decouple from fossil fuel dependence to reduce their environmental footprint.
SDG12: Sustainable consumption and production	- A third of the food produced each year in the world is lost or wasted - Food production systems should be transformed to ensure sustainable production of food while reducing environmental impacts (e.g., loss of soil, water and nutrients, greenhouse gas emissions, degradation of ecosystems). - Consumption patterns should be encouraged to shift to nutritious and safe diets that have a low footprint on the environment.
SDG13: Combat climate change	- The agriculture sector plays a key role in addressing challenges of climate change. - Despite the threats posed by climate change on agricultural production systems, investments in the sector can support both climate change adaptation and mitigation at the same time improving the livelihoods of billions of rural people that rely on the sector.
SDG14: Oceans, Seas and Marine resources	- Fish provides an important source of protein to billions of people daily, however, overfishing and sustainability of fisheries remains critical. - Sustainable management of ocean ecosystems is required to ensure sustainable fisheries. - Promote aquaculture intensification in an environmentally and socially responsible manner to meet growing demand for safe and nutritious food.
SDG15: Life on land	- Forest resources contributes to biodiversity and livelihood source (food, medicine, fuel etc.) for more than a billion people. - Mountains provide an important source of water for more than half of humankind. - Degradation of resources threaten sustainability of agricultural systems, for example: a third of farmland is degraded, at least 75% of crop genetic diversity has been lost and 22% of animal breeds are at risk. - There is need to sustainably use and manage terrestrial ecosystems, forests, mountains, land and soils and biodiversity for the sustainability of life on land.

Source: Adapted from Food and Agriculture Organization of the United Nations (FAO) [5].

2.2. Importance of Agriculture in Contributing to Sustainable Development in Southern Africa

The agricultural sector's role in economic development and sustainable livelihoods is acknowledged at the continental and global level through initiatives of the African Union Commission (AUC), which complement the SDGs and other national development efforts of member states. For example, Aspiration 1 of the African Union Commission (AUC)'s continental framework for eradicating hunger and driving inclusive economic transformation and inclusive development aims at achieving "a prosperous Africa based on inclusive growth and sustainable development" [10,11]. The elements of this aspiration directly related to agriculture include the need to ensure that member countries modernize the agriculture sector "for increased production, productivity and value addition contributes to farmer and national prosperity and Africa's collective food security". In addition, the aspiration emphasizes the need to ensure that natural endowments, environment and ecosystems are "healthy, valued and protected" including ensuring climate resilient economies and communities [10,11]. This emphasizes the critical role the agricultural sector should play in driving economic transformation and inclusive development of member countries. Increasing agricultural production remains a critical part of efforts to drive inclusive economic growth, creating jobs and ending hunger and malnutrition in Africa.

As part of the operationalization of the AUC Agenda 2063 aspirations, member states committed to scale up value addition and productivity as part of efforts to consolidate modernization of African agriculture and agribusinesses [10,11]. This commitment has been translated in the 2014 Malabo Declaration on Agricultural Transformation and Inclusive Development. The commitments that reiterates the critical role of the agriculture sector are elaborated in the Malabo Declaration commitments such as: "completely ending hunger and food insecurity; reducing food imports and raising intra-Africa trade in agriculture and food to 50% of total formal trade in food and agriculture commodities; expanding modernization of agricultural systems, etc., [10].

The adoption of the 2014 Malabo Declaration by African Heads of State and Government, heightened the importance of the agriculture sector as a driver of shared prosperity and improved livelihoods [12]. The Malabo Declaration and the subsequent implementation plan reconfirmed the importance of agriculture on the African development agenda as a driver of economic growth, transformation and poverty reduction efforts. The African Heads of State and Government adopted concrete and more targeted agricultural sector goals and outcomes, which each member states is expected to attain by 2025.

At the regional SADC level, the strategic thrust of the agricultural sector and cross-cutting issues of the environment and sustainable development are critical for attainment of sustainable development goals in the region. The continental frameworks related to agricultural and economic transformation and development (such as AUC Agenda 2063, CAADP, and post-2015 Development Agenda), are presented above. These frameworks provide strategic areas that regional frameworks such as the Regional Indicative Strategic Development Plan (RISDP) and Regional Agricultural Policy (RAP) address. In line with promoting sustainable development in the region, part of the focus of the agriculture and food security sectors include increasing agricultural production, productivity and competitiveness while promoting sustainable utilization of natural resources and environment [13,14].

The revised RISDP 2015–2020 identified food security and trans-boundary natural resources as part of the special programs of regional dimension [13]. The specific objective of revised RISDP 2015–2020 related to agriculture, food security and natural resources sectors is to increase production, productivity and competitiveness of the sectors as drivers of achieving food security and sustainable economic development in Southern Africa. Furthermore, other special objectives are to reduce 'social and economic vulnerability in the context of food and nutrition security' and enhance 'sustainable management and conservation of natural resources, environment, plant and animal genetic resources [13].

To operationalize the strategic goals elaborated in the revised RISDP for the agriculture, food security and natural resources sectors, the region as developed the Regional Agricultural Policy

Investment Plan that focus on addressing policy, regulatory and institutional frameworks to facilitate achievement of the sector goals discussed above. The SADC RAP's environmental sustainability guiding principle states that "regional programs should aim at maintaining the region's "natural capital" and, along with both social sustainability and economic sustainability, contributing to sustainable development that meets the needs of the present without compromising the ability of future generations to meet their own needs". This emphasizes that the region embraces the need to steer the regional economy into a sustainable development path. The RAP aims to "contribute towards the attainment of the SADC Common Agenda which promotes sustainable and equitable economic growth and socio-economic development" [14].

