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Agricultural Sector Performance in SADC Countries

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Abstract

This paper reviews the agricultural sector performance of Southern African Development Community (SADC) countries, specifically the efficiency of agricultural production and the overall competitiveness of their agricultural sectors. The study uses data spanning the period from 2001 to 2019 to assess agricultural production performance, and from 2001 to 2021 to investigate the competitiveness of the agricultural sectors. Using Malmquist productivity indices, the findings reveal that while overall productivity has increased in SADC, with 11 out of 15 countries recording an upward trajectory during the review period, technological progress has regressed. The gains in productivity have been driven by technical efficiency rather than advancements in technology. On the other hand, the Normalized Revealed Comparative Advantage (NRCA) index shows that 11 out of the 16 SADC countries were competitive, especially among diversified economies like South Africa, Zimbabwe, and Tanzania, compared to less diversified countries. This demonstrates that diversification plays a critical role in resilience to shocks such as climate change, variability, and global commodity price fluctuations. The findings further reveal that mineral-rich countries have less competitive agricultural sectors, potentially reflecting the presence of Dutch disease. These findings highlight the need to attract foreign direct investment (FDI) not only to reduce the funding gap in the agricultural sectors of SADC countries but also to bring much-needed technological innovation that can drive agricultural productivity, meet the food needs of the fast-growing population, and contribute to the overall growth of their economies.

Keywords: Efficiency, competitiveness, SADC, Malmquist index, Normalized Revealed Comparative Advantage index

JEL classification : F14; F15; F21; Q10; Q17

1. Introduction

Agriculture serves as the primary economic sector across most African countries, particularly in rural areas where it sustains approximately 70% of households (Modi, 2019), employs 60% of the workforce, and one of the major contributors to Gross Domestic Product (GDP) in most African economies (Abdulai, 2016; AUDA-NEPAD, 2013). Therefore, growth of the agricultural sector is crucial, as it facilitates the effective integration of the working-age population, enhances income generation, alleviates poverty, and bolsters food security within the region (Modi, 2019). This has been echoed by several regional bodies including the African Union's (AU) Maputo (2003) and Malabo (2014) Declarations, the African Development Bank's 'Feed Africa' strategy (2016) and the Southern African Development Community (SADC) Regional Agricultural Policy. These initiatives aim to unlock Africa's agricultural potential and develop value chains for agro-products, foster greater intra-regional trade, and align with broader objectives of regional integration and economic development. SADC, in particular, has recognised the agricultural sector as a critical catalyst for both economic growth and regional trade (SADC, 2024b).

The Comprehensive African Agriculture Development Programme (CAADP), established under the Maputo Declaration (2003), and reaffirmed under the Malabo Declaration (2014), obliges member states to spend a minimum of 10% of their national budget allocation on the agricultural sector, with the aim of achieving a 6% annual growth in agricultural GDP (AUDA-NEPAD, 2024) and to strengthen the competitiveness of African countries in agriculture and agri-food industries (Bouët & Odjo, 2020). CAADP serves as a continent-wide framework to operationalise these commitments and to position the agricultural sector as a cornerstone for Africa's economic development, improving the livelihoods of smallholder farmers, enhancing agricultural productivity, eradicating hunger, and fostering inclusive economic growth (Modi & Cheru, 2013). Over two decades of CAADP implementation have yielded notable progress in the agricultural sectors of African countries. Between 2000 and 2018, Sub-Saharan Africa (SSA) emerged as the global leader in agricultural production value growth, encompassing both crop cultivation and livestock farming, with an annual expansion rate of 4.3% in real terms, surpassing that of any other region worldwide, while the world average during this timeframe registered at 2.7% annually (Fuglie, 2018; Jayne & Sanchez, 2021).

However, significant challenges persist, and the continent remains off-track to attain the Malabo 2025 targets. No single country has sustained consistent progress; periods of progress have been interspersed with phases of regression, resulting in alternating cycles of development and decline (see Figure 1). Public spending on agriculture in Africa has consistently been lower than other developing regions, both as a proportion of total government expenditure and relative to the sector's contribution to agricultural GDP (Goyal & Nash, 2016; RESAKSS, 2025). Since the establishment of CAADP, agricultural spending as a share of total public spending has averaged 2.94% between 2003 and 2023, and 2.66% between 2018 and 2023. The southern Africa region, and in particular, SADC has recorded the lowest share of agricultural spending compared to other regional economic communities (RECs). This underinvestment highlights the need to reduce the financing gap in the agricultural sector.

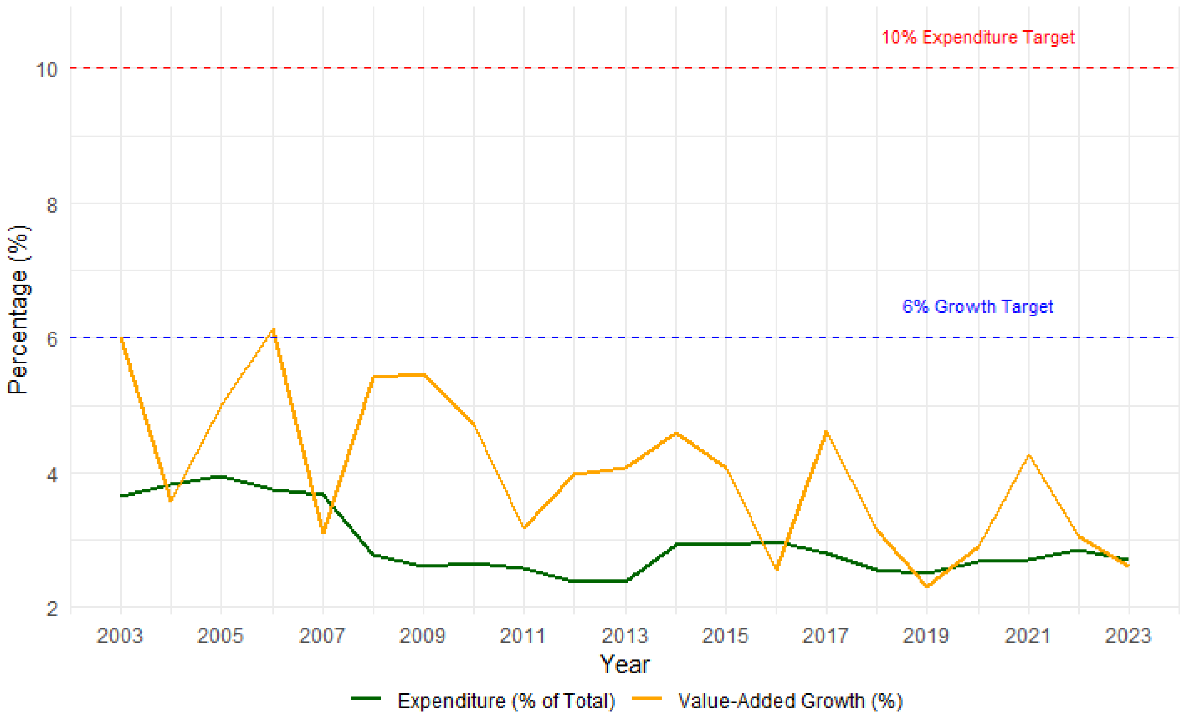

Figure 1: Tracking progress toward achieving CAADP targets of African countries.

Source: Author's compilation based on data from Regional Strategic Analysis and Knowledge Support System (ReSAKSS)

The trends at regional economic level mirror those observed at Africa-wide level. The share of agricultural spending and the growth of agricultural GDP in SADC countries have remained well below the CAADP targets (see Figure 2). The share of agricultural expenditure in total spending and the growth of agricultural GDP between 2003 and 2023 have averaged 2.33% and 3.23%, respectively. It is also evident from Figure 2 that there is no clear correlation between agricultural spending and growth. Some countries have achieved agricultural GDP growth above the CAADP target in some years despite a declining share of agricultural expenditure or spending less than the 10% CAADP target. On the other hand, some countries that have met their 6% 10% expenditure threshold have not achieved their 6% agricultural growth rate target. Twelve out of the SADC countries reported achieving an agricultural GDP growth rate of 6% or more at least once, while only 6 met the 10% agricultural spending target at least once. Notably, some countries, such as Malawi, have failed to achieve the 6% agricultural GDP growth rate despite allocating more than 10% of their budget to the agricultural sector for much of the period from 2003 to 2023. Meanwhile, other countries have achieved 6% agricultural GDP growth rate multiple times despite not meeting the spending target in any year between 2003 and 2023.

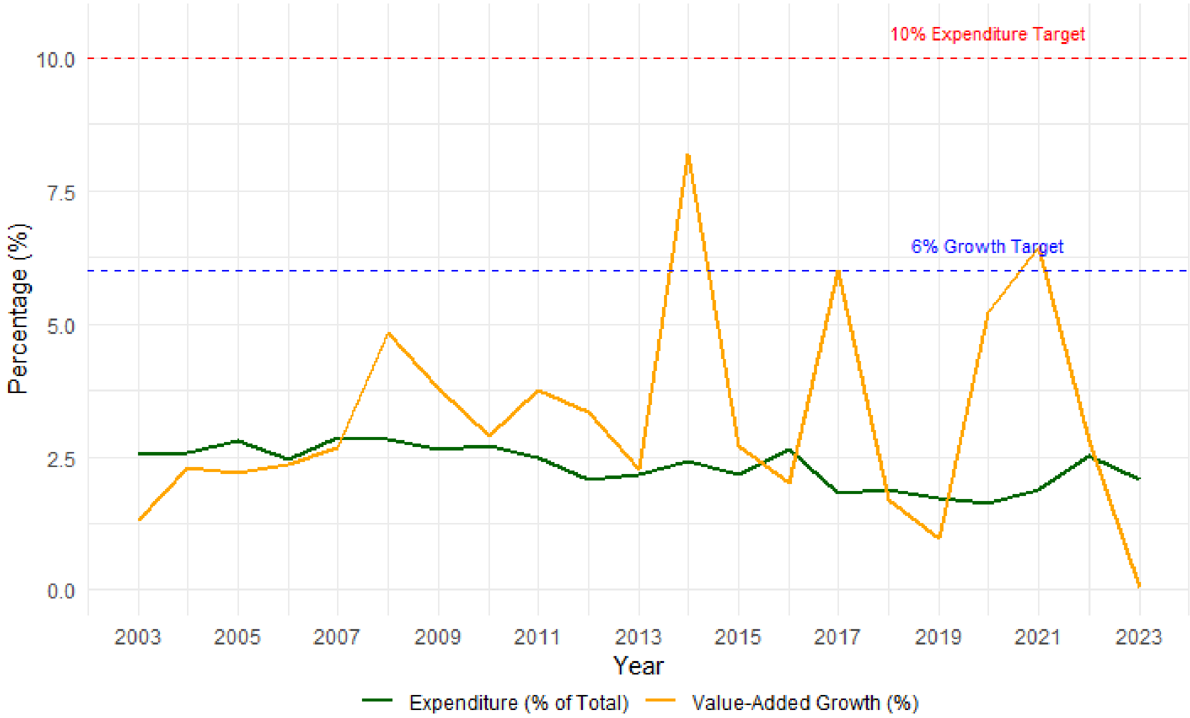

Figure 2: Tracking progress toward achieving CAADP targets of SADC countries.