Overall, the agriculture sector remains an important livelihoods source (directly and indirectly) to over 60% of the population in the SADC region implying that economic growth, poverty reduction and food security are significantly affected by the performance of the sector [14,15]. In addition, the agricultural sector contributes an average of 17% to the regional Gross Domestic Product (GDP) and the contribution increases to over 28% excluding all middle income countries [14]. Despite its importance the average growth rate of the agriculture sector (around 2.6% per annum) is way below the RISDP and CAADP targets of at least 7% and 6% respectively. The current annual performance of the sector has been insufficient to significantly contribute to regional economic growth and address poverty, as well as food and nutrition security in the region [15]. For example, review of the food security indicate in the RAP highlight that food and nutrition security remain critical challenges in the region. Also, these issues have been prioritized in the revised RISDP 2015–2020 as special programs of regional dimension and key area towards achieving poverty reduction in the region. Trends of different dimensions of food and nutrition security for Southern Africa indicate that the current levels are too low for member states to achieve regional and continental targets. This emphasizes the need to track progress in the agriculture sector and identify intervention areas which can enhance its performance and contribution to economic growth, poverty reduction and sustainable development in the region.

3. Materials and Methods

3.1. Overview of Application of Composite Indicators/Indices

A composite indicator or index is a mathematical aggregation or combination of a set of indicators measuring multi-dimensional concepts, usually without common units of measurement and no obvious weighting approach of the sub-indicators [16–19]. Composite indicators have been applied in different fields including environment, economy, and society to monitor performance, for benchmarking, policy analysis and public communication [16,19–21]. Composite indicators help with interpretation of different indicators compared to trying to find common trends across many separate indicators [16]. Examples of composite indicators widely used include the Environmental Performance Index [22] and Human Development Index [23].

Despite the controversy on composite indicators (such as lack of standard methodology for their construction, subjectivity involved in their construction), they remain important tools for policy evaluation and communication [21,24]. Stakeholders and practitioners are tempted to summarize complex and sometimes elusive processes into a single figure to benchmark country performance for policy and public communication and or consumption, making composite indicators irresistible [19]. For example, they provide stakeholders, decision makers and exports with important information that include: direction of developments; comparison across situations, places and countries; tracking progress in relation to goals and targets; identifying areas requiring urgent attention; planning for expected future conditions and trends; communication tool for public, stakeholders and decision makers [17,21,24].

The same as mathematical or computational models, composite indicators are justified based on their fitness for the intended purpose and peer acceptance [21]. For example, in multi-criteria decision

methodology, the sensitivity of the weighting factors may affect results as discussed below and these issues should be addressed. Similar to other composite indicators such as the Human Development Index, Technology Advancement Index, and Environment Performance Index, the construction of the agriculture-related SDG index for Southern Africa is intended to be the starting point for assessment of performance in the region and in individual countries. Furthermore, composite indicators should not be considered as the goal of the analysis, rather they should be seen as a starting point for discussion and attracting public interest and concern [16]. In view of that, the current analysis aimed to construct a regional agriculture-related SDGs for Southern Africa to initiate discussion and generate stakeholder interest in the performance of the agriculture sector and the related SDGs. The pros and cons of composite indicators are summarized in Table 2 below.

Table 2. Pros and cons of composite indicators.

Pros	Cons
• Composite indicators summarize complex or multi-dimensional issues that can be used to support decision making • Composite indicators through aggregating several sub-indicators allow easier interpretation and ranking of countries on complex or multi-dimensional issues • Composite indicators can be used for communication and advocacy on issues of public interest through providing summary of performance of one country or entity compared to others including tracking performance over time • Composite indicators help reduce size of the list of indicators or can be used to include more information within limited size	• Poorly constructed or misinterpreted composite indicators can provide misleading, non-robust policy messages. Robustness of the composite indicators can be tested using sensitivity/uncertainty analysis • Simplistic conclusions can be drawn based on the simple big picture results shown by composite indicators. To address this potential problem, sound policy conclusions from composite indicators should be drawn in combination with sub-indicators • Judgement in the construction of composite indicators has to be made at different stages (such as identification of indicators, weighting of indicators, and treatment of missing values). It is important that these judgements are based on sound statistical principles • Construction of composite indicators requires substantial data as all sub-indicators require data for statistically significant analysis to be performed

Source: [16,17].

3.2. Indicator Selection and Data Used for Empirical Analyses

Table 1 provided a link of the selected SDGs to the agricultural sector in order to guide the development of the composite index based on selected SDG targets. The indicators selected for this study were taken from the SDG indicator framework developed by the Inter-Agency and Expert Group on SDG Indicators (IAEG-SDGs). The IAEG-SDGs categorized the SDG indicators into three "tiers" (as of April 2017): (a) Tier One constitute 82 indicators where methodology is internationally established and data are already available; (b) Tier Two consists of 61 indicators where methodology is internationally established but the data are not available; and (c) Tier Three constitutes 84 indicators where methodology is still not internationally established, as well as 5 indicators with multiple tiers [25]. While not all indicators in the SDG indicator framework have been finalized in terms of methodology and data sources, evaluation and benchmarking of progress in the SDGs with established methodology and readily available data can be conducted to inform decision making.

The selection of indicators used for the current assessment was based on the following criteria: availability of data for the indicators across most or all countries in the SADC region; applicability to regional and country settings in Southern Africa. As with many indicators, the paper acknowledges that data availability is an issue, since some of the SDG indicators (such as SDG 12 and SDG 13) don't have data for inclusion in the current computation of the composite index. Nevertheless, in the absence of full datasets, the identified indicators provide an important starting point to develop baseline for monitoring progress towards the implementation of the SDGs. An important example is the work of the Sustainable Development Solutions Network (SDSN) on assessing progress of the SDGs where baselines were development in 2016 based on indicators that had data and these are improved with each assessment [26].

Similar to the SDG Index and Dashboards [26], the current study made use of the Tier 1 agriculture-related SDGs to provide an initial regional assessment of the status quo of the selected SDGs in the Southern African countries in this area. Table 3 summarizes the indicators selected for the assessment of agriculture-related SDG index for Southern Africa. It is important to note that changes in weighting of indicators and selection of sub-indicators (such as application of different weights and omitted variables) may affect the results of the composite indicator and this is discussed in detail in Section 3.3.4 below.

Table 3. Indicators selected for the agriculture-related SDG index for Southern Africa.

SDG	Indicators Used for Agric.-Related SDG Index *,**
SDG1: End poverty	- 1.1.1 Proportion of population below the international poverty line, by sex, age, employment status and geographical location (urban/rural) - 1.2.1 Proportion of population living below the national poverty line, by sex and age
SDG2 : Zero hunger	- 2.1.1 Prevalence of undernourishment - 2.2.1 Prevalence of stunting (height for age <−2 standard deviation from the median of the World Health Organization (WHO) Child Growth Standards) among children under 5 years of age - 2.2.2 Prevalence of malnutrition (weight for height >+2 or <−2 standard deviation from the median of the WHO Child Growth Standards) among children under 5years of age, by type (wasting and overweight) ***2.a.2 Total official flows (official development assistance plus other official flows) to the agriculture sector
SDG6: Water	- 6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
SDG7: Energy	- 7.1.1 Proportion of population with access to electricity - 7.1.2 Proportion of population with primary reliance on clean fuels and technology - 7.2.1 Renewable energy share in the total final energy consumption - 7.3.1 Energy intensity measured in terms of primary energy and GDP
SDG12: Sustainable consumption and production	No indicators with data identified
SDG13: Combat climate change	No indicators with data identified
SDG14: Oceans, Seas and Marine resources	- 14.5.1 Coverage of protected areas in relation to marine areas ****
SDG15: Life on land	- 15.1.1 Forest area as a proportion of total land area - 15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type

* Based on the UN Inter-Agency and Expert Group on Sustainable Development Goals Indicators (IAEG-SDGs) (updated as of 20 April 2017); ** Based on relevance to agriculture and data availability; *** In the calculation prevalence of overweight was replace with underweight among children under 5 years of age; **** This indicator was initially included and later dropped as 6 countries didn't have data.

The data used in the paper were gathered from the World Development Indicators, Regional Strategic Analysis Knowledge Support Systems and Food and Agriculture Organization Statistical Database (FAOSTAT). The analyses presented in the paper provide useful insights in the current performance of member countries and the region on agriculture-related SDGs. The assessment at the regional level would contribute to peer review of performance among countries and encourage knowledge sharing and learning similar to other regional platforms such as the CAADP Biennial Review. In addition, reflecting on the progress with agriculture related SDGs would also contribute to building data systems for country reporting at different platforms such as the CAADP Biennial Reviews, SDG interim reporting and others. Another contribution of this assessment is to act as a baseline from which future assessment can be compared to assess progress in attaining the agriculture-related SDGs. However, the assessment in this study should not be seen as a comprehensive assessment of progress on the SDGs for the region and or performance of the agriculture sector. The current analyses should be used to complement other efforts such as the CAADP Biennial Review assessment being implemented across the continent led by the African Union Commission, NEPAD Planning and Coordinating Agency and partners.

3.3. Methodology for Computing the Baseline Agriculture-Related SDG Index

3.3.1. Normalization and Weighting of Indicators

Raw data and sub-indicators used to calculate composite indices/indicators are normalized for comparability [16,17]. It is noted that the available data and the analyst determine the appropriate methods selected for normalization of the data. Using the min-max normalization method, the individual indicators were re-scaled from 0 to 100, with 0 being the lowest (worst) performance and 100 the highest (best) possible score. Following Sachs et al., [17] the data were ordered for each indicator from worst to best using the above scale. It is important to note that very high numerical scores for some indicators represents worst performance (such as infant mortality) and for others they represent best performance (such as life expectancy). The index is a measure that indicate the success or failure of a country to achieve set targets. The success/failure is measured by the distance between the current status of the country for each SDG to the set target. The min-max normalization method is also widely used in other composite indicators such as the Gender Development Index, the Human Development Index [23], and the SDG Index [26].

Explicit weighting (equal weighting, expert weighting), statistical weighting (regression analysis, factor analysis) are some of the methods used in the development of composite indices/indicators [16]. Weighting impacts of the outcome of the composite indicator as well as ranking of country performance therefore requires important considerations. This paper applies equal weighting similar to other research that has constructed SGD indices and indicators, particularly the work of the SDSN [26,27]. These prior analyses justified equal weighting for its reflection of the commitment by policy makers to treat all SDGs equally important. Furthermore the SDGs are presented in the 2030 Agenda as integrated and indivisible [1], making them equally important.

However, it is important to note that although equal weighting is justified for the SDG index computation, there are possibilities of using different indicators based on various criteria. For example, different weights could be applied to enabling factors and target parameters, such as "access to electricity" and "the percentage of the population below poverty line" respectively. In this case different expert weights for example can be applied to these indicators. As more data become available future research should explore these options and see how they affect the overall index results.

3.3.2. Calculation of the Baseline Agriculture-Related SDG Index

The composite index CI_c for each country c is usually a simple linear weighted function of a total of N normalized sub-indicators y_{it} with weights w_i. The calculation of composite indices/indicators is usually based on standardized values (Equation (1a)) or on rescaled values (Equation (1b)) [19].

$$CI_c^t = \frac{\sum_{i=1}^{N} w_i \sigma\, y_{it}^t}{\sum_{i=1}^{N} w_i}, \text{ where } \begin{cases} y_{it}^t = \frac{x_{it}^t - \bar{x}_i^t}{\sigma_i^t} & \text{(a)} \\ y_{it}^t = \frac{x_{it}^t - \min\left(x_i^t\right)}{range\left(x_{it}^t\right)} & \text{(b)} \end{cases} \quad (1)$$

where x_{it}^t represents value of indicator i for country c at time t, w_i represents the weight for indicator i.

The standardized values method (Equation (1a)) provides a robust way of addressing outliers and is commonly applied in calculating composite indices. However, the method does not completely solve the problems of outliers as the range between the maximum and minimum observed standard values vary for each indicator. In addition, the method rewards exceptional behavior by giving more weight to indicators with extreme values [17]. Equation (1b) method is the same as Equation (1a) except that instead of standardized values, re-scaled values are used in the calculation of the composite index. Compared to the first method, the re-scaled values method provides more robust results when outliers are a problem since the range is the same for all standardized scores. The limitation of this method is that indicators with small variation will have increased range and tend to contribute more to the composite index than they would in Equation (1a) and the composite index depends on variance

in the indicator and the weighting [17]. Therefore, the weighting methods selected is very critical in the construction of the composite index.