Source: Author’s compilation based on data from Regional Strategic Analysis and Knowledge Support System (ReSAKSS)

Despite the evolvement of the global agricultural landscape in agricultural production methods and advancements in technology that have played a significant role in increasing productivity and efficiency, several reasons have contributed to the underperformance of African agriculture. Agricultural production has faced numerous challenges such as climate change, water scarcity, outbreak of pests that cause considerable damage to crops, and environmental degradation, and political instability (Baudron, Zaman-Allah, et al., 2019; Bjornlund et al., 2020a; Ray et al., 2019). Climate change poses a significant risk that undermines agricultural gains, particularly in sub-Saharan Africa, where it has adversely affected production of staple crops like maize (Tesfaye et al., 2015). Agricultural practices in the region are also characterised by low input use and limited commercialisation, which have contributed to reduced crop productivity, with average yields falling well below global benchmarks (Li & Wang, 2016; Modi, 2019). Africa's agricultural productivity still lags behind that of other developing regions, failing to deliver the development gains necessary to significantly reduce rural poverty and contributing to higher food prices for the continent's growing urban populations. (Goyal & Nash, 2016). Further, agriculture has suffered significantly due to insufficient post-harvest storage and processing facilities, restricted financial services, weak market linkages, and incoherent government policies (Dehasse, 2017). These challenges have caused agricultural production to not maintain pace with the rapid increase in population growth, leading to demand outstripping supply (Baion et al., 2023). This has escalated food imports making the majority of African countries net food importers, contrary to the 1960s when Africa was self-sufficient in food production (Bjornlund et al., 2020a). This paradox is underscored by the fact that, despite possessing 60% of the world's uncultivated arable land, Africa remains food deficient (AfDB, 2016). Projections indicate an increase in food import expenditures from $35 billion in 2015 to approximately $110 billion by 2025 (AfDB, 2016). The slack performance of the agricultural sector has further exacerbated poverty levels and hunger situation in the region (Li & Wang, 2016).

Against this backdrop, the overarching objective of this paper is to enhance the performance of the agricultural sectors of SADC countries, with particular emphasis on improving intra-regional trade. Specifically, the main objective of this study is to provide a comprehensive analysis of the sector's performance, focusing on key aspects such as production, exports, efficiency, and competitiveness. SADC presents a compelling case for understanding these elements, given its unique economic structure, growth potential, and the recognised importance of the agricultural sector in delivering broad-based economic development to its member states.

2. Overview of the agricultural sectors of SADC countries

2.1 Importance of agriculture to SADC countries

As alluded to earlier, the agricultural sector has a key role to play in the economies of SADC countries. SADC countries, like many other African countries are richly endowed with vast expanses of arable land, much of which remains either underutilised or entirely uncultivated (Modi, 2019). Because of its huge economic potential, the African Union (AU) has placed a premium on this sector as agriculture-centred development serves as a powerful engine for job creation, economic acceleration, and the promotion of socio-economic equity (Modi, 2019). There are numerous benefits that could arise from improved performance of this sector. First, growth of the agricultural sector catalyses backward and forward linkages across the broader economy. These backward linkages increase demand for various agricultural inputs, such as seeds, agrochemicals, machinery, repair services, and transport infrastructure. On the other hand, production of agricultural commodities can spur the establishment and expansion of value chains within processing industries that are reliant on agro-based raw materials (Goyal & Nash, 2016). Growth of these value chains can ultimately translate into increased contribution of the agricultural sector to GDP. As it stands, such value chains in most SADC countries remain largely underdeveloped hence the low contribution of the agricultural sector to GDP (see Figure 3).

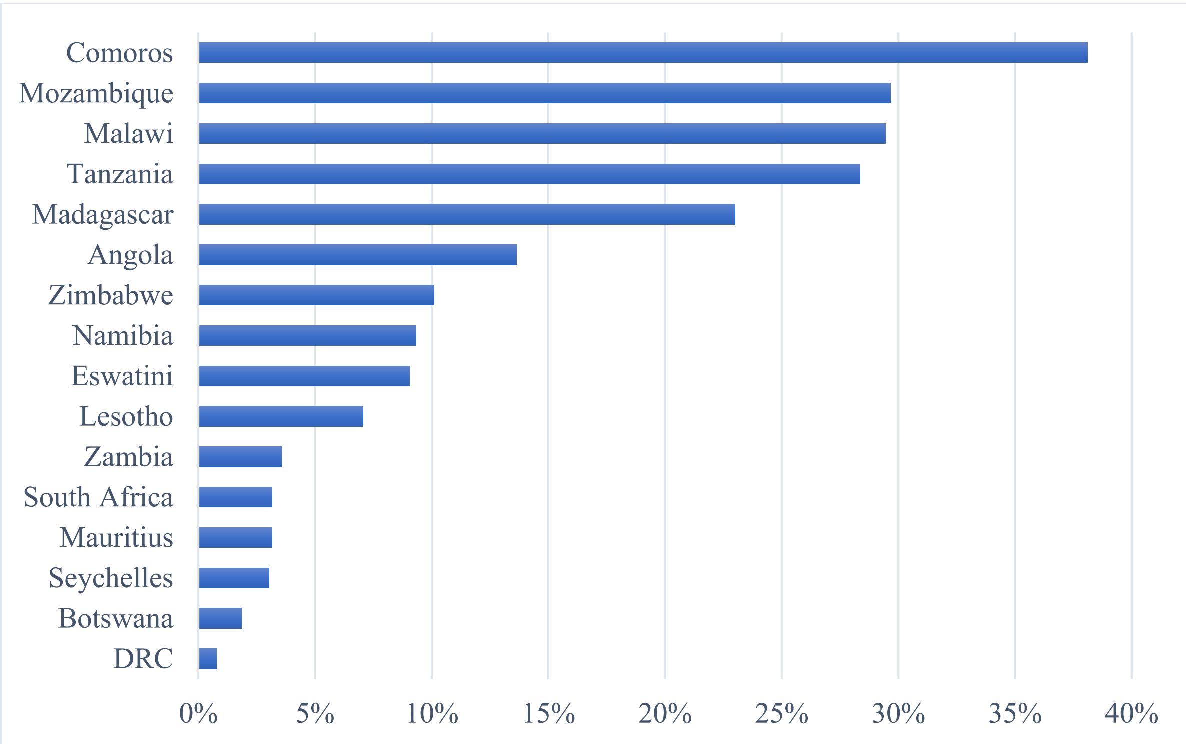

Figure 3: Share of agriculture in GDP of SADC countries in 2022.

Source: Author's compilation from https://www.sadc.int/sadc-statistics/statistics-database

Second, the agricultural sector offers SADC countries an opportunity to diversify and broaden their export earnings beyond traditional export commodities such as minerals and metals, which are susceptible to global commodity price volatility (AfDB, 2016). Third, the agricultural sector is instrumental in ensuring food security and generating employment opportunities. Therefore, growth of the sector drives socio-economic development in rural areas, where a sizable proportion of farming households and impoverished reside. Also and the non-farming population stand to benefit from lower food prices as a result of increased agricultural output (Goyal & Nash, 2016). Over 60% of the region's workforce is directly engaged in agricultural activities, underscoring its critical role in sustaining livelihoods and driving economic participation (SADC, 2024a). Figure 4 presents a detailed breakdown of agriculture's share in total employment across SADC countries.

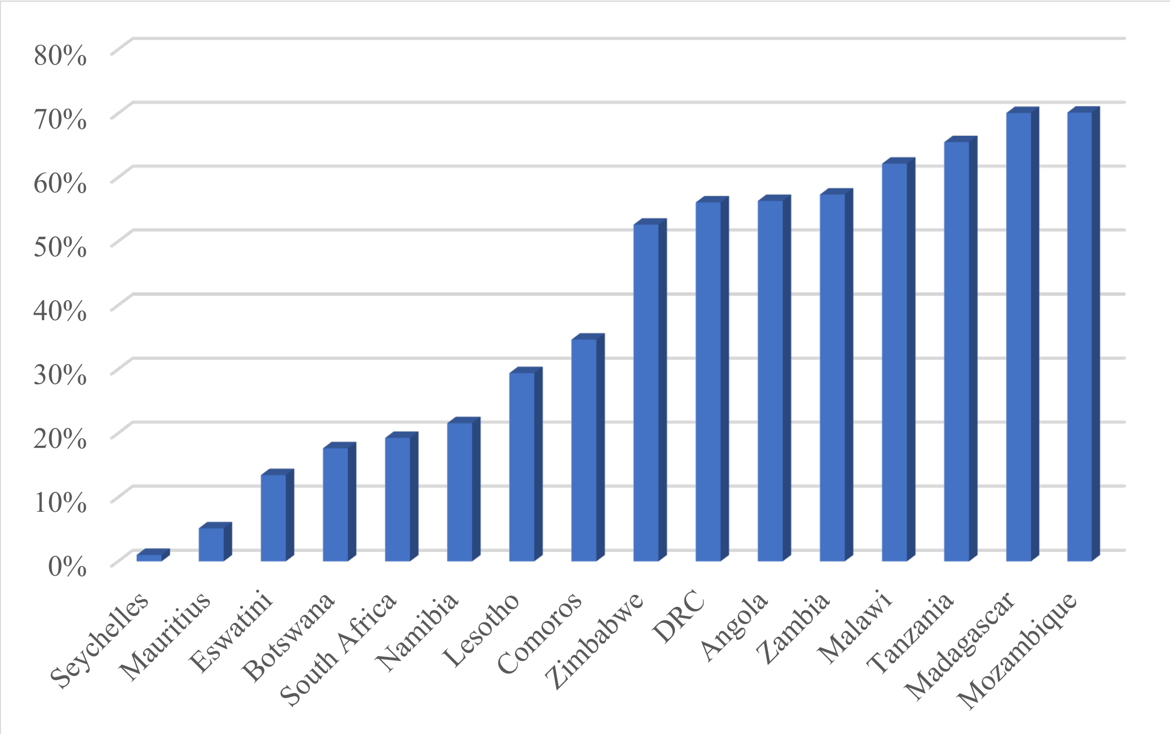

Figure 4: Agriculture's share in total employment across SADC countries in 2022.

Source: Author's compilation from https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?name_desc=true

2.2 Overview of agricultural production

2.2.1 Trends and patterns of agricultural production

Agricultural production in southern Africa is diverse, with different countries excelling in various sectors. Remarkable disparities exist across regions, between countries, and even within individual countries. While some countries focus on crop production, others have shown potential in animal husbandry and aquaculture. This diversity highlights the region's potential for growth and development in the agricultural sector. This diversification could indicate potential for growth and development in the region's agricultural sector. All three sub-sectoral outputs, crops, livestock, and fisheries, show an increasing trend over the years (see Figure 7), indicating growth in agricultural production. The rate of increase varies across categories, with output for crops and animals showing steady growth, while output for fish appears to have more fluctuations. Output levels for crops are consistently the highest among the three categories throughout the period, followed by animals and fish. This suggests that crop production is the dominant component of agricultural output, reflecting the importance of crop farming in the economy. The top three producers in terms of crops have been South Africa, Tanzania, and Congo. Regarding animals, the major three producers have been South Africa, Zimbabwe, and Tanzania. While South Africa remains a key player in both crops and animal production, other countries are emerging as leaders in aquaculture. Countries like Madagascar, Zambia, and Zimbabwe have taken up the lead in this sector. Figure 5 shows the trends in production for all three subsectors during the period 2001 to 2019.

Within the crops sector, cereals, roots and tubers, pulses, and fruits and vegetables have recorded positive growth rates. However, a common concern and pattern that has been observed across several countries is that the growth in agricultural production, especially for crops, has been primarily driven by the expansion of cultivated cropland rather than by increased productivity through the intensification of input use and higher yields per hectare. For instance, Mabeta & Smutka (2023) and Goyal & Nash (2016) highlight the persistently low average yields across most sub-Saharan African countries, which have stagnated or even declined over time, particularly in the sugar industry. Several factors contribute to these low yields, including low intensification in the use of inputs, cultivation of crops in marginal and degraded soils, heavy reliance on rain-fed agriculture despite climate change challenges, and the use of conventional, less technologically advanced production and management methods, especially in pest control (Dzanku et al., 2015; Goyal & Nash, 2016; Kim et al., 2021; Kirui et al., 2023; Mabeta & Smutka, 2023a; Sheahan & Barrett, 2017). Consequently, relying on the expansion of cultivated cropland is not a sustainable solution for enhancing the performance of the agricultural sectors in SADC countries. With SADC‘s increasing population, improving crop yields and agricultural productivity has become increasingly critical. SADC estimates that approximately 44.8 million individuals in urban and rural regions across 13 member states are not food secure (SADC, 2022).

In the livestock sector, notable progress has been made in meat production, particularly from pigs and poultry. The sector serves as a safety net for rural households during periods of low crop production induced by droughts. This sector has been integral to the regions agricultural economy, particularly for countries such as South Africa, Namibia, and Botswana, which are the leading producers of beef and milk.

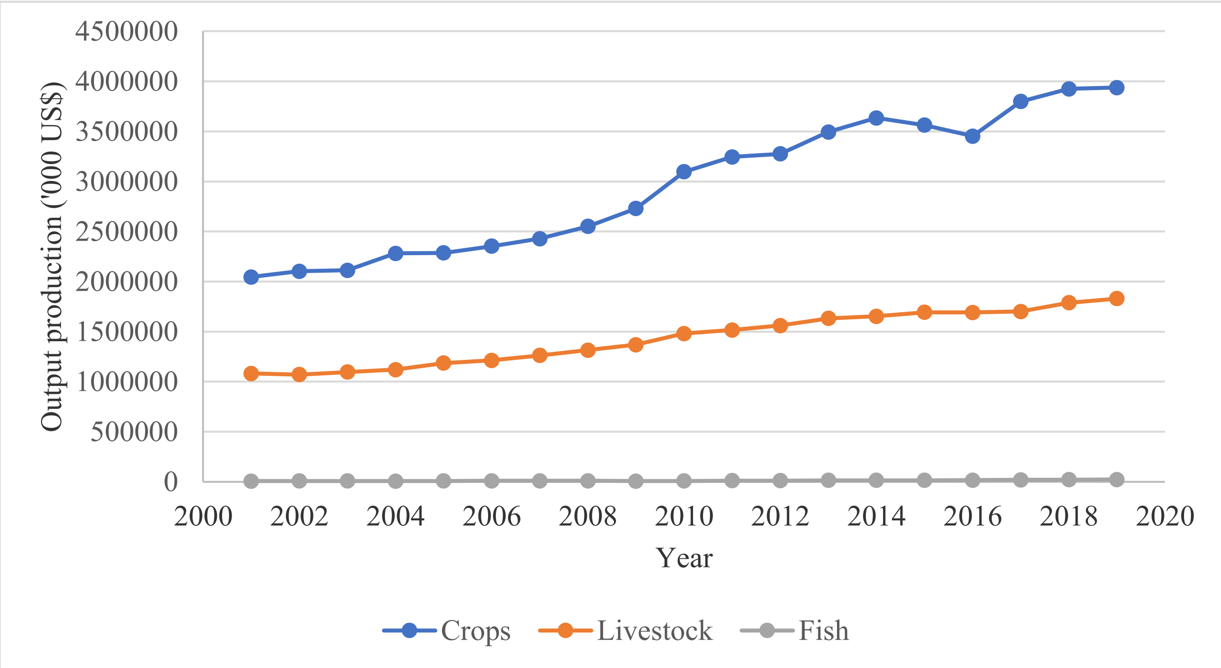

Figure 5: Trends in Agricultural production: 2001-2019.

Source: Author's compilation based on data from United States Department of Agriculture (USDA)

2.2.2 Composition of agricultural output

The composition of agricultural output in SADC countries has remained largely unchanged over the past three decades. Production is heavily concentrated in key product categories—livestock, cereals, and roots and tubers, which collectively account for 66% of the total production value (see Figure 6).

A comprehensive analysis across twelve countries highlights the performance of specific crops and agricultural enterprises. Staple food crops in the region such as maize, sorghum, millet, rice and wheat account for the largest share of total cereal production and cropland in the SADC region, representing 27% of world cereal production (Benjamin et al., 2024). These crops are the most consumed staples in the region (Okou et al., 2022). The horticultural sector has shown substantial growth potential. In 2022, fruits and vegetables accounted for over 20% of the total gross value of production. There is a growing trend toward the cultivation of high-value crops such as citrus fruits and vegetables, driven by rising global demand and favourable climatic conditions in countries such as Zambia, Mozambique, and South Africa.

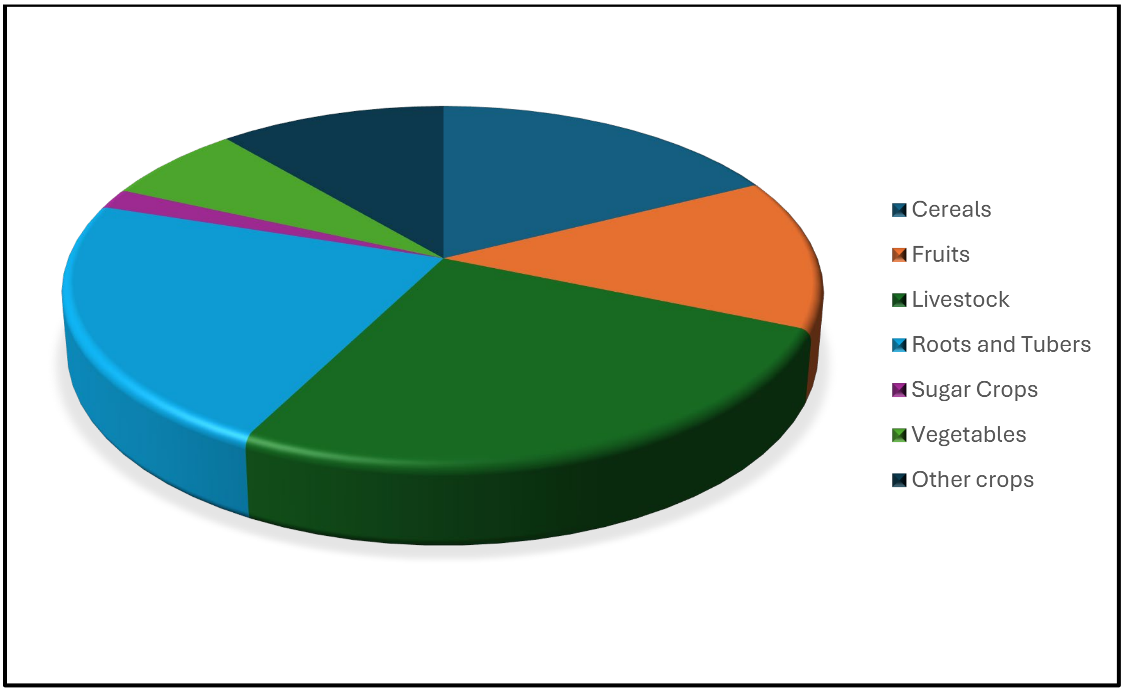

Figure 6: Composition of agricultural output of SADC countries, 2022.

*Note: Data for some countries not available. The figure pertains to only 12 SADC countries.

Source: Author's compilation based on data from **(FAOSTAT)**

2.3 Overview of SADC agricultural exports

Historically, the southern African region has recorded the highest volume of agricultural exports compared to other African regions particularly for crops such as tobacco, maize, citrus fruits, sugarcane. The southern African region has firmly established itself as a leader in agricultural exports, outpacing other regions within the continent and only behind the north African region. Between 2018 and 2022, agricultural exports growth in the north and southern African regions averaged approximately 6%, compared to 5% in east Africa, 4% in central Africa, and 2% in west Africa. Despite this positive and upward trajectory, the share of agricultural exports from the southern African region, like the overall share from the African continent, remains low in the global market. Southern Africa accounts for a meagre 1%, while Africa as a whole represents 4% of global agricultural exports. This is significantly lower compared to other regions, such as the Americas (31%), Asia (20%), Europe (41%), and Oceania (4%).

One notable thing about the agricultural sector of SADC countries is that export volumes do not necessarily exhibit a direct correlation with the production levels. For instance, crops while crops such as sorghum, millet, groundnuts, rice, and wheat account for the largest share of total cereal production and cropland, their share of agricultural exports is low. On the other hand, sugar crops while their share of agricultural production is low, they rank high in terms of agricultural exports. Maize and tobacco are both major production and export commodities.

The two crops dominate SADC's export profile in terms of export value by a substantial margin. Over the past few decades, the export volumes of both cotton and rice have contracted, to the extent that they no longer feature among the principal commodities in the export portfolio. This situation highlights the quintessential challenges facing agricultural export development of Africa's key export commodities, including price fluctuations, exchange rate volatility, institutional and production arrangements, tariff peaks and tariff escalations, inefficient customs, and a lack of appropriate institutional frameworks and systems for managing trade policy (Bjornlund et al., 2020b). The major and top 20 traditional exports agricultural exports in 2022 are shown in Figure 7. Table 1 shows that the leading agricultural exporting countries and their major agricultural export commodities between 2001 and 2022 are Eswatini (raw sugarcane), Madagascar (vanilla and cloves), Malawi (unmanufactured tobacco and groundnuts), Mozambique (pulses and unmanufactured tobacco), South Africa (maize, citrus fruits, and sugarcane), Tanzania (cashew nuts, rice, and unmanufactured tobacco), Zambia (unmanufactured tobacco, maize, and raw sugarcane), and Zimbabwe (unmanufactured tobacco and cotton).

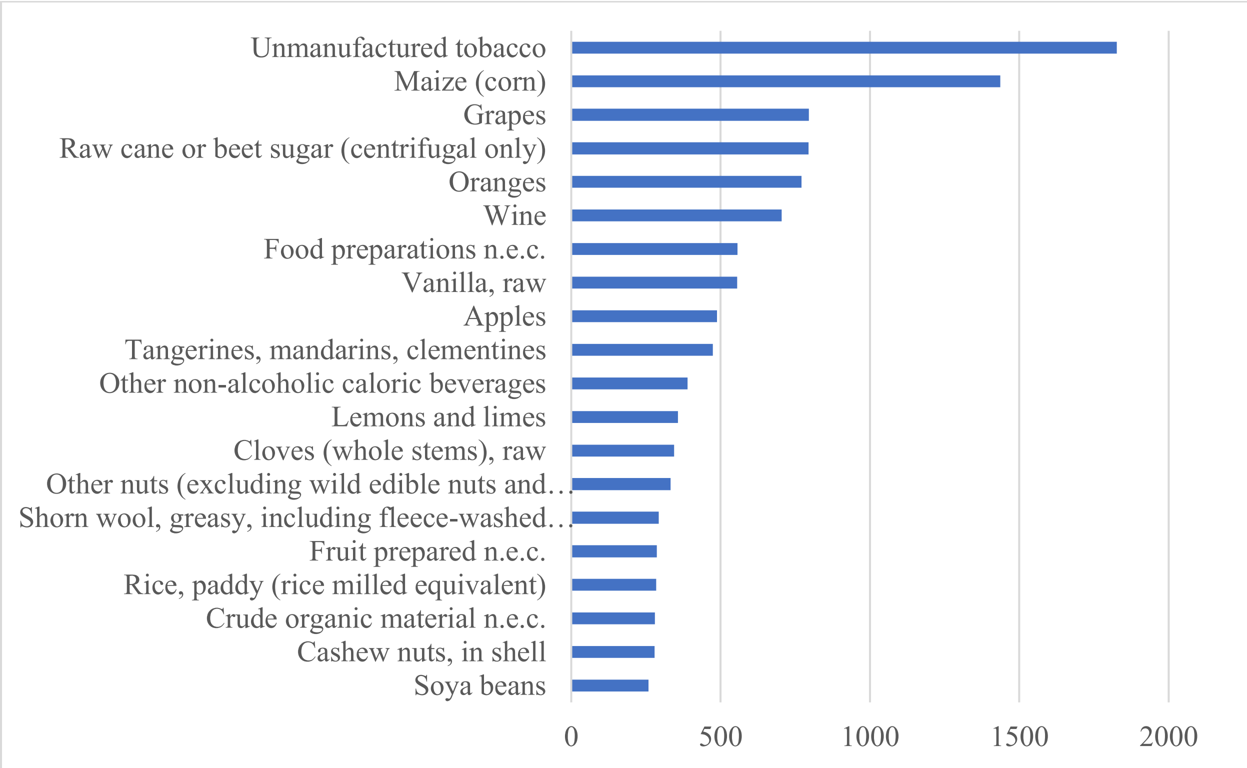

Figure 7: Major export commodities of SADC countries, 2022.