The agriculture-related SDG index for Southern Africa was constructed according to the re-scaled values method (Equation (1b)) based on its wide application in literature and ease of implementation. However, no major statistically significant differences in the composite index were expected from using either of the methods.

3.3.3. Aggregation

The calculation of the agriculture-related SDG index for Southern Africa was based on the arithmetic mean method of aggregation. The arithmetic mean aggregation method has been widely applied in the calculation of composite indices such as the United Nations Human Development Index [23], Gender Development Index [23], baseline African Green Growth Index [28], Global Innovation Index [29], SDG indicator and dashboards for countries [26,27]. Other functional forms usually used for aggregation in calculating composite indices are the geometric average and Leontief production function [26]. The arithmetic mean method is widely used compared to the other methods for its ease of application and communication.

3.3.4. Robustness and Sensitivity Analysis

Changes in weighting of indicators, normalization method, imputation of missing data and selection of sub-indicators affect the results of the composite index. It is important to test the sensitivity of the country rankings to these changes to ensure that policy messages are not based on rankings that have high sensitivity to small changes in the calculation of the composite index [16,17]. The robustness of the calculated composite index should be tested to the above changes. For example, imputation of missing data may bring uncertainties in the composite index. Also, applying different weights could also result in changes in overall performance of different countries. In this case, expert weights on the selected SDGs could be applied. However, given time limitations, for the current paper this could not be done. Nevertheless, given that most SDG indicators and dashboards are based on equal weights as indicated above [17,27], the current analysis could spur discussions and improvements of monitoring and measuring of progress in the agriculture SDGs. Combining this assessment with the progress reviews of regional and continental commitments in the agriculture sector provide useful information that could be used to engage different stakeholders in promoting investments in different sub-sectors of agriculture to enhance performance and contribution towards achievements of inclusive and sustainable growth. Future assessments should explore the impacts of different scenarios highlighted above on the overall index and compare any changes in ranking and performance of countries.

4. Results and Discussion

The results from the baseline agriculture-related SDG composite index for Southern Africa are presented in Table 4 below. The index is a measure to indicate the progress made by a country to achieve set targets on each of the SDGs. The analysis indicates that Botswana, Angola, Namibia, Zambia and South Africa are the top performing countries (1st to 5th) based on the analysis of indicators with data. Mozambique (11th), Malawi (12th) and Madagascar (13th) are the least performing countries. It is important to note that Mauritius and Seychelles were excluded in the analysis as they did not have any data on SDG 2 indicators.

Table 4. Agriculture related SDG index for SADC countries with ranking.

Country Name	Country Code	Score/100 Points	Rank/13 Countries
Botswana	BWA	66, 97	1
Angola	AGO	65, 86	2
Namibia	NAM	54, 08	3
Zambia	ZMB	50, 33	4
South Africa	ZAF	49, 51	5
Tanzania	TZA	49, 40	6
Lesotho	LSO	47, 25	7
Congo, Dem. Rep.	COD	47, 24	8
Swaziland	SWZ	44, 33	9
Zimbabwe	ZWE	43, 78	10
Mozambique	MOZ	40, 01	11
Malawi	MWI	38, 42	12
Madagascar	MDG	17, 80	13

Source: Authors based on calculations using data from World Bank's World Development Indicators (WDI), FAOSTAT and Regional Strategic Analysis and Knowledge Support System (ReSAKSS).

The spider web diagram presented in Figure 1 below presents all the identified indicators used in the calculation of the agriculture-related SDG index for Southern Africa. The countries that performed well in the ranking presented above had high scores in SDG 1, 2 and & 7 indicators. Except Angola, Democratic Republic of Congo (COD) and Lesotho, most of the countries in the region performed poorly on the SDG 6 indicators on level of water stress measured by agriculture freshwater withdrawal as a proportion of available freshwater resources.

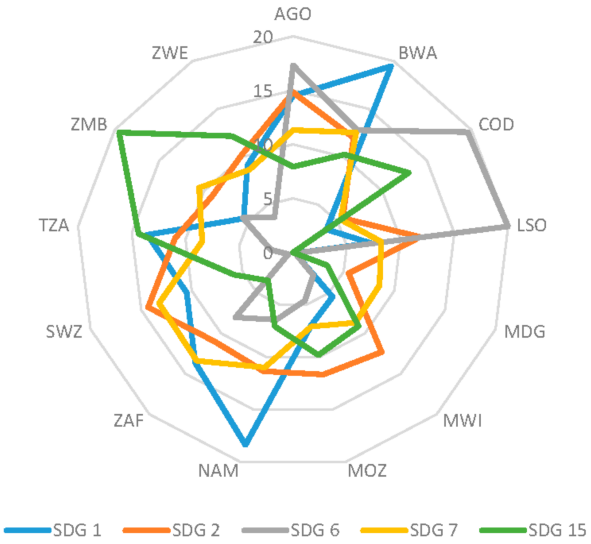

Figure 1. Baseline indicators of the agriculture related SDG composite index spider web. Source: Authors based on calculations using data from WDI, FAOSTAT and ReSAKSS.

Figures 2–6 present the analyses of each of the identified SDG indicators used in the calculation of the agriculture-related SDG index for Southern Africa. The graphs shows weighted scores for each country out of 20 percentage points for each SDG. The countries that performed well (indicator of >10%) for SDG1 (ending poverty in all its forms) are as follows: Botswana (19%), Namibia (18%), Angola (15%), Tanzania (14%) and Swaziland (11%) as shown in Figure 2. The first three countries were also the overall top performers in the composite indicator (Table 3 above). The COD (4%) and Madagascar (0.2%) (Figure 2) were the least performers on the SDG 1 highlighting the poverty challenges faced in these countries. Ending poverty also remains a priority area for action at the regional

level as indicated in the Revised SADC RISDIP, Regional Agricultural Policy and the outcomes of the SADC ministerial workshop on food security and poverty reduction [13–15]. The challenge for the region is to ensure that there is implementation at national and local levels for the continental and regional goals and targets to be realized.

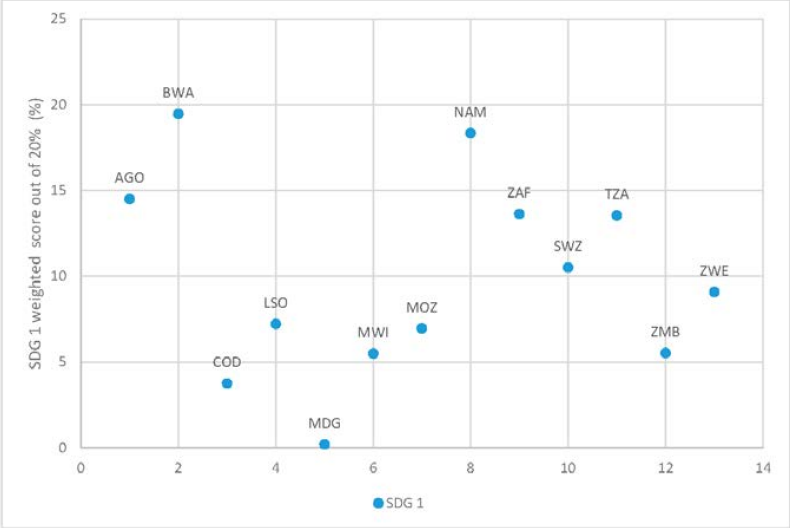

Figure 2. Baseline SDG 1 indicators used in the agriculture related SDG composite index. Source: Authors based on calculations using data from WDI, FAOSTAT and ReSAKSS.

The results for SDG 2 related to ending hunger indicators indicate that all the countries performed above the weighted score of 10 except Zambia (9%), COD (6%) and Madagascar (5%) (Figure 3). The three countries that performed poorly on both SDG 1 and 2 also had the least scores on the overall agriculture-related SDG composite index. In line with the Malabo Declaration commitment and the Africa Regional Nutrition Strategy (2015–2025) of ending hunger in Africa [12,30], the progress in Southern African countries should be strengthened to ensure that progress in the agriculture sector makes significant contributions achieving the targets of this goal.

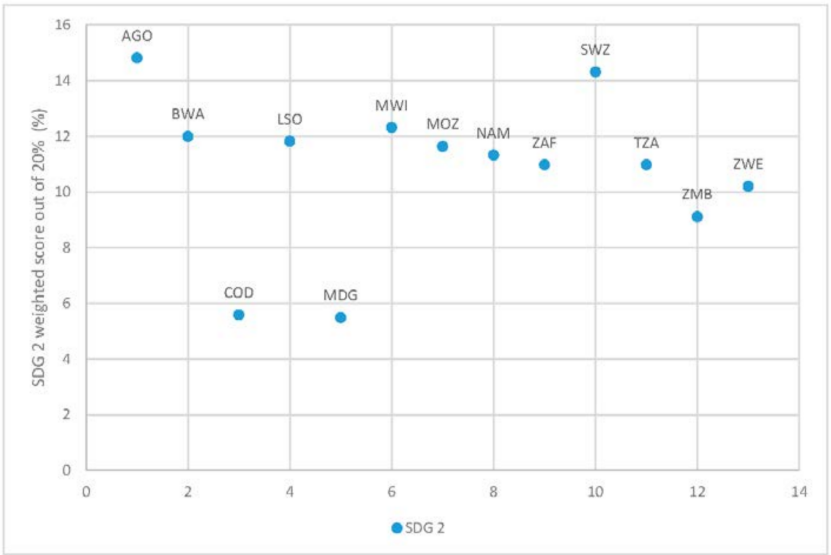

Figure 3. Baseline SDG 2 indicators used in the agriculture related SDG composite index. Source: Authors based on calculations using data from WDI, FAOSTAT and ReSAKSS.

The SDG 6 indicator on level of water stress measured by agriculture sector freshwater withdrawals as a proportion of available freshwater resources shows that most of the countries performed poorly (less than 10%). Lesotho (20%), COD (19.59%), Angola (17.31%) and Botswana (12.76%) (Figure 4) are the only countries that recorded high scores. The overall results point to a water stressed region. Despite a lot of agricultural freshwater withdrawals, a lot of agriculture activities (particularly smallholder agriculture) are rainfed and less than 5% of arable land is under irrigation [31]. There is need not only to increase area under irrigation, but to improve efficiency and sustainable water use in the agriculture sector. Furthermore, the second generation of national agriculture investment plans integrating the 2014 Malabo Declaration commitments should ensure that adequate resources are allocated for both agricultural water management and irrigation and complementary high value inputs to improve performance of the agriculture sector.