Source: Author's compilation based on data from (**FAOSTAT**)

Table 1: Agricultural exports by country, 2001 to 2022 in US$ millions

Country	2001-2006	2007-2012	2013-2018	2019-2022	Total
Angola	17	83	341	238	678
Botswana	398	989	870	465	2722
Comoros	93	88	148	89	417
DRC	180	361	459	587	1588
Eswatini	1669	1417	2914	2261	8262
Lesotho	14	12	226	446	698
Madagascar	971	1368	4511	3635	10486
Malawi	2591	5698	5154	3242	16684
Mauritius	2224	2122	2157	1077	7580
Mozambique	809	2527	4183	2983	10502

Namibia	1255	1742	2772	1327	7096
Seychelles	9	22	58	41	129
South Africa	18207	34163	54779	43375	150524
Tanzania	2525	5753	10158	7103	25539
Zambia	1367	3654	4648	3192	12861
Zimbabwe	4295	5031	6772	4380	20478

2.4 Intra-SADC agricultural trade

Intra-regional trade serves as one of the drivers of economic growth, diversification, industrialization, and regional integration. Following its establishment as a Free Trade Area (FTA) in 2012, SADC has the highest volume of intra-regional agricultural trade on the African continent compared to other Regional Economic Communities (RECs), accounting for over 50% of total intra-African trade (Bouët et al., 2022; Moyo, 2024). Despite efforts to promote intra-regional SADC trade, there has been a strong orientation toward global markets, with extra-SADC trade outstripping intra-SADC trade (Figure 8). This trend suggests the negligible impact of SADC in altering the trajectory and geographic distribution of the region's trade flows. Intra-regional agricultural trade, and overall intra-regional trade, remain low, and their proportion of total agricultural trade has not changed much over time. This is in sharp contrast to the European model of regional economic integration (largely considered as the epitome, model, and benchmark of regional economic integration), which has been hugely successful mainly due to its regulatory approach that goes beyond trade and non-trade barriers (Begg, 2021; Bjornlund et al., 2020b; Ngepah & Udeagha, 2018). This model could therefore be replicated and influence regional integration efforts of developing countries. However, replication of the European model of regional economic integration should not be construed as a panacea to the current impediments of African regional integration. This is because of the disparities and heterogeneity in economic composition and activity between developing and developed nations (Moyo, 2024).

Several factors could explain the minimal trade among SADC member states. First, high tariffs, and infrastructural and transaction costs continue to impede deeper regional integration for SADC countries, which calls for harmonizing tariff structures and policy frameworks (Sandrey et al., 2018). Sugar, for instance, is one commodity that is still subject to high tariffs and illustrates the complexities of intra-regional trade among SADC countries (Mabeta & Smutka, 2023b; Viljoen, 2014). Second, the distortionary policies of the European Union (EU) and the US, particularly dumping of subsidised products such as sugar and milk, contribute to the slow growth of the sectors and value chains of agricultural trade for SADC countries (Bjornlund et al., 2020b).

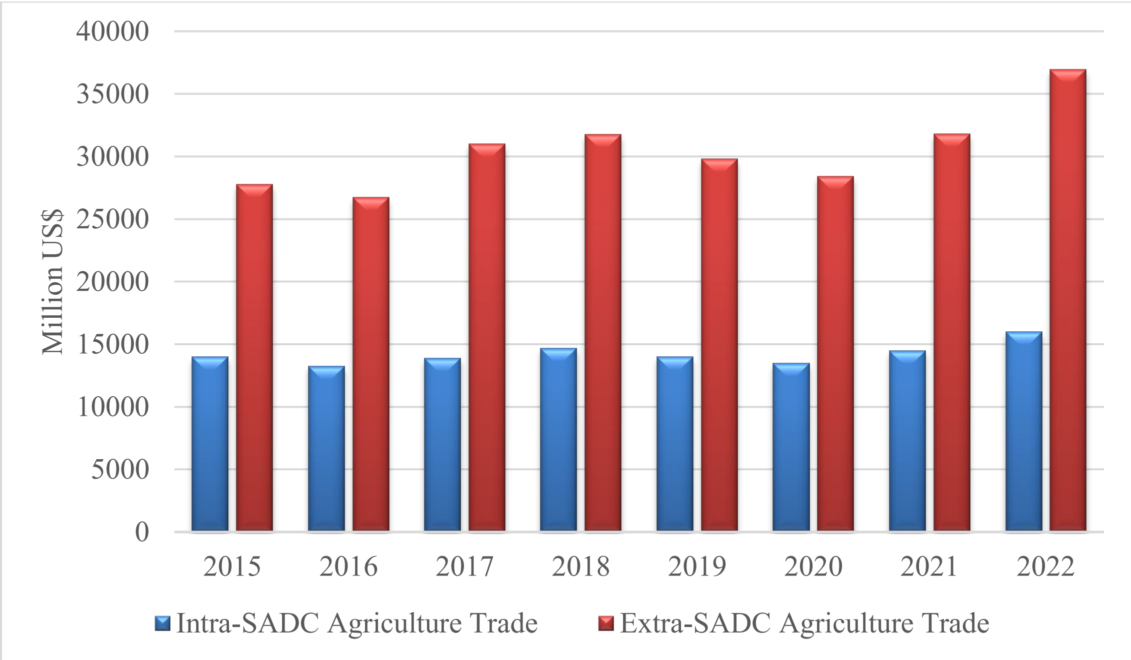

Figure 8: Trends in SADC agricultural exports, 2001 to 2022 in US$ millions.

Source: Author's compilation based on data from **Statistics Database | SADC**

Figure 9 shows that despite their proximity, SADC countries tend to trade more with non-members, particularly the European Union and the US, than amongst themselves. It is also evident that that intra-regional trade is high for landlocked African countries compared to coastal countries. South Africa is the sole African country that serves as both a major import destination and export origin for not only intra-SADC but also intra-African agricultural trade flows. South Africa has dominated exports of agricultural commodities such as maize, apples and fodder mainly to Botswana, Lesotho, Mozambique, Namibia and Zimbabwe, accounting for over a third of intra-SADC agricultural exports and about 50% of total extra-SADC exports. The key commodities traded among SADC nations largely align with the dominant categories shaping the regions global trade profile, with the exception of some product groups; cotton and horticulture (fruits, vegetables and flowers) that are more traded globally than intra-regionally, and cereals on the other hand that are traded more within SADC than exported globally (SADC, 2025). A further breakdown of value addition in traded agricultural products shows that while processed products dominate intra-SADC agricultural trade, extra-SADC trade is largely dominated by unprocessed or semi-processed exports highlighting the structural limitations that may impede the competitiveness of SADC agricultural exports in global agriculture value chains.

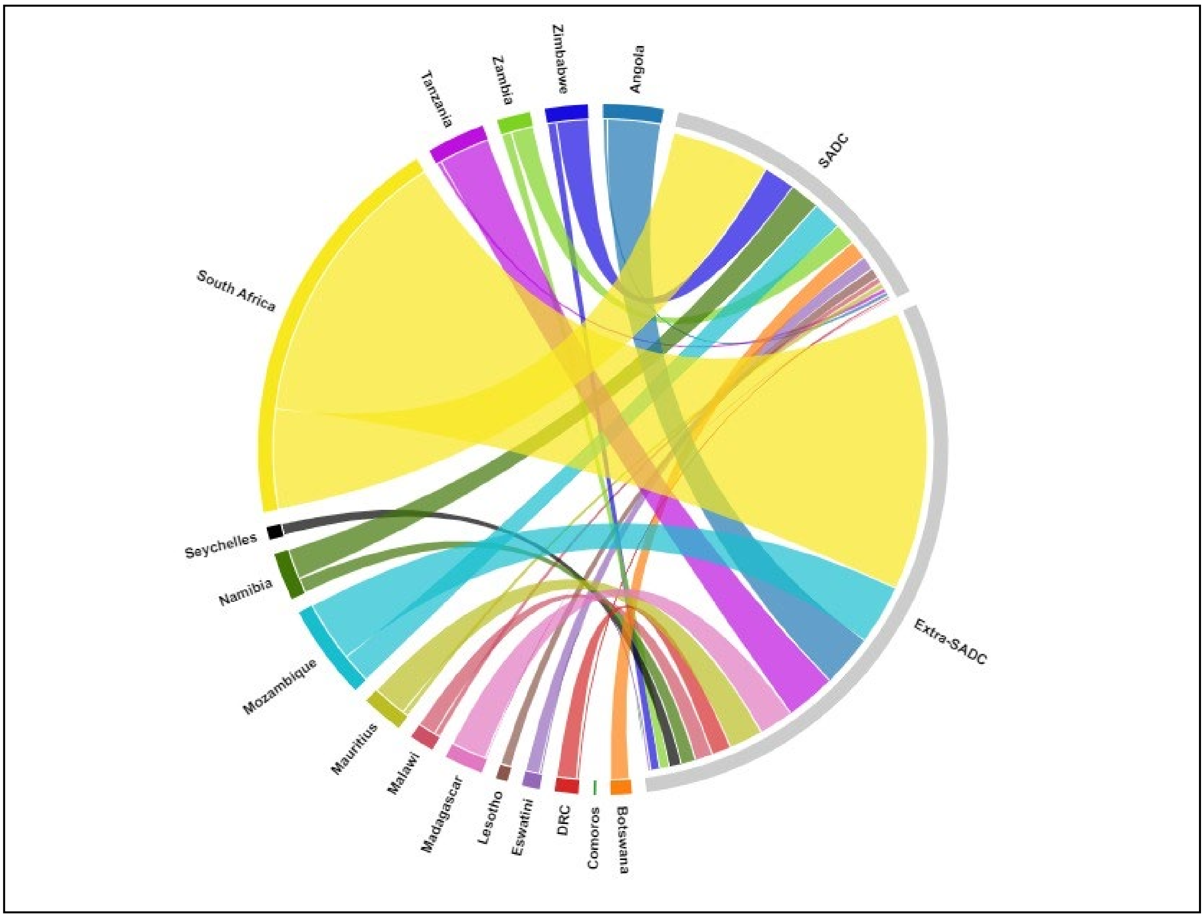

Figure 9: Intra-regional agricultural exports by country, million US$ 2015-2022.

Source: Author's compilation based on data from **Statistics Database | SADC**

Note: The outer arcs represent various SADC countries. The size of the arc shows each country's share of exports to the two categories: intra and extra-SADC regions. The inner bands depict the flow of exports from a country to either intra or extra-SADC regions with thicker bands signifying higher export volumes between the two regions.

3. Efficiency in agricultural production among SADC member states

3.1 Background to efficiency in agricultural production among SADC countries

Concerns have arisen that the marginal increase in agricultural production in most African countries may stem from expanded land area rather than enhanced productivity, potentially resulting in adverse environmental consequences and exacerbating the ongoing climate change crisis (Jayne & Sanchez, 2021; Mabeta & Smutka, 2023a). Djoumessi (2022) notes that the driving force behind the growth in agricultural production has been the expansion of cultivated areas, contrary to other regions such as Asia during the green revolution, which witnessed a swifter increase in production, while the cultivated land remained relatively stable between 1960-1980 and subsequently from 1990-2012. This situation has led to food insecurity and increased reliance on imports to meet the growing demand for food. Consequently, efforts to improve agricultural productivity through the adoption of modern technologies and sustainable practices to address these challenges and ensure food security for the region emerge as a fundamental strategy for fostering comprehensive development within the region.

Several studies have endeavoured to explain why the sub-Saharan Africa region is lagging behind in terms of agricultural production. Empirical literature has imputed the current low production for the majority of the African countries to low productivity (Djoumessi, 2022; Jayne & Sanchez, 2021). However, these studies have only considered a few inputs and how they impact agricultural productivity. A wider range of factors of production that could be influencing agricultural productivity in sub-Saharan Africa have been neglected. For instance, Amare et al. (2018) investigated how rainfall shocks have impacted agricultural productivity. Nakawuka et al. (2018), on the other hand analysed the role of irrigation in enhancing agricultural productivity. Other studies have looked at inputs such as fertiliser use (Cui et al., 2018; Jayne et al., 2019; ten Berge et al., 2019), the growing influence of investments in research and development (R&D) (Adetutu & Ajayi, 2020; Alene, 2010; Udimal et al., 2022), mechanisation (Adu-Baffour et al., 2019; Kirui et al., 2023), human capital (Baudron, Misiko, et al., 2019). Studies on the agriculture sector in Africa have also been crop-production centric without giving particular attention to other sub-sectors such as livestock, fisheries, or agro-processing. Understanding the full spectrum of factors influencing agricultural productivity is crucial for developing effective policies and interventions to improve food security and economic development in the region.

To the best of the author's knowledge, no study has conducted a holistic analysis at the sub-sectoral level on the trends and changes in agricultural productivity of African countries. Baion et al. (2023) conducted a comprehensive analysis although it was aggregated for the entire agriculture sector making it difficult to unmask the nuances that may vary depending on the sector under consideration. This study, therefore, contributes to the literature by employing a multifactorial production function at the sub-sectoral level and examining how these inputs have influenced agricultural productivity across several African countries, unlike other studies which have primarily focused on individual factors. By examining the combined impact of various inputs, this research provides a more comprehensive understanding of the complex dynamics at play in agricultural development in Africa. Due to non-availability of data, the analysis is limited to six southern African countries.

3.2 Model specification and data

3.2.1 Data

The study covers 15 southern African countries, several of which are among Africa's largest agricultural producers. Several countries have been excluded primarily due to insufficient and non-availability of data. The research focuses on the output of key agricultural sub-sectors such as crop production, livestock, and fisheries, particularly aquaculture, in the selected countries. The data covers a period spanning from 2001 to 2019. The data were obtained from the United States Department of Agriculture (USDA). Crop, livestock, and aquaculture outputs respectively comprise the harvested yield of 162 diverse crops, the aggregate worth of 30 animal-based products, and the total value of 8 aquaculture products, all expressed in $1000 constant 2015 global average farm-gate prices. Unlike Baion et al. (2023), who aggregated the three output variables, this study estimates sector-specific indices. Aggregating sub-sectoral values poses a challenge due to varying input requirements across different sectors. Moreover, including zero entries in the aggregation fails to provide an accurate representation, underestimates the annual agricultural value added and obscures sector-specific productivity changes over time. Employing a three-sector framework would yield more accurate results. The output metrics show the agricultural production orientation of individual nations, with distinct tendencies observed towards either crop-centric, animal-centric, or a combination of both production modalities. However, there is no indication of any singular nation favouring aquaculture over either crop or animal husbandry.

In this study, 6 distinct input variables, comprising quantities of land, labour, capital, livestock, machinery, and fertiliser. Land is measured in terms of rain-fed-equivalent cropland in 1000 hectares. Productivity weights of 1 are assigned to each of the various land categories such as rain-fed cropland, irrigated areas, and pasturelands. It is important to note that rain-fed cropland is defined as the portion of cropland not serviced by irrigation, thus excluding irrigated areas from the calculation. Labour is operationally conceptualised as the aggregate number of economically engaged adults, encompassing both genders, employed in the agricultural sector, quantified in units of 1000 individuals. These metrics are derived from comprehensive analyses sourced from the International Labour Organization's rigorous labour force surveys, where feasible, complemented by predictive models extrapolated by the Food and Agriculture Organization to enhance data integrity and coverage. Capital is measured in terms of the monetary valuation of net capital stock, standardised to $1000 at constant 2015 price levels. The dataset is sourced from FAO FAOSTAT Net Capital Stock (1995+), which is computed by aggregating historical capital investments subject to depreciation due to wear and tear, assessed utilizing the Perpetual Inventory Method (PIM). Antecedent to 1995, estimations are extrapolated from inventories of livestock and machinery capital.

Livestock is quantified through the assessment of farm inventories, encompassing a variety of livestock and poultry species, measured in terms of 1000 Standard Livestock Units. This metric, sourced from the FAO FAOSTAT database, includes an array of livestock varieties such as dairy cows, non-dairy cattle, buffaloes, sheep, goats, pigs, poultry, camels, camelids, draft horses, mules, and asses. These categorizations are meticulously weighted based on the seminal work of (Hayami & Ruttan, 1985). Machinery denotes the inventory of agricultural equipment utilised in farming operations, quantified in units of thousands of metric horsepower (1000 CV) across various categories such as tractors, combine-threshers, and milking machines. This dataset amalgamates information from diverse sources, including pre-2010 statistics sourced from FAOSTAT, post-2010 data extracted from National Agricultural Censuses, sales data pertaining to new tractors and combines from the private sector, and modelled estimates. Fertiliser represents the cumulative quantity of nitrogen (N), phosphorus pentoxide (P_2O_5), and potassium oxide (K_2O) nutrients from inorganic fertilisers, alongside nitrogen from organic fertilisers, administered to soil surfaces, measured in 1000 metric tons. This dataset is sourced from FAO.

3.2.2 Data Envelopment Analysis

Efficiency measurement methodologies encompass a spectrum ranging from parametric to non-parametric approaches, each yielding viable outcomes. Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) epitomise the parametric and non-parametric paradigms, respectively, and stand as quintessential tools that have been employed in recent empirical analysis. The selection between these methodologies hinges upon the underlying assumptions regarding the Decision-Making Units (DMUs). In a broad sense, a DMU is an entity responsible for transforming inputs into outputs and is subject to performance evaluation in managerial applications, encompassing a diverse array of entities including, but not limited to, banks, department stores, supermarkets, car manufacturers, hospitals, schools, and public libraries and countries (Cooper et al., 2007). As posited by Udimal et al. (2022), the primary weakness of the SFA lies in its restrictions and strong that deviations of decision-makers from the production frontier stem from stochastic disturbances and technical inefficiencies, with the former encompassing statistical noise, following a symmetrical distribution, and the latter involving asymmetrical distribution. The SFA is therefore not apt for this study. The DEA, on the other hand, has found significance in the assessment of efficiency. Particularly in the context of agricultural Research and Development (R&D), DEA emerges as an ideal tool for measuring efficiency in food production vis-à-vis investment. It is preferred to the SFA because it can handle multiple inputs and outputs without requiring pre-estimation of production functions (Hatami-Marbini & Saati, 2018).

DEA deploys a sophisticated linear programming approach to construct a frontier surface characterised by piece-wise linearity, utilizing input-output data. This method harnesses precise information regarding input and output quantities to meticulously craft a multifaceted representation, enabling comprehensive analysis and evaluation of the efficiency levels within the examined group of countries (Coelli & Rao, 2005). DEA analysis can assume either Constant Returns to Scale (CRS) or Variable Returns to Scale (VRS) under input or output orientations. When CRS is assumed, there are no variations in efficiency scales between input and output orientations. The converse holds true. In the input-oriented orientation, the DEA methodology establishes the frontier by striving to achieve the optimum input utilization while maintaining a constant output level for each country, whereas in the output-oriented scenario, it endeavours to attain the maximum possible output that can be attained while keeping input levels constant. Following Baion et al. (2023) and Coelli & Rao (2005), this study adopts a CRS as failure to do so may result in the Malmquist index inaccurately capturing gains or losses in Total Factor Productivity (TFP) stemming from scale effects. Additionally, it may not be plausible to assume CRS when the data is aggregated at the country level; hence, VRS may only be feasible at a granular or farm level.

Given the scarcity of inputs in the African context, where resources are limited and efficiency in resource use is crucial for sustainable development, most African countries are striving to maximise output from their scarce resources. Therefore, this study adopts an output-oriented Data Envelopment Analysis (DEA) model comprising six input variables: land, labour, fertiliser, capital, machinery, and livestock, and three output variables: crops, fisheries, and livestock production. Therefore, the linear programming problem under the existing assumption of CRS entails estimating the following Charnes, Cooper, and Rhodes (CCR) model that is designed to measure the relative efficiency of each DMU by maximizing output, while maintaining the same level of inputs as follows:

$$Maximize\ e_H = \sum_{j=1}^{n} v_{jH} y_{jH}$$

$$subject\ to \sum_{j=1}^{m} u_{iH} x_{iH} = 1$$

$$-\sum_{j=1}^{m} u_{iH} x_{ik} + \sum_{j=1}^{n} v_{jH} y_{jk} \leq 0,\ \ \forall k = 1,2,\dots,p,$$

$$v_{jH} \geq 0, \quad \forall j = 1,2,\dots,n,$$

$$u_{jH} \geq 0, \quad \forall i = 1,2,\dots,m. \tag{1}$$

Where k is the number of DMUs to be analysed and k=1, 2…, p. Each DMU has m inputs and n outputs, x_{ik} is the ith input of the kth DMU, y_{jk} is the jth output of the kth DMU, i=1,2,…,m, j=1,2,…,n, v_{jH} and u_{jH} are the non-negative weights for outputs y_{jH} and inputs x_{iH} for unit H (one of the specified p units), respectively.

DEA, despite its effectiveness in measuring and assessing performance, presents limitations in effectively handling time-series data and panel data, rendering it less than ideal for the current study. To address these deficiencies, the Malmquist-DEA Index emerges as a promising alternative, offering a robust framework to overcome the challenges inherent in DEA methodology. The Malmquist-DEA index methodology is adept at analysing panel data, affording the capability to decompose total factor productivity(TFP) metrics into constituent components such as technical efficiency (TECCH), technological change (TECH), and scale efficiency (SECH) (Luo et al., 2019).