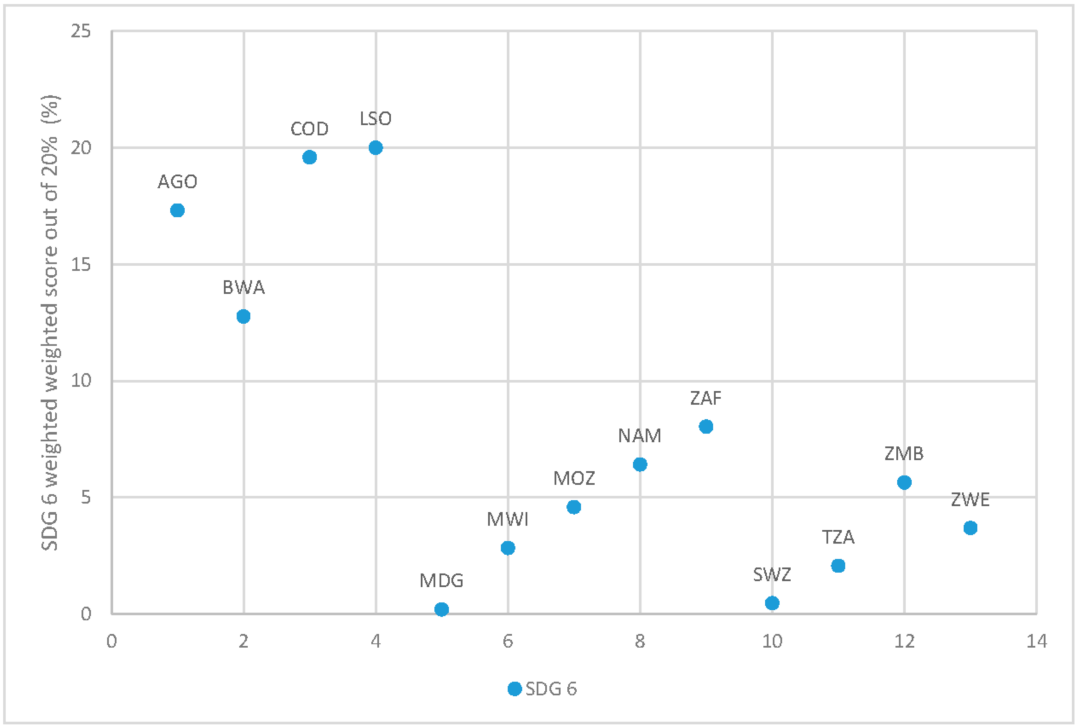

Figure 4. Baseline SDG 5 indicators used in the agriculture related SDG composite index. Source: Authors based on calculations using data from WDI, FAOSTAT and ReSAKSS.

Figure 5 shows the results of the energy related indicators SDG 7 which plays an important role in the achievement of food security and better nutrition [5]. The analysis showed that South Africa (13.40%), Swaziland (13.23%), Botswana (12.53%), Namibia (10.95%) and Zambia (10.53%) were top performers with a score above 10%. The best performance for South Africa could be attributed to a combination of legislation and incentives to manage and stimulate the country's transition to a low carbon, environmentally sustainable economy and society. For the rest of the countries Mozambique (7.05%) and COD (5.35%) were the least performers. Overall, there is still need for more efforts in the region regarding investments in energy and its utilization in agriculture to improve both performance of the sector and achievement of food security and better nutrition among the member states.

The results for the identified indicators for SDG 15 (life on land) are presented in Figure 6. The two indicators used for SDG 15 are: proportion of forest area and proportion of terrestrial and freshwater biodiversity covered by protected areas. The analysis shows that Zambia (19.52%), Tanzania (14.37%), COD (12.96%), Zimbabwe (12.16%) and Botswana (10.24%) recorded weighted

scores above 10%. South Africa (3.45%), Madagascar (3.37%) and Lesotho (0.00%) were the worst performers for the identified SDG 15 indicators. The results highlight the need for concerted effort in the region to advance sustainable utilization and management of terrestrial ecosystems, forests, land, soils and biodiversity to achieve sustainability of life on land.

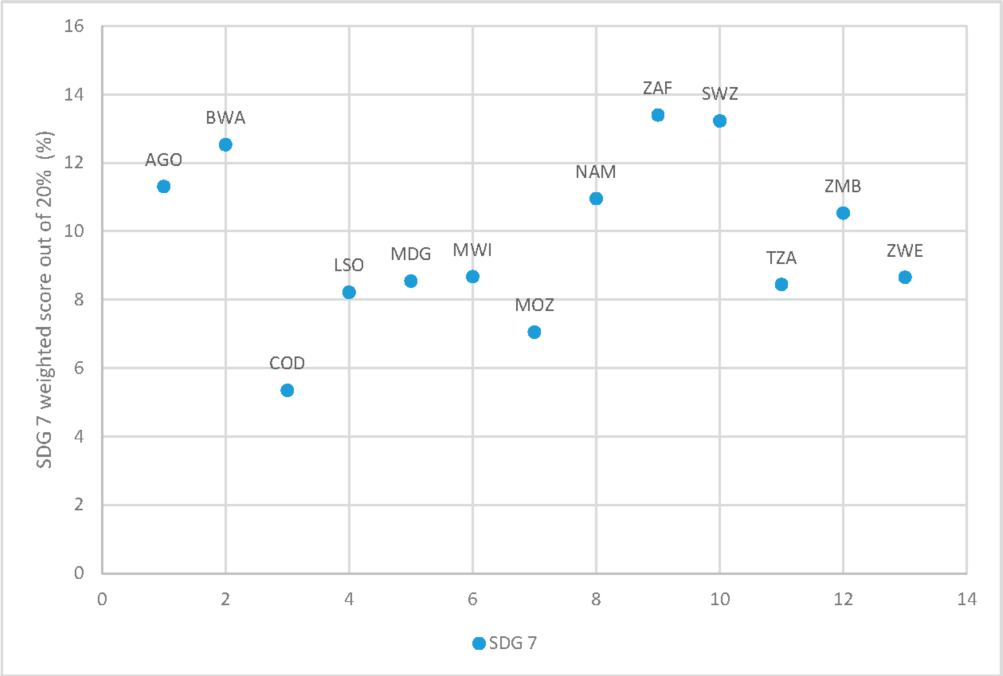

Figure 5. Baseline SDG 7 indicators used in the agriculture related SDG composite index. Source: Authors based on calculations using data from WDI, FAOSTAT and ReSAKSS.