3.2.3 Application of DEA to the Malmquist Index

The methodology for computing the Malmquist index is drawn from Cooper et al. (2007). The Malmquist index, an exemplar of "comparative statics" analysis, assesses the productivity shift of a DMU across two time periods. Given a set of *n* DMUs, $(\boldsymbol{x}_j, \boldsymbol{y}_j) \forall\ (j = 1, \dots, n)$ each having a set of *m* inputs represented by a vector $\boldsymbol{x}_j \in R^m, \boldsymbol{x}_j > 0$, and *q* outputs represented by a vector $\boldsymbol{y}_j \in R^q, \boldsymbol{y}_j > \boldsymbol{0}$, between periods 1 and 2. The input-output combination for $\text{DMU}_o (o = 1, \dots, n)$ for the respective two time periods is denoted by $(\boldsymbol{x}_o, \boldsymbol{y}_o)^1 = (\boldsymbol{x}_o^1, \boldsymbol{y}_o^1)$ and $(\boldsymbol{x}_o, \boldsymbol{y}_o)^2 = (\boldsymbol{x}_o^2, \boldsymbol{y}_o^2)$. The production possibility set $(X, Y)^t$ for *t*=1 and *t*=2 spanned by $(\boldsymbol{x}_j, \boldsymbol{y}_j)^1$ $(j = 1, \dots, n)$ is expressed as:

$$(X, Y)^t = \left\{ (\boldsymbol{x}, \boldsymbol{y}) | \boldsymbol{x} \geq \sum_{j=1}^{n} \lambda_j \boldsymbol{x}_j^t, 0 \leq \boldsymbol{y} \leq \sum_{j=1}^{n} \lambda_j \boldsymbol{y}_j^t, L \leq e\lambda \leq U, \lambda \geq 0 \right\} \tag{2}$$

Where e denotes a colum vector whose elements are all equal to one, $\boldsymbol{\lambda} \in R^n$ represents the intensity vector, *L* and *U* are the lower and upper bounds respectively resulting from the summation of these intensities. Arising from the assumption of CRS for this study, $(L, U) = (0, \infty)$. The production possibility set $(X, Y)^t$ contains frontiers $(\boldsymbol{x}, \boldsymbol{y})$ such that it is not possible to make $\boldsymbol{x}$ or another input for $\boldsymbol{y}$ better off without making the other inputs or output worse off. To estimate the Malmquist index, frontier technologies in periods 1 and 2 are used to evaluate two DMUs $(\boldsymbol{x}_o, \boldsymbol{y}_o)^1$ and $(\boldsymbol{x}_o, \boldsymbol{y}_o)^2$ using the catch up effect (the extent to which a DMU enhances or diminishes its efficiency) and the frontier-shift effect (shows the shift in efficient frontiers from one period to the other) as follows:

$$\text{Catch} - \text{up effect} = \frac{efficiency\ of\ (\boldsymbol{x}_o, \boldsymbol{y}_o)^2\ with\ respect\ to\ period\ 2\ frontier}{efficiency\ of\ (\boldsymbol{x}_o, \boldsymbol{y}_o)^1\ with\ respect\ to\ period\ 1\ frontier}$$

$$= \frac{\delta^2((\boldsymbol{x}_o, \boldsymbol{y}_o)^2)}{\delta^1(\,(\boldsymbol{x}_o, \boldsymbol{y}_o)^1)}$$

(3)

$$\text{Frontier} - \text{shift effect} =$$

$$\sqrt[2]{\frac{efficiency\ of\ (\boldsymbol{x}_o,\boldsymbol{y}_o)^1\ with\ respect\ to\ period\ 1\ frontier}{efficiency\ of\ (\boldsymbol{x}_o,\boldsymbol{y}_o)^1\ with\ respect\ to\ period\ 2\ frontier} \times \frac{efficiency\ of\ (\boldsymbol{x}_o,\boldsymbol{y}_o)^2\ with\ respect\ to\ period\ 1\ frontier}{efficiency\ of\ (\boldsymbol{x}_o,\boldsymbol{y}_o)^2\ with\ respect\ to\ period\ 2\ frontier}}$$

$$= \sqrt[2]{\frac{\delta^1((\boldsymbol{x}_o, \boldsymbol{y}_o)^1)}{\delta^2(\,(\boldsymbol{x}_o, \boldsymbol{y}_o)^1)} \times \frac{\delta^1((\boldsymbol{x}_o, \boldsymbol{y}_o)^2)}{\delta^2(\,(\boldsymbol{x}_o, \boldsymbol{y}_o)^2)}}$$

(4)

Therefore, the Malmquist index is computed as a geometric mean of the two effects as follows:

$$= \sqrt[2]{\frac{\boldsymbol{\delta}^{\mathbf{1}}((\boldsymbol{x}_o, \boldsymbol{y}_o)^{\mathbf{2}})}{\boldsymbol{\delta}^{\mathbf{1}}(\,(\boldsymbol{x}_o, \boldsymbol{y}_o)^{\mathbf{1}})} \times \frac{\boldsymbol{\delta}^{\mathbf{2}}((\boldsymbol{x}_o, \boldsymbol{y}_o)^{\mathbf{2}})}{\boldsymbol{\delta}^{\mathbf{2}}(\,(\boldsymbol{x}_o, \boldsymbol{y}_o)^{\mathbf{1}})}}$$

(5)

A Catch-up effect of 1 indicates no change in relative efficiency, while a value greater than 1 indicates an increase in efficiency, and a value less than 1 indicates a regression in relative efficiency. Similarly, a frontier-shift effect greater than 1 or less than 1 indicates no change, advancement, or regression in frontier technology from period 1 to period 2. The product of these two effects yields the Malmquist index, which indicates progress, deterioration, or no change in total factor productivity depending on whether the value is greater than, less than, or equal to1, respectively. The first ratio reflects changes in efficiency based on period 1 technology, while the second ratio shows changes in efficiency associated with period 2 technology.

3.3 Results and Discussion

3.3.1 Sequential changes in total productivity by country

Sequential Malmquist measures are deemed progressive due to their resilience against the confounding impacts of weather conditions, unlike conventional measures (Kirui et al., 2023) and may exhibit lesser susceptibility to outliers (Alene, 2010). Figure 10 summarises the sequential changes in total productivity across all 15 countries, with comparisons highlighted for the periods 2001–2002, 2009–2010, and 2018–2019. Most of the computed TFP indices are clustered between 0.5 and 1.5. Overall, the Malmquist index indicates significant fluctuations in TFP, especially for Angola, Namibia, and Tanzania, which experienced notable periods of productivity decline. Most of the countries recorded positive productivity growth, albeit with variations the magnitude of growth and minor fluctuations for countries such as Botswana, Lesotho, Madagascar, Malawi, Mozambique, Zambia, and Zimbabwe during some periods. On the other hand, Comoros, Congo DR, Eswatini, Mauritius, and South Africa exhibited positive productivity growth throughout the entire analysis period. Mauritius recorded the highest growth in TFP at 93% during the period from 2003 to 2004, while Lesotho experienced the highest decline of 27% between 2005 and 2006. The decomposition of the TFP indices into their constituent components shows that the major contributor to TFP growth is technical efficiency change, while technological progress and scale efficiency have remained unchanged or regressed in some periods. Scale efficiency has contributed very little towards overall agricultural productivity and has remained relatively stable during the period under analysis. Djoumessi (2022) has attributed this to poor agricultural land cover. Therefore, implementing sustainable land management practices could potentially improve scale efficiency and overall agricultural productivity in the future. These findings suggest that although African countries have made headway in utilising factors of production efficiently, there is still room for improvement in terms of innovation and technological advancements to drive overall agricultural productivity growth. None of the countries sourced their increase in productivity from technological progress. While agricultural output growth in the regions outside the African continent has been driven by intensification of agricultural inputs use and advancement in production technologies, most African countries, including SADC member states are lagging behind. Instead, the increase in agricultural production among SADC member states has been driven by the expansion of cultivated cropland. However, despite possessing relatively abundant land resources, accounting for approximately 45% of the world's surface area suitable for agricultural expansion (Goyal & Nash, 2016), such an expansionary approach remains inherently unsustainable in the long term.

These results are in congruent with past studies on the productivity of the agricultural sector of African countries that underscore the declining technological progress and increasing importance of technical efficiency in influencing agricultural productivity of African countries (Baion et al., 2023; Djoumessi, 2022; Goyal & Nash, 2016; Kirui et al., 2023; Mabeta &

Smutka, 2023a; Udimal et al., 2022). However, the results are contrary to Abed & Acosta (2018) who found that technological change was the major contributor to overall agricultural productivity for the livestock sector of African countries. The notable discrepancies in the findings of this study emanate from the sensitivity of the Malmquist index to the type of data used in its computation and the sector under consideration. The notable discrepancies in the findings of this study emanate from the sensitivity of the Malmquist index to the type of data used in its computation and the sector under consideration. For instance, Abed & Acosta (2018) used only two output variables, aggregate figures for beef cattle and dairy cow milk output, and two input variables, land and capital (cattle stocks and permanent pastures and meadows), to assess livestock productivity in selected African countries.

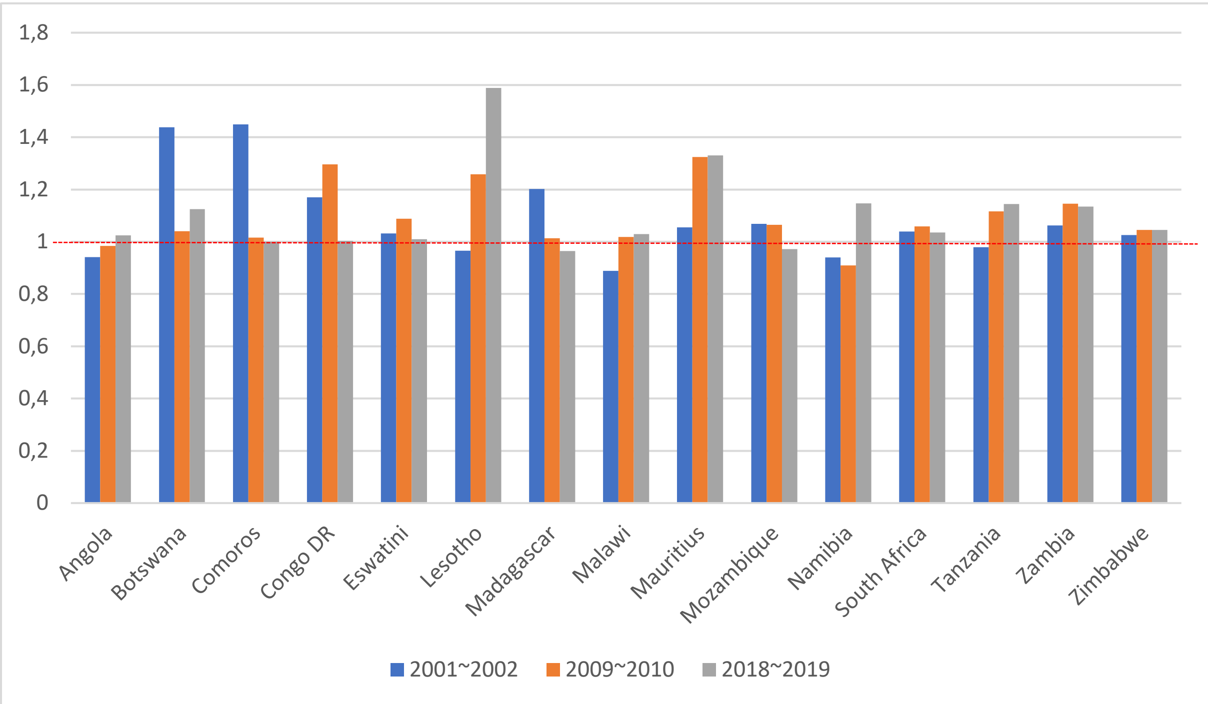

Figure 10: Sequential changes in productivity growth by country: 2001 to 2019.

Source: Author's compilation based on data from USDA

3.3.2 Productivity changes over six-year periods and overall

The computed TFP indices across the 15 countries over different periods (2001-2007, 2007-2013, 2013-2019, and 2001-2019) are presented in Table 2. The highest productivity growth rate was in the period 2007 to 2013, with nine countries achieving this feat. The same number of countries recorded the lowest productivity growth rates in the period 2001 to 2007 as in the period 2013 to 2019. Among the lowest recorded growth rates across all the countries, only

Mauritius, South Africa and Zambia exhibited positive productivity growth. Put differently, these three countries are the only ones to have had positive productivity gains in each of the three periods, while the rest of the countries alternated between periods of positive and negative productivity growth. Mauritius stands out with exceptional productivity growth of about 207% achieved during the period 2013 to 2019 and by over 500% overall between 2001 and 2019. Countries with the lowest and negative productivity growth rates in the period 2001-2007 and 2007-2013 are Malawi and Botswana, respectively. Namibia not only recorded the lowest and negative productivity growth in the period 2013 to 2019 but also overall for the period 2001 to 2019 and had negative growth rates in each period. Overall, considering the changes in productivity over a long horizon from 2001 to 2019, most countries experienced positive productivity growth, except for Angola, Botswana, Madagascar, Namibia, and Tanzania which witnessed a regression in productivity. Again, positive overall productivity can be attributed to technical efficiency changes and partly to scale efficiency, albeit declining in certain years. This implies that the productivity of African agricultural sectors depends on the optimum utilization of factors of production, given the significant changes in the levels of technical efficiency. Although scale efficiency is positive and indicates a stable level of efficiency, it has emerged as a significant impediment to TFP expansion, as evidenced by variability in the productivity indices over the duration under scrutiny, alternating between periods of efficiency and inefficiency. The fluctuations in scale efficiency are because of minimal progress in agricultural land use during the study period. The trends also highlight that African countries are lagging in terms of technological efficiency and suggest that they may benefit from investing in technology and innovation to improve productivity levels.