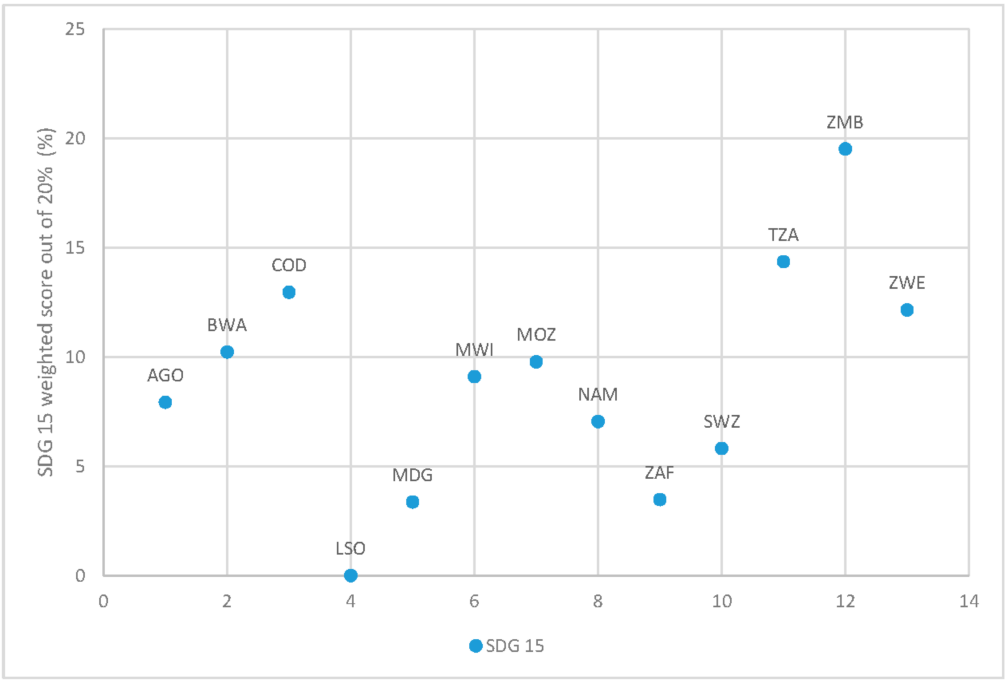

Figure 6. Baseline SDG 15 indicators used in the agriculture related SDG composite index. Source: Authors based on calculations using data from WDI, FAOSTAT and ReSAKSS.

5. Conclusions

The paper developed a baseline assessment of the agriculture-related SDGs in Southern Africa using thirteen countries from the SADC region. The composite index analysis provides knowledge that could be used to facilitate debate on progress on the attainment of the identified SDGs and identification of priority areas for enhancing performance of the agriculture sector. Despite the challenges in data availability for all the possible indicators for the SDGs related to agriculture, the analysis in this paper presents a good baseline assessment and starting point for future analyses of progress to achieve the SDG targets, the 2014 Malabo Declaration and other regional development initiatives. The paper used the weighted average method to compute a composite index for the selected countries, ranging between 0–100.

In terms of the SDG composite indicator ranking, the results show that high performing countries with an index of more than 50 are as follows: Botswana; Angola; Namibia: Zambia; and South Africa. These countries (except Zambia) recorded high scores in in the baseline assessment of SDG1 (ending poverty); SGD2 (zero hunger), and SGD7 (energy). However, more efforts are required to strengthen performance of these SDGs, particularly their linkage with the agriculture sector to ensure that the performance of the sector is enhanced including its contribution to the respective SDGs. The two countries (COD and Madagascar) that performed poorly on both SDG 1 and 2 also had the least scores on the overall agriculture-related SDG composite index. The water stress indicator for SDG 6 recorded the worst performance among most countries in the region. As with many indicators, the paper acknowledges that data availability is an issue, since some of the SDG indicators (such as SDG 12 and SDG 13) don't have data for inclusion in the current computation of the composite index. Nevertheless, in the absence of full datasets, the identified indicators provide an important starting point to develop baseline for monitoring progress towards the implementation of the SDGs. An important example is the work of the Sustainable Development Solutions Network (SDSN) on assessing progress of the SDGs where baselines were development in 2016 based on indicators that had data and these are improved with each assessment.

Possible approaches to improve the contribution of agriculture to SDGs may include investing more resources in priority areas for each agriculture-related SDG depending on baseline country conditions. At the continental level, the African Union Commission through the 2014 Malabo Declaration re-emphasized the importance of the agricultural sector in driving inclusive growth and development in Africa. At the regional level, the SADC Secretariat has championed the development of the Regional Agricultural Policy (RAP) further reiterating the central role agriculture plays in the region. The implementation, monitoring and evaluation of regional and continental commitments in the agriculture sector and the SDGs are critical for achievement of the targets at the national and local levels. In closing, it is important to state that while the methods employed are well-grounded in literature, data unavailability for some of the SDGs in some countries presented a limitation to the study and future efforts should focus on collecting data for the other SDGs in order to permit a wider application.

Acknowledgments: The authors are grateful to the Bill and Melinda Gates Foundation (BMGF), United States Agency for International Development (USAID) and International Food Policy Research Institute (IFPRI) who supported the researchers with funding for various activities in support of the Comprehensive African Agriculture Development Program, one of which led to this paper.

Author Contributions: Charles Nhemachena conceptualized the article content and compiled the first draft. Greenwell Matchaya, Charity R. Nhemachena, Selma Karuaihe, Binganidzo Muchara and Sibusiso Nhlengethwa revised and made conceptual contributions, additions, and refined the article.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. United Nations. Transforming our world: The 2030 agenda for sustainable development. In *A/RES/70/1*; United Nations: New York, NY, USA, 2015.