Table 2: Productivity growth over six-year periods and overall, by country

Country	**2001-2007**	**2007-2013**	**2013-2019**	**2001-2019**
Angola	0.9572	1.178	0.8771	0.7543
Botswana	1.1286	0.607	0.8821	0.6785
Comoros	1.6144	1.0348	0.7754	1.1811
Congo DR	0.8883	1.4371	0.8407	1.0676
Eswatini	0.9758	1.1498	1.0255	1.223

Lesotho	0.9744	1.0619	1.9733	2.5214
Madagascar	1.2371	0.8002	0.7988	0.8213
Malawi	0.8749	1.3295	1.1775	1.6537
Mauritius	1.2373	1.4976	3.0658	5.5626
Mozambique	1.0241	1.0984	0.9978	1.179
Namibia	0.9304	0.727	0.7664	0.4732
South Africa	1.1691	1.2441	1.0145	1.5861
Tanzania	0.9629	1.1432	1.0471	0.8325
Zambia	1.163	1.6631	1.4937	2.2731
Zimbabwe	0.9109	1.501	0.973	1.5676

4. Competitiveness of agricultural exports of SADC countries

4.1 Measuring competitiveness

Different measures have been used to assess export competitiveness, which is fundamentally based on the concept of Revealed Comparative Advantage (RCA). Recent empirical literature uses a variety of indices, often in combination, which are summarised in Table 3.

Table 3: Measuring export competitiveness

Index Name	Description	Recent Applications
Revealed Comparative Advantage (RCA)	Measures relative export performance of a country in a specific product relative to the world.	(Balassa, 1965; Bojnec & Fertő, 2015; Matkovski et al., 2019; Stellian et al., 2024; Stellian & Danna-Buitrago, 2022a)
Trade Balance Index (TBI)	Compares a country's exports and imports of a specific product.	(Lafay, 1992; Szczepaniak, 2019)
Constant Market Share (CMS)	Decomposes export growth into market size,	(Dai et al., 2020; Gilbert & Muchová, 2018; Odjo & Badiane,

	competitiveness, and structural effects.	2018; Zdráhal et al., 2023; Zhou & Tong, 2022)
Revealed Symmetric Comparative Advantage (RSCA)	Symmetric version of RCA, ranging from -1 to 1, to eliminate skewness.	(Banerjee et al., 2021; Laursen, 2015; Naseer et al., 2019; L. Wang et al., 2022)
Normalized Revealed Comparative Advantage (NRCA)	Adjusts RCA to address World trade imbalances.	(Mabeta & Smutka, 2023b; Seleka & Dlamini, 2020; Seleka & Kebakile, 2017; Szamosközíné Kispál, 2015; Yu et al., 2009)
Export Similarity Index (ESI)	Compares the similarity of export structures between countries.	(Kanupriya, 2020; Lee et al., 2022; P.-Z. Wang & Liu, 2015)
Trade Competitiveness Index (TCI)	Integrates export and import data to determine a country's competitive stance in global markets.	(Chen et al., 2020; Fam, 2016; Lee et al., 2022)
Trade Performance Index (TPI)	Evaluates a country's trade performance by assessing its export and import dynamics.	(Corovic & Jestratijevic, 2021; Fortis et al., 2015; ITC, 2020)
Export Concentration Index (ECI)	Measures the degree to which a country's exports are concentrated in a few products.	(Can et al., 2023; UNCTAD, 2024)
Relative Trade Advantage (RTA)	Combines RCA metrics with import-related data to evaluate trade competitiveness.	(Rooyen & Esterhuizen, 2012; Szamosközíné Kispál, 2015; Vollrath, 1989, 1991)
Additive Revealed Comparative Advantage (ARCA)	A modified RCA index that avoids extreme values and provides a more balanced measure.	(Dimitrijević, 2023; Hoen & Oosterhaven, 2006; Szamosközíné Kispál, 2015)

Contribution-to-the-Trade-Balance (CTB) indexes	Measures the contribution of a specific product or sector to a country's overall trade balance	(Danna-Buitrago & Stellian, 2021; De Saint, 2008; Stellian & Danna-Buitrago, 2022a)

Since Balassa (1965) introduced his groundbreaking work in 1965, the Revealed Comparative Advantage (RCA) index has become a widely used tool for assessing competitiveness in international trade. The basic RCA is calculated as the proportion of a specific product in a country's total exports relative to the proportion of that same product in global exports as follows:

$$BI_j^i = \frac{\left(E_j^i / E_j^w \right)}{E^i / E^w} \quad (7)$$

Where E_j^i represents the exports of a specific commodity j from country i, while E_j^w denotes the global exports of the same commodity j. Similarly, E^i shows total exports of all commodities from country i, and E^w signifies the total exports of all goods worldwide. For the agricultural sector, Balassa's index can be modified as:

$$RCA_j^i = \frac{\left(X_A^i / X_M^i \right)}{X_A^W / X_M^W} \quad (8)$$

Where X_A^i country i's exports of agricultural products, X_M^i is country i's total exports of all merchandise commodities, X_A^W is the world exports of agricultural products, and X_M^W is world total exports of all merchandise goods.

Due to the fundamental limitations of Balassa's RCA Index, including its asymmetry resulting from unequal lower and upper bounds, its bias toward smaller countries where high index values may not reflect substantial export shares, and its lack of additivity across products and nations (Liu & Gao, 2019), more sophisticated analytical tools have been developed to assess export competitiveness. Despite the emergence of various RCA indices, no single universally superior measure exists, as their effectiveness varies depending on the countries, timeframes, and products analysed, often leading to inconsistent results (Stellian & Danna-Buitrago, 2022b). One of the most widely used measures of export competitiveness in recent years, developed to address the shortcomings of Balassa's index, is the Normalized Revealed Comparative Advantage (NRCA) index. This study particularly adopts the NRCA due to its symmetrical and additive properties, which distinguish it from Balassa's index. This approach has not been applied in previous studies of the agricultural sector as a whole but has been limited to product-level analyses (Mabeta & Smutka, 2023b; Odjo & Badiane, 2018; Seleka & Dlamini, 2020; Seleka & Kebakile, 2017). Studies assessing the entire agricultural sector have relied on alternative metrics, such as market share (Bouët & Odjo, 2020; Dedehouanou et al., 2019a; Odjo & Badiane, 2018), and price differences (Bouët & Odjo, 2020; Dedehouanou et al., 2019a) without examining how competitiveness has evolved over time. This study adopts an aggregate approach to account for synergies and spillover effects that transcend individual commodities, capturing the influence of shared drivers, policy levers, and systemic risks that shape the performance of the agricultural sector as a whole. Following Seleka & Dlamini (2020) and Yu et al. (2009), the NRCA index to assess the competitiveness of SADC countries' overall agricultural competitiveness is computed as:

$$NRCA = \frac{(X_A^i * X_M^w) - (X_M^i * X_A^w)}{(X_M^w)^2} \tag{9}$$

Where X_A^i is country i's total agricultural exports, X_M^i is country i's total merchandise exports, X_A^w is the world's total agricultural exports, and X_M^w is the world's total merchandise exports. A positive NRCA index indicates that the agricultural sector of a given country is competitive, a negative value shows that it is not competitive, while a value of zero indicates that the country's agricultural sector is neither competitive nor uncompetitive.

4.2 Data sources

NRCA indices are computed for 16 SADC countries for the period 2001 to 2021. Data on agricultural exports were obtained from the FAO, while data on merchandise exports were sourced from the World Development Indicators of the World Bank. Data from these same sources were also collected for the top 10 largest agricultural producers to gauge how they fare against the leading agricultural exporters on the global stage.

4.3 Results and discussion

Table 4 presents NRCA index variations in agricultural competitiveness across SADC countries from 2001 to 2021. Eleven of the 16 member states maintained positive indices, indicating overall competitiveness. Sectoral specialization and strong external demand for key products, including fruits, vegetables, avocados, nuts, spices, vanilla, sweet potatoes, and groundnuts, have driven agricultural competitiveness in most SADC countries (Dedehouanou et al., 2019b). More diversified economies, particularly South Africa, Zimbabwe, and Tanzania, demonstrated stronger performance than their less diversified counterparts. South Africa emerged as the regional leader with the highest mean NRCA index, though its competitiveness showed significant volatility, likely due to climate shocks and global commodity price fluctuations affecting key exports like citrus and wine. The analysis reveals a concerning trend among resource-dependent nations. Three of the five SADC countries with negative NRCA indices, Angola, Botswana, and the DRC, are mineral- and oil-rich, suggesting potential Dutch disease effects that structurally disadvantage agricultural trade. This pattern is most acute in Angola, which continues to underperform agriculturally despite its considerable arable land and water resources following its civil war. Among small island states, all except Seychelles recorded positive NRCA indices. Seychelles' slight negative performance reflects its land constraints and economic focus on tourism and fisheries rather than agriculture.

Table 4: Descriptive statistics of NRCA indices of SADC countries

Country	Mean NRCA	SD NRCA	Min NRCA	Max NRCA
Angola	-0.016541857	0.006542226	-0.02680572	-0.006829193
Botswana	-0.001628005	0.000589418	-0.002828828	-0.000522207
Comoros	0.000117382	6.68792E-05	4.67439E-05	0.000310423
DRC	-0.00267277	0.002044889	-0.007042511	-0.000563444

Eswatini	0.001674526	0.000707543	0.000543178	0.003125427
Lesotho	-0.000250725	0.000194081	-0.000471275	0.000365056
Madagascar	0.002038774	0.001473035	0.000515528	0.005165316
Malawi	0.004718499	0.001105123	0.003622054	0.007547795
Mauritius	0.001521189	0.00098187	0.000414429	0.003514335
Mozambique	0.001343692	0.000717395	0.000124235	0.002398267
Namibia	0.000572289	0.000762009	-0.000508405	0.002397921
Seychelles	-0.000167477	3.75732E-05	-0.000222913	-9.26981E-05
South Africa	0.006784553	0.006485356	-0.004602597	0.016080649
Tanzania	0.00544942	0.002128451	0.003156353	0.010806058
Zambia	0.000879057	0.000981569	-0.000217646	0.003404782
Zimbabwe	0.005115455	0.002409199	0.002382412	0.013108768

SADC countries demonstrate substantially lower agricultural export competitiveness compared to global leaders (Table 5). China and Germany represent exceptions among major economies, with their negative NRCA indices reflecting industrial sector dominance rather than agricultural performance. The competitive gap becomes particularly evident when comparing SADC's strongest performers - South Africa and Tanzania - to global agricultural powerhouses like Brazil and the Netherlands, where NRCA indices are typically 20-50 times higher. This disparity stems from fundamental differences in agricultural systems. Leading exporters combine scale and specialization (Brazil, U.S.) or focus on high-value products (Netherlands), supported by advanced technologies and efficient supply chains. By contrast, SADC countries face systemic constraints including fragmented smallholder production, inadequate infrastructure, limited mechanization, and minimal value addition. The inverse relationship between industrial development and agricultural competitiveness further manifests in cases like Germany and China, where manufacturing prowess appears to crowd out agricultural export performance.

Table 5: Descriptive statistics of NRCA indices of the world's leading agricultural exporters

Country	Mean NRCA	SD NRCA	Min NRCA	Max NRCA
Brazil	0.297163127	0.063796528	0.193570171	0.380777002

Canada	0.042413101	0.03402549	-0.016366384	0.100848638
China	-0.504330561	0.241365384	-0.915355717	-0.098408263
France	0.158879859	0.023971222	0.121399855	0.201406583
Germany	-0.172696296	0.03817914	-0.242080452	-0.106911099
Indonesia	0.098936625	0.042638035	0.009502425	0.155084591
Italy	0.023492772	0.015016844	-0.007942864	0.051610253
Netherlands	0.230778676	0.027975155	0.178021861	0.289720345
Spain	0.125356763	0.016719656	0.101288109	0.17136639
USA	0.143159543	0.03748103	0.079099452	0.216998613

A close examination of NRCA time series plots for the SADC countries (Figure 11) reveals varying patterns. Comoros, Eswatini, Madagascar, Malawi, Mauritius, Mozambique, Tanzania, Zimbabwe, all been competitive throughout the entire period although the degree has been fluctuating and weakened in some years suggesting erosion in comparative advantage with no clear upward trajectory. This may be due to limitations in agricultural export capacity, and reliance on a narrow export basket. While South Africa, Zambia, Namibia, largely been competitive, they have struggled to maintain competitiveness and have alternated with periods of uncompetitiveness. On the other hand, Lesotho transitioned from uncompetitive to gaining competitive in the last 2 years. Angola, Botswana, DRC, Seychelles had persistently negative NRCA values during the entire period indicating a lack of competitiveness. Regarding the trends for the world's leading agricultural exporters (Figure 12), Spain, United States of America (USA), France and Netherlands despite being competitive during the entire period do not show any upward trajectory while there is a clear upward trajectory and consistency in competitiveness for Brazil, Canada, Indonesia, and Italy. Germany's negative indices confirm it as a net exporter, while China's deteriorating competitiveness highlights its dependency on global markets to meet the consumption needs of its population.

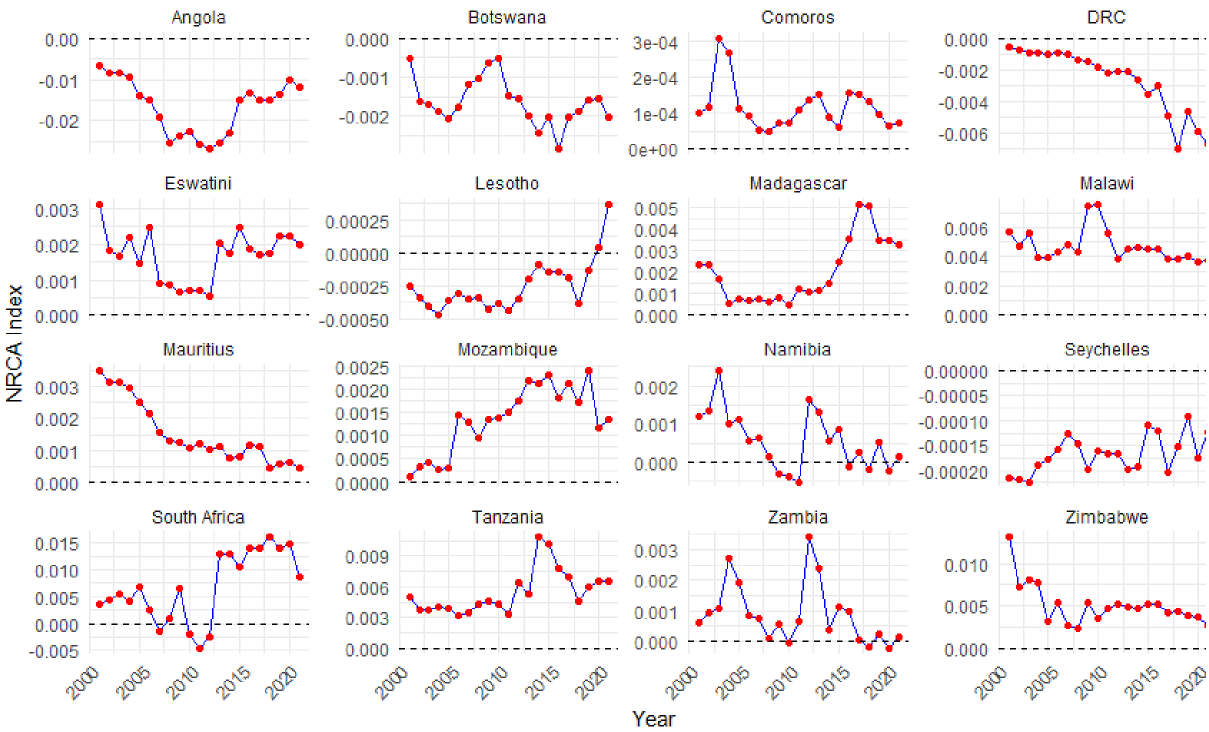

Figure 11: Trends in competitiveness of SADC countries.

Source: Author's compilation from various data sources

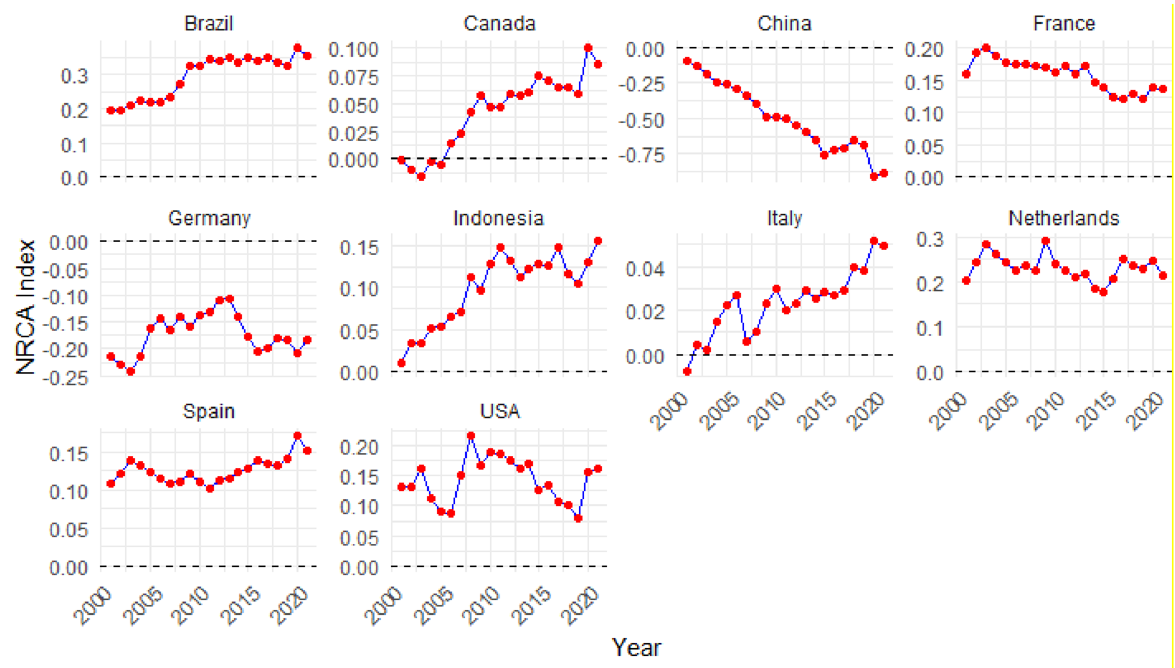

Figure 12: Trends in competitiveness of the world's leading agricultural exporters.

Source: Author's compilation from various data sources

4.4 Summary and recommendations

This study aimed at assessing the performance of agricultural sectors of SADC countries with particular emphasis on production, exports, efficiency, and competitiveness. To measure efficiency, the study employed DEA to compute Malmquist productivity indices for the agricultural sectors of 15 countries using data spanning 2001/2002 to 2018/2019. The TFP index is decomposed into technical efficiency change indices, indicating proximity to the production frontier, technology change indices, reflecting shifts in the production frontier itself and scale efficiency, measuring the ability of firms to operate at an optimal scale of production. The study deviates from previous research and contributes to the literature by employing a comprehensive and disaggregated analysis of the primary constituent sub-sectors of the agricultural sector, namely crop production, livestock, and fisheries.

The Malmquist indices unveil a positive trajectory in total factor productivity across the agricultural sectors for 11 out of the 15 SADC countries considered in this study from 2001 to 2021, with the period 2007 to 2013 recording the highest productivity growth rates. Distinct patterns are evident at country level. Only a few countries: Mauritius, South Africa and Zambia experienced positive productivity growth in each of the three periods, while the rest of the countries experienced periods of both productivity growth rate and regression. The worst performers in the period 2001-2007 and 2007-2013 are Malawi and Botswana, respectively while Namibia consistently recorded negative productivity growth in each of the three periods. While overall productivity has increased for African countries between 2001 and 2019, technological progress has regressed. This suggests that improvements in productivity have been driven more by technical efficiency gains rather than advancements in technology. These findings underscore the imperative for technological innovation and sustainable land management practices to drive agricultural productivity, especially given that African countries have the fastest-growing population in the world. With this population growth projected to persist until 2050, there is a pressing need for the region to accelerate agricultural productivity to meet escalating demand and surpass population growth. Emphasizing technology as the primary catalyst for global agricultural productivity growth underscores the urgency of technological advancement in the region. Further research is needed to understand other factors affecting overall productivity and those contributing to the regression in technological innovation and how it can be enhanced for sustainable growth.

The computed NRCA indices show that most SADC countries maintained agricultural export competitiveness throughout the 2001-2021 period. While this finding appears counterintuitive given the region's favourable production conditions and agricultural economic importance, significant gaps remain relative to global leaders. Achieving convergence will require comprehensive reforms across four key areas. First, climate adaptation measures must be prioritised, particularly through expanded irrigation infrastructure to enhance resilience. Second, technological modernization of agricultural production systems is urgently needed to overcome persistent productivity constraints. Third, strategic integration into the global value chains through targeted investments in agro-processing would enable greater value capture. Fourth, regional market diversification through strengthened integration and coordinated agricultural policies could mitigate the limitations reflected in the current modest NRCA indices. Fifth, African governments should prioritise institutional reforms, particularly streamlining customs procedures and reducing transaction costs through enhanced communication and transportation infrastructure. Finally, given the distinct patterns of agricultural competitiveness and heterogeneity in economic structures, diversified economies such as South Africa, Zimbabwe, and Tanzania should leverage their export potential in high-value commodities such as citrus fruits, wine, and spices. Meanwhile, resource-rich countries such as Angola, the DRC, and Botswana should counteract the effects of Dutch disease by ring-fencing mineral revenues for the modernization of their agricultural sectors.

In addition to the proposed policy actions above, African countries have significant potential to improve the performance of their agricultural sectors by adopting liberal policies to integrate into global or regional value chains and attracting increased FDI to meet the sector's investment needs. When agriculture is given priority and investments are directed toward improving the skills and resources of smallholder farmers, it is more likely to result in increased productivity and exports, decreased reliance on imports, and more inclusive economic growth. It is in this regard that developing nations, often constrained by limited domestic savings, should prioritise attracting FDI to address the shortfall between available savings and the level of investment required. It ais also envisaged that given the disparities in economic growth among SADC member states, FDI can bridge this gap and strengthen regional integration efforts towards advanced levels such as an economic union. In this context, FDI can be seen as a catalyst for trade, and a means to deepen trade integration between countries and the global economy. By increasing exports and reducing imports, FDI can also lead to a favourable balance of payments for the host country. Studies on export-oriented growth highlight that FDI supports economic expansion in countries that implement trade strategies emphasizing exports as evident in East Asian economies like China, Hong Kong, Taiwan, and South Korea, where significant FDI inflows were concomitant with impressive export growth and strong economic performance (Gamariel & Hove, 2019). Given these insights on the demonstrated role of FDI in driving export-oriented growth in Asian countries, examining its effects on trade performance of African countries could provide valuable information for policymakers to strengthen regional integration efforts. In this regard, future research should conduct an econometric analysis of how FDI impacts trade performance, particularly with reference to exports and export competitiveness in African countries.

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