2. Food and Agriculture Organization (FAO). *Food and Agriculture: Key to Achieving the 2030 Agenda for Sustainable Development*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2016.
3. Food and Agriculture Organization (FAO). Fao and the sdgs. In *Indicators: Measuring Up to the 2030 Agenda for Sustainable Development*; Food and Agriculture Organisation of the United Nations: Rome, Italy, 2017.
4. Sustainable Development Solutions Network (SDSN). Solutions for sustainable agriculture and food systems. In *Technical Report for the Post-2015 Development Agenda*; Sustainable Development Solutions Network: Paris, France; New York, NY, USA, 2013.
5. Food and Agriculture Organization (FAO). *FAO and the 17 Sustainable Development Goals*; Food and Agriculture Organisation of the United Nations: Rome, Italy, 2015.
6. Anderson, W.; Johansen, C.; Siddique, K.H. Addressing the yield gap in rainfed crops: A review. *Agron. Sustain. Dev.* **2016**, *36*, 1–13. [CrossRef]
7. Food and Agriculture Organization (FAO); Daugherty Water for Food Institute (DWFI). Yield gap analysis of field crops—methods and case studies. In *FAO Water Reports No. 41*; Sadras, V.O., Cassman, K.G.G., Grassini, P., Hall, A.J., Bastiaanssen, W.G.M., Laborte, A.G., Milne, A.E., Sileshi, G., Steduto, P., Eds.; Food and Agriculture Organization of the United Nations: Rome, Italy, 2015.
8. Sustainable Development Solutions Network (SDSN). *Getting Started with the Sustainable Development Goals: A Guide for Stakeholders*; Sustainable Development Solutions Network: Paris, France; New York, NY, USA, 2015.
9. Sustainable Development Solutions Network (SDSN). Indicators and a monitoring framework for the sustainable development goals: Launching a data revolution for the sdgs. In *A Report to the Secretary-General of the United Nations by the Leadership Council of the Sustainable Development Solutions Network*; Sustainable Development Solutions Network: Paris, France; New York, NY, USA, 2015.
10. African Union Commission. *Agenda 2063 "The Africa We Want"*; African Union Commission: Addis Ababa, Ethiopia, 2015.
11. African Union Commission. *Agenda 2063 First Ten Year Implementation Plan 2014–2023*; African Union Commission: Addis Ababa, Ethiopia, 2015.
12. African Union Commission. *Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods*; African Union Commission: Addis Ababa, Ethiopia, 2014.
13. Southern Africa Development Community (SADC). *Revised Regional Indicative Strategic*; Development Plan 2015–2020; Southern Africa Development Community: Gaborone, Botswana, 2015.
14. Southern Africa Development Community. *Regional Agricultural Policy*; Southern Africa Development Community: Gaborone, Botswana, 2014.
15. Southern Africa Development Community. *Outcomes of the Ministerial Workshop on Food Security and Poverty Reduction: Towards a Poverty Free and Food Secure Future*; Southern Africa Development Community: Gaborone, Botswana, 2016.
16. Nardo, M.; Saisana, M.; Saltelli, A.; Tarantola, S.; Hoffman, A.; Giovannini, E. Handbook on constructing composite indicators. In *OECD Statistics Working Paper 2005/3*; OECD Publishing: Paris, France, 2005.
17. Saisana, M.; Tarantola, S. *State-of-the-Art Report on Current Methodologies and Practices for Composite Indicator Development*; European Commission, Joint Research Centre, Institute for the Protection and the Security of the Citizen, Technological and Economic Risk Management Unit: Ispra, Italy, 2002.
18. Saltelli, A. Composite indicators between analysis and advocacy. *Soc. Indic. Res.* **2007**, *81*, 65–77. [CrossRef]
19. Saisana, M.; Saltelli, A.; Tarantola, S. Uncertainty and sensitivity analysis techniques as tools for the quality assessment of composite indicators. *J. R. Stat. Soc. Ser. A (Stat. Soc.)* **2005**, *168*, 307–323. [CrossRef]
20. Zhou, P.; Ang, B.; Poh, K. A mathematical programming approach to constructing composite indicators. *Ecol. Econ.* **2007**, *62*, 291–297. [CrossRef]
21. Cherchye, L.; Moesen, W.; Rogge, N.; Van Puyenbroeck, T.; Saisana, M.; Saltelli, A.; Liska, R.; Tarantola, S. Creating composite indicators with dea and robustness analysis: The case of the technology achievement index. *J. Oper. Res. Soc.* **2008**, *59*, 239–251. [CrossRef]
22. Hsu, A.; Esty, D.C.; Levy, M.A.; de Sherbinin, A. *2016 Environmental Performance Index*; Yale University: New Haven, CT, USA, 2016.
23. United Nations Development Programme (UNDP). Human development report 2016. In *Human Development for Everyone*; United Nations Development Programme: New York, NY, USA, 2016.

24. Cherchye, L.; Moesen, W.; Rogge, N.; Van Puyenbroeck, T. An introduction to 'benefit of the doubt'composite indicators. *Soc. Indic. Res.* **2007**, *82*, 111–145. [CrossRef]
25. Inter-Agency and Expert Group on SDG Indicators (IAEG-SDGs). *Tier Classification for Global SDG Indicators*; Inter-agency and Expert Group on SDG Indicators (IAEG-SDGs): New York, NY, USA, 2017.
26. Sachs, J.; Schmidt-Traub, G.; Kroll, C.; Durand-Delacre, D.; Teksoz, K. *Sdg Index and Dashboards—Global Report*; Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN): New York, NY, USA, 2016.
27. Schmidt-Traub, G.; Kroll, C.; Teksoz, K.; Durand-Delacre, D.; Sachs, J.D. National baselines for the sustainable development goals assessed in the sdg index and dashboards. *Nat. Geosci.* **2017**, *10*, 547–555. [CrossRef]
28. Kararach, G.; Nhamo, G.; Mubila, M.; Nhamo, S.; Nhemachena, C.; Babu, S. Reflections on the green growth index for developing countries: A focus of selected african countries. *Dev. Policy Rev.* **2018**, *36*, O432–O454. [CrossRef]
29. Cornell University; INSEAD Business School; World Intellectual Property Organization (WIPO). *The Global Innovation Index 2016: Winning with Global Innovation*; Cornell University, INSEAD, and WIPO: Ithaca, NY, USA; Fontainebleau, France; Geneva, Switzerland, 2016.
30. African Union Commission. *Africa Regional Nutrition Strategy 2015–2025*; African Union Commission: Addis Ababa, Ethiopia, 2015.
31. Nhemachena, C.; Nhlengethwa, S.; Nhemachena, C. Exploring ways to increase public investments in agricultural water management and irrigation for improved agricultural productivity in Southern Africa. In Proceedings of the 2nd World Irrigation Forum (WIF2), Chiang Mai, Thailand, 6–8 November 2016.